4. POTENTIAL IMPACT ON ENVIRONMENT COMPONENTS. MITIGATION MEASURES.

According to the existing legislation, this chapter analyzes the potential impact of the completion and operation of the Cernavoda NPP Unit 3 and Unit 4. Direct and indirect impact aspects are taken into consideration, as well as the cumulated impact, having in view the Unit 3 and Unit 4 operation simultaneously with Units 1 and 2. The aspects regarding the decommissioning of the Units (the design life for each nuclear unit is 30 years) were analyzed in Chapters 2 and 3.

A special attention was given to the radiological impact, which is assessed separately in Chapter 4.9.

The non-radiological impact is analyzed in this chapter taking into consideration each environment component.

The main sub-chapters 4.1 – 4.5 present existing conditions within the site and in the surrounding zone regarding environmental factors. They analyze aspects regarding surface waters, ground waters, meteorological conditions, soil, subsoil, geology, seismicity, biodiversity and protected areas.

4.1. Potential Impact on Waters

The Cernavoda NPP site is at a relatively small distance (4 – 5 km) from the Danube River, on the northern side of the Danube - Black Sea Canal (DBSC), at about 0.5 – 0.8 km from the derivation canal. From Chiciu - Silistra and Calarasi, the Danube River is divided in two branches (Figure 4.1-1): Dunarea Veche (east) and Borcea (west), that join downstream of Harsova. After 25 km from this ramification, the Bala branch connects the branches Dunarea Veche and Borcea. The Cernavoda town is located at about the middle of the branch Dunarea Veche, about 75 km downstream from Silistra and 62 km upstream from Giurgeni (about 50 km upstream from Harsova). Just upstream Cernavoda, there is the water intake of the DBS Canal.

The necessary water for the units of the Cernavoda NPP flows from the Dunarea Veche branch through water race 1 of the DBS Canal and then through the derivation canal to the NPP water intake basin.

Since 1996, Unit 1 discharged its effluent to the Danube (at a very small distance downstream km 296) except for some periods of about 1 month when this effluent was evacuated to the DBSC. Unit 2 is envisaged to be completed and to start working in 2007, and it will discharge its effluent together with the Unit 1 effluent.

The Cernavoda NPP Units 3 and 4 will discharge their effluents consisting of cooling water and service water to the Danube branch Dunarea Veche or to the DBSC race 2, by means of the hydrotechnical constructions with this purpose.

The effluents coming from the Cernavoda NPP Units consist of Danube water with some additional small concentrations of substances due to the NPP activities, and a notable thermal load according to the design. The loads in the Unit 3 and Unit 4 effluents are envisaged to be similar to those in the effluent from Unit 1. Taking into consideration the temperature increase in comparison with the receptor, it was necessary to analyze the effluent discharge potential impact on the ecosystem in the receptor, especially the thermal impact. A main support of the assessments referring to the Units 3 and 4 effluents impact and the cumulated impact of the effluent from four units is represented by the field results regarding the Unit 1 effluent effects on the Danube and on the Danube - Black Sea Canal. With regard to Unit 1, ICIM performed field campaigns (of some days) and studies between 1999 - 2006. Table 4.1-1 presents, for each campaign, the type of measurements and water samples, the month, and also some important remarks for the specification of each situation. Previously, the Unit 1 potential influence had been studied by ICIM in the Environmental Impact Assessment (1994). In this Report, the effects are assessed using physical, chemical and biological data referring to the Danube and the DBSC in the effluent discharge area, before and after the Unit 1 commissioning. The analysis and characterization of the aquatic environment state on these water courses involved the examination of many aspects and multidisciplinary activities. This was the subject of several environmental studies for SNN and its companies CNE-PROD, CNE-INVEST (Ref. 4.1-12, 4.1-13, 4.1-14, 4.1-15). The impact of the Cernavoda NPP effluent thermal load is assessed having in view the direct and indirect potential influence of the temperature increase in the effluent on water temperature and quality indicators in the receptor.

The existing conditions along these receptor water courses are influenced by many natural factors and human activities. That is why field observation of the thermal plume and its extension, and water sampling from the river reach upstream and downstream the Unit 1 effluent discharge section and from the DBSC race 2, were essential for obtaining data and assessments of the real situation. Successive studies were necessary on the river stretch where the heated effluent is discharged and on the DBSC, due to the variable parameters of the water course. Each time, the dates of the field campaigns were chosen aiming at more complete knowledge of the effluent influence under various conditions. The indicators analyzed within the thermal impact study were selected on the basis of the legislation and water management license for CNE-PROD, taking also into consideration potential effects of an effluent with thermal load on the aquatic environment. The range of measurements and analyzed indicators included water temperature distribution, water reaction, oxygen regime indicators, nutrients, mineralization, specific chemical indicators, biological indicators and planktonic populations composition, microbiological parameters. The results are compared with the limits specified by the last regulations adopted starting from the Water Framework Directive 2000/60/EC.

According to the legislation, Chapter 4.1 analyses in detail the state of the surface water bodies in the neighborhood of the Cernavoda NPP, hydrogeological conditions, water supply, direct and indirect non-radiological potential impact of the Unit 3 and Unit 4 completion and operation on waters.

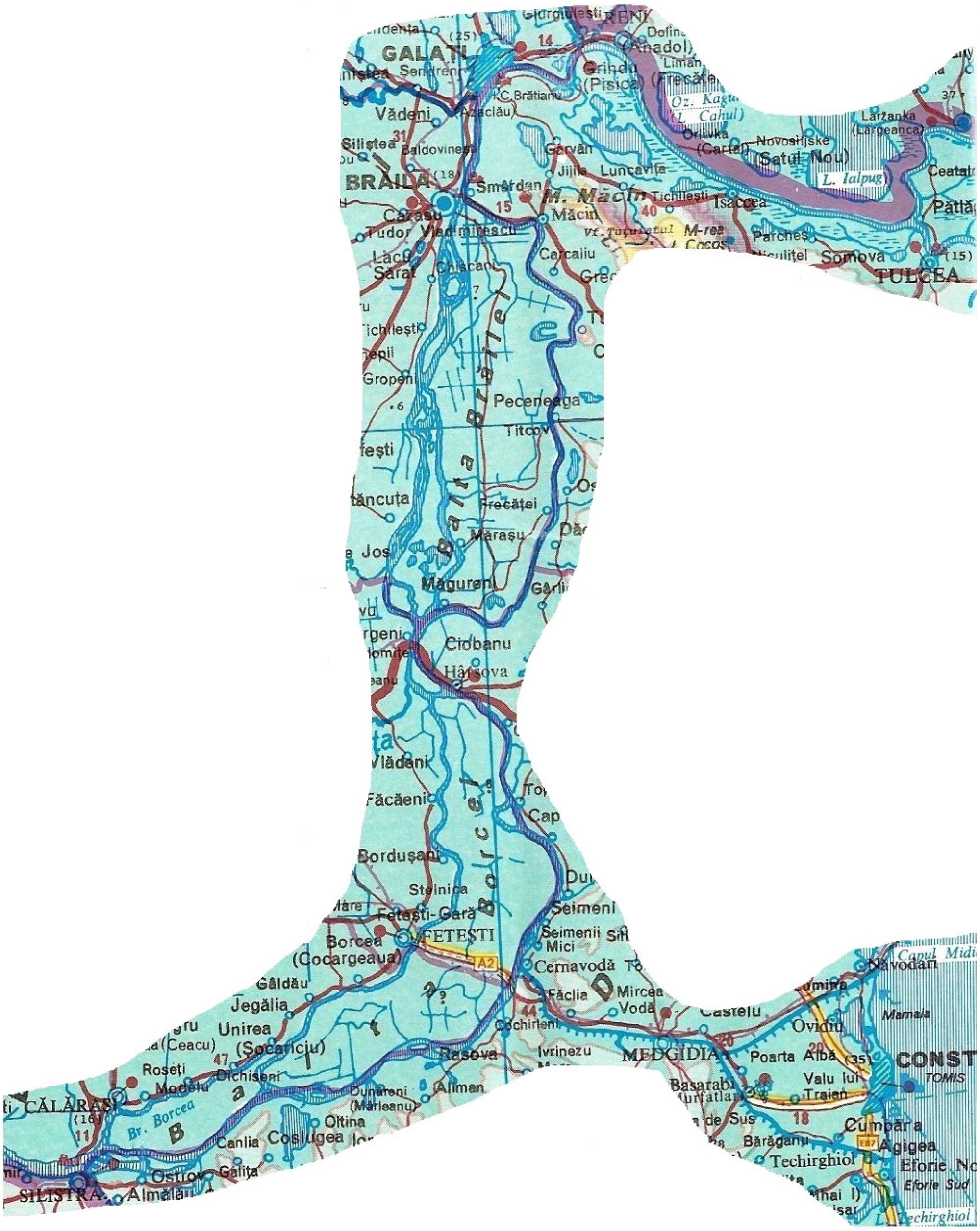

Figure 4.1-1. The Danube branches upstream and downstream Cernavoda, and the Danube - Black Sea Canal

Table 4.1-1. Field campaigns performed by ICIM on the Danube branch Dunarea Veche and on the Danube - Black Sea Canal

Month	Measurements and water samples	Remarks
February 1999	Water temperature measurements on the Danube at the DBSC intake and in the derivation canal	Effluent discharge into the Danube.
March 1999	Water temperature measurements on the Danube at the DBSC intake and along water race 1 and water race 2 of the DBSC. Water samples for chemical, biological and microbiological analyses.	50 % recirculation. Effluent discharge into the Danube.
April 1999	Water temperature measurements on the Danube at the DBSC intake and along water race 1 and water race 2 of the DBSC.	Effluent discharge into the Danube.
May 1999	Water temperature measurements on the Danube at the DBSC intake and along water race 1 and water race 2 of the DBSC. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into water race 2 since one month.
August - September 1999	Water samples from the Danube at the DBSC intake and from water race 1 and water race 2 of the DBSC, for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. After a very warm summer
July 2001	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
July 2001	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
August 2001	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
August 2001	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
April 2003	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
May 2003	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
June 2003	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	During the planned outage period of Unit 1.
July 2003	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. Extremely low water level.

Table 4.1-1. Field campaigns performed by ICIM on the Danube branch Dunarea Veche and on the Danube - Black Sea Canal (continued)

Month	Measurements and water samples	Remarks
August 2003	Water temperature measurements on the Danube upstream and downstream the effluent.	Effluent discharge into the Danube. Extremely low water level.
October 2003	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. Extremely low water level.
January 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. Recirculation.
February 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. Recirculation.
April 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube. High water level.
April 2004	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
May 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
May 2004	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into water race 2 since one month.
October 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
October 2004	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
November 2004	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into the Danube.
November 2004	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical, biological and microbiological analyses.	Effluent discharge into water race 2 since one month.
April 2005	Water temperature measurements in the area of the effluent discharge into DBSC water race 2.	Effluent discharge into water race 2 since one week.
May 2005	Water temperature measurements in the area of the effluent discharge into DBSC water race 2. Water temperature measurements on the DBSC water race 2 and water samples for water quality analyses.	Effluent discharge into water race 2 since one month.

Table 4.1-1. Field campaigns performed by ICIM on the Danube branch Dunarea Veche and on the Danube - Black Sea Canal (continued)

Month	Measurements and water samples	Remarks
August 2006	Water temperature measurements on the Danube upstream and downstream the effluent. Water samples for chemical and biological analyses.	Effluent discharge in the Danube. Average water level.
August 2006	Water temperature measurements on the DBSC water races 1 and 2. Water samples for chemical and biological analyses.	Effluent discharge in the Danube.

4.1.1. Hydro-geological Conditions of the Site. Underground Waters.

The hydro-geological studies performed in South Dobrogea showed the existence of a general aquifer stocked both in the Jurassic and Barremian limestones. In the limits of the aquifer (Jurassic and Barremian limestones), the underground waters circulate on the SW-NE direction, from the Danube towards the Black Sea, with low speeds of 4-8 m/year (Ref. 4.1-35).

In the Ovidiu - Constanta zone, about 60 km east from the site, drinking water is extracted through drillings from the Jurassic limestones with a flow rate of over 1 m^3/sec.

In the Cernavoda area, the deep waters in the Jurassic limestones are isolated from the surface waters and from those stored in the Barremian limestones by a thick layer of Vallanginian marl clays of about 130 m, being practically waterproof, but some slight connections have not been excluded between the two aquifers through the cracks existing in the marl clays.

From the hydro-geological point of view, there are three aquifers within the Cernavoda NPP zone: the phreatic aquifer, the aptian aquifer and the main aquifer of the zone, which is stored in the Barremian limestones, having a regional extension and a dynamic due to the relationship to the Danube (Ref. 4.1-6).

The phreatic aquifer is stored in the alluvial deposits containing gravels, sands, argillaceous sand, silty clay and silt from the alluvial plain of Valea Carasu, where the hydrostatic level varies between 2 and 5 m in depth, depending on the Danube level, which influences this aquifer. The main supplier of Valea Carasu aquifer is the Danube-Black Sea Canal.

The depth underground waters – are the underground waters belonging mainly to the main aquifer in Cernavoda area, which is stored in the Barremian limestones, and secondary, because of the reduced presence, to the Aptian – Sarmatian aquifer.

The Aptian – Sarmatian aquifer is stored in the permeable bodies of sand, gravel and limestone lens belonging to the Aptian –Sarmatian age.

The permeable bodies are sand and limestone lens with water, usually having no connection between them, isolated into the argillaceous mass, these local aquifers having an extension of tens of meters.

The experimental pumping tests carried out into the monitoring boreholes achieved flow rates ranging between 0.04 l/s and 0.3 l/s. These values reflect the fact that this aquifer is of no significance.

It can be assessed a permeability of $k = 10^{-2} - 10^{-3}$ cm/s for these local aquifers, and $k = 10^{-5} - 10^{-7}$ cm/s for the clays and marls around them.

The Barremian aquifer is stored in the Barremian limestone formations, with regional extension and dynamics due to the relationship with the Danube (the Danube-Black Sea Canal water race 1.

This aquifer, build up in the carst holes or in the fissures of the Barremian limestones, is the main aquifer of the area.

Due to the high level of the Barremian limestones in the Cernavoda NPP platform area, but also in the DBSC lock and Saligny bridge, where this limestone crops out, the water of this aquifer has free level between the DBSC and the Valea Cismelei, and then, northward and eastward it goes under pressure, being covered by an impervious stratum of aptian clays. The hydrostatic level of the waters in the limestone varies between + 5 and + 10 mBSL, depending on the Danube levels.

The multiannual monthly average Danube water levels have variations from 5 - 5.5 mBSL to 8 - 8.5 mBSL, and the highest monthly average levels reach 11 - 11.5 mBSL. During a year, the Danube water levels can have variations of 5 - 6 m.

In the period with low level of the Danube (levels of 5 - 7 mBSL), the discharge area for the Barremian aquifer is DBSC Water Race 1, the main direction of flow is NW-SE, with low hydraulic gradients, under 1 % (Figure 4.1.1-1). When the Danube levels are around 10 - 11 mBSL, a relative balance is reached (Ref. 4.1-6).

When the Danube has high and very high levels, higher than + 11 mBSL, above the Barremian limestone aquifer level, the relations between them become reverse, at least in the adjacent area.

The pumping tests and the permeability Lugeon tests, performed by GEOTEC during several years, showed large ranges of the flow rates (1 - 4 l/s) and of the permeability coefficient (k = 0.5 - 4.5 m/day), due to the inhomogeneity of these limestones.

Regarding the relationship between the three aquifers, the previous studies show that there is no communication between them, the hydrodynamic regime of these aquifers is totally differently.

The hydraulic gradients have been calculated based on the morphological model of the piesometric surfaces (Ref. 4.1-6), as shown in Figure 4.1.1-1.

For flow velocities calculation, the values of hydraulic gradients and hydraulic conductivities obtained by pumping tests were taken into consideration (Table 4.1.1-1).

The values of for the hydro-geological parameters are shown in Table 4.1.1-2.

The underground water quality was analyzed from chemical and radiometric point of view, taking water samples from the three piesometric bore holes, after washing them and testing them by pumping. The samples have been analyzed for all the elements and groups of elements group, according to the regulations in force, as shown in Table 4.1.1-3 (Ref. 4.1-6).

Regarding the aggressiveness on concrete, these waters show a low dealkalization aggressiveness in F1 and F2 boreholes, very low sulphatic aggressiveness in borehole F1 and no aggressiveness in borehole F3.

As for the aggressiveness on metals, according to the Mundlein criterion, the water is not corrosive.

The natural radioactivity of the underground water in Unit 3 area was analyzed (Ref. 4.1-6) for natural uranium (U) and radium (Ra^{226}), and also for gross alpha, gross beta radioactivity and gamma-ray spectrometry.

The results are shown in Tables 4.1.1-4 and 4.1.1-5.

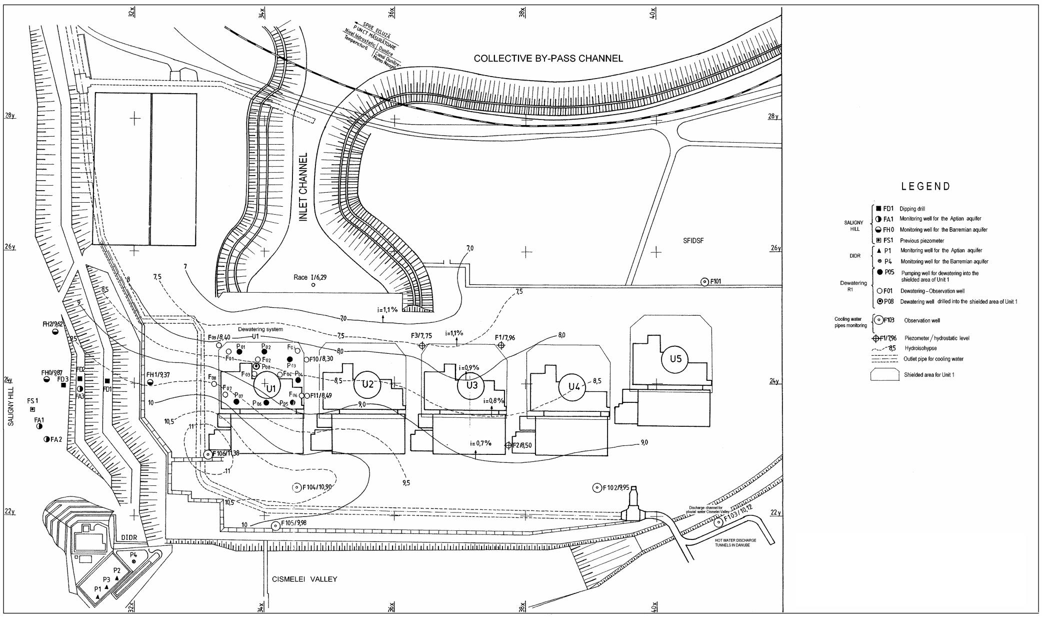

Figure 4.1.1-1. Hydroisohypse Map

Table 4.1.1-1. Flow velocities

Hydroisohypse (mBSL)	Hydraulic conductivity K (m/day)	Hydraulic gradient i	Flow velocity v_e (m/day)
9	0.334	0.007	0.16
8.5	0.052	0.008	0.03
8	0.052	0.009	0.03
7.5	0.048	0.011	0.035
7	0.048	0.011	0.22

Table 4.1.1-2. Hydro-geological parameters

Bore hole	Level differences	Flow rate Q		Specific flow rate Qs	Hydraulic conductivity k		Transmissivity T		Influence radius R
	m	l/s	m^3/day	l/s·m	m/day	cm/s	m^2/day	cm^2/s	m
F1	3.00	0.15	1.74×10^{-3}	0.05	0.052	6.02×10^{-5}	0.75	8.70×10^{-2}	6.84
F2	1.5	0.25	2.90×10^{-3}	0.17	0.334	3.87×10^{-4}	4.45	0.52	8.67
F3	4.00	0.10	1.16×10^{-3}	0.03	0.048	5.56×10^{-5}	0.80	9.30×10^{-2}	8.76

Table 4.1.1-3. Analyses results

No	Test name	Measure unit	Values			Law 458/2002* Maximum allowed	Aggressiveness STAS 3349/83
			Sample F1	Sample F2	Sample F3		
1	Fixed residue at 105 °C	mg/dm^3	520.00	290.00	330.00	-	10000
2	pH	-	7.90	9.20	10.20	6.5-9.5	6.5
3	Organic oxidizable substances, ($KMnO_4$)	mg/dm^3	40.44	15.16	32.86	20	
4	Alkalescency P	mval/l	0	0.10	0.60	-	-
5	Alkalescency M	mval/l	1.50	2.10	0.90	-	-
6	Carbon dioxide, CO_2	mg/dm^3	4.40	0.00	0.00		function of temporary hardness
7	Total hardness	°G	2.90	8.20	5.40	min. 5	-
8	Permanent hardness	°G	0	2.32	2.88	-	-
9	Temporary hardness	°G	2.90	5.88	2.52	-	-
10	Calcium, Ca^{2+}	mg/dm^3	17.45	31.27	34.90	-	
11	Magnesium, Mg^{2+}	mg/dm^3	1.78	16.03	1.78	-	100
12	Iron, Fe^{2-}/ Fe^{3-}	mg/dm^3	0.3/0.6	0.4/0.6	0.6/0.2	0.2	
13	Manganese, Mn^{2-}	mg/dm^3	0.00	0.00	0.00	0.05	
14	Sodium and kalium, Na^-. K^-	mg/dm^3	149.73	46.23	76.59	200	
15	Ammonium, NH_4	mg/dm^3	0.25	0.25	0.00	0.5	> 50
16	Chloride, Cl^-	mg/dm^3	67.45	49.70	49.70	250	-
17	Sulphate, SO_4^{2-}	mg/dm^3	165.56	68.29	109.02	250	450
18	Azotate, NO_3^-	mg/dm^3	45.00	0.00	4.00	50	
19	Nitrite, NO_2^-	mg/dm^3	0.37	0.0018	0.18	0.5	
20	Sulphuratted hydrogen, H_2S	mg/dm^3	0.00	0.00	0.00	0.1	
21	Phosphate, PO_4^{3-}	mg/dm^3	0.10	0.10	0.15	-	
22	Carbonate, CO_3^{2-}	mg/dm^3	0.00	6.00	36.00	-	
23	Bicarbonate, HCO_3^-	mg/dm^3	91.50	115.90	0.00	-	120

*) with modifications and completions from Law 311/2004 and later regulations

Table 4.1.1-4. Analyses results

Sample and type symbol	Radioactive elements	
	U (mg/l)	Ra ^{226} (Bq/l)
F1 borehole (water sample)	0.0042	0.09
F2 borehole (water sample)	0.0046	0.09
F3 borehole (water sample)	0.0056	0.16

Table 4.1.1-5. Analyses results

Activity	Results
Gross alpha specific activity - standard ^{241}Am- (mBq/l)	30.1 ± 3.0
Gross beta specific activity - standard ^{40}K- (Bq/l)	0.65 ± 0.04
Cs-137 (Bq/kg.f.w)	< 2.4
Cs-134 (Bq/kg.f.w)	< 2.0

4.1.2. Hydrological Characterization of the Main Water Source, the Branch Dunarea Veche, the thermal regime

The large surface water bodies near Cernavoda are the Danube branch Dunarea Veche and the Danube - Black Sea Canal. The DBSC is supplied with Danube water. The local open canals (the derivation canal, the NPP intake canal) are supplied from the DBSC.

The water resources in this zone are influenced by the Danube hydrological conditions.

4.1.2.1. Water Flows and Water Levels on the Danube in the Neighborhood of the Cernavoda NPP Site

The data in this section are referring to Dunarea Veche branch and they were obtained, according to standard methodologies, by hydrological processing of measured parameters at the Cernavoda Hydrometric Station (Ref. 4.1-7, 4.1-8).

The water level and flow values on Dunarea Veche are determined by the hydrological regime upstream on the Danube and the natural splitting of the total flow into the flows along the main branches Dunarea Veche and Borcea.

The multi-annual average monthly values of water flows at Cernavoda HS between 1961 - 2002 (Table 4.1.2.1-1) vary between 1470 m^3/s during autumn low waters and 3620 m^3/s during spring high waters. The average multi-annual flow is 2370 m^3/s.

Table 4.1.2.1-1. Average multi-annual values (m^3/s) of monthly average and annual average flows at Cernavoda HS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Multi-annual average flow
Q_{mean}	2300	2340	2810	3620	3540	2970	2380	1720	1470	1490	1670	2170	2370

The maximum and minimum annual water flows with various exceeding probabilities, calculated (Ref. 4.1-8) on the basis of the data between 1961 - 2002, are presented in Tables 4.1.2.1-2 and 4.1.2.1-3.

Table 4.1.2.1-2. Maximum annual water flows with various exceeding probabilities.

p (%)	0,01	0,1	1	2	5	10
Q_{max} (m^3/s)	9 460	8 400	7 300	6 920	6 350	5 910

Table 4.1.2.1-3. Minimum annual water flows with various exceeding probabilities.

p (%)	90	95	97
Q_{min} (m^3/s)	355	315	290

In 2003, special conditions occurred on the Danube, with very low flows and hydrological drought. The characteristic values of the water flow are shown in Table

4.1.2.1-4 (Ref. 4.1-9). The average flow value in 2003 was 62 % of the module flow of 2370 m^3/s in the period 1961 – 2002.

Table 4.1.2.1-4. Monthly and annual characteristic values of the water flow (m^3/s) at Cernavoda HS in 2003

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Mean	3150	2710	2150	2340	1800	1270	596	430	387	750	1310	822
Maximum	3870	3170	2780	2630	2130	1760	827	605	587	1360	1880	1010
Date	17	10	24	19	1	3	1	11	27	23	13	13
Minimum	2350	1800	1510	2120	1520	853	450	246	205	270	770	595
Date	1	28	6	5	25	30	28	31	10	8	30	23
Annual average 1480 m^3/s Annual maximum 3870 m^3/s /17 I Annual minimum 205 m^3/s /10 IX												

During the flood in April - May 2006, the maximum Danube flow at the entrance to Romania (Bazias section) was 15800 m^3/s, the highest flow value that occurred during the period of systematic observations and hydrometric measurements on the Danube (1840 - 2006). Consequently, the flow on the branch Dunarea Veche at Cernavoda had its maximum historical value.

Water levels at Cernavoda SH are recorded as values (H) over or under the reference level established at this station. The reference level is 4.35 mBSL.

The characteristic values of water level (monthly average, maximum and minimum) resulting from the data series between 1961 - 2002 are presented in Tables 4.1.2.1-5 and 4.1.2.1-6. The average multi-annual level during 1961 - 2002 was 219 cm, with a - 178 cm minimum in September 1990 and a 674 cm maximum in May 1970.

Table 4.1.2.1-5. Average multi-annual values (cm) of monthly average and annual average water levels at Cernavoda HS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
H_{mean}	215	228	295	397	382	307	222	120	79	81	109	192	219

Table 4.1.2.1-6. Minimum and maximum multi-annual values (cm) of monthly average and annual average water levels at Cernavoda HS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
$(H_{mean})_{min.}$	-16	-49	26	74	122	-3	-33	-139	-178	-109	-84	-106	-178
Year	1964	1989	1993	1972	1990	1993	1993	1990	1990	1961	1969	1986	1990
$(H_{mean})_{max.}$	519	472	572	622	674	657	588	361	374	368	513	428	674
Year	1982	1979	1977	1981	1970	1970	1965	1965	1966	1972	1974	1974	1970

Table 4.1.2.1-7 presents the minimum and maximum values of daily levels in the interval 1961 - 2002. The lowest level was - 207 cm in September 1990, and the highest was 708 cm in June 1970.

Table 4.1.2.1-7. Extreme water level values recorded at Cernavoda HS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
$H_{min.}$	-118	-82	-74	-31	53	-80	-85	-199	-207	-188	-172	-148	-207
Year	1969	1989	1993	1972	1990	1993	1993	1990	1990	1992	1985	1983	1990
$H_{max.}$	562	578	684	699	695	708	615	520	437	554	566	562	708
Year	1982	1977	1981	1981	1970	1970	1965	1975	1966	1972	1974	1981	1970

The levels corresponding to maximum and minimum annual water flows with various exceeding probabilities, calculated on the basis of the data in the period 1961 - 2002, are presented in Tables 4.1.2.1-8 and 4.1.2.1-9 (Ref. 4.1-12).

Table 4.1.2.1-8. The levels corresponding to maximum annual water flows with various exceeding probabilities (rating curve 1961 - 2002)

Qp (%)	$Q_{0.01\%}$	$Q_{0.1\%}$	$Q_{1\%}$	$Q_{2\%}$	$Q_{5\%}$	$Q_{10\%}$
H (cm)	870*)	812*)	743	716	680	650

*) Water levels obtained by extrapolating the rating curve (water levels above the left bank dyke level 773 cm, Ref. 4.1-8). The Cernavoda NPP platform level is 16.00 mBSL (Chap. 1.4, Chap. 2.1).

Table 4.1.2.1-9. The levels corresponding to minimum annual water flows with various exceeding probabilities (rating curve 1961 - 2002)

Qp (%)	$Q_{90\%}$	$Q_{95\%}$	$Q_{97\%}$
H (cm)	-186	-205	-216

Negative levels (under the Cernavoda HS reference level) occur seldom during winter months (December, January, February) and last about 10 – 15 days. Longer intervals were found in 1964 (33 successive days with negative levels, and the minimum level of -164 cm), 1983 (28 successive days in winter with negative levels, and the minimum level of -148 cm in January), 1986 (with negative levels in all the days in December, and the minimum level of -145 cm).

The dry months are those at the end of summer and in autumn. Among the driest years were:

- 1990, with 130 days with negative levels during August, September, October, November, and the absolute minimum of -207 cm (the lowest historical value before 2002) at 15 September 1990. The minimum water levels in 2003 were even lower, decreasing to the minimum values of -216 cm in August, -237 cm in September and -205 cm in October.

- 1983, with negative levels in 124 days during the period between the end of August and the beginning of December, and the minimum of -148 cm in December.

- 1971, with 117 days (11.08-6.12) with negative levels and the minimum of -106 cm in November.

- 1994, with negative levels in 101 days during summer and autumn and the minimum of -135 cm in August.

Very low water levels were recorded on the Danube in 2003, and also at Cernavoda, during long intervals (Ref. 4.1-9). High waters did not occur during spring, and the monthly average levels in October and December were under the gauge reference level. In September 2003, the lowest historical water level between 1961 - 2003 was recorded at Cernavoda HS.

Tables 4.1.2.1-10 and 4.1.2.1-11 present water levels in 2003 (monthly average values and extreme daily values). The monthly average levels in the first two months of 2003 were higher than the multiannual values. From March, the monthly average water levels were lower or much lower (with over 200 cm lower in July, August, September) than the multiannual monthly levels. Even the maximum water levels in July, August, September 2003 were negative.

The water levels corresponding to the minimum annual water flows with probabilities of 90 %, 95 % and 97 %, determined (Ref. 4.1-9) taking into consideration all the above mentioned data, are shown in Table 4.1.2.1-12 (the measurement performed in the year 2003 provided data for a better specification of the rating curve lower part at Cernavoda HS, Ref. 4.1-9). These values can vary in time due to natural phenomena in the branch Dunarea Veche, or due to works in the river channel on the branches Dunarea Veche and Bala.

During the April - May 2006 flood on the Danube, the historical maximum level in the Ceranvoda HS section occurred.

Table 4.1.2.1-10. Monthly and annual average water levels (cm) at Cernavoda HS in 2003

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
$H_{mean.}$ 2003	358	298	211	244	156	56	-99	-150	-167	-72	62	-40	71

Table 4.1.2.1-11. Extreme water levels (cm) recorded at Cernavoda HS in 2003

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
$H_{min. 2003}$ /date	246/ 1	157/ 28	105/ 6	210/ 5,6	107/ 25,26	-32/ 30	-142/ 28	-216/ 31	-237/ 10	-205/ 8	-52/ 30	-98/ 23	-237
$H_{max. 2003}$ /date	450/ 17,18	364/ 10,11	310/ 24,25	289/ 19,20	212/ 1	150/ 3	-38/ 1	-95/ 11,12	-100/ 27	75/ 23	170/ 13	4/ 13	450

Table 4.1.2.1-12. Water levels corresponding to minimum annual water flows with various exceeding probabilities (rating curve 1961 - 2003)

p (%)	90 %	95 %	97 %
$H_{Qmin. p\%}$ (cm)	-172	-188	-196

The problem of low flows on the branch Dunarea Veche was the subject of different studies made by specialty institutes: IPTANA, ICH (ICIM), INMH, ISPH, ISPE, and subject of some PHARE program studies, in order to ensure continually the conditions for navigation and water supply for various consumers, among which DBSC and Cernavoda NPP have a special importance. It is known that during low waters on the Danube there is a tendency of ratio growing between the flows along Borcea and Dunarea Veche.

The Danube river flow distribution to the branches Dunarea Veche and Borcea can be modified by carrying out hydrotechnical works. The environmental protection authorities are analyzing the environmental assessment report for a project required for the purpose of navigations conditions improvement on the Calarasi - Braila stretch of the Danube. The proposed hydrotechnical works to be performed on the branch Bala and on Dunarea Veche will result in the modification of the flow distribution coefficients on the mentioned branches and the water levels and flow values increase on Dunarea Veche during low waters on the Danube river (Chapter 4.1.9.4). After the completion of the hydrotechnical works, the minimum flow values at Cernavoda HS shown in this chapter and the corresponding water levels will change.

The hydraulic parameters of the water motion in downstream sections of the branch Dunarea Veche result by calculation (Ref. 4.1-13), using hydrological data from the upstream and downstream hydrometric stations, and a set of transversal profiles (Ref. 4.1-7). Due to the irregular shape of this natural river channel and to the range of water levels, the water flow velocities are variable from a section to another section and also during each season according to the Danube flow and levels variation. The average velocity in cross-sections in the stretch downstream Cernavoda vary between 0.3 and 1 m/s in most situations.

4.1.2.2. Characterization of Water Temperature on the Danube Stretch in the Neighborhood of the Cernavoda NPP Site

Water temperatures recorded at Cernavoda HS

Water temperature is a parameter measured within the hydrological activity, and also within the water quality monitoring programs. The reference data showing the Danube water thermal regime in the Cernavoda area are those measured at the Cernavoda Hydrometric Station. The Danube water temperature variations at Cernavoda HS (that are transmitted to the DBSC race 1, supplied directly from the Danube) were analyzed in specialized studies (Ref. 4.1-8, 4.1-9) as ten days interval average values, monthly and annual average values.

The water temperature characteristic values over the time interval 1961 - 2002 are presented Tables 4.1.2.2-1, 4.1.2.2-2 and 4.1.2.2-3.

Table 4.1.2.2-1. Average multi-annual values (ºC) of monthly average and annual average water temperatures at Cernavoda HS

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
T_{mean}	2.1	2.2	4.9	10.8	16.4	21.2	23.9	24.1	20.8	15.1	9.0	4.1	12.9

Table 4.1.2.2-2. Average multi-annual values (ºC) of average water temperature over ten days intervals at Cernavoda HS.

Month	I			II			III			IV			V			VI		
Ten days interval	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
T mean	2.7	1.9	1.6	1.7	2.1	2.8	3.7	4.6	6.5	9.1	10.8	12.4	14.4	16.4	18.3	19.7	21.2	22.4

Month	VII			VIII			IX			X			XI			XII		
Ten days interval	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
T mean	23.3	24.0	24.4	24.4	24.3	23.7	22.2	20.8	19.3	17.1	15.3	13.1	10.9	9.0	7.3	5.5	3.9	3.0

Table 4.1.2.2-3. Minimum and maximum values (ºC) of monthly average and annual average water temperatures at Cernavoda HS.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
$(T_{mean})_{min.}$	0	0.03	0.7	7.1	10	15	22.1	22	18.3	11	5.9	1.7	0
Year	1963	1963, 1964	1985	1980	1991	1991	1962, 1969	1968	1996	1991	1988	1998	1963
$(T_{mean})_{max.}$	5.1	5	9.5	15	19.7	25.5	26.4	26.7	23.6	19.7	14.2	7.3	26.7
Year	1991	1990, 1974	1990	1989	1968	1971	1988	1994	1994, 1977	1976	1962	1979	1994

Water temperature decreases to 0 °C in some years, especially in January and February (Table 4.1.2.2-4).

The highest water temperature during the interval 1961 - 2002 was recorded in July 1987 (instant water temperature of 29.6 °C), followed by the values recorded in August 1994 (28.6 °C) and June 1994 (26.6 °C).

Table 4.1.2.2-4. Extreme instant temperature values (ºC) recorded at Cernavoda HS.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I - XII
T_{min}	0	0	0	1.0	9.1	8.3	18.3	20.0	15.0	6.4	0.5	0.2	0
Year	1963,1964, 1966,1972, 1980,1982, 1987,2000, 2002	1963,1964, 1966,1972, 1982,1986, 1996,2000	1963, 1964	1976	1991	1991	1991	1965, 1987, 1990, 1993	1964, 1996	1988	1963	1961, 1963, 1986	1963,1964, 1966,1972, 1980,1982, 1986,1987, 1996, 2000, 2002
T_{max}	7.2	8.4	13.5	20.0	23.0	26.6	29.6	28.6	25.9	23.4	17.0	10.0	29.6
Year	1991	1989	1990	1977	1977	1994	1987	1994	1992	1994	1976	1977	1987

Table 4.1.2.2-5 shows the characteristic monthly and annual values of water temperature at Cernavoda HS in 2003 (Ref. 4.1-9).

Water temperature during the year 2003 was within the multi-annual range of values. The highest instant water temperature (27 ℃) was recorded in August.

Table 4.1.2.2-5. Monthly and annual characteristic values of water temperature at Cernavoda HS in 2003

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average	1.6	1.3	3.8	8.8	18.5	24.6	26.0	26.4	22.1	15.2	8.9	5.6
Maximum	2.0	2.0	6.5	12.5	22.0	26.8	26.7	27.0	26.5	19.0	11.0	7.8
Date	31	1	31	30	31	22	8	9	1	1	1 - 6	1
Minimum	1.3	1.0	1.3	6.5	12.8	22.1	25.4	25.3	19.0	11.0	7.8	3.0
Date	14 (6)	22 - 26	1 - 3	1, 2	1	1	19	16	29, 30	31	30	29 - 31
Annual average 13.6 Annual maximum 27.0/9 VIII Annual minimum 1.0/22 – 26 II												

The variations from year to year of the average monthly and annual water temperatures at Cernavoda HS are irregular, with small differences in some years and sharp differences sometimes from a year to the next one (Figures in Annex A.4.1.2). These natural variations are sometimes of 3 °C in January, of 5 °C in April, 3 °C in July, 6 °C in October (Ref. 4.1-7).

Water temperatures on the Danube stretch in the area of the Cernavoda NPP effluent discharge

Having in view the thermal load of the Cernavoda NPP effluent discharged from Unit 1 into the branch Dunarea Veche, the characterization of the water temperatures on the Danube stretch downstream Cernavoda includes both the data at Cernavoda HS and temperatures measured in the effluent discharge area.

The measurements performed in 2001, 2003, 2004, 2006 covered the river stretch between km 300 and 283. Vertical profiles of water temperature were measured in points of successive cross-sections (Fig. 4.1.2.2-1). Most of the measurement points were located in the cross-sections (at km 295, 294, 292, 291) within a distance of 5 km downstream the discharge section. Water temperature was also measured in points of a stretch with small islands (mainly at km 288 and 286) and in other downstream sections (at km 285, 284, 283). Some results of water temperature measurements are shown in Chapter 4.1.17. The detailed results were presented in several reports prepared by ICIM (Ref. 4.1-12, 4.1-13, 4.1-14).

The water temperature along the right bank downstream the effluent discharge has a difference of some degrees over the depth in the initial vertical mixing area. There are also differences between water temperature at the right bank and in the middle of the branch, downstream the discharge section. Water temperature in the middle and at the left bank of the branch Dunarea Veche is the natural one, very close to the values recorded at Cernavoda HS.

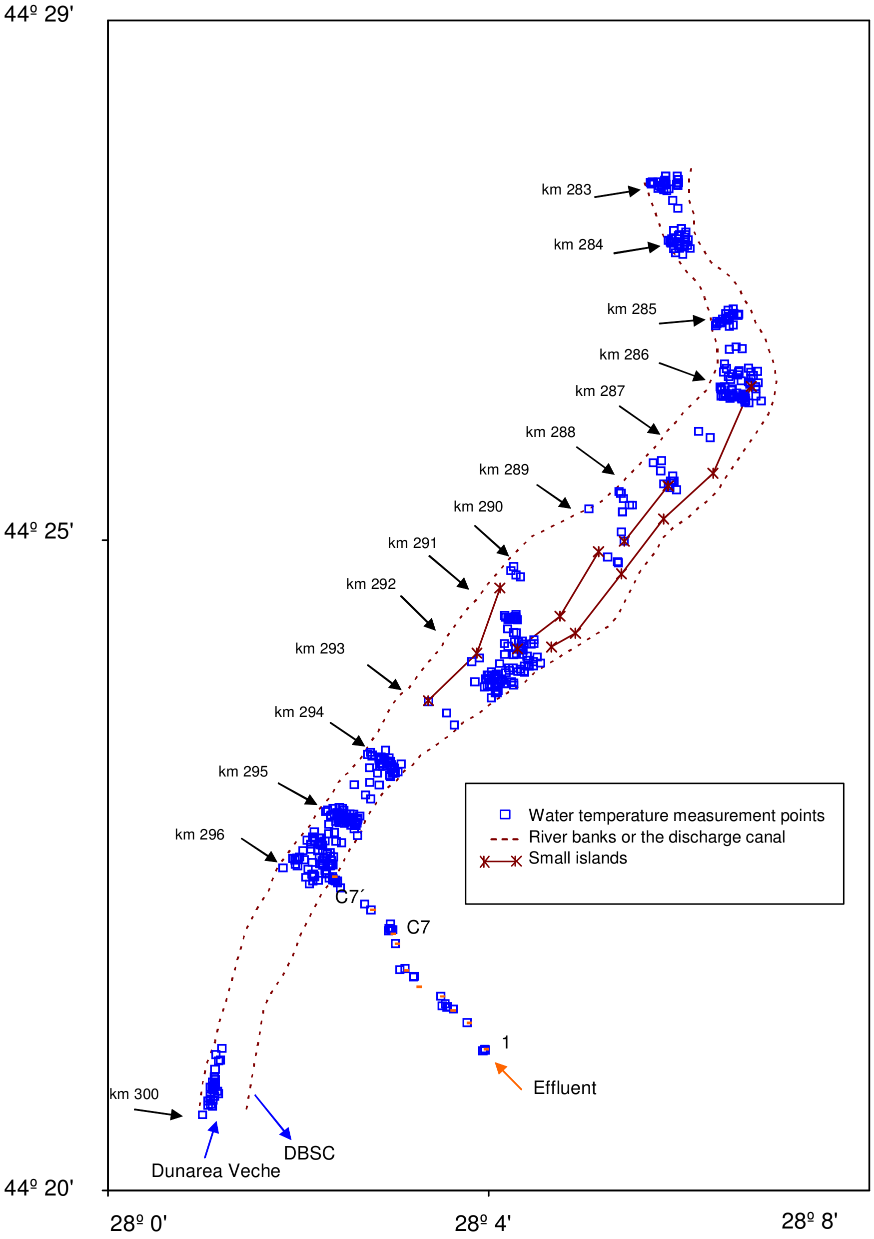

Figure 4.1.2.2-1. Water temperature measurement sections on the Dunarea Veche branch downstream Cernavoda SH, and in the effluent

4.1.3. Characterization of the Danube Water Quality in the Neighborhood of the Cernavoda NPP Site, According to Physical, Chemical and Microbiological Indicators, Radioactivity

The Danube River crosses several states and its water quality is subject to the monitoring activities carried out by the water management authorities from Romania and the other countries in the Danube hydrographic basin.

In 1985, the Bucharest Declaration has been adopted, for the promotion of a complex program for the Danube water quality monitoring by the riparian countries. At present, the Transnational Monitoring Network (TNMN) is under operation, continuing to control the water quality indicators along the Danube. Within this framework, a series of control sections have been established for monthly water sampling for physical, chemical and biological analyses. Among these sections, the closest to Cernavoda is Chiciu – Silistra, located upstream at km 375. This section provides relevant data on the quality of the water flowing to the branch Dunarea Veche towards Cernavoda.

Prior to the NPP Unit 1 operation, in the Cernavoda area there was no permanent control of the Danube water quality indicators.

In Romania, the Danube water quality was analyzed during different periods taking into consideration successively adopted regulations in the last tens of years: STAS 4706-88 (Surfaces waters - quality categories and conditions), Norm regarding reference objectives for surface waters quality classification (approved by Order 1146/2002). These regulations are abrogated at present and the regulation in force is the Norm regarding surface waters quality classification in the view of establishing the water bodies ecological state, approved by Order 161/2006. This norm specified chemical and physical-chemical quality elements and quality standards for these elements. The norm establishes limits for five quality classes regarding chemical and physical-chemical indicators, in support of the process of establishing the ecological state of natural or artificial aquatic ecosystems. The considered indicators show the thermal regime and the acidification, the oxygen regime, nutrients, salinity and the contents of specific toxic pollutants of natural origin and the contents of other relevant substances.

The limits of the intervals corresponding to quality classes I - V for chemical and physical-chemical indicators, according to Order 161/2006, are presented in Table 4.1.3-1.

Some of the data sets considered here were obtained before Unit 1 commissioning in 1996, and the other data were obtained after this year.

The results presented below on the basis of the data from Silistra and Giurgeni during the periods 1994 - 1996 and 1997 - 1999 show the Danube water quality upstream and downstream Cernavoda.

Table 4.1.3-1. Limits of water quality classes I - V specified for chemical and physical-chemical indicators by Order 161/2006

No.	Quality Indicator	Unit	Quality class				
			I	II	III	IV	V
C.1. Thermal regime and acidification							
1	Temperature	℃	Not standardized				
2	pH		6.5 - 8.5				
C.2. Oxygen regime							
1	Dissolved Oxygen	mg O_2/l	9	7	5	4	<4
2	Dissolved Oxygen saturation	%					
	-Epilimnion (stratified waters)		90-110	70-90	50-70	30-50	<30
	-Hypolimnion (stratified waters)		90-70	70-50	50-30	3040	<10
	-Non-stratified waters		90-70	70-50	50-30	30-10	<10
3	BOD_5	mg O_2/l	3	5	7	20	>20
4	COD-Mn	mg O_2/l	5	10	20	50	>50
5	COD-Cr	mg O_2/l	10	25	50	125	>125
C.3. Nutrients							
1	Ammonium (N-NH_4^+)	mg N/l	0.4	0.8	1.2	3.2	>3.2
2	Nitrites (N-$N0_2^-$)	mg N/l	0.01	0.03	0.06	0.3	>0.3
3	Nitrates (N-$N0_3^-$)	mg N/l	1	3	5.6	11.2	>11.2
4	Total nitrogen (N)	mg N/l	1.5	7	12	16	>16
5	Soluble orthophosphates (P-$P0_4^{3-}$)	mg P/l	0.1	0.2	0.4	0.9	>0.9
6	Total phosphorus (P)	mg P/l	0.15	0.4	0.75	1.2	>1.2
7	Chlorophyll "a"	µg/l	25	50	100	250	>250
C.4. Salinity							
1	Conductivity	µS/cm					
2	Filtered residue at 105 ℃	mg/l	500	750	1000	1300	>13000
3	Chlorides (Cl^-)	mg/l	25	50	250	300	>300
4	Sulphates (SO_4^{2+})	mg/l	60	120	250	300	>300
5	Calcium (Ca^{2+})	mg/l	50	100	200	300	>300
6	Magnesium (Mg^{2+})	mg/l	12	50	100	200	>200
7	Natrium (Na^+)	mg/l	25	50	100	200	>200
C.5. Specific toxic pollutants of natural origin							
1	Total chromium (Cr^{3+} + Cr^{6+})	µg/l	25	50	100	250	>250
2	Copper (Cu^{2+})[5]	µg/l	20	30	50	100	>100
3	Zinc (Zn^{2+})	µg/l	100	200	500	1000	>1000
4	Arsen (As^{3+})	µg/l	10	20	50	100	>100
5	Barium (Ba^{2+})	µg/l	0.05	0.1	0.5	1	>1
6	Selenium (Se^{4+})	µg/l	1	2	5	10	>10
7	Cobalt (Co^{3+})	µg/l	10	20	50	100	>100
8	Lead (Pb)[6]	µg/l	5	10	25	50	>50
9	Cadmium (Cd)	µg/l	0.5	1	2	5	>5
10	Total iron (Fe^{2+} + Fe^{3+})	mg/l	0.3	0.5	1	2	>2
11	Mercury (Hg)	µg/l	0.1	0.3	0.5	1	>1
12	Total manganese (Mn^{2+} + Mn^{7+})	mg/l	0.05	0.1	0.3	1	>1
13	Nickel (Ni)	µg/l]	10	25	50	100	>100
C.6. Other relevant chemical indicators							
1	Total phenols (phenolic index)	µg/l	1	5	20	50	>50
2	Active anionic detergents	µg/l	100	200	300	500	>500
3	AOX	µg/l	10	50	100	250	1>250

Water quality at Chiciu - Silistra, upstream Cernavoda

The intervals of quality indicators values in the Danube water in the Chiciu-Silistra section are presented on the basis of the data sets from the periods 1994 - 1996 and 1997 - 1999, and also from 2002 (Ref. 4.1-14, 4.1-24).

Tables 4.1.3-2, 4.1.3-3 and 4.1.3-4 specify the minimum, average and maximum values of the physical indicators or chemical indicators.

Water reaction was alkaline, the pH values ranging between 7.5 - 8.4 in 1994 - 1996, 7.6 - 8.5 in 1997 - 1999 and 7.9 - 8.7 in the year 2002.

The oxygen regime is characterized by several indicators: dissolved oxygen concentration, biochemical oxygen demand (BOD), chemical oxygen demand (COD). Generally, the Danube water was well-oxygenated, with average values of 8.46 mgO_2/l in the interval 1994 - 1996, 8.74 mgO_2/l in the interval 1997-1999 and 9.0 mgO_2/l in the year 2002.

The nutrients are presented by means of the concentrations of nitrates, nitrites, ammonium, phosphates and total phosphorus.

Other relevant indicators are those characterizing water mineralization: chlorides, calcium, magnesium, etc.

The average values of the indicators in the Chiciu - Silistra section are generally within the limits of the quality classes I and II (according to Order 161/2006).

Table 4.1.3-2. Water quality characterization in the Chiciu - Silistra section (January 1994 – September 1996)

Indicator	Unit	Number of results	Values			Flow-weighted concentration
			Minimum	Mean	Maximum	
Flow	m^3/s	29	2290	5601	10140	-
Water temperature	^0C	29	2.0	15.0	26.5	-
pH	-	30	7.5	7.9	8.4	7.9
Suspended solids	mg/l	30	3.3	67.5	385.0	79.5
Dissolved O_2	mgO_2/l	30	5.90	8.46	11.56	8.43
Saturation of O_2	%	27	57.5	78.4	135.4	76.5
BOD_5	mgO_2/l	30	1.5	3.7	5.8	3.5
COD-Mn	mgO_2/l	30	1.8	4.6	9.9	4.5
COD-Cr	mgO_2/l	26	8.1	11.0	17.0	10.9
Ammonium ($N-NH_4^+$)	mgN/l	30	0.08	0.30	0.97	0.27
Nitrites ($N-NO_2^-$)	mgN/l	30	0.003	0.014	0.043	0.016
Nitrates ($N-NO_3^-$)	mgN/l	30	0.1	0.5	1.5	0.5
Total P	mgP/l	28	0.0759	0.1298	0.1900	0.1305
Total dissolved solids	mg/l	29	189.0	290.2	377.3	287.8
Chlorides	mg/l	30	18.9	31.3	51.0	31.1
Sulphates	mg/l	30	34.2	58.5	88.6	57.9
Calcium	mg/l	30	46.3	55.8	68.3	56.0
Magnesium	mg/l	30	11.3	14.9	23.0	14.9
Sodium	mg/l	26	7.8	20.9	41.2	21.0
Alkalinity	mval/l	30	2.13	2.98	3.63	2.97
HCO_3	mg/l	30	130.1	182.0	221.6	181.3
Permanent hardness	^0G	11	2.0	4.3	9.8	4.6
Temporary hardness	^0G	11	7.0	8.0	10.0	8.0
Total hardness	^0G	29	3.5	7.5	16.9	8.0
Total iron	mg/l	25	0.02	0.32	1.09	0.35
Manganese	mg/l	10	0.01	0.05	0.09	0.05
Nickel	µg/l	4	2.0	23.0	40.0	20.7
Total chrome	µg/l	10	1.0	8.9	22.6	8.0
Copper	µg/l	10	4.0	17.0	48.0	17.5
Lead	µg/l	10	1.0	17.3	52.0	15.0
Zinc	µg/l	10	16.0	75.6	357.0	63.0
Cadmium	µg/l	10	0.4	6.4	46.6	3.9
Phenols	µg/l	29	4.0	19.0	93.3	20.3
Detergents	µg/l	27	10	41	157	42
Extractible substances	µg/l	11	0.0	55.7	123.0	51.8

Table 4.1.3-3. Water quality characterization in the Chiciu - Silistra section (January 1997 – December 1999)

Indicator	Unit	Number of results	Values			Flow-weighted concentration
			Minimum	Mean	Maximum	
Flow	m^3/s	21	2884	6697	10828	-
Water temperature	^0C	21	2.4	12.6	25.0	-
pH	-	21	7.6	7.9	8.5	7.9
Suspended solids	mg/l	22	11.7	37.3	95.0	36.8
Dissolved O_2	mgO_2/l	22	4.80	8.74	12.30	8.68
Saturation of O_2	%	21	58.7	79.7	99.1	80.0
BOD_5	mgO_2/l	22	2.6	3.8	5.6	3.8
COD-Mn	mgO_2/l	22	3.2	5.4	8.8	5.3
COD-Cr	mgO_2/l	22	10.6	22.2	45.3	21.4
Ammonium ($N\text{-}NH_4^+$)	mgN/l	22	0.02	0.35	0.90	0.36
Nitrites ($N\text{-}NO_2^-$)	mgN/l	22	0.001	0.017	0.082	0.018
Nitrates ($N\text{-}NO_3^-$)	mgN/l	22	0.1	0.8	2.3	0.9
Total P	mgP/l	21	0.0100	0.0862	0.2300	0.0821
Chlorides	mg/l	22	7.9	33.7	48.2	33.7
Sulphates	mg/l	22	32.2	46.9	59.4	47.6
Calcium	mg/l	22	47.2	62.2	142.8	63.0
Magnesium	mg/l	22	11.8	19.3	39.7	18.1
Sodium	mg/l	22	11.2	19.3	25.6	19.0
Alkalinity	mval/l	22	1.18	2.74	3.86	2.72
HCO_3	mg/l	22	72.2	167.4	235.2	165.8
Temporary hardness	^0G	1	-	4.2	-	4.2
Total hardness	^0G	9	4.7	5.3	5.8	5.3
Total iron	mg/l	18	0.26	1.04	4.01	1.06
Manganese	mg/l	18	0.00	0.08	0.32	0.09
Total chrome	µg/l	18	1.7	13.6	24.0	13.0
Copper	µg/l	18	3.0	23.9	46.0	23.1
Lead	µg/l	18	3.0	25.7	98.0	24.0
Zinc	µg/l	18	17.0	34.3	65.0	34.6
Cadmium	µg/l	17	0.0	3.3	20.0	2.8
Cyanides	µg/l	7	1.0	2.7	8.0	2.5
Phenols	µg/l	22	0.0	7.8	70.0	8.1
Detergents	µg/l	19	10	69	140	73
Extractible substances	µg/l	7	2530.0	5054.3	7070.0	5426.9

Table 4.1.3-4. Water quality characterization in the Chiciu - Silistra section (January – December 2002)

Indicator	U/M	Număr det.	Valori		
			Minima	Media	Maxima
Flow	m^3/s	365	3162	6100	8960
Water temperature	^0C	21	2.0	13.8	26.0
pH	-	21	7.9	8.2	8.7
Suspended solids	mg/l	21	1	13	56
Dissolved O_2	mgO_2/l	21	6.5	9.0	12.5
BOD_5	mgO_2/l	19	0.8	2.9	5.2
COD-Mn	mgO_2/l	15	2.8	4.3	6.6
COD-Cr	mgO_2/l	20	16.0	31.3	50.0
Ammonium ($N-NH_4^+$)	mgN/l	21	<0.020	0.395	1.390
Nitrites ($N-NO_2^-$)	mgN/l	21	0.017	0.047	0.122
Nitrates ($N-NO_3^-$)	mgN/l	21	0.87	1.85	2.75
Ortho-phosphates ($P-PO_4^{3-}$)	mgP/l	21	<0.005	0.043	0.289
Total P	mgP/l	7	0.02	0.09	0.19
Conductivity	µS/cm	21	359	437	742
Chlorides	mg/l	15	21	34	78
Sulphates	mg/l	12	13	25	54
Calcium	mg/l	13	19.4	40.8	73.9
Magnesium	mg/l	13	12.5	26.4	40.8
Alkalinity	mmol/l	13	2.3	3.0	4.0
Total iron	mg/l	24	0.052	0.674	2.645
Manganese	mg/l	24	0.033	0.111	0.334
Nickel	µg/l	22	1.11	3.96	13.12
Total chrome	µg/l	24	0.44	3.47	10.57
Copper	µg/l	23	1.22	9.56	26.10
Lead	µg/l	23	1.07	4.60	15.94
Zinc	µg/l	24	<10.0	44.5	85.0
Cadmium	µg/l	24	0.07	0.63	2.15
Phenols (phenolic index)	mg/l	11	<0.005	0.005	0.007
Detergents	mg/l	4	0.041	0.109	0.281

Water quality at Giurgeni, downstream Cernavoda

The Danube water quality in the Giurgeni section at km 238 was analyzed by the Romanian Waters Authority between 1994 - 1996 and 1997 - 1999.

The minimum, average and maximum values are presented here for each physical or chemical indicator (Tables 4.1.3-5, 4.1.3-6).

Water reaction was alkaline, the pH values ranging between 7.2 - 8.1 in 1994 - 1996 and 6.6 - 9.0 in 1997 - 1999.

The range of values of the dissolved oxygen concentration shows that the Danube water was well-oxygenated. The average values were very good, above the limit of quality class I.

The nutrients concentrations are presented by the values of nitrates, ammonium and total phosphorus.

Other relevant indicators are those characterizing water mineralization: chlorides, calcium, magnesium, etc.

It is assessed that the average values of the indicators in the Giurgeni section are generally within the limits of the quality classes I and II (according to Order 161/2006).

Table 4.1.3-5. Water quality characterization in the Giurgeni section (January 1994 – September 1996)

Indicator	U/M	Number of results	Values			Flow-weighted concentration	Class
			Minimum	Mean	Maximum		
Flow	m^3/s	12	2540	5390	9960	-	-
Water temperature	^0C	3	4.0	10.3	17.0	-	-
pH	-	12	7.2	7.7	8.1	7.6	I-IV
Suspended solids	mg/l	12	4.0	16.3	47.0	16.0	-
Dissolved O_2	mgO_2/l	11	8.64	9.02	12.18	8.82	I
Saturation of O_2	%	3	92.8	96.6	99.9	96.5	-
BOD_5	mgO_2/l	12	3.1	4.2	5.4	4.2	II
COD-Mn	mgO_2/l	12	6.3	9.5	13.3	9.6	I
COD-Cr	mgO_2/l	6	12.0	15.6	21.0	15.6	-
Ammonium ($N\text{-}NH_4^+$)	mgN/l	12	0.06	0.37	0.81	0.37	III
Nitrites ($N\text{-}NO_2^-$)	mgN/l	12	0.008	0.022	0.063	0.025	II
Nitrates ($N\text{-}NO_3^-$)	mgN/l	12	0.1	0.3	1.0	0.2	I
Total P	mgP/l	12	0.0090	0.0514	0.0980	0.0449	I
Total dissolved solids	mg/l	11	228.0	351.9	479.0	353.2	II
Chlorides	mg/l	11	28.4	40.7	56.8	39.8	II
Calcium	mg/l	12	30.8	64.4	78.6	63.4	I
Magnesium	mg/l	12	9.5	16.0	21.6	16.7	II
Sodium	mg/l	5	12.3	13.9	15.4	14.4	I
Alkalinity	mval/l	12	1.40	2.10	4.72	2.03	-
HCO_3	mg/l	12	85.4	128.2	288.0	123.9	-
Total hardness	^0G	12	11.0	13.1	14.8	13.0	-
Total iron	mg/l	12	0.02	0.24	0.59	0.20	III
Manganese	mg/l	1	-	0.01	-	0.01	I
Phenols	µg/l	9	1.0	5.0	9.0	6.1	III
Detergents	µg/l	9	8	26	48	24	I
Extractible substances	µg/l	9	2200.0	3448.9	8000.0	3838.3	-

Table 4.1.3-6. Water quality characterization in the Giurgeni section (January 1997–December 1999)

Indicator	U/M	Number of results	Values			Flow-weighted concentration	Class
			Minimum	Mean	Maximum		
Flow	m^3/s	23	4050	7021	11360	-	-
Water temperature	^0C	23	2.0	12.2	25.0	-	-
pH	-	25	6.6	8.0	9.0	7.9	I-IV
Suspended solids	mg/l	25	6.0	32.8	211.0	33.7	-
Dissolved O_2	mgO_2/l	24	5.30	9.33	13.10	9.13	I
Saturation of O_2	%	22	50.6	87.4	124.6	86.4	-
BOD_5	mgO_2/l	25	2.1	4.2	6.7	4.0	II
COD-Mn	mgO_2/l	25	4.5	7.0	10.4	6.8	I
COD-Cr	mgO_2/l	3	10.0	21.0	30.0	21.5	-
Ammonium ($N-NH_4^+$)	mgN/l	25	0.17	0.60	2.14	0.52	III
Nitrites ($N-NO_2^-$)	mgN/l	25	0.005	0.026	0.082	0.025	II
Nitrates ($N-NO_3^-$)	mgN/l	25	0.4	1.5	2.8	1.5	II
Total P	mgP/l	18	0.0000	0.0956	0.5600	0.0989	I
Total dissolved solids	mg/l	21	257.0	326.3	410.0	321.5	II
Chlorides	mg/l	25	9.2	35.7	50.2	35.6	II
Sulphates	mg/l	4	18.5	48.3	89.7	45.3	I
Calcium	mg/l	25	40.1	64.2	138.4	62.5	I
Magnesium	mg/l	25	7.3	23.5	37.9	23.1	II
Alkalinity	mval/l	25	1.34	2.26	3.26	2.30	-
HCO_3	mg/l	25	75.0	143.8	198.8	148.2	-
Permanent hardness	^0G	14	0.7	3.9	11.1	3.7	-
Temporary hardness	^0G	14	6.2	10.3	13.8	10.1	-
Total hardness	^0G	23	10.0	14.2	19.5	14.0	-
Total iron	mg/l	20	0.05	0.40	2.70	0.43	IV
Phenols	µg/l	17	1.0	5.4	10.0	5.8	III
Detergents	µg/l	20	10	118	580	123	I

Water quality characterization on the Danube stretch downstream Cernavoda in 2001, 2003, 2004, 2006

The Dunarea Veche branch channel is very wide in the neighborhood of the effluent discharge section. The lateral limits of the water stream are variable depending on the water level which changes within a range of several meters. That is why the water sampling and measurement sections downstream the effluent discharge were established in relation to the thermal plume generated by the effluent along the right bank of the river.

Farther downstream, there are several small islands. The water temperature in that area was measured in relevant sections across the river channel. The campaigns included many sections downstream so that to cover the river reach up to the mixing of the effluent with the river water. Other control sections were established upstream the effluent discharge in order to get data in areas that are not influenced by the effluent.

The sampling sections for water quality analyses on the branch Dunarea Veche are shown in Fig. 4.1.3-1, and, at a larger scale, in Fig. 4.1.3-2 (sections C3, C10, C11, C11´, C12, C13 and C14).

The analyzed quality indicators include physical parameters, oxygen regime indicators, nutrients, dissolved ions, and also specific substances used by Unit 1 during normal operation. These parameters are relevant for assessing potential effects of the NPP effluent discharge on water quality and aquatic environment state.

The results obtained in July and August 2001, April, May, June, July and October 2003, January, February, April, May, October and November 2004, and also in August 2006 are presented in Annex A.4.1.3.

The dissolved oxygen concentrations in the Danube water depend on complex phenomena and processes: biochemical oxygen consumption, reaeration, algal photosynthesis, chemical oxygen consumption. Therefore, the values are variable in time and from a section to another section (Ref. 4.1-23, 4.1-24).

The dissolved oxygen concentrations are generally within the quality classes I and II (according to Order 161/2006), indicating that the Danube water is well oxygenated.

The values of the indicators on Dunarea Veche downstream Cernavoda are close to those in the upstream section (Danube section at the DBSC intake, upstream the effluent). The values of the water quality indicators are within class II in most cases. Some temporary exceeding values are determined by the existing conditions and pollution sources in the Danube hydrographic basin.

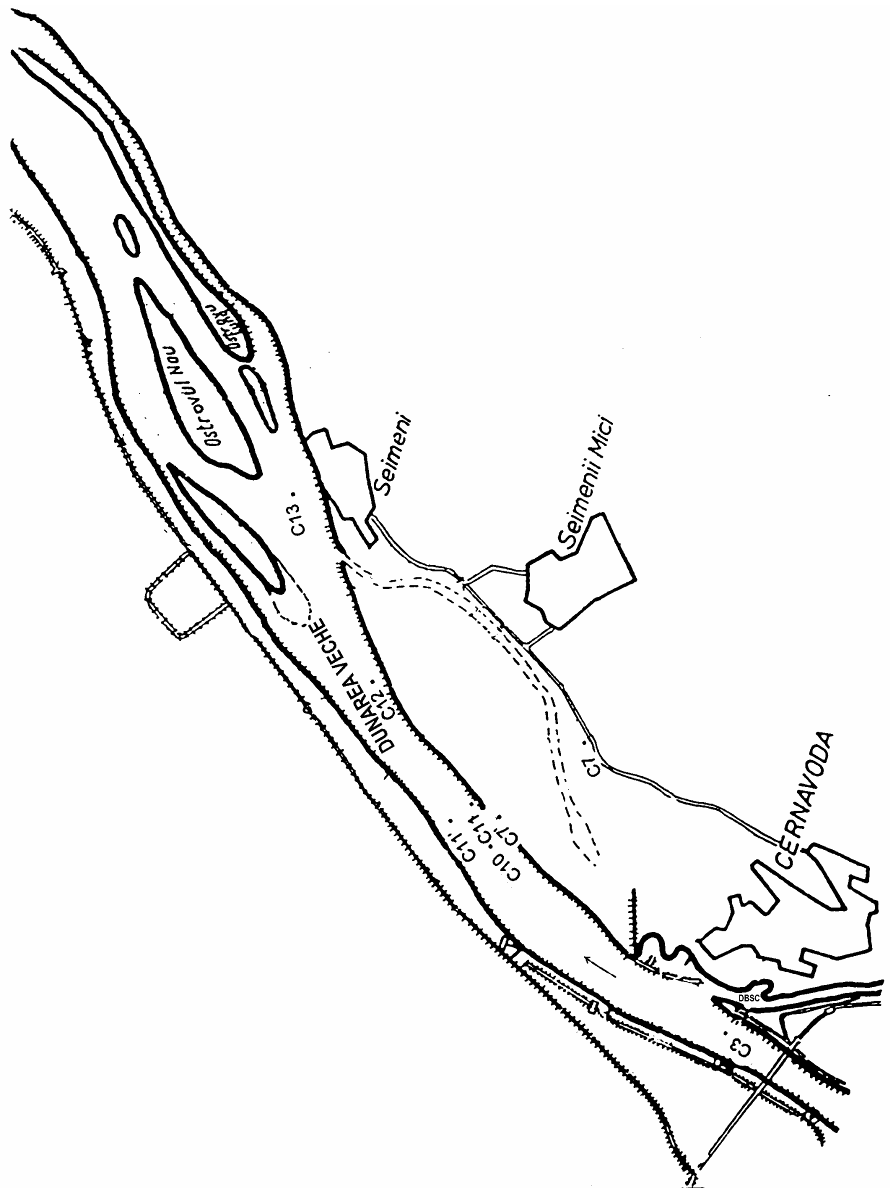

Figure 4.1.3-1. The Dunarea Veche branch, water sampling sections

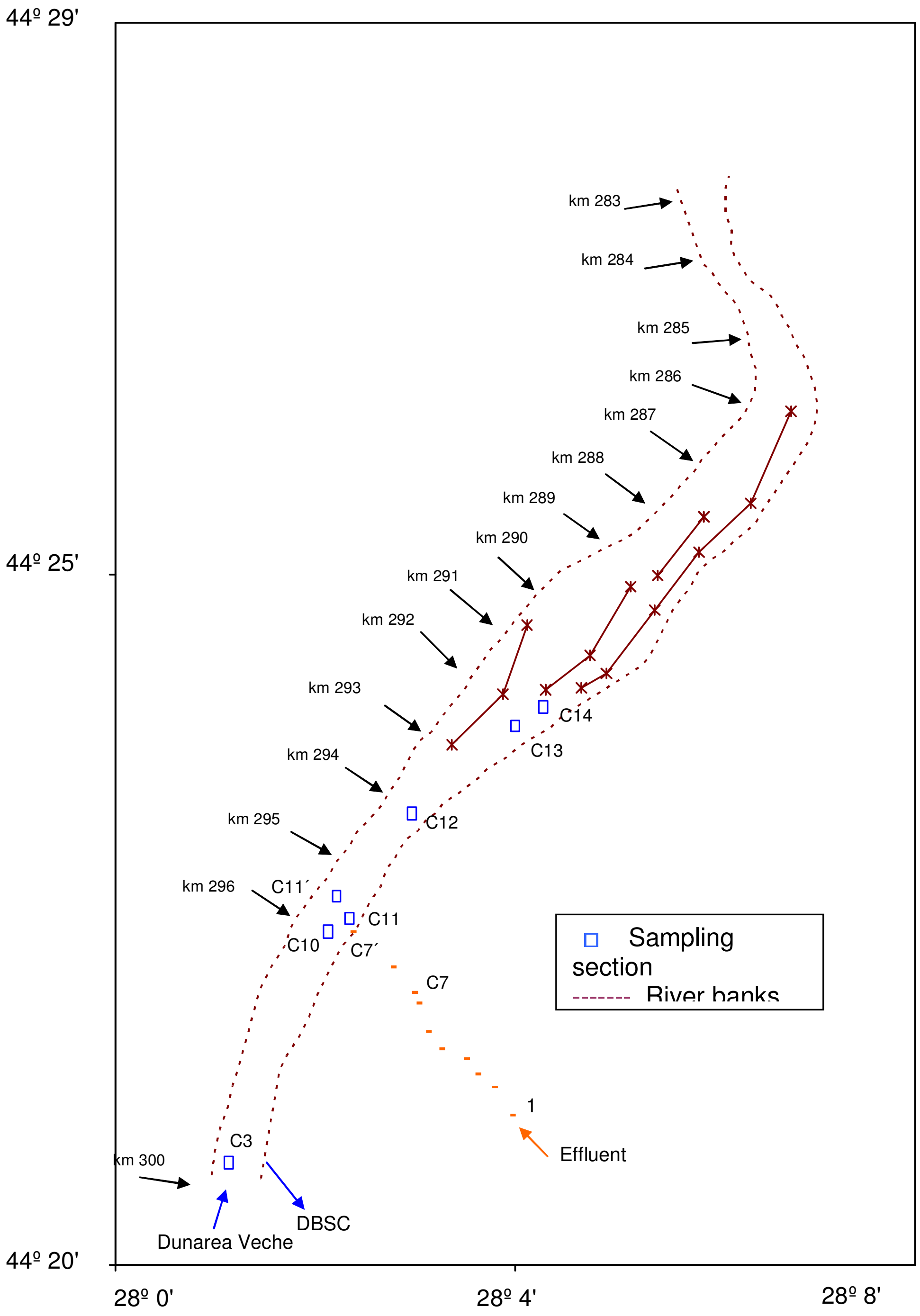

Figure 4.1.3-2. Water quality control sections on the Dunarea Veche branch and in the effluent

Characterization according to microbiological indicators

The Danube water microflora includes autochthonous species, characteristic to the ecosystem and allochtone species coming from the soil, precipitations, tributaries and from various contamination sources. Generally, the allochthone microorganisms, including also the coliforms as indicator bacteria group for the pathogenic germ pollution, have an ephemeral existence due to their incapacity to adapt to the ultraviolet radiation effect, and to the competition with other microorganismus.

The assessment of the water pathogenesis is carried out indirectly by the total coliform number quantification.

The microbiological indicators values in the Danube water, recorded between 1996 - 2000 in sections at relatively long distances from Cernavoda, show some exceeding values. For example, the maximum values at Chiciu - Silistra (upstream section, far from the NPP) of the total coliform bacteria were 16 000 TCB/l in April 1997, 2 800 000 TCB/l in July 1998 (the highest bacterial pollution on the Danube), 240 000 TCB/l in June 1999 and 16 000 TCB/l in October 2000. In the year 2002, the recorded values of the total coliforms in the Chiciu - Silistra section were between 1300 and 9200 BCT/100 ml.

More detailed studies were carried out by ICIM, taking water samples from the river stretch downstream Cernavoda

The Danube water microbiological characterization at Cernavoda was based on the following bacteriological indicators: total coliforme bacteria (BCT, assessing general pollution by pathogenic germs), fecal coliforme bacteria (BCF), fecal streptococci, heterotrophic germs at 22 ^{0}C (that indicate water load with decomposing and mineralizing bacteria acting on easy biodegradable organic matter).

The microbiological analyses were performed on water samples taken at the same times as the samples for chemical and biological analyses.

The microbiological results obtained by ICIM during the campaigns in 2001, 2003, 2004 are presented in Annex A.4.1.3.

These results show fluctuant values due to variable conditions in the Danube water and variable loads from the upstream hydrographic basin.

Radioactivity

In the year 2004, ICIM took samples from various sections and locations for radioactivity analyses (Ref. 4.1-14).

Figure 4.1.3-3 presents the values of the gross beta activity (Bq/m^3) in water samples from the Danube (Saligny Bridge), and also from the Danube at Calarasi and Zimnicea.

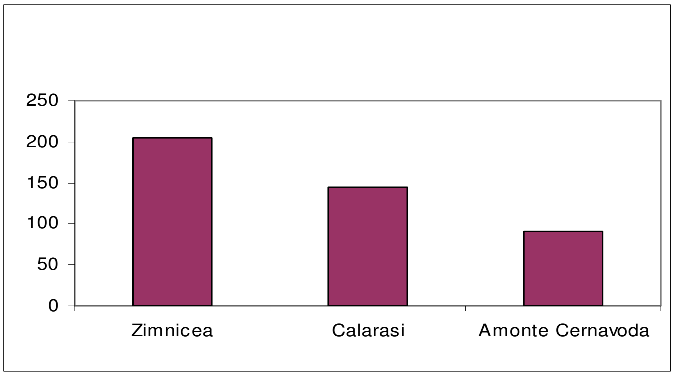

Figure 4.1.3-3. Gross beta activity (Bq/m^3) of water samples from the Danube (in sections upstream Cernavodă)

Performing spectrometric gamma analyses for surfaces water samples taken from the zone upstream Cernavoda, gamma - emitting radionuclides were not detected, except the natural radionuclid K-40 having an average concentration of 110.89 ± 24.4 Bq/m^3. The K-40 levels in the analyzed water samples are presented in Figure 4.1.3-4.

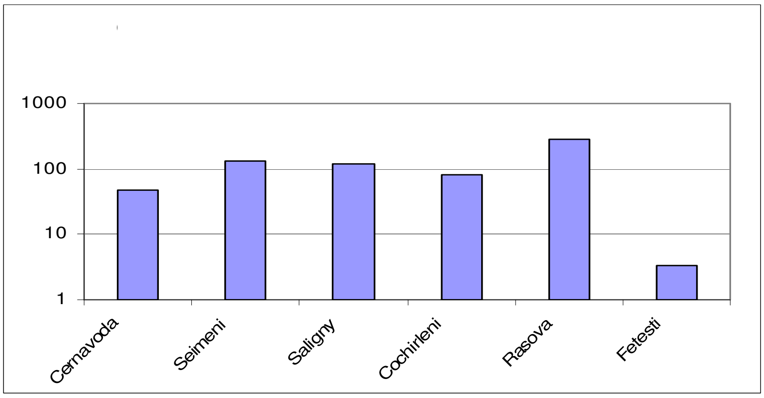

Figure 4.1.3-4. K-40 levels (Bq/m^3) in water samples from the Danube in sections upstream the Seimeni section

The tritium concentration in water samples from the Danube was 7.1 ± 1.2 (Bq/l) in the Rasova section and 10.2 ± 1.5 (Bq/l) in the Cernavoda Port section. Figure 4.1.3-5 present tritium levels in surface water samples from the Danube in the sections Cernavoda Port (GF), Saligny Bridge (D14), Rasova (D15), and also in the Calarasi section (PR) on the Borcea branch.

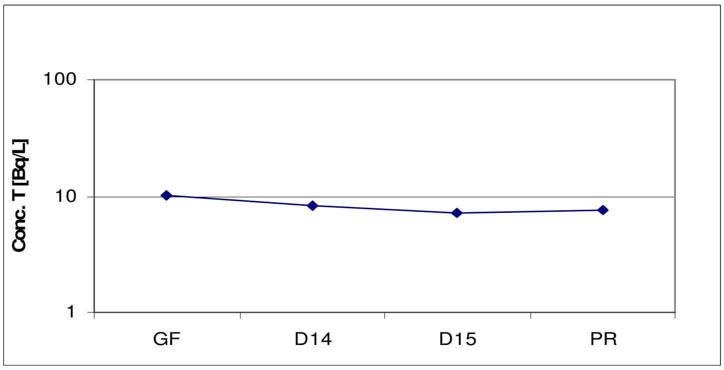

Figure 4.1.3-5. Tritium concentrations in water samples from the Danube

In the water samples taken from the Seimeni canal (the NPP effluent discharge canal to the Danube), gamma - emitting radionuclides were not detected, except the natural radionuclid K-40 having an average concentration of 58.2 ± 11.0 Bq/m^3.

In the water samples from the Seimeni canal, taken daily and cumulated monthly, in the period January – July 2004, the tritium concentration values were within the interval 9.3 ± 1.5 Bq/l (July) - 297.4 ± 9.0 Bq/l (January), the average value being 65.8 ± 3.5 Bq/l. Figure 4.1.3-6 presents the monthly average values of tritium concentration in water samples from the Seimeni canal.

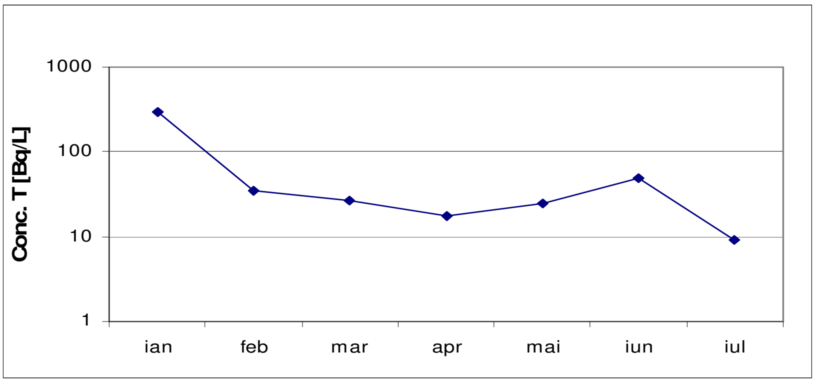

Figure 4.1.3-6. Tritium concentrations in water samples from the Seimeni canal

Downstream the NPP effluent discharge section, the gross beta activity in water samples from the Danube had the minimum value 52.8 ± 2.3 Bq/m^3, the maximum value 119.8 ± 5.2 Bq/m^3 and the average value 80.4 ± 4.2 Bq/m^3. Figure 4.1.3-7 presents the gross beta radioactivity level in the water samples from the Danube from sections downstream the Seimeni canal, and also the average value for the measurements with significant recorded values.

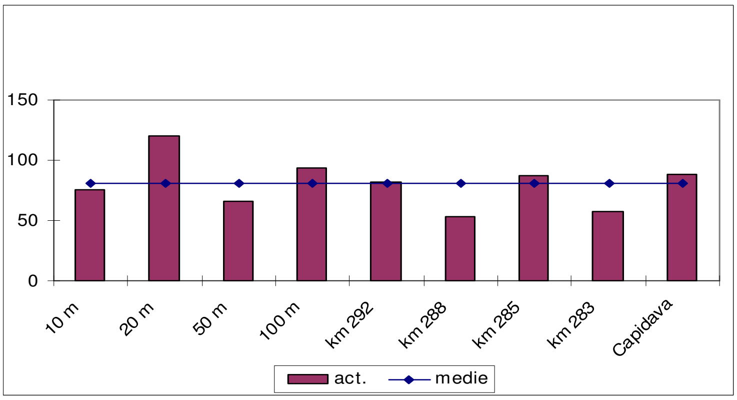

Figure 4.1.3-7. Gross beta activity (Bq/m^3) of the water samples from the Danube in sections downstream the Seimeni canal

In the water samples from the Danube in sections downstream the Seimeni canal, gamma - emitting radionuclides were not detected, except the natural radionuclid K-40 having an average concentration of 91.0 ± 14.6 Bq/m^3, the K-40 concentration variation domain being 51.6 ± 19.6 - 139.0 ± 23.1 Bq/m^3. Figure 4.1.3-8 presents the K-40 levels in water samples from different sections.

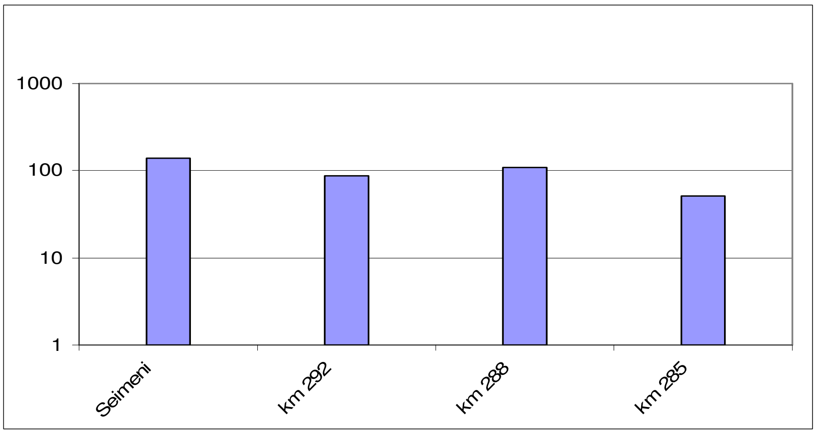

Figure 4.1.3-8. K-40 levels (Bq/m^3) in water samples from the Danube in sections downstream the Seimeni canal

The tritium concentration in water samples from the Danube in sections downstream the NPP effluent discharge had the minimum value 7.2 ± 1.2 (Bq/l) in the Capidava section and the maximum value 19,0 ± 2,1 (Bq/l) in a section at 10 m downstream the discharge. Figure 4.1.3-9 presents tritium levels in water samples from the Danube in sections D1 (10 m downstream the Seimeni canal), D2 (20 m downstream the Seimeni canal), D3 (30 m downstream the Seimeni canal), D4 (50 m downstream the Seimeni canal), D5 (100 m downstream the Seimeni canal), D6 (Seimeni locality), D7 (km 292), D8 (km 288), D9 (km 285), D10 (km 284), D11 (km 283), D12 (Capidava, km 281), and also in the Calarasi section located upstream on the Borcea branch.

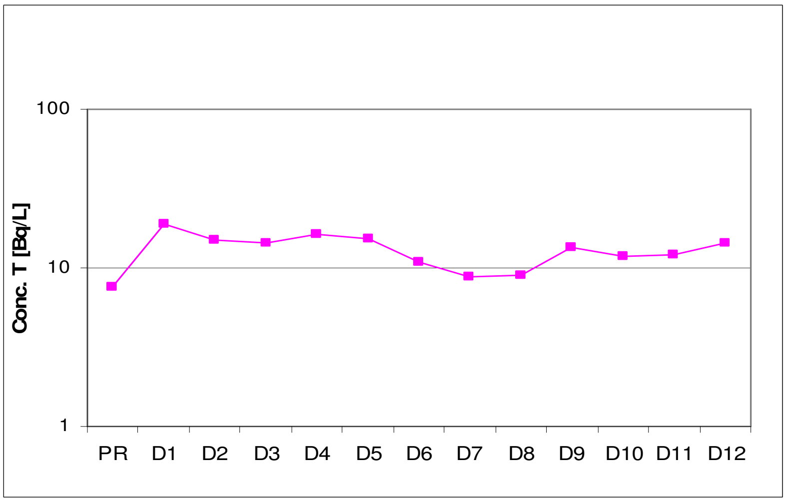

Figure 4.1.3-9. Tritium concentration in water samples from the Danube in sections downstream the Seimeni canal

In addition to the water samples, radioactivity analyses were also performed for sediment samples.

For the sediment samples taken from the Seimeni canal, the minimum value of the gross beta activity was 358.3 ± 14.8 Bq/kg, and the maximum value was 589.5 ± 24 Bq/kg. The average value of the gross beta activity of the sediment samples was 473.9 ± 19.4 Bq/kg.

For the sediment samples from the Danube, the minimum value of the gross beta activity was 225.3 ± 9.4 Bq/kg, and the maximum value was 461.9 ± 18 Bq/kg. din Dunăre valoarea minima a activității beta globală a fost de 225.3 ± 9.4 Bq/kg, iar valoarea maxima a fost de Bq/kg. The average value of the gross beta activity of the sediment samples was 368.8 ± 15.2 Bq/kg.

In the sediment samples from the Seimeni canal, gamma emiting radionuclides were not detecting.

For the sediment samples taken from the DBSC race 1, from the Seimeni canal and from the Danube, it was obtained an average value of C-14 concentration of 258 ± 26 Bq/kg - carbon fw. The C–14 concentration values in sediment samples are presented in Figure 4.1.3-10.

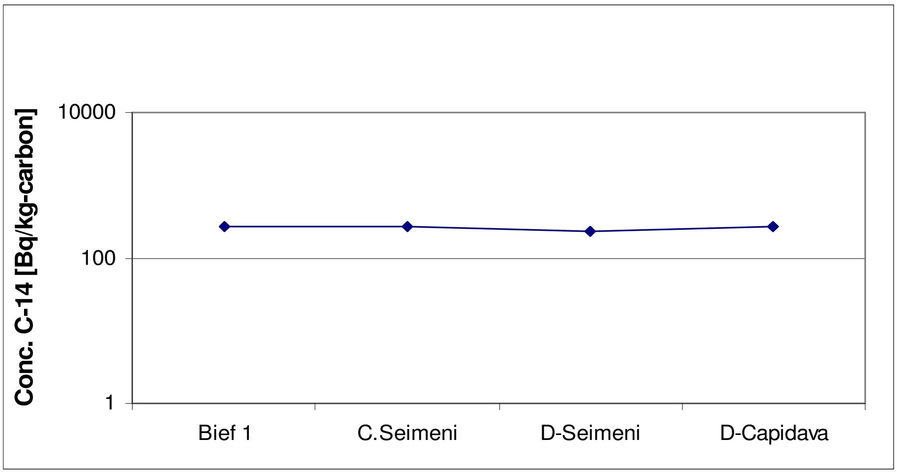

Figure 4.1.3-10. C-14 concentrations in sediment samples

In mollusks samples taken from the Danube from sections downstream the Seimeni canal, gamma - emitting radionuclides were not detected, except the natural radionuclid K-40 having an average concentration of 3.2 ± 0.5 Bq/kg fw.

For the mollusks samples taken from the Danube from sections downstream the Seimeni canal, it was obtained an average value of tritium concentration of 12.3 ± 2.0 Bq/kg fw.

Performing analyses of C-14 in mollusk samples, it was obtained an average value of 288 ± 29 Bq/kg – carbon fw.

For the fish samples taken from the Danube downstream the Seimeni discharge canal and from the Danube - Black Sea Canal (downstream and upstream the Cernavoda lock), it was obtained an average value of tritium concentration of 44.6 ± 6.9 Bq/kg fw, observing relatively small variations from a location to an other and among different species.

The average values of tritium concentration in fish samples from the Seimeni canal were 62.1 ± 7.0 and 25.1 ± 4.1 in fish samples from the Danube downstream the Seimeni canal.

The average values of tritium concentration in fish samples from the DBSC, from the Seimeni canal and from the Danube downstream the Seimeni canal are presented in Figure 4.1.3-11.

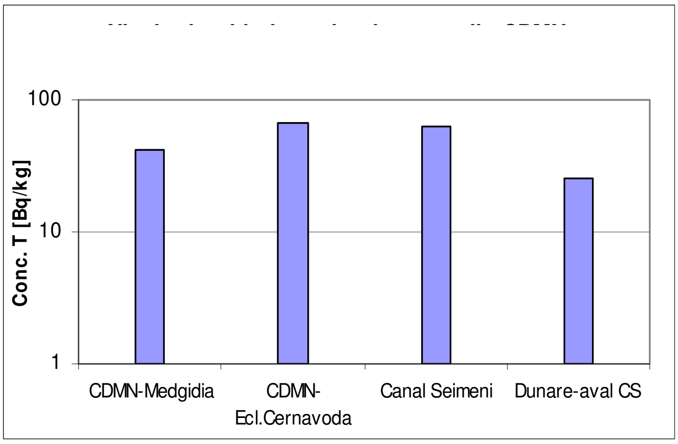

Figure 4.1.3-11. Tritium concentrations in fish samples from the DBSC, the Seimeni canal and the Danube downstream

As regards C-14 analyses in fish samples, it was recorded an average value of 268 ± 28 Bq/kg – carbon fw.

For macrophyta samples taken and analyzed from the Seimeni canal, the minimum recorded value of gross beta activity was 26.4 ± 1.1 Bq/kg, and the maximum value was 65.8 ± 2.7 Bq/kg. The average value of gross beta activity in macrophyta samples in the Cernavoda zone was 46.1 ± 1.9 Bq/kg.

For aquatic vegetation samples taken from canals, gamma - emitting radionuclides were not detected, except the natural radionuclid Be-7 having an average concentration of 279.7 ± 33.7 Bq/kg fw.

For algae samples, it was obtained an average value of tritium concentration of 38.9 ± 5.2 Bq/kg fw.

Ads regard the C-14 analyses in algae samples, it was recorded an average value of 270 ± 29 Bq/kg – carbon fw.

The C-14 concentration values mentioned in this paragraph were within the natural background values limit (230 Bq/kg – carbon).

4.1.4. Biocenosis Components in the Aquatic Environment of the Branch Dunarea Veche

According to the regulations (Directive 2000/60/EC, Law 310/2004, Order 161/2006), among the quality elements that are taken into consideration with the view of establishing the ecological state of water bodies, there are biocenosis components.

The aquatic biocenosis depends of many abiotic environmental factors: water chemism (organic load, oxygen regime, mineralization, nutrients concentrations, toxic substances presence), the substrate nature, slope, stream velocity, thermal regime, etc.

One of the biocenosis component that are taken into consideration during the study of water bodies is the phytoplankton (Fig. 4.1.4-1).

The phytoplankton qualitative structure in the Danube comprises species belonging to the systematic groups Cyanophyta (*Anabaena, Coelosphaerium, Microcystis, Nodularia, Oscillatoria, Rivularia),* Bacillariophyta *(Achnanthes, Coscinodiscus, Epithemia, Fragilaria, Navicula, Nitzschia, Surirella, Synedra),* Euglenophyta *(Euglena),* Pyrrophyta *(Ceratium, Glenodinium, Peridinium, Phytodinium),* Chlorophyta *(Cladophora, Chlorococcus, Oedogonium, Scenedesmus, Tetradesmus, Volvox), Chrysophyta (Enochromonadaceae).* Dominant species are *Anabaena, Microcystis, Oscillatoria. Epithemia, Navicula, Nitzschia, Surirella, Synedra, Euglena, Peridinium* Among these, *Anabaena, Microcystis, Oscillatoria. Epithemia, Navicula, Nitzschia, Surirella, Synedra, Euglena, Peridinium*.

Zooplankton includes species belonging to the classes *Protozoa, Rotatoria (Rotatoria sp., Notholca sp.), Copepoda (Acanthocyclops sp., Cyclops sp.), Cladocera*. The dominant group is rotifera (67 %) with the species *Brachinus, Keratella, Notholca.* The zooplankton composition and density varies within wide limits because of the water exchange between the Danube and the ponds during floods. Most of the zooplankton species belong to the primary consumers and to a less extent to the secondary consumers. The trophic spectrum of the zooplankton species is represented by algae, bacteria and very fine detritus. Zooplankton biomass is a main feeding source for the young fish.

The benthonic fauna consists of worms, mollusks, shell fish and insects. The benthonic fauna in the Danube depends on the river bed characteristics. The structure of the benthonic macro-invertebrates communities in sections on the lower course of the Danube is presented in Annex (Tables A.4.1.4-1, A.4.1.4-2, in Annex A.4.1.4). The main components at Calarasi and Harsova are the following: worms *(Policheta, Oligocheta),* mollusks *(Bivalves, Gasteropoda),* crustaceans *(Gamarides, Misides),* insects *(Chironomida, Efemeroptera, Trichoptera).* Most benthonic organisms are in the trophic basis of the benthonophague ichtiofauna.

The vegetation presence and grow depend directly on the time variations of the hydrological conditions, and also on the river bed features in various sections. It is often a visible concordance between the vegetation distribution and morphological and hydrographic elements.

The vegetation on the lower course of the Danube is generally of three categories: aquatic, swamp and land vegetation.

The Danube ichtyofauna in the Oltina-Harsova sector includes 66 species, of which 28 are more frequently met. The following families and species are mentioned (including local names):

- *Acipenseridae* family*: Acipenser gueldenstaedti colchicus* (nisetru)*, Acipenser sturio* (şip)*, Acipenser stellatus* (păstrugă)*, Acipenser nudiventris* (viză)*, Acipenser ruthenus* (cegă)*, Huso huso* (morun)*;*
- *Clupeidae* family*: Alonsa pontica pontica* (scrumbie de Dunăre)*, Alonsa caspia nordmanni* (rizeafcă)*, Clupeonella cultriventris cultriventris* (gingirică)*;*
- *Salmonidae* family*: Salmo trutta labras* (păstrăv de mare)*;*
- *Umbridae* family*: Umbra krameri* (ţigănuş)*;*
- *Esocidae* family*: Esox lucius* (ştiucă);
- *Ciprinidae* family*: Rutilus rutilus carpathorossicus* (babuşcă)*, Rutilus rutilus heckeli* (tarancă)*, Rutilus frissi frissi, Leuciscus borysthenicus borysthenicus, Leuciscus cephalus cephalus* (clean)*, Leuciscus idus idus* (văduviţă), *Scardinius erythrophthalmus erythrophthalmus* (roşioară)*, Aspius aspius aspius* (avat)*, Leucaspius delineatus* (fufă)*, Tinca tinca* (lin)*, Chondrostoma nasus nasus* (scobar)*, Gobio kessleri* (porcuşor de deltă)*, Gobio albipinnatus vladykovi* (porcuşor de şes)*, Barbus barbus barbus* (mreană)*, Alburnus alburnus alburnus* (oblete)*, Chalcalburnus chalcoides mento* (obletul mare), *Blicca bjoerkna bjoerkna* (batcă)*, Abramis brama brama* (plătică)*, Abramis sapa sapa* (cosac cârn)*, Abramis ballerus* (cosac cu bot ascuţit)*, Vimba vimba carinata* (morunaş)*, Pelescus cultratus* (săbiuţă)*, Rhodeus sericeus amarus* (boarţă)*, Carassius carassius* (caracudă)*, Carassius auratus gibelio* (carasul argintiu)*, Cyprinus carpio carpio* (crap)*, Cyprinus carpio morpha elatus, Cyprinus carpio morpha hungaricus, Cyprinus carpio morpha*

oblongue, Cyprinus carpio morpha Lausitz, Cyprinus carpio morpha Galitzian;

- *Cobitidae* family*: Misgurnis fossilis* (chişcar)*, Cobitis taenia taenia* (zvârlugă)*, Cobitis aurata bulgarica* (dunărița)*;*
- *Siluridae* family*: Silurus glanis* (somn)*;*
- *Gadidae* family*: Lota lota lota* (mihalț)*;*
- *Gasterosteydae* family*: Pungitius platygaster platygaster* (osar)*;*
- *Syngnatidae* family*: Syngnatus nigroleatus nigrolineatus* (undrea)*;*
- *Percidae* family*: Perca fluviatilis fluviatilis* (biban)*, Stizosthedion lucioperca lucioperca* (şalău)*, Stizosthedion lucioperca volgensis* (şalău vărgat)*, Aspro streber streber* (fusar)*, Aspro zingel* (pietrar)*, Acerina cernua* (ghiborț)*, Acerina shaetser* (răspăr)*.*

Out of these, 18 species feed on benthonic organisms, plankton and periphyton, the rest being predatory species. Within the first fish category, the most frequent species are: *Cyprinus carpio – 37 %, Abramis brama – 6 %, Blicca bjoernika – 5.54 %, Carassius auratus gibelio – 3 %, Leuciscus idos – 2.10 %, Rutilus rutilus, Acipenser ruthenus, Alburnus alburnus*, the last three species representing less than 2 % of the total fishing from the Danube. The most frequent predatory species are *Silurus glanis - 21 %, Lucioperca lucioperca* - 4.31 %, *Esox lucius* - 2.01%, *Acerina cernua* - 1.19 %, *Aspius aspius* - 1.53 %.

In the Cernavoda area, samples of 29 species were identified during a study carried out at the Cernavoda NPP water intake in the interval June 2004 - June 2005 (Ref. 4.1-25). In addition to samples of some species mentioned above, some samples from the following families were identified: *Cyprinidae (Alburnoides bipunctatus), Gobiide (Gobius fluviatilis, Benthophyloides braunerii), Petromyzonidae (Eudontomyzon danfordii mariae), Atherinidae (Atherina mohon pontica), Gasterosteidae (Gasterosteus aculeatus).* Some of these species pass occasionally to the Danube water, coming from tributaries or from the Danube Delta zone or from lakes with saltish water.

The results of the biological analyses show that the Danube water quality is within the ß-mesosaprobe category (moderate load with biodegradable organic substances) from the biological point of view.

In the Cernavoda area, the biological analysis carried out by ICIM in 2001 comprised the study of the qualitative composition (taxonomic groups, species, prevailing forms) and of the quantitative composition (density, density abundance, biomass, biomass abundance) of the phytoplanktonic and zooplanktonic organisms population.

The results of the biological analyses of water samples from sections C3, C10, C7, C7', C11, C11', C12 and C13 are presented in Annex A.4.1.4 (Tables A.4.1.4-3 to A.4.1.4-7).

In all the analyzed control sections, about 40 phytoplanktonic taxons have been identified, belonging to the groups: *Cyanophyta, Bacillariophyta, Euglenophyta, Pyrrophyta, Chlorophyta* (Table A.4.1.4-7).

The zoobentos in the analyzed control sections was poorly represented and less diversified, including some olygocheta and chironomida. *Dreissena polymorpha*, traced as larvas in the plankton, is an almost permanent presence in this biocenosis.

As a whole, the Danube water in the summer of 2001, in the studied sector, was within the β-mesosaprobic category (corresponding to the second quality category from the biological point of view).

Other detailed biological studies in the Cernavoda area were carried out in 2003 and 2004, analyzing water samples from sections C3, C10, C7, C7', C11, C11', C12, C13 and C14 (Ref. 4.1-13, 4.1-14). The results are presented in Annex A.4.1.4 (Tables A.4.1.4-8 to A.4.1.4-29). Furthermore, some bioindicator species relevant for the biological element assessment were identified in the water samples, by biological analyses (Ref. 4.1-26).

In May 2004, the following bioindicator phytoplankton species were found:

Cyanophyta: *Merismopedia glauca - β.*

Bacillariophyta: Asterionella formosa - o - β, Cyclotella meneginiana - α - β, Diatoma elongatum - o, Fragilaria crotonensis - o, Melosira granulata - β, Nitzschia palea - α, Surirella ovata - β, Synedra acus - β

Chlorophyta: Actinstrum hantzschii - β, Ankistrodesmus falcatus - α - β, Chlorella vulgaris - p - α, Crucigenia tetrapedia - o - α, Eudorina elegans - β, Oocystis lacustris - o - β, Pandorina morum - β, Pediastrum boryanum - β, Pediastrum duplex - β, Scenedesmus acutus - β, Scenedesmus quadricauda – β.

Other bioindicator species were identified analyzing the zooplankton structure (Ref. 4.1-26) in the studied river stretch:

Rotatoria: Brachionus angularis - β - α, Keratella cochlearis - β, Keratella ticinensis - o- β, Keratella quadrata - β, Lecane luna- o- β, Polyarthra remata - o;

Copepoda: Cyclops strenuus - β- α, Eucyclops serrulatus - o- β;

Cladocera: Bosmina longirostris, Chydorus sphaericus- o- β,

Bivalvia: Dreissena polymorpha - o- β, Viviparus viviparus – β

In the year 2006, biological analyses in the Cernavoda area were also performed. The results regarding phytoplankton density and biomass, and also the phytoplankton structure in Danube sections in the Cernavoda zone are presented in Annex (Tab. A.4.1.4-30 and A.4.1.4-31 in Annex A.4.1.4).

According to the results of the biological studies, the Danube water quality was good, in the beta-mesosaprobe category (Ref. 4.1-26), both in the river stretch upstream the effluent discharge section and in the downstream stretch, similar to the situation in the previous years.

The aquatic biocenosis in the branch Dunarea Veche is formed on river stretch that is permanently under the influence of the human activities in the Danube hydrographic basin and on this river sector: navigation, waste waters discharge, agriculture, fishing, etc.. The Danube River is a pan-European transport corridor (Corridor VII) between Western and Central Europe and the Black Sea. These activities are performed under the conditions of the regulations in the Romanian legislation and in international conventions, and the Danube water quality is monitored within the activities of the International Commission for the Protection of the Danube River (ICPDR). Romania is also part to international conventions that have flora and fauna protection as purpose.

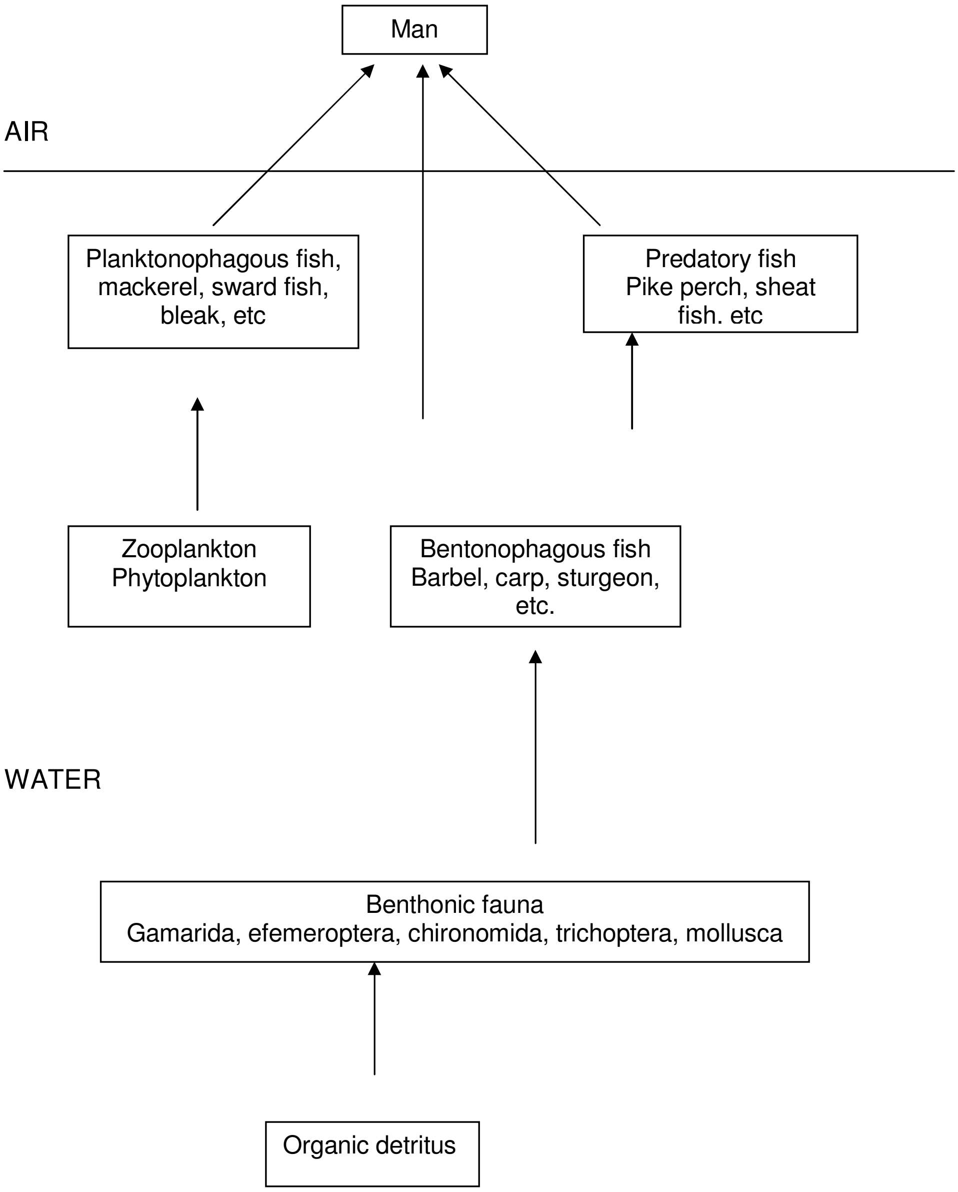

Figure 4.1.4-1. Danube ecosystem trophic structure

4.1.5. Characterization of the Danube - Black Sea Canal

4.1.5.1. Water Races and Characteristic Cross-Sections

The DBSC hydrotechnical system comprises the races of the main waterway named the Danube - Black Sea Canal, and the races of a long branch named the Poarta Alba - Midia Navodari Canal (PAMNC).

The Danube - Black Sea Canal (Ref. 4.1-17, 4.1-18), has a 64432 m length and is a navigable way with complex functions, that connects the Danube (at Cernavoda) and the Black Sea (at Agigea).

This canal consists of three water races, separated by the Cernavoda and Agigea locks:

- The water race 1, with a length of about 4.1 km, between the Danube and the Cernavoda lock (upstream head). In the Cernavoda lock area, the derivation canal was built that connects the water races 1 and 2, by-passing the lock.
- The water race 2, with a length of about 58 km, between the Cernavoda and Agigea locks.
- The water race 3, with a length of about 1.5 km, between the Agigea lock and the Black Sea.

The Poarta Alba-Midia Navodari Canal intake from the DBSC race 2 is located near Poarta Alba village.

The characteristic sections of DBSC are presented in Table 4.1.5.1-1. Because there are two systems to mark the canal distances, in this study the distances from Danube to Black Sea will be used, specifying between parentheses the distances from Black Sea to Danube.

In water race 1, the cross sections have trapezoidal shape, with side slopes between 1:2 and 1:4.5. The canal bottom is at level - 1.50 m BSL. The canal width at bottom is variable, between 70 and 160 m.

The connection area of race 1 with the derivation canal that by-passes the Cernavoda lock begins at km 2+864. In the Cernavoda NPP area, the intake canal (towards the pumps at the end of the distribution basin) begins from the derivation canal, having 340 m length, with a trapezoidal section, having a bottom width of minimum 35 m and side slopes of about 1:5.

Table 4.1.5.1-1. DBSC characteristic sections locations.

Section	Km	
	Danube – Black Sea	Black Sea – Danube
Danube River	0+000	64+432
Join with the derivation canal	3+420	61+012
Cernavoda lock (upstream)	3+886	60+546
Cernavoda lock (downstream)	4+710	59+722
Join with the derivation canal	5+732	58+700
Join with the PAMN Canal	35+332	29+100
Agigea lock (upstream)	62+278	2+154
Agigea lock (downstream)	63+102	1+330
Black Sea	64+432	0+000

In water race 2, the canal bottom is at level +0.50 m BSL. The cross sections have trapezoidal shape, with sides slopes between 1:0.2 and 1:4.5. The canal width at bottom is variable, between 70 and 141 m.

The water race 3 has a 1330 m length and connects Agigea lock with Black Sea. The canal bottom is at level - 7.50 mBSL. The transversal section is trapezoidal, with a bottom width of 150 m.

The canal Poarta Alba-Midia Navodari (PAMNC) connects with water race 2 at km 35+332. It has a length of about 26 km and consists of two main water races:

- The water race 1 of PAMNC, with a 15230 m length, is between DBSC race 2 and Ovidiu lock. The canal bottom is at level 1.50 mBSL. The cross section is trapezoidal, with a bottom width between 35 - 57 m, and sides slopes between 1:4 and 1:0.2. The normal operation level is 7.50 m BSL.

- The water race 2 of PAMNC, with a 9940 m length, starts from Ovidiu lock, passes along Siutghiol and Tasaul lakes and ends at Midia Navodari lock. The canal bottom is at level - 2.00 mBSL. The cross section is trapezoidal, with a bottom width between 35 - 57 m, and sides slopes between 1:0.2 and 1:4. The normal operation level is 4.00 mBSL.

The bathimetric measurements done by IPTANA in October 1997 showed important alluvial deposits in the area of the DBSC water intake from the Danube. These deposits are due to the local streams structure and occur in any conditions. The alluvial deposits from the DBSC intake area are removed by dredging works. Dreadging works were also performed in the derivation canal in the last years.

4.1.5.2. DBSC Operation Parameters

The hydrotechnical scheme of the navigable Danube - Black Sea Canal was realized taking into consideration the water needs and the following uses:

- navigation;
- irrigation;
- draining;
- electric energy generation;
- water supply for permanent consumers;
- sewage discharge;
- flood flows discharge from the DBSC hydrographic basin to the Black Sea;
- cooling water intake by CNE Cernavoda.

The DBSC operation is done by the Administration of the Navigable Canals Constanta - Agigea.

The main water supply source of DBSC is the Danube River by free flow to water race 1.

The water taken over from the Danube River has to cover the usage mentioned above, including the flow necessary to Cernavoda NPP Units 1, 2, 3 and 4. This is possible when the water levels on Dunarea Veche branch are over the zero level of Cernavoda HS (Ref. 4.1-17). Water supply of the users is analyzed in Chapter 4.1.9. During very low water flow on the Danube (mainly in autumn), the discharge of cooling water from Cernavoda NPP in the water race 2 can contribute to satisfy the water supply needs for all usage.

The water level in water race 1 of DBSC and in the derivation canal is determined directly by the Danube water level.

The water level in water race 2 of DBSC is maintained at 7.50 mBSL in normal operation conditions.

The water race 2 is supplied with water from Danube, through the derivation canal and the Complex Pumping Station (with a 205 m^3/s installed flow).

When the Danube water level exceeds the normal operation level in water race 2 with 0.7 m, water supply to race 2 can be done gravitationally, with a flow up to 225 m^3/s. Otherwise, the water supply to water race 2 is done by the pumps of the Complex Pumping Station.

The water needs for different consumers supplied by water race 2 (the necessary flow values) are presented in the following, according to design data, in comparison with the average values of recorded consumption during 1990 - 2000 (recorded at ACN Constanta).

The water flow used in order to compensate the water volumes lost from water race 2 through the locks activity at Cernavoda, Agigea, Ovidiu, Midia Navodari, was estimated in the design to be between 8 m^3/s and 38 m^3/s. The multi annual monthly average values of the flows taken for lock emptying compensation during 1990 - 2000 were between 3.15 - 4.93 m^3/s (Figure 4.1.5.2-1) with the highest monthly average flow value of 9.18 m^3/s.

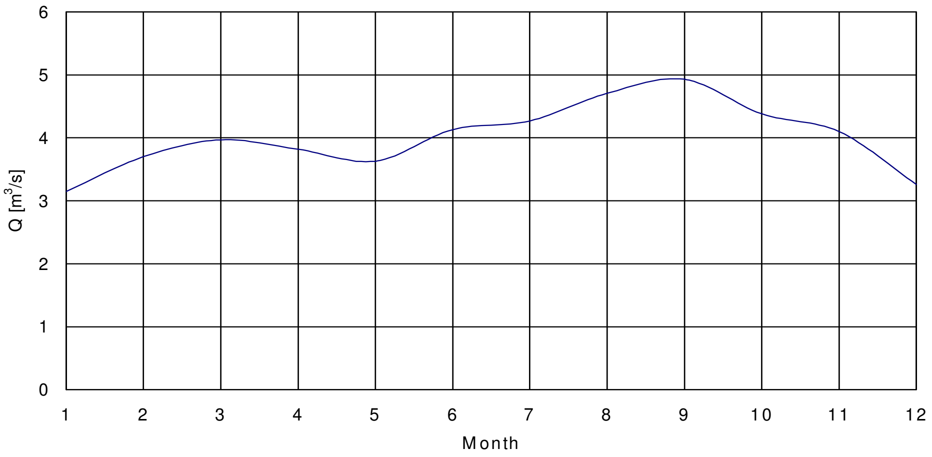

Figure 4.1.5.2-1. Average water flows used for lock emptying compensation during 1990 - 2000

Along the water race 2, there are 26 pumping stations for water supply of the irrigation systems in the Carasu complex and in the flood plain Carasu. The total design water flows envisaged to be taken from the canal reach the maximum value of 148 m^3/s in the average year (calculation assurance of 50 %), and the maximum value of 189 m^3/s in the dry year (calculation assurance of 80 %). The maximum multi-annual monthly average flow value consumed for irrigation during 1990-2000 was of 28 m^3/s (Figure 4.1.5.2-2), with the highest monthly average flow value of 64.94 m^3/s.

The water flow use for generating electrical energy in the Agigea hydroelectric station was sporadic, on short periods, when the water race 2 of DBSC could be supplied gravitationally or sometimes when NPP discharged the cooling water in this water race.

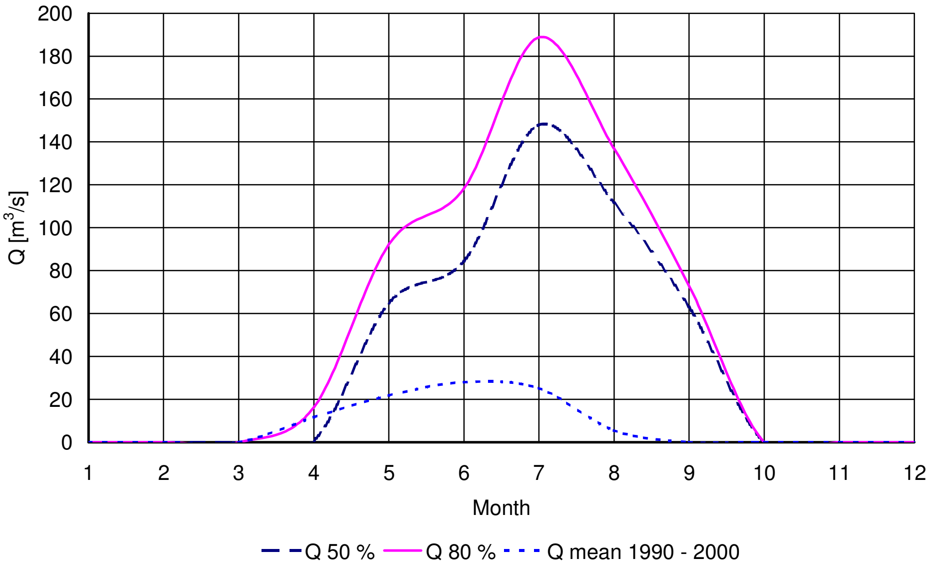

Figure 4.1.5.2-2. Consumed flows for irrigation

The water race 2 is a water supply source for industry and population. The DBSC design provided a total consumption of 15 m^3/s in the year 2000 for industrial water and drinking water treatment station supply. The multi-annual monthly average consumption values recorded during 1990-2000 were between 2.64 - 3.10 m^3/s, with the the highest monthly average flow value of 4.21 m^3/s. The main users were Romcim Medgidia, Sursal Saligny and the water treatment station Palas.

The wastewater and rain water discharged into the DBSC come from the safety discharges of SP IACN (in Valea Cismelei), SP Parc, SP Atom (in Valea Viteilor) and SP Columbia (discharge of harbor basin) in water race 1, from the waste water treatment stations of Medgidia and Poarta Alba in water race 2.

Waters from draining works are discharged in water race 2 through the Defending Stations Saligny, Faclia and Mircea Voda.

The rainwater sewage of Cernavoda NPP discharges into the distribution basin. The rainwater flows from DIDR and from the 40 kV station platform are discharged in Valea Cismelei, towards the derivation canal.

The DBSC hydrographic basin has a 878 km^2 total area. The floods occurring due to precipitations are discharged as follows:

- the waters from about 43 km^2 are discharged in water race 1;
- the waters from about 817 km^2 are discharged in the water race 2 of DBSC;
- the waters from about 18 km^2 are discharged in the water race 3, with direct discharge to the Black Sea.

The floods from the affluent valleys and slopes influence considerably only the water race 2 of DBSC, that collects the water from 23 affluent valleys. These valleys, as well as those ones with discharge in water races 1 and 3, generate spontaneous floods, without forecasting opportunity.

The water volumes from race 2 are discharged into the water race 3 (and then to the Black Sea) through 2 outlet tunnels with 150-190 m^3/s flow capacity each, as well as through 2 hydroelectric stations existing near the Agigea lock upstream end, with a 75 m^3/s flow each. During exceptional high floods, the filling and emptying tunnels of the Agigea lock can also be used for water discharge to the Black Sea.

The water level along water race 2 is of maximum 8.50 m BSL at a flood with 1% probability and 9.26 m BSL at a 0.1 % probability flood.

The necessary water for Units 1, 2, 3 and 4 of the Cernavoda NPP is taken from the derivation canal through the intake canal and the pumping station placed at the distribution basin end. According to the design, the taken and then discharged flow is of 53.8 m^3/s for one unit. The highest monthly average flow values taken by Cernavoda NPP during 1996 - 2000 (recorded at ACN Constanta, Table 4.1.9.3-3) were between 19.62 m^3/s (January 1999) and 43.66 m^3/s (September 1999).

4.1.6. Characterization of the DBSC Water Quality According to Physical, Chemical and Microbiological Indicators

The DBSC water quality was analyzed on the basis of the data determined in several years in the interval 1996 and 2006.

The values of physical and chemical indicators were determined in sections of the DBSC and PAMNC presented in Figure 4.1.6-1.

Beginning from the campaign of ICIM in May 1999, when the Unit 1 effluent was discharged into DBSC race 2 for one month, water temperature was measured in the sampling sections and in many other points along the canals (Fig. 4.1.6-2).

Time intervals of the Unit 1 effluent discharge into the DBSC race 2

The cooling water used by Unit 1 has been discharged into the Danube most of the time since the NPP commissioning. In some periods the heated effluent was discharged to the upstream end of the DBS Canal water race 2: between 21 April - 20 May 1999, and then during time intervals in September and December. Other intervals of about one month of effluent discharge into water race 2 were between 21 April - 20 May and 22 October - 22 November 2004, and also a litle longer interval in April - May 2005.

These periods were used by ICIM for studying in detail the water temperature, the physical and chemical indicators and the qualitative and quantitative composition of some basic biocenosis components. The campaigns for measurements and water sampling were performed just before the diversion of the effluent towards water race

2, and also during the effluent flow along the canal, after an interval of about one month of heated water discharge into the DBS Canal.

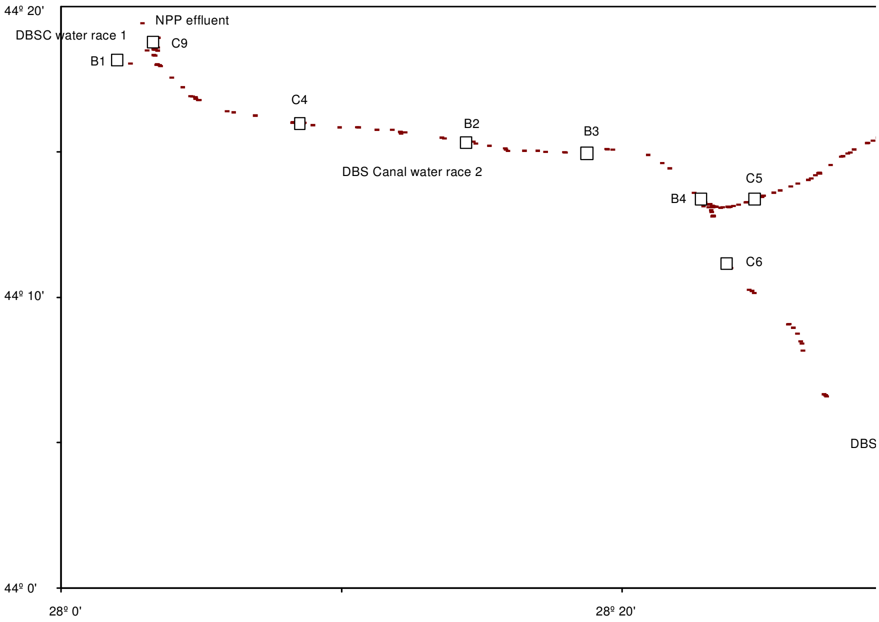

Figure 4.1.6-1. Water quality control sections on the DBS Canal and PAMN Canal and in the efflue

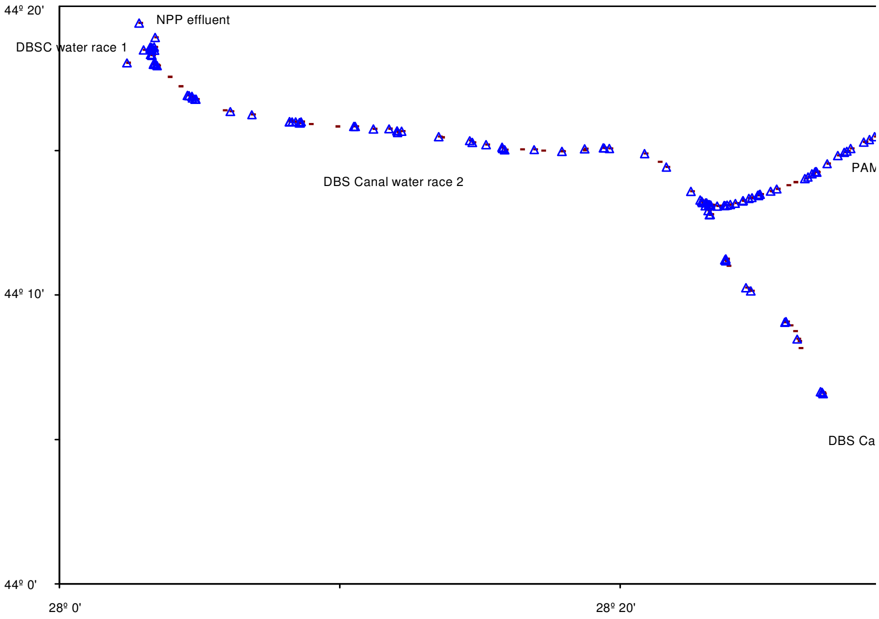

Figure 4.1.6-2. Water temperature measurement sections on the DBS Canal and PAMN

Characterization of the DBSC water quality

The DBSC and PAMNC receive water from the Danube with its chemical load. Moreover, the DBSC water quality is influenced by the additional loads from waste waters and by the specific water flow regime.

Water quality in the DBSC races after about ten years of utilization of this hydrotechnical system (in the absence of the Cernavoda NPP effluent) was characterized by indicators values obtained in 1996 - 1997 (Ref. 4.1-14) in 5 sections B1 - B5 (Fig. 4.1.6-1).

Water reaction was alkaline, the pH values ranging between 7.0 - 8.0.

The dissolved oxygen concentrations were between 6.0 and 14.7 mgO_2/l (with average values of 7.2 mgO_2/l and 11.5 mgO_2/l in the two years) in section B1, between 5.6 and 11.0 mgO_2/l (with average values of 6.9 mgO_2/l and 8.1 mgO_2/l in the two years) in section B2, between 5.4 and 11.8 mgO_2/l (with average values of 7.3 mgO_2/l and 8.3 mgO_2/l in the two years) in section B3, between 5.1 and 16.5 mgO_2/l (with average values of 6.8 mgO_2/l and 8.9 mgO_2/l in the two years) in section B4 and between 5.4 and 13.3 mgO_2/l (with average values of 7.3 mgO_2/l and 9.0 mgO_2/l in the two years) in section B5. These results show that the water in the DBS Canal was well-oxygenated, many of the values being within the quality classes I and II (according to the norm approved by Order 161/2006).

The values of the indicators regarding organic substances were within the quality class II, with exceeding values sometimes.

The load with nutrients increases generally along the canal from upstream to downstream, most values being within the quality class II.

Water quality in the Danube - Black Sea Canal did not change significantly after ten years of utilization.

The tables in Annex A.4.1.6 (Tables A.4.1.6-1 to A.4.1.6-11) show the results of the analyses performed in 1999, 2001, 2003, 2004, 2005 and 2006. Water quality was studied with regard to temperature, water reaction, oxygen regime, dissolved ions and mineralization, nutrients.

The dissolved oxygen values were high, within quality classes I and II, the DBSC water being well oxygenated.

Most values of the other analyzed indicators were within quality class II. Some temporary exceeding values were found sometimes for nutrients.

The water quality state was comparable from a year to another, both in spring and autumn.

Water quality in the DBSC race 2 is the result of several factors: the loads coming with the Danube water, the loads from local sources (waste waters discharge, runoff from slopes), water flow conditions and ship traffic influence, climate, aquatic biocenosis evolution during each year, processes in the aquatic environment.

The microbiological indicators were analyzed in 1999, 2001, 2004 in the same sections where chemical indicators were determined.

The results regarding total coliforme bacteria, fecal coliforme bacteria, fecal streptococci and heterotrophic germs are presented in Annex A.4.1.6 (Tables A.4.1.6-12 to A.4.1.6-15). The values reflect the influence of the water sources (the Danube river), of various contamination sources along the canal and the influence of other local factors.

Characterization of water temperature in the DBSC

Water temperature along the DBSC race 2 and PAMNC race 1 was measured in many sections and points across them aiming at obtaining relevant data sets regarding the water temperature distribution in these canals which are very long.

The data sets regarding water temperature consist of measured vertical profiles and they were presented in detail (Ref. 4.1-12, 4.1-14) in previous studies elaborated by ICIM for assessing the effects of the Unit 1 effluent discharge into DBSC. Some of the results are shown in Chapter 4.1.18.

Examining the data, it is found that water temperature in DBSC without heated water discharge into race 2 has small natural variations from a point to another, within about 1 ℃, under the influence of various factors.

During the periods when the Unit 1 effluent with its thermal load was discharged in DBSC, the data measured along the canal, during a day, showed a decreasing temperature distribution from upstream to downstream, along DBSC race 2 and along PAMNC.

On the days of 18 and 19 May 2004, the temperature at the effluent discharge had values of 25.16 ℃ and respectively 25.53 ℃ in the two days. The depth-averaged temperatures in race 2 at Agigea were 19.57 ℃ and 19.31 ℃. The temperatures in race 1 of PAMNC near the Ovidiu lock were 18.07 ℃ and 18.16 ℃. Water temperature in race 1 of DBSC (near the NPP intake) was 17.74 ℃.

On the days of 18 and 19 November 2004, the temperature at the effluent discharge had values of 19.17 ℃ and respectively 19.32 ℃ in the two days. The depth-averaged temperatures in race 2 at Agigea were 14.05 ℃ and 13.67 ℃. The temperatures in race 1 of PAMNC near the Ovidiu lock were 11.49 ℃ and 11.26 ℃. Water temperature in race 1 of DBSC (near the NPP intake) was about 11 ℃.

On the day of 19 May 2005 the effluent temperature was 24.87 ℃, and then, after mixing with the flow from the Complex Pumping Station, the water temperature was 22.60 ℃. The depth-averaged temperature in race 2 at Agigea was 20.05 ℃. The measured temperature after the first half of the PAMNC race 1 was 19.29 ℃. Water temperature in race 1 of DBSC (near the NPP intake) was 17.13 ℃.

The temperature values presented above include the effects of the Unit 1 effluent mixing with different flows coming in some days from DBSC race 1 through SPC, and also the effects of the variable meteorological conditions during the effluent flow from Cernavoda to Agigea.

Radioactivity

În the year 2004, ICIM took samples from various sections of the Danube - Black Sea Canal for radioactivity analyses (Ref. 4.1-14).

The analyzed water samples were taken from the DBSC and from the PAMNC in May 2004, during the NPP effluent discharge to the DBSC race 2. Previous samples were taken in April 2004, during the NPP effluent discharge to the Danube.

In May 2004, the gross beta activity had the minimum record value of 52.6 ± 2.5 Bq/m^3, and the maximum value has 87.6 ± 3.8 Bq/m^3. The average value of the gross beta activity has 66.9 ± 3.1 Bq/m^3. The gross beta radioactivity level in water samples from sections of DBSC and PAMNC is presented in Figure 4.1.6-3.

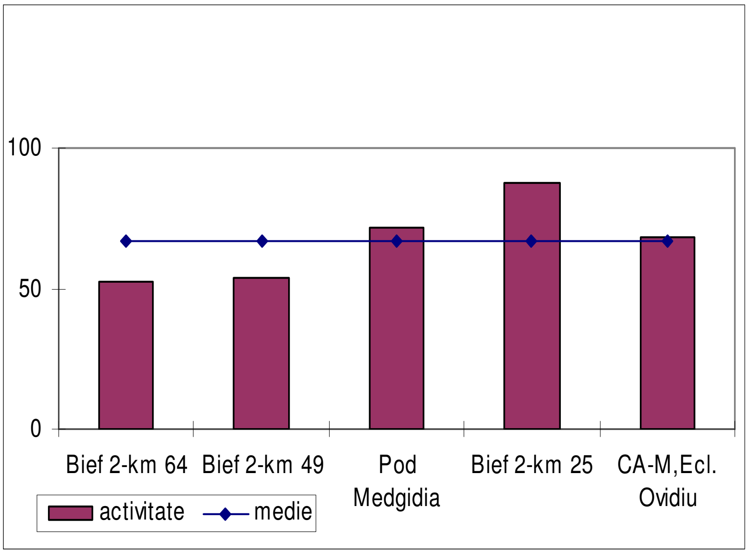

Figure 4.1.6-3. Gross beta activity (Bq/m^3) of water samples from DBSC and PAMNC in May 2004

For the water samples taken from DBSC before the NPP effluent discharge to race 2, the minimum value of the gross beta activity was 10.9 ± 0.5 Bq/m^3, and the maximum value was 87.5 ± 4.2 Bq/m^3. The average value of the gross beta activity in the water samples from the DBSC was 67.9 ± 3.2 Bq/m^3. The values are presented in Figure 4.1.6-4.

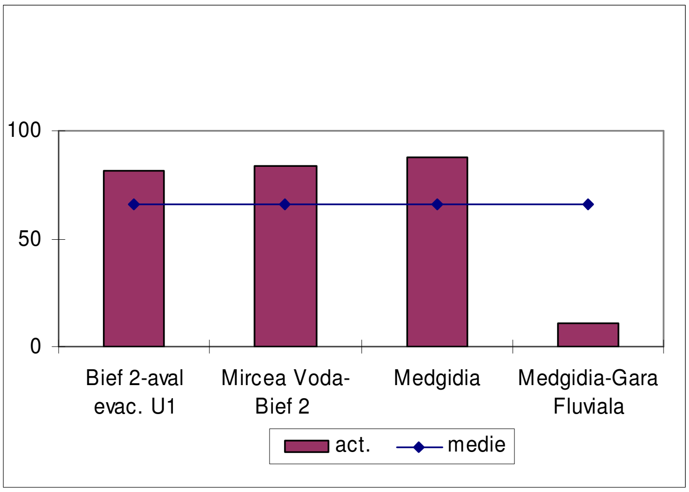

Figure 4.1.6-4. Gross beta activity (Bq/m^3) of the water samples from DBSC in the absence of the NPP effluent

The average concentration of the natural radionuclid K-40 was 65.5 ± 10.7 Bq/m^3 and other gamma emitting radionuclids were not detected. The K-40 levels in the water samples from DBSC are shown in Figure 4.1.6-5.

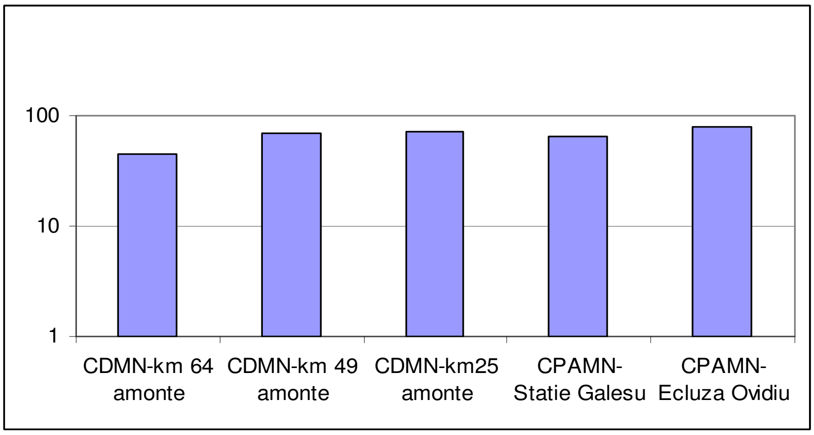

Figure 4.1.6-5. K-40 levels (Bq/m^3) in water samples from DBSC in the absence of the NPP effluent

In the DBSC water samples taken before the NPP effluent discharge period, gamma emitting radionuclides were not detected.

The tritium levels in water samples taken from DBSC during the NPP effluent discharge are presented in Figure 4.1.6-6. The sampling sections are specified in Table 4.1.6-1.

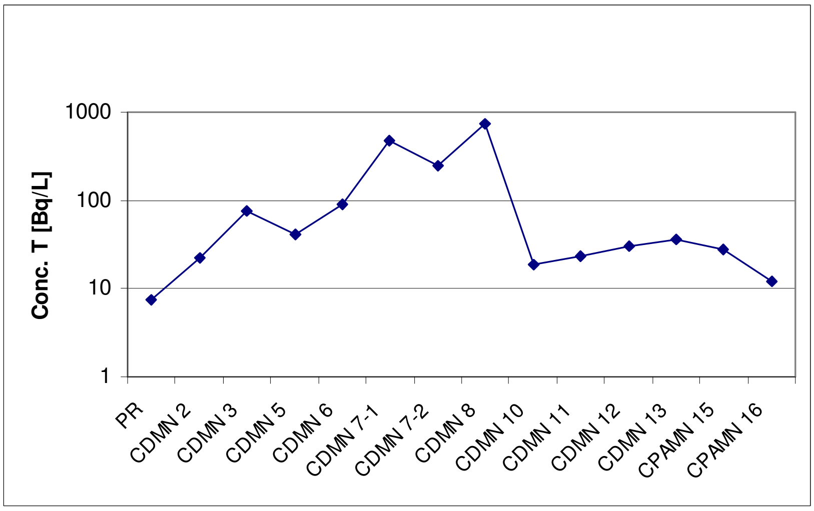

Figure 4.1.6-6. Tritium concentrations in water samples from DBSC, in May 2004

Table 4.1.6-1. Locations of water sampling from DBSC, in May 2004

Code	**Location**
PR	Danube Cernavoda Port (reference point)
CDMN 2	DBSC-km 64
CDMN 3	DBSC, km 58
CDMN 5	DBSC, km 49
CDMN 6	DBSC, km 45
CDMN 7-1	DBSC, Medgidia bridge – 200 m upstream
CDMN 7-2	DBSC, Medgidia bridge
CDMN 8	DBSC- Medgidia Port
CDMN 10	Middle ramification DBSC - PAMNC
CDMN 11	DBSC, km 25
CDMN 12	DBSC, km 15
CDMN 13	DBSC, km 2
CPAMN 15	PAMNC, Pumping station Galesu
CPAMN 16	PAMNC, Ovidiu lock–Palas drinking water treatment

	station intake

The tritium levels in the water samples taken from DBSC and PAMNC in April 2004, before the effluent discharge to race 2, are shown in Figure 4.1.6-7. The sampling locations are specified in Table 4.1.6-2.

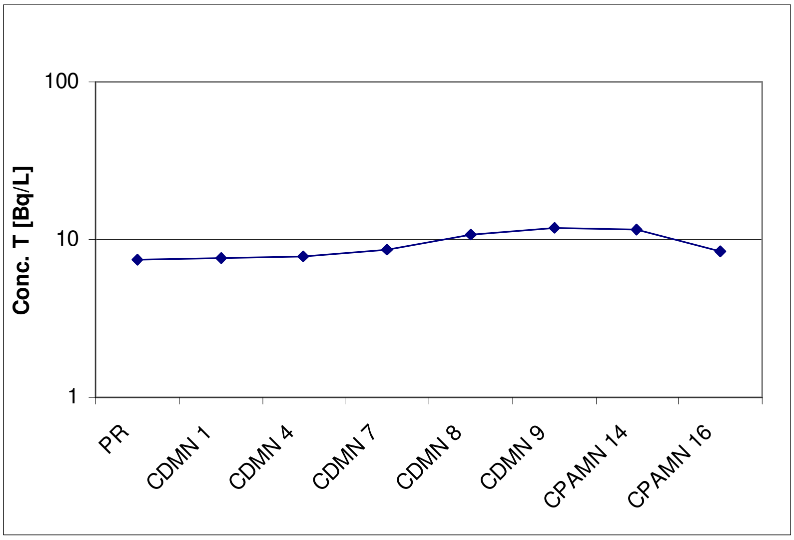

Figure 4.1.6-7. Tritium concentrations in waters samples from the DBSC in the absence of the NPP effluent

Table 4.1.6-2. Locations of water sampling from DBSC

Code	Location
PR	Danube Cernavoda Port (reference point)
CDMN 1	Derivation canal race 2, downstream the U1 effluent discharge
CDMN 4	DBSC race 2 - Mircea Voda-km 50*
CDMN 7	DBSC, Medgidia
CDMN 8	DBSC- Medgidia Port
CDMN 9	DBSC, Basarabi
CPAMN 14	PAMNC, 1 km from the junction with DBSC
CPAMN	PAMNC, Ovidiu lock, Palas drinking water treatment

16	station intake

For comparison, Table 4.1.6-3 presents monthly average, minimum and maximum values of tritium concentration, in the period January – July 2004, in water samples from the DBSC race 1 and the Danube (Figure 4.1.6-8).

Table 4.1.6-3. Minimum, average and maximum concentrations of tritium in the water from the race 1 and the Danube

Sampling points	Min. conc [Bq/L]	Month	Average conc. [Bq/L]	Max. conc [Bq/L]	Month
DBSC (CE - effluent discharge)*	8.1 ± 1.4	July	39.9 ± 2.6	245.0 ± 8.6	May
Danube Cernavoda Port*	8.4 ± 1.2	January	10.2 ± 1.5	12.2 ± 1.6	February
Danube –Borcea branch Calarasi*	6.8 ± 1.0	April	7.5 ± 1.1	8.5 ± 1.2	January

* daily samples, monthly cummulated

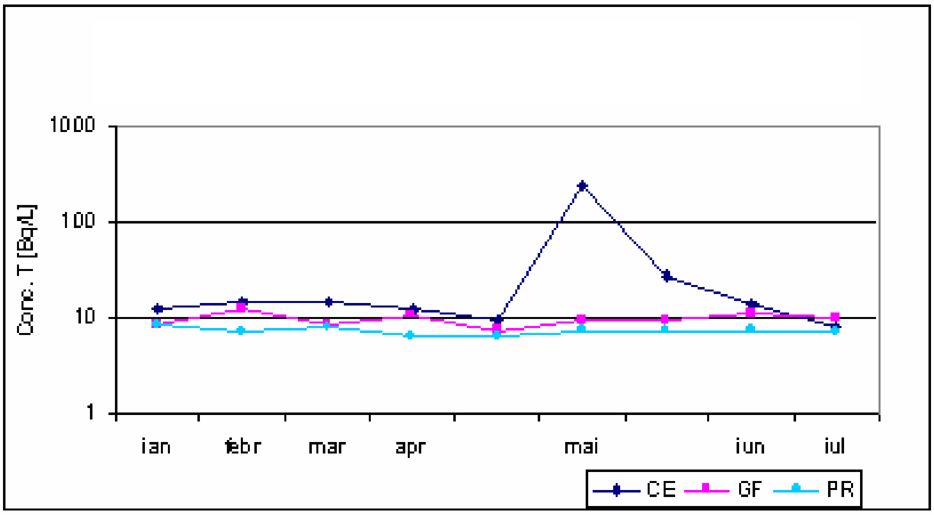

Figure 4.1.6-8. Tritium concentrations in DBSC race 1 water, in comparison with water from the Danube at Cernavoda and Calarasi, in the period January – July 2004

For sediment samples from race 1 - CPPON bridge area, the minimvalue of the recorded gross beta activity was 227.1 ± 11.5 Bq/kg, and the maximum value was 302.8 ± 12.5 Bq/kg. The average value of the gross beta activity of the sediment samples was 289.9 ± 12 Bq/kg.

For sediment samples from the DBSC and the Seimeni canal, gamma emiting radionuclides were not detected.

For the sediment samples taken from the race 1, the Seimeni discharge canal and the Danube, it was obtained an average value of C-14 concentration of 258 ± 26 Bq/kg – carbon fw. Figure 4.1.3-10 presents the values of C14 concentration in sediment samples, for sampling locations.

For the fish samples taken and analyzed from the DBSC, the minimum recorded value of gross beta activity was 68.2 ± 2.8 Bq/kg, and the maximum value was 117.6 ± 4.7 Bq/kg. The average value of gross beta activity in fish samples was 85.7 ± 3.5 Bq/kg.

For the fish samples from the DBSC, gamma emitting radionuclides were not detected, except the natural radionuclid K-40, for which an average concentration of 195.4 ± 24.7 Bq/kg fw was recorded.

For the fish samples taken from the DBSC, downstream and upstream the Cernavoda lock, it was obtained an average value of tritium concentration of 44.6 ± 6.9 Bq/kg fw., observing relatively small variations from a location to another and among different species.

The average values of tritium concentration in fish samples from DBSC are presented in Table 4.1.6-4.

Table 4.1.6-4. Tritium concentrations in fish samples

Sample type	Location	Average value H-3 [Bq/kg fw.]
Fish	DBSC - Cernavoda lock	66.5 ± 10.4
	DBSC - downstream Cernavoda lock	42.3 ± 6.2

Figure 4.1.3-11 presents the average values of tritium concentration in fish samples from the DBSC, The Seimeni canal and the Danube.

As regards the C-14 analyses in fish samples, it was recorded an average value of 268 ± 28 Bq/kg – carbon fw.

For the macrophyta samples taken an analyzed from the DBSC, the minimum recorded value of gross beta activity was 63.9 ± 2.6 Bq/kg, and the maximum value was 97.6 ± 3.9 Bq/kg. The average value of gross beta activity in macrophyta samples in the Cernavoda zone was 80.1 ± 3.3 Bq/kg.

For the aquatic vegetation samples taken from the canals, gamma emiting radionuclides were not detected, except the natural radionuclid Be-7 having an average concentration of 279.7 ± 33.7 Bq/kg fw.

For algae samples, it was obtained an average value of tritium concentration of 38.9 ± 5.2 Bq/kg fw.

As regard C-14 analyses of algae samples, it was recorded an average value of 270 ± 29 Bq/kg – carbon fw.

The values of the C–14 concentrations were within the limit of the natural background values (230 Bq/kg – carbon).

4.1.7. Biocenosis Components in the Aquatic Environment of the DBSC

Similar to the case of the branch Dunarea Veche, having in view the existing regulations, the biocenosis component in DBSC and PAMNC were analyzed during biological studies. Such studies were performed in more detail beginning with the year 1994.

The aquatic environment in the DBSC is a young ecosystem with a structure permanently influenced by the Danube River and by the pollution sources generated by the human activities in the Danube hydrographic basin.

The biocenosis trophical structure in the DBSC aquatic environment is basically like that in the Danube, which is the main source of water supply for DBSC.

More than in the Danube, the annual evolution of the biocenosis components in the DBSC water is closely related to the climatic conditions in that year and to other local factors, because of the water flow with very small velocities along race 2, which determines long residence times of water in this race.

In the year 1994, the development of the main biocenoses in the canal water was rather limited. The phytoplankton included unicellular and filamentous blue algae, diatoms and green algae, a group or another one being dominant depending on the season and the analyzed control point.

Zooplankton included rotifera, copepoda and cladocera, the rotifers being dominant numerically.

The benthonic fauna, under the conditions of a thin silt deposit covering the initial substrate of the canal, was formed only by oligocheta and chiromonida and *dreissena* shell larvae. These organisms, and also those within the water are food for fish.

In the year 1995, the favorable conditions (light, temperature, nutrients budget, etc.) existing in water at that time lad to the intense growth of algal communities in the water of DBSC and PAMNC. Late in the autumn and during winter, when water temperature decreased, water quality in the canal improved.

In the year 1996, the planktonic biocenoses in the DBSC water had a better development in the warm seasons of the year, in comparison to those with low temperatures, an evolution that occurs normally during each year.

In the year 1999, ICIM carried out biological research campaigns on DBSC in March, May and at the end of August (Ref. 4.1-12). The results regarding the phytoplankton are presented in Annex A.4.1.7 (Table A.4.1.7-1).

Correlating the results of the biological and the physical and chemical analyses, it can be noticed that the primary productivity varied along the DBSC from season to season during 1999, depending on a series of factors, among which the nutrients budget in the water. The higher phytoplankton biomass in some sections can be associated with higher values of the total mineral N and the total P.

Zooplankton, the secondary trophic chain link within an aquatic ecosystem, has been studied both from the qualitative and quantitative point of view. Among the most frequently found species were: *Asplanchna priodonta, Brachionus leydigi, Keratella cochlearis (Rotifera), Copepoda* in different growth stages*, Bosmina longirostris, Chydorus sphaericus (Cladocera)*.

In the thin silt deposits on the canal bottom, zoobentonic organisms grow, such as olygocheta and tubuficides (worms), and insects larvas (chyronomida). This trophic chain link is dominated by the bivalve *Dreissena polymorpha* which, as adult, attaches to the hard sublayers.

The macrophyta, significant contributors to the primary productivity in an aquatic ecosystem, were mainly represented in the DBSC by the following species: Ceratophyllum, Miriophyllum, Potamogeton.

The results of the biological analyses of the water samples taken from DBSC and PAMNC in the warm period of 2001 are presented in Annex A.4.1.7 (Tables A.4.1.7-2 to A.4.1.7-4).

The phytoplankton taxonomic spectrum in the DBSC and PAMNC water included species belonging to the following systematic groups: *Cyanophyta, Bacillariophyta, Euglenophyta and Chlorophyta*. Among the algal taxons found in the analyzed sections, the diatoms and chlorophyta were met almost constantly, the rest being considered accompanying species (Table A.4.1.7-4).

Zooplankton was represented by species of *Ciliata*, *Rotatoria, Copepoda, Cladocera* and *Lamellibranchiata* larvas, without one or another group in some sections. Generally, the planktonic population had not high biomass values (Ref. 4.1-12).

The zoobentos in the analyzed control sections was poorly represented and less diversified, including some olygocheta and chyronomida. The *Dreissena polymorpha* larvas are an almost permanent presence in the zoobentos.

The biological analyses carried out in 2004 comprised determinations of the qualitative composition (taxonomic groups, species, dominant forms) and quantitative composition (density, density abundance, biomass, biomass abundance) of the phytoplankton and zooplankton (Ref. 4.1-13, 4.1-14).

The phytoplankton and zooplankton in these canals were studied in May 2004, during the NPP effluent discharge in the DBSC water race 2. The results are presented in Annex 4.1.7 (Tables A.4.1.7-5 to A.4.1.7-7).

The zooplankton qualitative structure includes species mainly from the groups *Ciliata, Rotifera, Copepoda, Cladocera.*

The macrozoobentos in the DBSC and PAMNC was represented especially by the bivalve *Dreissena polymorpha.* Other organisms were found in the thin silt deposits which cover the canal bottom.

The results obtained in May 2005 (Tables A.4.1.7-8 to A.4.1.7-11 in Annex A.4.1.7) show the phytoplankton development that occurs when passing from spring to summer. The bioindicator species found in the studied sections are shown in Table A.4.1.7-11. The phytoplankton numerical density and biomass had relatively low values in all the analyzed sections. Zooplankton was poorly represented and less diversified.

In the year 2006, the biological analyses shown the phytoplankton density and biomass in 3 sections of race 2 in August. Furthermore, the alga taxons were identified in the water samples from these sections (Tab. A.4.1.7-12 and A.4.1.7-13 in Annex A.4.1-7).

During the studies carried out, in all the control sections, the correlation between the biotic component and abiotic component analyses results was taken into consideration for water quality assessment from the biological point of view. Depending on the values of the quantitative biological indicators (phytoplanktonic density and biomass), on the bioindicator species presence and on the structure of the entire biocenosis, the DBSC and PAMNC water was biologically included in the β-mesosaprobe category (Ref. 4.1-26) in all the years. In this category, high dissolved oxygen quantities are present in the water, the organic load is reduced, the self-purification process is advanced, the organic matter mineralization is almost finished. A general characteristic of the organisms populating the β-mesosaprobe category, is the high degree of sensibility to the dissolved oxygen concentration decrease and to the pH variations.

The ichthyofauna in DBSC, similar to that in the Danube, consists mainly of carp, crucian, sheatfish, brean, rapacious carp, bleak, ide (*leuciscus idus idus*). Samples of other fish species pass to race 2 through the locks during spring and summer: Danube mackerel (*Alonsa pontica pontica*), *Alonsa caspia nordmanni*.

Within the study carried out at the Cernavoda NPP water intake during the interval June 2004 - June 2005 (Ref. 4.1-25), samples of 29 fish species were identified, which pass from the Danube to the DBSC race 1. Other aquatic organisms coming from race 1 are also mentioned in the Report to this study: macrophyita (aqatic superior plants *Ceratophyllum demersus* and *Myriophyllum verticillatum,* and macroalgae *Chladophora glomerata* and *Pleurobrachia lacustris*) and macroinvertebrates (colonial hidrozoara, worms with species belonging to the *Hirudineea* class and to the *Lumbriculidae* family, mollusks from the *Bivalvia* class*,* the species *Dreissena polymorpha, Corbicula fluminalis* and *Anodonta cygneae,* from the *Gasteropoda* class*, Theodoxus* genus and *Viviparus* genus, crustaceans from the *Amphypoda, Mysidaceea* and *Decapoda* orders, insects with larvae of *Chironomide* and *Odonate*, and also aquatic *Coleoptera*).

The aquatic biocenosis in DBSC is formed in a navigable canal, permanently under the influence of human activities: navigation, waste waters discharge, agriculture. The DBSC connects the Danube (the pan-European transport corridor VII) and the

Constanta harbor at the Black Sea, being a component of the European waterways network.

The Administration of Navigable Canals (ACN) ensures the necessary conditions for the ship traffic and for water supply to irrigations, industry and population. One of the obligations of ACN is to take water samples and to performed analyses for obtaining data on water quality and for pollution control of the aquatic environment.

4.1.8. Other Water Bodies

Valea Cismelei

Valea Cismelei borders Cernavoda NPP Site from the north eastern side to the western side. The afferent hydrographic basin area is 21 km^2. The characteristic flow values considered along this valley are:

- Q 10% probability = 53.10 m^3/s;
- Q 1% probability = 127 m^3/s;
- Q 0.1% probability = 240 m^3/s;
- Q 0.01% probability = 458 m^3/s.

These flows (from the whole catchment area) are discharged to the derivation canal, upstream the NPP intake canal.

The solution for water discharge from Valea Cismelei, consists of a 15.00 m wide trapezoidal open canal, with 1:2 slopes, 4.00 m deep and 0.002 slope of the basemat.

Protection of the canal slopes is by rubble stone dry wall made, 30 cm thick and 2.50 m high corresponding to the water level with 1% probability. At this level, grass seedling of the slopes has been provided.

On the upstream area of Valea Cismelei, on about 800 m distance (the area associated to the row of NPP units), the natural flow section was maintained and the valley bottom was leveled in a 0.002 slope. The protection dike of the Plant at El. +18.00 mdMB is beveled 1:3, 4.00 m crest hight and the slope towards Valea Cismelei has been protected by dry wall made of rubble stone.

At the discharge to the derivation canal, it was designed an energy distributor made of a fast channeling with rock-fill and concrete anchers supported on faggot layers both on the slopes and on the basemat.

Valea Cismelei was also provided with the discharge of about 54 m^3/sec (water flow associated to one Unit) through a spill way, for emergency cases that may occur during the heated water discharge into the Danube.

Valea Viteilor

Valea Viteilor is outside the Cernavoda NPP area and it does not influence directly the NPP. The maximum water flows (Ref. 4.1-3) considered along this valley are the following:

- Q 10% probability = 19.7 m^3/sec;
- Q 1% probability = 47.1 m^3/sec;
- Q 0.1% probability = 88.9 m^3/sec.

Water flowing through Valea Viteilor is discharged into water race 1 of the Danube – Black Sea Canal.

Canals for Cernavoda NPP Water Supply

These canals are described in Chapter 4.1.10 regarding the NPP hydrotechnical instalations.

The intake canal was so dimensioned that at the Danube River low water levels corresponding to the 97 % probability flow, it should transit the maximum cooling water flow of 269 m^3/sec required for the 5 units of Cernavoda NPP, with

1.12 m/sec speed. This 1.12 m/sec speed does not cause erosions of the canal bottom because the hydraulic slope is 0.00054.

4.1.9. Water Supply to Units 3 and 4 and to Other Current or Predicted Water Users

4.1.9.1. Water Sources

The water source necessary for the technological processes of the Plant is the Danube River via race 1 of the Danube - Black Sea Canal, and the derivation canal wherefrom the water is taken by the Plant water intake.

The hydrological characterization of the water source, the Danube branch Dunarea Veche, was done in detail in chapter 4.1.2.

The Danube water quality was characterized according to physical, chemical and microbiological indicators, in chapter 4.1.3.

Another water supply source is deep underground water, as presented below.

4.1.9.2. Water use and consumption at Cernavoda NPP

Cooling Water (circulation water and raw service water)

Starting from the Danube River capacity to supply the required flow for cooling, the hydrotechnical circuit was designed to operate in open circuit. For one unit the maximum flow rate is 53.8 m^3/s and it comprises the cooling water flow for the condensers (46 m^3/s) and the raw service water flow (7.8 m^3/s) (Ref. 4.1-35).

Filtered raw water (circulated water) is distributed to the Turbine Hall where it provides the condenser cooling.

Sizing of the circulation water system for a unit considered the following data:

- number of pumps: 4;

- circulation water flow rate: 46 m^3/s;
- nominal temperature of water at circuit intake: 15 °C;
- water heating in the condensers: $\Delta t_{med} = 7.05$ °C;
- maximum allowable heating in the condensers: $\Delta t_{max} = 10.3$ °C;
- maximum water level in the condensers: 20.45 mBSL.

The supply water to the Water Chemical Treatment Plant - WCTP is the circulation water after getting out from the turbine condensers. The required entrapped flow for the preparation of clear water and demineralized water for a unit is 250 m^3/hour.

Filtered raw water (raw service water) is also distributed in the Service Building and Turbine Hall where it provides the cooling of the below mentioned equipment:

- heat exchanger for the reactor core emergency cooling;
- heat exchanger for cooling the water inside the spent fuel bay;
- turbine oil chillers;
- intermediate cooling water chillers;
- chilled water production plant;
- auxiliary steam condensers;
- cooling water tanks for emergency Diesel units.

Sizing of the raw service water system for a unit is based on the following data:

- number of pumps: 4;
- service water flow rate: 7.8 m^3/s;
- number of operational pumps (in normal operation regime): 3;
    - flow/pump: 2.61 m^3/s;
    - minimum temperature of sampled water: 2 °C.

Raw Service Water Back-up Cooling System – BCW

The main function of the system is to provide an alternative source of cooling water for the chillers and the emergency Diesel generators in case of RSW system unavailability.

The system is supplied with filtered raw water from the intake (suction) header of the Fire Water System and it is interconnected with the following systems:

- Chilled Water System
- Emergency Diesel generators
- Raw Service Water
- Water Chemical Treatment Plant - WCTP

The main components of the system are:

- Centrifugal type pumps located in the Pump Station (Double Pile);
- Filters located in the Screen House;
- Pneumatic valves.

Characteristics of the system / Classification:

special safety system:	NOT;
safety-related system:	YES;
seismic qualification:	NOT;
operation pressure:	5.33 ÷ 5.7 bar;
operation temperature:	3 ÷ 28 ℃;
system flow rate:	795 ÷ 995 m^3/hour.

Fire Water

The system provides the fire protection by the supply of water to the following areas of Unit 3, respectively Unit 4:

- Service Building;
- Electrical Bay;

- Reactor Building;
- Degaser Building;
- Turbine Building;
- Emergency Diesel Units;
- K-L Column Line;
- Transformer area (T01/T06).

The source of water for extinguishing fires is the Danube River water taken either from the derivation canal via a filter, or after having been filtered through the rotating screens associated to the raw service water system and Brassert filters associated to the fire water system.

The required flows and pressures for the categories of fires are the followings:

- inside fire: Qi = 5 l/s (inside hydrants), Pn = 10 atm;
- outer fire: Qe = 25 l/s (outer hydrants), Pn = 10 atm;
- stationary fire suppression equipment at the cable tray: Q ≈ 120 l/sec (of an automatic fire suppression equipment), Pn = 10 atm;
- stationary fire suppression equipment at transformers: Q ≈ 120 l/s (of an automatic fire suppression equipment), Pn = 10 atm;
- cooling of the motor oil tank shell (the most severe condition: the system must be capable to cool 2 × 1000 m^3 tanks and 2 × 100 m^3 tanks): Q = 140 l/s, Pn = 10 atm.

All the categories of fires are supplied from the same pressurized water network both for BOP and NSP.

The design flow for the fire water supply system for Unit 3 and Unit 4 is 155 l/s and the network is maintained at a pressure of 9.5 ÷ 10.3 atm, all the time.

The stored volume of water required for the fire suppression system is 2 x 1500 m^3.

The make-up flow of the fire water is 200 ÷ 400 m^3/hour, and since the tank volume is

1500 m^3 each, the time required to make-up the water stock in the tanks of Cernavoda NPP is 3.5 ÷ 4 hours.

The supply of fire water is made by connection to the main fire water supply system of the Plant, provided via the water supply hydrotechnical units (intake, tanks, pump stations, distribution network).

Domestic Water

The Domestic Water System provides the domestic water supply to the units inside the Cernavoda NPP, including:

- Service Building;
- Turbine Building;
- Administrative Ward;
- Screen House.

The domestic water source for Cernavoda NPP is the drinking water supply network made-up of an underground own source (Pits Fj1 and Fj2) located at 600 ÷ 700 m in depth and Fj3 pit located in Campus 2.

The supply connection to the drinking water network of Cernavoda Town is maintained only for emergency cases.

The domestic water flow for the supply of Unit 3 enclosure, respectively Unit 4, is about 10 l/s.

The domestic water network is common to the Plant NSP and BOB.

Emergency Cooling Water - EWS

The Unit 3, respectively Unit 4, Emergency Cooling Water Supply System - EWS, BSI 34610, provides:

- removal of decay heat from the reactor in case of normal decay heat systems unavailability;
- independent water source for the stem generators, ECCS heat-exchangers and PHT System.

The Emergency Water Supply system is a nuclear safety related system.

The coolant is the Danube water from the distribution basin. For Unit 3, respectively Unit 4, two 100 % assurance pumps with a 114 l/s flow are designed to provide the required raw water distribution to the systems serviced by EWS system.

The EWS System represents an alternative cooling water supply source in case of the following events that may lead to the loss of normal decay heat removal:

- DBE or fires;
- Loss of Class III electric power supply;
- Loss of cooling water supply to the steam generators;
- Loss of raw service water supply to the ECCS heat-exchanger.

In case of a DBE, the system is capable to provide the water supply to the secondary circuit of the steam generator and the make-up water to the PHT circuit (into the failed loop).

In case of Class III electric power supply, EWS system provides the water supply to the steam generator secondary circuit.

In case of the third event, the EWS system is designed to provide the water supply to the steam generator secondary circuit. In case of the fourth event, the EWS system provides the water supply to the ECCS heat-exchanger.

During the reactor normal operation, the system is in stand-by.

The EWS system is designed to become operational in 30 minutes after the loss of Class III electric power supply or after the occurrence of a Design Base Earthquake (DBE).

Table 4.1.9.2-1 presents the water consumption balance (m^3/day) for a unit of the Cernavoda NPP.

Table 4.1.9.2-1. Water Consumption Balance Sheet for a unit of Cernavoda N

Technologic process	Water source (supplier)	Total water consumption (col 4, 10, 11)	Water sampled from source						F		
			Total	Domestic consumption	Industrial consumption				Fr		
					Underground water	Surface water	To compensate losses in the closed circuit systems				
							Underground water	Surface water			
1	2	3	4	5	6	7	8	9			
Condenser cooling (recirculation water)	The Danube River	3.974.400	3.974.400	-	-	3.974.400	-	-	max (win		
Service Building and Turbine Building equip. cooling (raw service water)	The Danube River	673.920	673.920	-	-	673.920	-	-	max (win		
Alternative water source for chillers and emergency Diesel units (raw service water and make up water)	The Danube River	23.880	23.880	-	-	23.880	-	-	-		
NSP & BOP fire water	The Danube River	1.600	1.600	-	-	1.600	-	-	-		
NSP & BOP drinking water	- Ground water; - The Danube River.	864	864	864	-	-	-	-	-		
Emergency Cooling Water Supply System - EWS	The Danube River	9.850	9.850	-	-	9.850	-	-	-		

4.1.9.3. Other Current or Predicted Water Users in the Units 3 and 4 Impact Zone

4.1.9.3.1. Unit 1 and Unit 2

The Cernavoda NPP Unit 1 and Unit 2 need water flows similar to those presented for each of the Units 3 and 4 (Ref. 4.1-35).

The necessary water is taken over from the distribution basin for all the Cernavoda NPP units.

4.1.9.3.2. Danube Water Use for Irrigation on the Sector Cernavoda - Harsova

Table 4.1.9.3-1 presents data about the irrigation systems Seimeni, Topalu and Terasa Harsova that use Danube water.

The necessary water flows are taken over directly from river sections downstream Cernavoda.

Table 4.1.9.3-1. Characteristics of the irrigation systems supplied from the Danube

System	Realization year	Area (ha)			Arrangement type (ha)			Design flow at water intake m^3/s
		Total	Aspersion	Furrow	Main pumping station	Equipments	Canals	
Topalu	1976	16.296	11431	4180	10476	415	1.226	13.5
Seimeni	1978	23.402	18191	5211	10793	1277	-	18.3
Harsova	1977/1980	39.030	21496	17561	13482	9201	748	27.6

4.1.9.3.3. DBSC Water Use for Irrigation

DBSC water race 2 is the source for water supply to the irrigation systems in the Carasu Complex, with a total irrigated area of 187 913 ha:

- Faclia system, located on the right side of the DBSC, with pumping intake near Faclia and a 8 490 ha surface.
- Nicolae Balcescu system, with pumping intake near Mircea Voda and a 28 125 ha surface.
- Mihail Kogalniceanu system, with pumping intake near Castelu and a 22 290 ha surface.
- Poarta Alba system, with the intake from a canal diverted from DBSC, with a surface of 3 545 ha.
- Basarabi system, with the intake at south from Poarta Alba and a surface of 6 490 ha.
- Galesu system, with the intake at east from Poarta Alba and a surface of 5 304 ha.
- Valea Seaca system, with the intake downstream Basarabi and a surface of 7 716 ha.
- Negru Voda system, with the intake located on a canal diverted from DBSC and a surface of 105 323 ha included in 5 subsystems.

The Carasu Complex is situated in a semi arid area, the water deficit during the warm season being increased by the high drainage, due both to the slopes of the land and to the soil good permeability.

Table 4.1.9.3-2 presents the estimated water need of the irrigation systems supplied from DBSC water race 2. The data could be corrected by taking into consideration the pumping equipment efficiency at present.

The water volumes taken for irrigation from DBSC water race 2 during 1990 - 2000 were sensibly lower than the values considered at the system design time. Table 4.1.9.3-3 presents the minimum, maximum and average values of the monthly average flows during this time interval.

Table 4.1.9.3-2. Necessary flows (m^3/s) for the irrigation systems in the Carasu Complex

System	p %	Necessary flows (pumping time schedule 20/24 or 24/24)					
		IV	V	VI	VII	VIII	IX
Faclia	50	-	2.55	3.60	6.5	5.1	2.6
	80	0.39	4.00	4.21	8.8	6.4	3.1
Poarta Alba	50	-	1.0	1.80	2.7	2.1	1.1
	80	0.16	1.65	2.40	3.7	2.7	1.3
Nicolae Balcescu	50	-	8.4	14.0	21.4	16.8	8.6
	80	1.29	13.0	18.7	29.2	21.1	10.4
Mihail Kogalniceanu	50	-	6.7	11.0	16.9	13.3	6.6
	80	1.02	10.3	14.8	23.1	16.7	8.2
Basarabi	50	0.13	2.70	3.1	5.6	4.1	2.1
	80	0.80	3.60	4.6	6.7	4.8	2.5
Galeşu	50	0.10	2.2	2.5	4.6	3.3	1.7
	80	0.65	3.0	3.8	5.5	3.9	2.1
Valea Seaca	50	0.15	1.2	3.6	6.6	4.8	2.5
	80	0.94	4.3	5.5	8.0	5.6	3.0
Negru Voda	50	0.29	40.0	44.8	83.6	62.2	37.8
	80	11.0	52.4	64.3	103.8	75.7	42.3

4.1.9.3.4. DBSC Water Use for Permanent Consumers

The water treatment station downstream Poarta Alba takes over water from the PAMN Canal (supplied by the DBSC water race 2) for the purpose of drinking water supply to population.

The main water users for industrial purpose are Romcim Lafarge – Medgidia, Sursal – Saligny and Petromidia Navodari.

The minimum, maximum and mean values of the monthly average flows taken from DBSC for the industrial consumers and for the population between 1990 – 2000 are presented in Table 4.1.9.3-3.

4.1.9.3.5 Other Uses of Surface Waters

Navigation

The Dunarea Veche Branch is a permanent navigation way, important for the economic activities in the Danube basin. For this reason, it is important to maintain water depth as necessary for ship traffic on this waterway, having also in view to assure the relation between DBSC and the upstream ports. The Danube flow distribution to the branches Dunarea Veche and Borcea, influenced by the river channel configuration and flowing conditions in the Bala area, causes difficulties for normal navigation during low waters on Dunarea Veche. The studies carried out previously showed that these difficulties increase.

The main function of the Danube – Black Sea Canal is of navigable way between the Danube River at Cernavoda and the Black Sea at Agigea. The DBSC water consumption caused by operations at the locks depends on their frequency and on the water level difference between water races 1 and 2. The water volumes lost during lock operation are compensated by water supply to water race 2. The necessary flows for compensation are presented in Table 4.1.9.3-3 for the period 1990 – 2000.

Discharge of waste waters

The branch Dunarea Veche and the DBSC water races are receptors of waters discharged from different sources and of runoff from precipitations. Cernavoda Town discharges its waste waters to the Danube and to DBSC race 1 (a waste water treatment station is envisaged to be constructed). The DBSC race 2 receives waste waters from industry and from localities. DBSC also receives also runoff from precipitations that fall within its hydrographic basin.

Fishing

Within the 30 km radius area around the NPP, the Danube branches, the lakes and ponds provide conditions for commercial and recreation fishing.

Table 4.1.9.3-3. Minimum, maximum and mean values of the monthly average flows (m^3/s) consu
2000

	Month											
	I	II	III	IV	V	VI	VII	VIII				
	Water for navigation											
Minimum flow	1.43	1.51	2.08	2.07	1.74	1.92	2.32	2.20				
Maximum flow	6.30	7.24	7.79	9.18	7.80	8.14	7.03	7.62				
Mean flow	3.15	3.70	3.97	3.82	3.63	4.13	4.27	4.71				
	Water for industry and population											
Minimum flow	2.22	1.93	1.98	1.41	1.85	2.06	1.81	2.07				
Maximum flow	3.22	3.66	3.34	3.13	3.01	3.80	4.21	3.94				
Mean flow	2.78	2.92	2.72	2.64	2.56	2.80	2.96	3.10				
	Water for irrigation											
Minimum flow	-	-		7.17	0.76	2.89	9.51	0.28				
Maximum flow	-	-	4.01	30.67	36.36	41.06	64.94	56.05	2			
Mean flow	-	-			11.59	21.78	27.99	25.12				
	Water taken by Cernavoda NPP (1996 - 2000											
Mean flow	19.62	22.19	36.67	38.95	39.72	41.83	43.07	42.33	4			

4.1.9.4. Solutions Considered in Specialized Studies for Increasing the Water Source Capacity to Provide the Necessary Flows to Cernavoda NPP

One of the main uses of the DBSC is to supply with Danube water the Cernavoda NPP and other users along the DBSC.

During the DBSC design phase, open circuit operation was taken into consideration for the Cernavoda NPP units. The hydrological data taken into account were those available 25 years ago, during the DBSC design phase.

The present hydrological data show that the intercept of the necessary water from the Danube for the simultaneous full power operation of Units 1, 2, 3 and 4 and for other water uses of the DBS Canal water race 2 does not raise problems under the present flow conditions on the Dunarea Veche branch, except when the water flow and the levels are low in the DBS Canal intake area. At water levels below the Cernavoda HS reference level, the water flow distribution in the Danube branches begins to be important, the present trend being of increased flow in the branch Borcea, to the detriment of that in the branch Dunarea Veche. This evolution of the flow distributions is due to the Danube channel configuration in the Bala branch area and to the flowing conditions along Dunarea Veche, with its many secondary branches.

The problem of the water flows and levels on Dunarea Veche for ensuring the navigation and water supply conditions was studied successively by several specialized institutes (Ref. 4.1-2, 4.1-17, 4.1-28) and there were elaborated solutions and projects of works, based on the hydrological, morphological and bathymetric data available at those moments, aiming at correcting the trend mentioned above.

In order to solve the problems related to taking over the flows for various uses, from the Danube to DBSC, hydrotechnical works were proposed (e. g. in Ref. 4.1-2) on the Danube and in the DBSC race 1. On the Danube, it was envisaged to build a weir (bottom sill) on the Bala branch and a directing dyke, and also Rock blasting at Parjoaia Rock. On the DBSC race 1, it was envisaged to perform dragging works and canal cross-section local modification works.

Based on the construction designs elaborated by IPTANA, the works in the Bala mouth area described above were performed partially: Turcescu swamp bank protection, closing and directing dyke (80 % completed), low weir (about 10 % completed). Due to suspending the works, the hydromorphological effects in Bala mouth area have grown higher, generating the increase of the minimum flows to this branch, to the detriment of the branch Dunarea Veche, and an evident deepening of the river bed downstream the bottom sill. The works for cross-section local change envisaged in the DBSC race 1 have not started, but dragging works were performed.

Within the project "Technical Assistance for the Improvement of Navigations Conditions on the Danube - Improvement of Navigations Conditions on the Danube between Calarasi and Braila (km 375 - km 170) and complementary measures" (EUROPEAID/114893/D/SV/RO), the existing situation on the Danube was studied in the year 2005 and variants of hydrotechnical works on this Danube stretch were analyzed. The resulting technical solutions, in line with previously considered solutions (Ref. 4.1-28, 4.1-29), with new developments and sizing, consist of: bottom sill on the Bala branch, water guiding dyke in neighborhood of the sill, reconstruction or construction of bottom sills in some small side branches, dragging works, bank protection works. The project has in view that the works in the river channel be the minimum necessary works so that the impact on the aquatic environment be as reduced as possible. ICIM completed in 2006 the environmental assessment report for this project, and the environmental protection authorities are analyzing it with the purpose to issue the environmental agreement.

The envisaged duration for performing the hydrotechnical works is three years at the most. Therefore, it is expected that their effects will be produced before the completion of the Cernavoda NPP Units 3 and 4.

According to the calculations performed by the designer, using Danube channel cross-sections measured in the year 2005, the water levels in the Cernavoda section will increase with about 130 cm during low flows on the Danube (2000 m^3/s in the Silistra section). During average flows on the Danube, the water levels in the Cernavoda section will increase with about 30 cm, and the water levels increase during very high flows will be under 5 cm.

As a result of the mentioned hydrotechnical works, the flow values on the branch Dunarea Veche downstream Bala will increase considerably during low waters on the Danube. It is estimated that the water flow value on Dunarea Veche downstream Bala (and at Ceranvoda) will be over 800 m^3/s at a total Danube flow of 2000 m^3/s in the Silistra section, that is over 40 % of the flow at Silistra. It is expected that, during smaller total flows on the Danube at Silistra, the percentage will be larger because due to the bottom sill on the Bala branch. This means that the minimum flow value on the Dunarea Veche branch at Cernavoda will be at least 700 m^3/s even under low water conditions on the Danube similar to those occurred in the year 2003 (with a minimum flow value of about 1800 m^3/s in the Silistra section, Ref. 4.1-30). During average waters, a smaller increase of the flows in the Cernavoda section will be produced. During high waters and very high waters on the Danube, the flow increase on Dunarea Veche at Ceranvoda will have an insignificant effect on the maximum water levels.

The future assessment of the situation of flows and water levels on Dunarea Veche, in correlation with the water uses will show the necessary maintenance works, taking into consideration the operation duration envisaged for the Cernavode NPP Units 1, 2, 3, 4.

In the period before carrying out the above mentioned works in the Bala area, the water supply conditions to DBSC during low waters on the Danube can be improved by local works at the DBSC water intake and in race 1 of the DBSC.

Dredging works in these areas have already been performed in some periods, improving the intake capacity during low waters on the Danube. Such local works do not influence the Danube flow distribution between the branches Borcea and Dunarea Veche.

The local alluvial deposits are monitored and they are corrected by dredging to ensure that the navigational conditions are maintained on Dunarea Veche and at the entrance of the DBS Canal. As a matter of fact, the alluvial transport decreased considerably during the last tens of years because of various works carried out in the Danube basin, but the alluvial deposition phenomenon in the river channel and in the DBSC race 1 did not stop, because of the configuration of the water streams. Since starting the operation of the DBSC till present, significant alluvial deposits accumulated at the canal intake on the Danube and in race 1. Based on the topo-hydrographic measurements performed in October 2002, the volume of deposits was assessed at the end of that year to be 1300 tho. m^3, out of which 679 tho. m^3 in the Danube channel (between the canal mouth and the Danube navigable stream), 457 tho. m^3 in the navigable canal (race 1) and 164 tho. m^3 in the derivation canal). In the confluence area of the DBSC with the Danube, the alluvial deposit were of 1.5 m - 4.5 m, much larger than the depositions admitted through the Regulation of DBSC operation and maintenance. Consequently, dragging works were carried out both at the DBSC water intake and in race 1, and also in the derivation canal, for which financial sources were allocated to ACN Constanta by the Government (Government Decision 884/2003). Such dragging works will also be necessary in the future.

4.1.10. Hydrotechnical Installations

The cold water source for the service cooling water circuits (circulation and service water) of the Plant is the Danube River water. Water is taken from the Danube at the DBSC intake, passed through the Canal - Race 1 and the derivation canal wherefrom it is overtaken, via some hydroworks, for the NPP units. Since the Danube River is capable to supply the required flows for cooling, the operation of the cooling circuits is in an open circuit for the service raw water systems (Ref. 4.1-35).

For one unit, the maximum flow rate is about 54 m^3/s and it consists of the cooling water to the condensers, the service water and other consumers associated to the Plant.

Water discharge from Unit 3, respectively Unit 4, is either into the Danube, or into DBSC - Race 2.

The works related to the water intake, the intake duct, the distribution pool and the discharge of heated water are common for the condenser cooling water system and the service water system.

4.1.10.1. Water Intake and Canal

In order to take the water from DBSC – Race 1 derivation canal, a free intake type suction was designed and constructed in the sizes proper for the intake of a Q = 269 m^3/s flow (condenser cooling water flow and service water flow calculated for 5 units).

The shape of the intake (suction) provides water access with minimum hydraulic losses for the Danube water levels, with 97 % assurance (El. 2.75 mBSL, the elevation considered in the initial design of Cernavoda NPP) and it was set on bases of the case studies.

The most recent hydrological data from Cernavoda Hydro Scheme, obtained by the processing of the measurements developed during 1961 ÷ 2003, showed that the minimum level of the water in the Danube corresponding to a flow of 97 %, is El. 2.19 mBSL.

The sloped of the intake are 1:4.5 and they are protected by rockfills placed on fascina beds up to El. 10.0 mBSL and above that elevation, the slopes are grass covered.

Water taken from DBSC derivation canal is directed to the Pump Station inside the Plant via an open intake duct. The intake duct was so sized that during low levels of the Danube water, El. 2.75 mBSL, corresponding to 97 % installed flow, the required cooling flow for Cernavoda NPP may pass through (Q = 269 m^3/s for 5 units) with a speed of about 1.12 m/s. Such a speed does not generate the erosion of the canal bed because the pitch is i = 0.00054.

The intake duct (370 m long) has a trapeze cross-section with the base width of 34.0 m, the bottom elevation at - 1.00 mBSL and the slopes (dykes) of 1:4.5 protected by rockfills, oriented on opposite direction as to the river stream. The crowns of the dykes are located at El. 13.50 mBSL in order to provide flooding protection to the lower areas, with 1 % assurance flow, likewise the derivation canal. The dyke slopes are provided with 2m wide bermes at El. 7.50 mBSL and El. 10.00 mBSL.

Two floating barriers, C 300 type, made of ultra violet radiation resistant material were installed to protect against oil products. When influenced by the river stream, the two oil-proof barriers make up a kind of enclosure (chain) on the water surface, encompassing the rainfall water pipe and the mixing canal.

Upstream the first oil-proof barrier a nylon net made of 3 mm diameter twisted thread and 50 mm mesh was installed for entrapping any floating objects. The net is vertically installed, stabilized in its lower part by a 10 mm diameter chain and by floating devices in its upper part, forming a 1m free boundary above the water surface. The mechanical resistance of the net is large enough to retain even fallen trees.

4.1.10.2. Distribution Pool

The distribution pool is making the connection between the intake canal and the screen house providing the uniform access of the water to the screen house. The shape of the distribution pool was designed on basis of model studies. The distribution pool is sided by slopes, identical with the slopes of the intake canal, closing – up on the side supporting walls of the screen house.

The distribution pool is also the supply source for the Emergency Water Pump Station and therefore the slopes of the distribution pool were calculated for DBE earthquake (the maximum effect of a DBE earthquake having the rate of occurrence of 1:1000 years for a site).

Since in such a design case the stability of the slopes can be accomplished only by very expensive and very deep constructions, the displacement of the slopes in case of a DBE was allowed. The performed dynamic analyses showed a displacement of the left bank slope of maximum 1.5 ÷ 3.0 m which allows the preservation of the required emergency water volume inside the pool.

4.1.10.3. Circulation Water System

Screen House

The Screen House purpose is to provide the mechanical filtering of the raw water required for cooling the condensers. For that purpose, the following equipment is provided for each group:

- 4 strainers: 7111-STR 001 ÷ 004 of 4.50 x 4.00 – 60/3 m;
- 4 cofferdams: 7111-BA 001 ÷ 004;
- 1 grippers for cleaning the strainers;
- 4 rotating grate racks: 7111- STR 021 ÷ 024, each having the sizes 5.0 x 5.0 x 5/3 m;
- 4 rotating grate racks: 7111-SC 001 ÷ 004 with 4 x 4 mm mesh stainless steel net outfitted with strainer cleaning and floating debris discharge devices;
- 4 cofferdams 7121-BA 001 ÷ 004 for providing an isolation as to the pump suction (7121-P1 ÷ P4);
- 1 screen washing (Q = 100 m^3/s) and floating debris discharge facility.

Pump Station

The circulation water pump station is aimed to pump the necessary water for cooling the Plant condensers (46 m^3/sec for each unit).

For Unit 3, respectively 4 operation, 4 electric pumps with the below characteristics, are provided:

- pump type: NMV 2000-RA
- nominal flow rate: Q = 11.5 m^3/sec
- pump head: H = 12.0 ÷ 24.2 mH_2O (function of the Danube water level)
- minimum submersion allowed: 3300 mm
- speed: n = 295 RPM

Cold Circulation Water Pipes and Canals

The connection between the Pump House and the Turbine Hall is made, for each group, by two Dn 3600 mm diameter metal pipes embedded in concrete. Between the pipes there is a pipe connection of Dn 2800 mm diameter with a check valve in order to provide the flow balance along the two Dn 3600 mm diameter pipes.

4.1.10.4. Raw Service Water Installations

Screen House

The equipment associated to the Raw Service Water are located in the Screen House and include:

- 2 strainers: 7111 - STR 005 ÷ 006 of 4.50 x 4.00 – 60/3 m;
- 2 cofferdams: 7111- BA 005 ÷ 006;
- 2 rotating grate racks: 7111- STR 011 ÷ 012, each having the sizes: 5.0 x 5.0 x 5/3 m;
- 2 rotating screens: 7111- SC 005 ÷ 006 with 2 x 2 mm mesh stainless steel made net, provided with screen washing and debris removal devices;
- 2 cofferdams: 7131 - BA 001 ÷ 002 for isolation as to the RSW suction pumps.

Pump Station

For the operation of the Unit 3, respectively Unit 4, 4 electric pumps are designed (3 in-service pumps and 1 stand-by pump), having the following characteristics:

- pump type: NMV 1000-RA
- nominal flow rate: Q = 2.61 m^3/sec
- nominal pump head: H = 30 mH_2O (H = 25 ÷ 40 mH_2O)
- minimum submersion allowed: 2660 mm
- speed: n = 740 RPM

Service Water Discharge Pipes

Service Water from the Pump Station is discharged to the consumers in Unit 3, respectively in Unit 4, via two Dn 1500 mm diameter metal pipes embedded in concrete.

4.1.10.5. Back-Up Service Water System

The main components of Unit 3, respectively Unit 4 – Back-up Service Water System are:

- pumps (centrifugal type) located in the Pump Station (Double Pile);
- filters (strainers) located in the Screen House;
- pneumatic valves.

4.1.10.6. Fire Water System

The required Fire Water is supplied by the Danube River via the derivation canal after been filtered through a 5 mm diameter mesh strainer or a rotating screens associated to the service water system and Brassert filters associated to the Fire Water system.

On-Ground Tanks: 7140 – TK 1 and TK 2

The tanks are made of reinforced concrete and have a capacity of 1500 m^3/s each. The water supply to the tanks is made via 2 x Dn 250 mm diameter pipes by means of the pumps for making-up the fire water stock in the tanks and by Brassert filters.

The tanks are connected between them and the intake (suction) to the electric pump or the motor pump is provided via one Dn 400 mm diameter pipe located in the valve room; the valve room includes 2 powered and manual Dn 400 mm valves which allow operation with both tanks in - service or with only one tank operational and the other tank in repair or maintenance.

Fire Water Pump Station

The station is a half-embedded type including the following equipment:

- 1 + 1 electric pumps (SADU type) 100 - 80 - 210 x 2 LOMC/198; Q = 40 m^3/h, H = 95 mH_2O, N = 22 kW, n = 3000 RPM, for to maintain the pressure in the system and the compensation of losses due to faulty sealing as well as for fighting any fire;

- 2 + 1 electric pumps (SADU type) 100 - 80 - 210 x 3 LOMC/198; Q = 60 m^3/h, H = 100 mH_2O, N=37 kW, n = 3000 RPM for providing the required fire water flow;
- 3 + 1 electric pumps DN 125 - 80 - 315 NOMC, Q = 150 m^3/h, H = 95 mH_2O, N = 75 kW, n = 3000 RPM for to provide the required fire water flow;
- 1 + 1 house water supply plant, V = 5000 l, Pn = 10 atm for to maintain the pressure in the system and get an automatic in-step pressure start-up of the electric pumps;
- 1 + 1 electric compressor (INGERSSOL – RAND type), Q = 560 l/min, Pn = 10 atm;
- 1 motor pump, Q = 560 m^3/h, H = 100 mH_2O for to provide the required back-up fire water flow and/or, in case of total electric power supply unavailability.

Pump Station for Fire Water Stock Make-Up.

- 2 pumps FNC 150 - 125 - 315 with: Q = 200 m^3/h, H = 30 mH_2O, N = 32 kW, located in the Screen House (Double Pile) – Unit 1.

Pump suction is by a Dn 500 mm metal pipe with the possibility to intake the water either from the service water pump intake or from the distribution pool. The elevation of the pump and intake pipe location is El. 1.00 mBSL. An intake pipe is so selected and installed to provide the water intake from El. - 2.00 mBSL, irrespective of the water level in the distribution pool or the intake pool of the cooling service water system.

The flow is taken only during a fire event or for making-up the water stock in the fire water tanks.

Fire Water Pipe Network

The outer pipe network for each unit is circular in shape and sized to maintain the pressure at 9.5 ÷ 10 atm. The network is provided with outer fire hydrants (Dn 100 mm or /and 150 mm, Pn = 10 atm) check valve manholes (separation valves), hose boxes foe mobile fire fighting units and on-ground fire fighting hydrants.

Automatic Fire Suppression Systems with Sprinklers, Fuses and Indoor Hydrants

The maximum flow for an automatic fire suppression system operation with sprinklers and nozzles is about 400 m^3/h and for the inside hydrants the flow is 5 l/sec (about 20 m^3/h).

So, the maximum flow of about 0.1 m^3/sec fire water that must be taken from DBSC – Race 1 (NPP distribution pool) is falling, as flow rate, in the intake flow rate value of about 54 m^3/sec.

4.1.10.7. Domestic Water System

The source of domestic water for Cernavoda NPP is represented by the domestic water supply system made up of a underground source (pits Fj1 and Fj2) located in depth (600 ÷ 700 m) and pit Fj3 from Campus 2.

The supply connection to the domestic water network of Cernavoda Town is maintained only for emergency cases.

Water distribution inside the Plant enclosuree is made via the Pump Station which take the water from the two tanks through a Dn 400 mm diameter metal pipe. The domestic water pipe network is common for NSP and BOP.

Pump Station

The station is sized for 5 units and consists of the following equipment:

- 5 electric pumps (SADU type) 100 x 2C with the following characteristics: Q = 65 m^3/h, H = 70 mH_2O, N = 30 kW, n = 2930 RPM;
- 2 electric compressors ECR 350 with the following characteristics: Q = 0.25 m^3/min, P = 10 atm, N = 2.2 kW;
- 3 house water supply plant V = 15 m^3, Pn = 10 atm.

Domestic Water Network

The domestic water network inside Unit 3, respectively 4 enclosure is a branched type. The pipes are made of carbon steel and high density polyethilene (PEHD), with diameters encompassed between 400 and 50 mm.

Manholes with check valves, discharge / vent valves are provided in the pipe network. The required permanent pressure in the pipe network is 6 atm and it is assured by the water tanks supplied by electric pumps which operate automatically function on the requirements.

Domestic Water Tanks

The tanks are made of concrete and sized for the maximum dayly flow required by 5 units, each tank having 1000 m^3 capacity.

The hydraulic equipment in the valve room associated to the tanks consists of:

- supply pipe: Dn 200 mm;
- overflow pipe: Dn 250 mm;
- distribution pipe: Dn 400 mm;
- discharge pipe: Dn 150 mm.

Possible leakage occurred in the valve room are collected in the floor bays wherefrom it is discharged to the rainfall water drainage by means of a drainage pumps (7150 - P008).

4.1.10.8. Emergency Cooling Water

The Unit 3, respectively 4 Emergency Cooling Water System –EWS, is aimed to provide:

- removal of decay heat from the nuclear reactor in case the normal removal of heat by the heat removal system is unavailable;
- an independent source of water supply to the steam generators, ECCS heat exchangers.

The Emergency Cooling Water System is a nuclear safety function system.

The cooling water is the water taken from the Danube, from the distribution pool. For Unit 3, respectively 4 two (2) x 100 % pumps (NMV 253 x 3 type) are provided to supply a flow of 114 l/sec, with the maximum allowable submersion limit of 1650 mm. They assure the distribution of the raw water to the systems served by the emergency water system. The pumps are located in Unit 3, respectively 4 – EWS building.

A intake Dn 914 mm duct is connecting the distribution pool with the intake pit of the pumps and it is located at El. 0.50 mBSL – at center line.

The discharge pipe of the pumps is embedded and is branching as follows:

- one pipe goes to the reactor building providing the raw water supply to the steam generators and primary heat transport system;
- one pipe gets into the service building and gets connected with the raw cooling water of the heat exchanger in ECCS system piping.

The Emergency Water Supply System represents an alternative source of cooling water in case of the below mentioned events that may lead to the loss of normal decay heat removal:

- DBE or fire;
- Loss of Class III power supply;
- Loss of cooling water supply to the steam generators;
- Loss of raw cooling water to the ECCS heat exchanger.

In case of a DBE, the system provides the water supply to the secondary cooling circuit of the steam generators and the make-up water to the primary cooling circuit (faulted loop).

In case of Class III power supply loss, the emergency cooling water system provides water to the secondary circuit of the steam generators.

In the third case, the EWS system provides the cooling water supply to the secondary circuit of the steam generators. In case of the fourth event, the EWS system provides the water supply to the heat exchanger 3432-HX 1 of the ECCS system.

Flow requirements for the emergency cooling water system:

System/ Equipment	**DBE**	**Class III power loss**	**LOCA**
Steam generators	30 l/sec	30 l/sec	30 l/sec
PHT system	114 l/sec (cooling) 16 l/sec (make-up)	NOT	NOT
3432-HX1 at 24 h after LOCA	NOT	NOT	84 l/sec
EWS pumps required (pcs.)	1 of 2	1 of 2	1 of 2

During the reactor normal operation, the system is in stand-by.

The system must become operational in 30 minutes after the loss of Class III power supply or after the occurrence of a DBE.

4.1.11. Site Drainage Systems

Drainage outside NSP building

The drainage from Unit 3, respectively Unit 4 shielded enclosure consists of:

- dewatering pits outfitted with submersible electric pumps;
- collecting and drainage ducts;
- electric, automatic and dosimetric control systems.

Based on the data supplied by ICH (Ref. 4.1-1), the technical solution with dewatering pits is providing the followings: pits drilled down to the marl layer, having the diameter of 600 mm and located in the inside of the shielding at a distance of about 45 m between the pits.

Water is extracted from the pits by the submersible electric pumps of HEBE 65 x 4 type (Q = 35 m^3/h, H = 30.00 mH_2O). Water is discharged via a steel - made pipe system of 100 mm diameter into the main rainfall drainage system. The discharge pipe associated to each pit is provided with a by-pass line for the cases when the flow collected into the pit is smaller than the flow considered by design.

A manhole is provided on the discharge pipe network for sampling the water (dosimetric control point).

The location and sizing of the shielded enclosure are determined by the necessity to accommodate all the nuclear buildings as well as the location of the dewatering pits in the spaces available inside the enclosure at the distance of 11.00 ÷ 15.00 m as to the shield, according to the specifications supplied by ICH. The enclosure is rectangular in shape, with the sides of about 135.00 m.

On vertical direction, the shield is developing between the front of the platform El 15.80 mBSL and a line situated at about 5.00 m below the upper limit of the waterproof marl layer, namely at El. – 25.00 mBSL, so it has a total average high of 40.00 m.

NSB - Auxiliary Service Building Drainage (NASB)

The drainage of Unit 3, respectively Unit 4 Service Building consists of two main parts: collection and drainage.

Water collection is made via a PVC - made pipe network 1600 x 7.7 mm outer diameter drilled in their lower part, located under NASB into a permeable material, between floor elevation at El. 10.20 mBSL and the leveling concrete at El. 6.50 mBSL. The location elevations are from El. 9.95 mBSL down to El. 7.70 mBSL.

These pipes discharge in Pit 1 located in Nuclear auxiliary Building at El. 7.70 mBSL.

The discharge of the water from the pit is via a steel - made pipe 114.3 x 6.02 mm outer diameter which leads up to the drainage pipe inside the nuclear enclosure outside the building and henceforward, through the sealing shield, to the main rainfall water drainage header (sump). The flow sheet specifies the required valves and piping to make the transfer of the water to the sampling station and the radwaste treatment system.

Drainage around the Spent Fuel Bay

The drainage around U3, respectively Unit 4 Spent Fuel Bay consists of two main parts: collecting and drainage.

Water collection is made via a PVC - made pipe 160 x 7.7 mm outer diameter, perforated on its lower side and embedded into the permeable material between the spent fuel bay walls, the leveling concrete and its related shield, between El. 7.21 mBSL and El. 6.70 mBSL.

Seepage water is collected into a pit wherefrom it is discharged, by pumping via a steel pipe to the radwaste treatment system.

Reactor Vault Drainage

The drainage of U3, respectively Unit 4 reactor building consists of two main parts: collecting and drainage. Water collection from around the reactor building is performed via 3 pipes 160 x 7.7 mm outer diameter perforated in their lower part and embedded between the reactor walls (containment walls) and its related shield, into a permeable material, at El. 7.64 mBSL and El. 7.50 mBSL.

Infiltrated water is collected in two pits and herefrom, by pumping, the water passes through a pipe 88.9 x 5.49 mm outer diam. being discharged in the drainage pipe of the NASB. The flow sheet specifies the required pipes and valves to make possible the transfer of the water to the sampling station and the radwaste treatment plant.

4.1.12. Waste Water Management During Construction Period

For Cernavoda NPP-Unit 3 and respectively Unit 4, water demand for site planning will be provided, as follows (Ref. 4.1-35):

- drinking water for social groups will be supplied using connections to the existing network supplying also the other Cernavoda NPP Units;

- fire water will be also provided by connections to water ring of the existing fire.

The spent waters exhausted from site planning will be gathered as follows:

- the impurified ones obtained in the mechanic shops will be collected in a pitch and one separator, out of which, after separation, waters will be exhausted in the raining drainage;
- the waters obtained from the social groups and other project in the site planning will be exhausted using direct connections in the existing domestic of Cernavoda NPP.

4.1.13. Estimated Impact on Waters During the Construction Period

During the period envisaged for the completion of the Cernavoda NPP Units 3 and 4 (till the year 2013 for U3 and till the year 2014 for U4) the works to be performed will be construction works, equipment and pipe installation works, electrical and I & C works, and clearing and flushing of the process systems and their hydraulic testing (Chapter 2.1.2). The resulting waste waters from these activities will be taken over in the existing sewerage systems and drainage systems.

Formatiert: Nummerierung und Aufzählungszeichen

The domestic waste waters will be collected by the existing sewage network, similar to those that result from other buildings within the NPP site. They will be treated in the future waste water treatment plant of the Cernavoda Town.

The waste waters from the mechanic shops discharged to the rain water drainage network after passing through a separator of oil and black oil, will go to the distribution basin.

The rainwater will be collected and discharged in the same conditions as at present, through the existing collecting system, with discharge in the distribution basin.

The rainwater is evacuated after passing through a desilter.

The waters generated by the pipes chemical treatment workshop that is located in the building site area, are discharged in a neutralizing station that reduces their potential effect.

The waters from clearing and flushing of the process systems and their hydraulic testing are discharged through the existing systems, under the regulations for the NPP platform.

The water discharge to the receptors (the Danube, DBSC, the distribution basin, Cernavoda town sewerage) is done under the conditions of the water management authorization issued for Unit 1 and the NPP platform.

The impact on waters during the Units 3 and 4 completion period will be much lower than that produced during the NPP platform realization and Unit 1 construction.

Having in view the categories of wastes that result during the Units 3 and 4 completion period (Chapter 3.1), and the obligation of the constructors to manage these waste within the building site organization, according to the existing legal regulations, it is not expected an impact of these wastes on waters.

The impact on surface waters and groundwater, due to accidental leaks of oil and fuel, as well as due to materials and waste small amounts that can fall on soil, will be reduced to minimum through equipment and vehicles periodic maintenance, and by proper handling and storage of fuels and materials, and waste management.

Respecting the leaks reducing measures and procedures and the waste management procedures, the impact on ground water will be insignificant.

4.1.14. Waste Water Management During Operation Period

4.1.14.1. Description of the Waste Water Generation Sources

Circulation Water

The condenser cooling water circuit is an open circuit of raw water from the Danube, with continuous operation, which supplies the cooling water for the turbine steam condensation – a mandatory requirement for the nuclear units operation (Ref. 4.1-34, 4.1-35).

The water source is the Danube River. Water is intake via the Danube – Black Sea Canal – Race 1 – derivation canal – intake canal – distribution pool, which are common to the circulation water and raw service water circuits.

Water discharge from Unit 3 and 4 is into the Danube or the Danube – Black Sea Canal – Race 2 via the siphonatting bays and the discharge canals.

Service Water

The Service Water Circuit is an open circuit of raw water from the Danube, that is continuously in-service providing the required cooling water to the heat exchangers in the intermediate cooling water circuit.

The water source is the same with the circulation water circuit.

Water discharge from Units 3 and 4 is made to the Danube or the Canal – Race 2 via the siphonating bays and the discharge canals.

Rainfall Water Sewage Network

The Unit 3, respectively Unit 4 network provides the discharge of:

- rainfall waters (BSI 71760);
- waste waters from mechanical (sand) filter washing in the Water Chemical Treatment Plant;
- waters from the ground-water table inside the shielding which surrounds the nuclear buildings (BSI 15310);

- waste waters from the motor oil separator (BSI 72230);
- inactive drainage from the Turbine Building (BSI 71770, 71790);
- inactive drainage from the syphonating bay, Diesel units building and Chiller building;
- drainage of water collected in the Service Building basement, below the basemat.

Water Chemical Treatment Plant – WCTP

The discharges from the water chemical treatment plant are represented by:

- sludge from the separation tanks;
- neutralized waters from the neutralizing tanks in the Water Chemical Treatment Plant;
- waste waters from mechanical filter washing;
- waters resulted from the outer tank overflow (raw water, coagulated water, demiwater, neutralized water).

Liquid Radwaste Management

The liquid radwastes are represented by the waste waters collected in the NSP and resulted from the operation of Unit 3, respectively Unit 4 NSP systems as well as a result of maintenance, inspection, repair and decontamination activities. Such liquid radwastes consist of:

- domestic water used for decontamination of humans, cloths, that mostly contains detergents and soap. The large volume of clear water used for such washings, impose a substantial initial dilution;
- demineralized water radiochemically impurified and resulted from the drainages from the spent fuel tanks or from the spent ion-exchange resin collection tanks;
- chemically and radiochemically impurified demi water and sewage water resulted from decontamination operations of equipment, from the chemical lab and from the dosimetric lab;

- demiwater, slightly impurified with tritium and/or chemical substances, resulted from de-deuteration operations of spent ion-resins in the heavy water purification systems;
- floor drainage;
- waters collected in the inactive drainage pits in NSP;
- demiwater used in the process circuits in the NSP in which chemical additives were added to control corrosion.

Sewage Network

Spent sewage waters discharged from Cernavoda NPP – Unit 3, respectively Unit 4 enclosure consist of:

- sewage waters coming from BOP;
- sewage waters coming from Service Building.

Waters discharged into the sewage water network are coming only from clean areas (non-contaminated areas).

4.1.14.2. Reuse / Recirculation of Discharged Waters

Cold-Warm Water Mixture Canal for Recirculation

The canal is aimed to provide for Cernavoda NPP, the discharge of a part of the hot water flow during freezing periods in order to avoid water freezing and to maintain a minimum temperature of the water between 5 ÷ 7 °C in the Pump station.

The sizing of the recirculation canal considered a maximum flow of 100 m^3/sec. The recirculation canal is located at the boundary of Cernavoda NPP enclosure.

Sampling of warm water is from the warm water discharge duct to the Canal – Race 2 and therefrom into the distribution pool.

The hot–cold mixing canal is made up of a metal Dn 3600 mm pipe embedded in concrete. The length of the canal is about 400 m. In the connection point of the warm water discharge canal into the Canal – Race 2, there is a 6.00 x 5.50 m valve manhole equipped with 4 double sealing plane valves.

Warm water discharge into the distribution pool is via a reinforced concrete duct placed on the bottom of the intake duct, provided with openings to direct the water to the Cold Water Pump Station for the condensers and service water.

4.1.14.3. Installations for Pollutant Load Decreasing

The main installations provided for diminishing of spent waters pollution are the followings:

- pitch separator for spent process waters in the pitch management, as well as for raining waters from vat of both oil and oil tanks;
- sands separator from raining waters;
- neutralization system for spent waters neutralization under regenerating process, equipment, floor, etc cleaning from WCTP;
- decommissioning sub-system provided for liquid wastes decommissioning having a radioactivity which exceeds 5 x 10^3 Bq/l.

4.1.14.4. Spent Water Collection Systems

Works on the Warm Water Recirculation at the Danube and the Danube-Black Sea Canal

The hydrotechnical works for the discharge of warm water resulted from cooling the condensers and from the intermediate water chillers consist in the followings:

- canals and ducts for circulation warm water discharge, syphonating bays and special manholes;
- warm water discharge duct to DBSC – Race 2;
- warm service water discharge canals and pipes;
- hot-cold water mixture canal for the operation regime with recirculation;
- warm water discharge ducts to the Danube.

Circulation Warm Water Discharge Ducts and Canals, Syphonating Bays and Special Manholes

The warm water canals were sized to discharge a flow of about 54 m^3/sec at each unit.

Warm water discharge from the condensers is performed via 6 Dn 2000 mm diameter pipes which get connected to 2 Dn 3600 mm pipes embedded in reinforced concrete. The pipes of Dn 2000 mm diameter provide the discharge of 9 m^3/sec each.

The 2 x Dn 3600 mm diameter pipes are connected to a encased canal made of cast-in-place reinforced concrete (2 x 3.00 x 5.00 m) which makes the connection to the canals in Line “U”.

The U3, respectively U4 warm water discharge canals are connected to the canals in Line “U” via cast-in-place reinforced concrete manholes. These canals give the possibility, via the syphonating bay and the valve manholes, to discharge the warm water either to DBSC – Race 2 or to the Danube (switching time is about 30 minutes). Upstream the syphonating bays there are sluice type valves which assure the discharge of the water either to DBSC – Race 2 or to the Danube.

To empty the warm water canals in Line ”U” and of the connection pipes to the Turbine Hall, a pump station is operating.

Works for Warm Service Water Discharge

The entire warm service water (max. 7.8 m^3/sec for a unit) is discharged to the warm water canal in the condenser cooling circuit.

Water discharge is performed via 6 underground metal pipes connected to both streams of the warm water canal of the condenser cooling circuit along Line “A”.

Warm Water Discharge Canal to DBSC – Race 2

The warm water discharge canal is aimed to make the connection between the warm water discharge pipes inside the enclosure (Line “U”) and a micro hydrostation.

The warm water discharge canals are sized for a flow of 215 m^3/sec corresponding to 4 units. The selected solution is the discharge of the water into Race 2, through a encased canal with two sections (one for each two units) in order to minimize the occupied space.

When selecting the solution, the followings were considered:

- in case of emergency on the canal, warm water may be discharged into the Danube;
- by discharging into DBSC – Race 2, part of the pumping energy is recovered.

The encased canal includes two 5.50 x 6.00 m compartments (sections).

Encased Discharged Canal – Outside the Enclosure

The encased canal (2 x 6.00 x 5.50 m) is continued by an open encased canal made of cast-in-place reinforced concrete (2 x 8.00 x 8.25 m).

Hot-Cold Water Mixture Canal for Recirculation

During cold seasons, this canal is aimed to provide the discharge of a part of hot water flow in order to avoid water freezing and to maintain a water temperature at minimum 5 ÷ 7 ℃ in the Pump Station.

Sizing of the recirculation canal considered a maximum flow of 100 m^3/sec. The recirculation canal is located at the boundary of Cernavoda NPP enclosure.

Warm water sampling is from the warm water discharge canal to DBSC – Race 2 and next to the distribution pool.

Cooling Water Discharge Circuit to the Danube

The discharge of the cooling water from Cernavoda NPP – U3, respectively U4 to the Danube is via a system made up of an open canal (concret covered) and an earth made canal with the discharge into the Danube. The circuit starts from the syphonating bay no. 1, under – passes Valea Cismelei, the hill between Valea Cismelei and Valea Seimeni and goes on to the base of the left side of Valea Seimeni. After having passed Cernavoda – Harsova highway, the canal passes the Danube Swamp and discharges into the Danube at km 296.00. The circuit is so sized to provide the discharge of a water flow coming from 2 NPP units along one stream (casing, canal, tunnel).

The circuit starts with a double-case segment of 5.75 x 5.75 m in size. This connection case segment makes the connection with the valve house in Valea Cismelei.

Adjacent to the valve house towards Valea Cismelei, there is a spillway capable to discharge 53.8 m^3/sec emergency flow required to be discharged in case of both circuits failure: the circuit towards the Danube and the circuit to DBSC.

The connection between the valve house and the 2 tunnels is made via some simple case-segments which under-pass Valea Cismelei and simple-case segments up to the connection to each tunnel. The cross-section of these works is 5.75 x 5.75 m.

The emptying of the under-passing segments during maintenance and inspection periods is made by dewatering procedures. Adjacent to TS2 case segment there is a discharge manhole outfitted with EPEG 100 pumps. At the tunnel entrance there is the ventilation manhole used during the tunnel emptying procedures.

The tunnel of 2780 m width is circular with 5.40 m diameter. The tunnel discharges to Valea Seimeni and next, via a case segment like that in Valea Cismelei, into the concrete covered canal.

Valea Seimeni valve house outfitted with a plane valve of 5.75 x 5.75/18.4 m is located between the case and the open canal.

The concrete covered canal goes up to the base of the left side of Valea Seimeni and is 2500 m long, with a trapeze cross-section with the 12.0 m base and the slopes are 1:2.5. The concrete covered canal route is along Seimeni side at its base. Seimeni side is harnessed to prevent silting due to erosion.

For the valleys which cross the canal, in the crossing point, works have been made for discharge into the canal. The valleys were harnessed upstream against torrents; during heavy rain periods, solid materials are taken along the formed streams and they may clogg the canal. Beyond DJ 223 county road, the canal route follows the Danube and it has a trapeze cross-section with 29 m base (earth made) and 1:4 slopes. On the right side there is a protection and circulation dike with the berme at El. 11.50 mBSL with a protection spurdike made of crushed rock towards the canal and the spurdike, draining downstream. Facing the two swamps the canal is crossing over, dikes were provided upstream, with 1:4 slopes inside the canal and 1:3 slope for the slope fillings.

The passing from the concrete covered canal to the earth-made canal is via a spillway with the crown at El. 10.40 mBSL and a energy dissipator with the foundation on walls and the elevation at El. 4.0 mBSL. The spillway is aimed to separate the upstream and the downstream race during the Danube high water periods simultaneously with the discharge of a water flow coming from 4 NPP Units.

The emptying of the discharge circuit is gravitational until the balance of the levels and next via Valea Cismelei pump house, Valea Seimeni pump house and spillway. Between the syphonating bay no. 1 and no. 2, the double segment of the canal is getting empty via the drainage pit.

The emptying of the tunnel is made by pumping with two alternative solutions for the relief:

- to Ramadan canal;
- to concrete covered open canal.

When the entire circuit must be emptied, water discharge is to Ramadan canal.

Facing the Valea Seimeni spillway, there is a pump station for emptying the canal. Release is developing in the dissipator in front of the spillway.

Rainfall Waters and Waste Service Water Canaling; Water Drainage from the Ground-Water Table

The collection of rainfall waters, waste service waters and water drainage from the ground-water table associated to Unit 3, respectively 4 is made via a canal network with manholes.

The discharge of the rainfall collected waters is via a Dn 1600 mm metal pipe located in the Plant distribution pool.

Water collected from Service Building basement is drained to the rainfallwater discharge system only in case that radioactivity is missing. When radioactivity is traced in the waters, the water is pumped to the liquid radwaste system (BSI 7921).

Rainfall and Waste Service Water System

The rainfall water flow collected all around Cernavoda NPP site surface was estimated to 3.4 m^3/sec. That estimation imposed the sizing of the main collection header for 1200 ÷ 1600 mm.

The maximum flow made-up of the ground-water collected and discharged via the drainage system to the rainfall water drainage is 100 l/sec for Cernavoda NPP platform.

The headers located inside have the diameters ranging between 200 ÷ 1000 mm and are made of concrete canals or PREMO embedded tubes.

The rainfall water headers are provided with manholes.

The waste service waters from the motor oil station and the rainfall waters from the tank trays are passed through an oil separator before discharge in order to avoid pollution.

Before discharge to the intake pool, the rainfall waters are passing a desilter.

Drainage of the Ground Waters from the Shielding Inside

In natural regime, the underground water level on Cernavoda NPP site is varying between 8.50 mBSL (normal elevation) and 12.00 mBSL (maximum elevation) function of the Danube River water level (distribution pool) (Ref. 4.1-35). The protection against the level variations of the ground waters in NPP-NSP part is performed by an underground shielded enclosure (injection shield and reinforced concrete) and a drainage system.

The drained shielded enclosures are made around the buildings of each unit and constructed between the ground surface (El. 15.80 mBSL) and the impervious marl layer. The shielded enclosures were made by cement grouting into the limestone layer and by reinforced concrete into the upper filling layer.

The discharge of the water from U3, respectively 4 enclosure is provided by a drainage system by pumping (Qmax. = 20 l/sec). Water is discharged to the rainfall water drainage system after having been dosimetrically controlled (tritium and gamma). In case of accidental contamination, the discharge is stopped until managing.

Unit 3, respectively Unit 4 – NSP is provided with its own drainage system and it consists of:

a) Collection system

It is made up of drilled pits made in inverted circulation hydraulic system, of maximum 40 m depth. Each drill consisted of:

- a 609 mm diam. drill hole;
- inverted filter with the grain size ranging between 5.6 ÷ 11.20 mm;

- final column of 250 mm diam. aimed to reinforce the drill hole wall, the sand filter support and the pumping equipment protection;
- filtering column of 250 mm diam. provided with slots to collect the ground waters.

b) Hydraulic installations

Hydraulic installations consisting of:

- pump units: HEBE 65 x 4 type electric pump with: $Q = 15 \div 20$ m^3/h; $H = 46.5 \div 42$ mH_2O, $P = 7.5$ kW;
- valves: Dn 0.5 inch check valve for sampling;
- Dn 100 mm gate valve on the overflow pipe;
- instrumentation and controls: 100 diam. flowmeter.

The ground water level is measured in the 1 piezometric pits located inside and outside the shielded enclosure, by means of a gauge marked every one meter.

c) Instrumentation and control system

It provides:

- control of the drainage pumps;
- measurement of the water level into the pump pits;
- remote controls for minimum, average and maximum levels at pumps.

All signals and controls are displayed on the local control panel located on Line K-L.

The I&C system provides the operation of the pumps in the following regimes:

- pump stop when the underground water level reaches El. – 5.00 mBSL;
- pump start-up at the level of 8.00 mBSL and signal on the pump motor condition.

Pump control may also be manual.

Sewage Water Discharge

Sewage waters discharged from Cernavoda NPP U3, respectively 4 enclosure are made-up of:

- sewage waters from BOP;
- sewage waters from Service Building.

The waters discharged into the sewage water system come not only from clean areas (non-contaminated areas).

The materials used to make the routes and pipes for drainage are FC100 cast iron and concrete ducts of Dn 200 mm diameter and Dn 300 mm, with manholes along the lines located at max. distance of 30 ÷ 40 m between them.

The sewage water flow is 10 l/sec (max. 36 m^3/h) for Cernavoda NPP U3, respectively U4.

The waste waters are transported gravitationally through the drainage canals to the sewage water Pump Station (7175-SP2) located between Unit 3 and Unit 4. There from the water is pumped to Valea Cismelei Pump House of Cernavoda Town.

The waste waters resulted from Unit 1 & 2 operation, including common services, are gravitationally transported through the drainage canals to sewage water Pump House (7175-SP1) located inside Unit 1, next to syphonating bay no. 1. There from the waters are transported, by means of 3 pumps, to the sewage water pump station 7175-SP2.

The pump station 7175 - SP 1 is a circular construction of 4.50 m diameter and 10.1 m depth., outfitted with 2 + 1 pumps EPEG 80 - 40/2 E with the below characteristics:

- Q = 90 m3/h, H = 36 mH_2O, P = 45 kW, n = 1450 RPM.

The pump station 7175 - SP2 consists of a single access and collection chamber for the sewage water in which there are pumping equipment and associated devices. This station is outfitted with 3 + 1 pumps EPEG 80 - 30/2 E with:

- Q = 75 m^3/h, H = 21 mH_2O, P = 22 kW, n = 1450 RPM.

At the exit from the Pump Station 7175 - SP 1 and SP 2, the following works were made:

- a manhole for sampling to control the sewage waters from the enclosure;
- a manhole for the relief valve.

The hydraulic installations include the submersible pumps mentioned above herein for each station, the relief and emptying pipes that include gate type valves, throttles and flowmeters on the pump discharge (SP 1, SP 2).

According the design, the pumps should automatically start at the set maximum level and automatically stop at set minimum level.

Both installations shall be maintained operational during the time there is personnel inside the pump station.

Water Chemical Treatment Plant - WCTP

Outgoings from WCTP for a unit of NPP:

- Slime from the slurry tanks. A Dn 200 mm diam pipe is installed between the slurry collection tanks in the WCTP and the syphonating pools no. 1 & 2. The volume of the collection tank is 20 m^3. The discharge is discontinuous;
- Neutralized waters from the neutralizing tanks in WCTP. A Dn 250 mm pipe is installed between WCTP and the syphonating bays nr 1 & 2. When regenerating a demineralization line, the volume of the spent waters is 330 m^3;
- Washing waters from the mechanical filters. Such waters are discharged to the rainfall water system via an embedded Dn 400 mm diam. pipe. The flow is $120 \div 240$ m^3/h; maximum duration is 45 minutes, 3 times a day;
- Waters from the overflows outside (raw water, coagulated water, demi water, neutralized water) is discharged to the rainfall water discharge system.

Collection of the Liquid Radioactive Effluents

Collection, storage, sampling, decontamination (if necessary) and controlled discharge of the liquid radioactive wastes resulted from both the plant process system operation and from the maintenance, repair and decontamination operations are performed by the Liquid Radioactive Waste System (LRWS).

The radioactive liquids are either directly transferred from some of the Plant systems to LRWS (Liquid Radioactive Waste System), or are collected by the Plant drainage systems and then transferred to LRWS.

The liquid waste transfer to LRWS is made via the plant drainage systems (active, non-active) and the corresponding ducts, the radioactive water being separately directed to two groups of storage vaults as follows:

a) active drainage systems

a1) The active drainage system in the Reactor Building has the function to identify and collect the radioactive leakages from different areas of the Reactor Building. Light and heavy water leakages are identified by beetle-type transmitters.

The collected drainages are transferred according to the quantity, the liquid type (heavy water or light water) and the radioactivity level of the leakages (determined from the sample analysis), as follows:

- to low radioactivity floor pit in the Service Building, if the liquid volume is large 20 l, the heavy water content is maximum 2 % and the beta/gamma radioactivity is below 0.37 Bq/ml ($10^{-5}\mu Ci/m^3$);
- in drums, in order to be transferred to the D_2O clean-up system, if the leakage volume is greater than 20 l and the heavy water content exceeds the value of 2 % or the beta/gamma activity is greater than 0.37 Bq/ml (10^{-5} $\mu Ci/m^3$).

a2) The active drainage system in the Service Building ensures the continuous collection of all normally active or low active drainages from building, including water for fire protection system. The system takes up also the liquids transferred from the active drainage of the Reactor Building .

The leakages from the heavy water areas in Service Building (D_2O primary coolant and moderator deuteration and dedeuteration system area, D_2O tower) are collected and contained in a special tank, by this system, too. The system has the possibility of sampling.

The collected liquids will be selectively transferred to the LRWS or D_2O clean-up system, if the heavy water content of the liquid is below or over 2 %.

b) non-active drainage systems which operate in nuclear area, ensure the collection of the underground waters from outside Reactor Building, outside Service Building and outside Spent Fuel Bays areas.

The waters collected from the SFB area are directly discharged to the LRWS, while the others will be transferred to LRWS or to rainfall water drainage system, depending on their radioactivity (after a previous sampling).

The liquids from the following plant systems are directly transferred to the Liquid Radioactive Waste System:

- Spent Fuel Bay cooling and purification system (after analysis of samples taken from the water after purification through the ion exchangers of the system, this is either transferred to the LRWS or is recycled by bay the cooling and purification system, depending on the result of the sample analysis);
- primary coolant deuteration/dedeuteration system (after the samples analysis taken from the deuteration/dedeuteration tanks).

Liquid wastes collected by the Liquid Radioactive Waste Management System are classified as follows:

- **Category 1** resulted from the laundry, showers, labs and floor drainage in Service Building. These wastes are called low level active wastes; their activity ranges between 3.7×10^{-1} Bq/l and 3.7×10^{2} Bq/l and the average weighted activity is 1.85×10^{2} Bq/l;
- **Category 2** resulted from the depleted D_2O upgrading tower, the equipment decontamination system, rubber washing room, labs and floor drainage from

the Service Building. These wastes are called medium active wastes; their activity ranges between 3.7 x 10^2 Bq/l and 3.7 x 10^4 Bq/l;

- **Category 3** resulted from the drainage in Reactor Building, Spent Fuel Bay, Spent Resin Storage Bays, Spent Fuel Bay underground drainage pits, Reactor Building and Service Building underground drainage pits and the D_2O systems area. These wastes are coming from special sources and their activity ranges between 3.7x 10^4 Bq/l and 3.7 x 10^6 Bq/l. Category 3 wastes can be sent directly to the decontamination system before being discharged into the Liquid Radioactive Waste Management System – storage bays. Usually, they are collected together with the category 2 wastes. The resulting mixture has an activity ranging between 3.7 x 10 Bq/l and 3.7 x 10^5 Bq/l (the average weighted activity is 1.85 x 10^3 Bq/l).

The collection and storage of the radioactive liquid effluents are carried out in 5 concrete tanks lined with epoxy resin, located in the basement of the Service Building. Two of the tanks are used to collect the radioactive wastes of level 2 and 3; the other 3 tanks are used to collect the wastes of level 1 (low-active).

The tanks are so sized to ensure for each tank a volume (50 m^3) corresponding to a double daily-averaged quantity of radioactive liquid wastes produced in the plant, as well as the storage of the additional waste quantities resulted from a potential failure or abnormal situation in the plant operation.

The number of tanks should ensure the normal operation or in accident conditions, without treatment, during a week-end period of 3 days. The content of one tank can be treated during 24 hours. Normally, the liquid waste radioactivity is low enough to be permitted their discharge without previous decontamination. In special cases, when decontamination is necessary, an assembly filter/ion exchanger with the auxiliary equipment is provided.

All valves and C & I of the system, used in normal operation, are located in the Service Building basement, reducing thus the risk that the potential failures in the system determine radioactive releases to the environment.

After a tank is filled half of its volume and the content is homogenized, sampling is carried out to establish if the content can be discharged directly to the cooling water canal from the condenser or decontamination is necessary. A trench for sampling is provided on this purpose.

Radioactivity of the discharged wastes is measured continuously by a monitor (MEL), which automatically closes the releasing circuit when the limit of 5 x 10^3 Bq/l is reached, and the wastes are returned to the tank, for analyses and decontamination.

A subsystem for continuous sampling from the discharge duct of the cooling water from condensers is also provided, after mixing with the radioactive wastes dispersed in the duct.

The samples must be analyzed weekly, to determine their content regarding beta/gamma activity and tritium.

The sampling subsystem ensures an additional control of the radioactivity released from the plant.

Decontamination of the liquid wastes whose radioactivity exceeds 5 x 10^3 Bq/l is carried out by the decontamination subsystem.

As the main radioactive contaminants consist of a combination of colloidal particles and ionic material in the demineralized water, decontamination is carried out by mechanical filtering and ion exchange, by means of a filter with special natural fiber to perform the colloidal filtering process and a filter with resin bed prepared previously, used for filtering with ion micro-resins. The preparation of the filtering material consists of a mixing process with demineralized water in a tank provided with a mixer. The operation capacity of the tank is 233 l. The filter supply is provided by a centrifugal pump of 4.55 l/s flow.

The subsystem is capable to reduce the beta-gamma activity of the liquid wastes in a tank down to allowable limits throughout a day also considering the time necessary to prepare the installation for flushing at the end of the decontamination operation. Considering an average flow rate of 3.8 l/sec and a decontamination factor ranging from 10 (at the beginning of the cycle) to 2 (at the end of the cycle); in 8 hours, by recirculation via a filter the contents of a tank can be treated. At these average values of the flow rate and the decontamination factor, the radioactivity in a tank containing about 35 m^3 liquid wastes, reduces with a factor of 2 each 1and 1.5 hours.

In case that the radioactivity of the liquid wastes is entirely ionic, the decontamination capacity depends on the total concentration of the solids dissolved. If the concentration of dissolved solid is high, the filter cannot retain but a part of the dissolved solids and consequently only part of the radioactivity. In such cases, it is mandatory to repeatedly use the ion-exchange filter until an allowable concentration is obtained.

The discharge of the spent filtering material is made by filter flushing in counter flow of the demineralized water. The filtering mass shall be transferred as slurry to the spent ion resin management system collecting bays. The flushing water is returned to the liquid radioactive waste system (LRWS) via the overflow nozzles of the bays.

The wastes collected by this system are discharged into the Raw Service Water System (RSW), through the warm water discharge pipe. Finally the mixture of liquid wastes and raw water is discharged, for dilution, into the common discharge duct of the Raw Service Water System (RSW) and Condenser Circulating Cooling Water System (CCW), taking all necessary measures, so as when they are discharged into the emissary (Danube), the concentration of radioactive isotopes in the effluents is lower than the Derived Emission Limits (DEL), and the effluent monitoring program requirements are met.

4.1.14.5. Quantities and Physical and Chemical Characteristics of the Discharged Waste Waters

The evacuated waste water quantities and their physical-chemical characteristics were established starting from the data obtained during the Unit 1 operation, with the mention that the design improvements at Units 3 and 4 will lead to the decrease of the pollutant concentrations in these waste waters.

Warm Circulation and Service Water

The total flow of warm circulation water and service water discharged from one NPP unit is 53.8 m^3/sec.

Rainfall Water Drainage

The total flow of rainfall water drainage discharge from NPP platform is about 3.4 m^3/sec.

Sewage Water

The total flow of sewage discharge from one NPP unit is about 10.0 l/sec.

Liquid Radioactive Effluents

The annual average volume of the liquid radioactive effluents for Unit 3, respectively 4 is 18,000 m^3; this value is estimated based on CANDU 6 NPPs releases during a 7 years operation period.

The radioactivity present in the liquid radioactive effluents was estimated to 172 TBq for tritium and to 2.1 GBq for gross beta/gamma activity. This estimation is based on the results from 6 CANDU NPPs during a 7 years operation period (Ref. 4.1-31).

The annual volume of liquid effluents reported at Cernavoda NPP Unit 1 was of 21780 m^3 in 1998, 21100 m^3 in 1999, and respectively 25950 m^3 in 2000.

The Balance of the waste waters is presented in Table 4.1.14.5-1.

Table 4.1.14.5-2 presents the results of the chemical analysis of the service water from Cernavoda NPP Unit 1 and the results demonstrate that the authorized limits are satisfied (Ref. 4.1-32).

The quality indices for the waste sewage waters from Cernavoda NPP Unit 1 during 2001÷2002 operating period are presented in Table 4.1.14.5-3 (Ref. 4.1-35).

The annual activity of liquid effluents (considering all the radioactive isotopes) recorded at Cernavoda NPP Unit 1 during 1996÷2004 operating period is indicated in Table 4.1.14.5-4.

Table 4.1.14.5-1. Waste Water Balance - for one Unit of Cernavoda N

Waste water source technologic process	Total generated waste water		Discharged waste waters										
	m^3/day	m^3/year	Sewage		industrially		rain						
			m^3/day	m^3/year	m^3/day	m^3/year	m^3/day	m^3/year	m^3/da				
Warm circulation & service water	4 648 320	1 696 636 800	-	-	4.648.320	1 696 636 800	-	-	2 376 0				
Rainfall water drainage	294	107 310	-	-	-	-	294	107 310	-				
Sewage water drainage	864	315.360	864	315 360	-	-	-	-	-				

Table 4.1.14.5-2. Results of Chemical Analyses of the Non-radioactive Effluents at Cernavo

No.	Parameter	Allowable limits within authorization (mg/l)	Max. allowable limits NTPA 001 (mg/l)	1997 (mg/l)	1998 (mg/l)	1999 (mg/l)	2000 (mg/l)			
1	pH (dimensionless)	6.5-9	6.5-9	8.19	8.17	8.1	8.12			
2	Suspended solids	25	60	9.9	11.6	12.18	11.48			
3	Ionic iron	1.5	5	0.11	0.163	0.23	0.14			
4	Chloride	250	500	21	16.6	16.62	17.41			
5	Sulphates	200	600	34.9	35.8	32.91	33.14			
6	Ammonium	3	3	0.08	-	-	-			
7	Biochemical oxygen demand (BOD_5)	7	20 - 25	-	1.80	2.26	1.55			
8	Sodium	100	-	18.0	16.5	15.22	17.93			
9	Calcium	150	300	38.2	45.3	44.72	39.25			
10	Magnesium	50	100	12.0	10.2	13.02	12.15			
11	Hydrazine	0.1	-	< 0.005	< 0.005	< 0.005	< 0.005			
12	Morpholine	0.4	-	< 0.100	< 0.100	0.100	< 0.100			
13	Cyclohexylamine	0.1	-	-	interfere with morpholine	interfere with morpholine	interfere with morpholine	n		
14	Lithium hydroxide	0.025	-	< 0.010	< 0.010	< 0.010	< 0.010			
15	Nitrate	1	2	< 2	< 2	< 2	< 2			
16	Petroleum products	-	5	absent	absent	absent	absent			

Table 4.1.14.5-3. The quality indices for the waste sewage waters from Cernavoda NPP Uni

Quality indices	MU	Max. allowable limits NTPA 002/2002 (mg/l)	Allowable limits within authorization (mg/l)	2001 SP-1 Pumping Station	2001 SP-CPPON Pumping Station	Pum	
pH		6.5-8.5	6.5-8.5	7.5	7.5	7	
NH^+_4	(mg/l)	30	30	4	4	2.	
CCOCr	(mgO_2/l)	500	500	250.25	267.75	2	
CBO_5	(mgO_2/l)	300	150	109	117	7	
Suspended solids	(mg/l)	350	300	120	134	1	

Table 4.1.14.5-4. Liquid emissions for the period 1996-2004, recorded at Cer

Isotope		Regulatory limit (Annual DEL)	1996	1997	1998	1999	2000	2001			
		kBq	kBq	kBq	kBq	kBq	kBq	kBq			
H-3	D	7.3E+13	7.88E+08	1.12E+10	6.17E+10	1.40E+10	4.13E+10	5.21E+10			
	C	7.3E+13		4.21E+08	1.41E+08	5.29E+09	2.15E+09				
Cr-51	D	2.7E+13	3.91E+03	6.95E+04	1.13E+03	6.62E+04	9.17E+04	5.57E+03			
	C	2.7E+13		1.09E+03		6.79E+04	1.05E+03				
Mn-54	D	1.2E+11			4.26E+02	1.71E+03					
	C	1.2E+11									
Fe-59	D	2.3E+11	9.09E+02			4.86E+03					
	C	2.3E+11									
Co-58	D	2.55E+09									
	C	2.55E+09									
Co-60	D	6.9E+09		8.76E+03		5.88E+03	2.15E+04	5.57E+03			
	C	6.9E+09									
Zn-65	D	6.9E+10	2.53E+03	1.24E+03							
	C	6.9E+10									
Zr-95+	D	1.8E+11		4.29E+05	2.86E+05	1.04E+06	2.36E+05	5.61E+04			
	C	1.8E+11		1.44E+04		1.63E+05	3.26E+04				
Nb-95	D	1.5E+11		7.05E+05	7.45E+05	1.97E+06	6.06E+05	1.47E+05			
	C	1.5E+11		3.50E+04		2.99E+05	6.72E+04				
Ru-103	D	1.1E+11	2.25E+03	2.57E+03	1.34E+03						
	C	1.1E+11									
Sb-124	D	2.3E+11	1.71E+03	5.22E+05	3.81E+05	1.59E+04	2.67E+04	9.66E+03			
	C	2.3E+11		5.44E+04		3.28E+02	5.37E+02				

Isotope		Regulatory limit (Annual DEL)	1996	1997	1998	1999	2000	2001			
		kBq	kBq	kBq	kBq	kBq	kBq	kBq			
Sb-125	D	7.3E+10			1.11E+04		2.40E+02				
	C	7.3E+10									
I-131	D	3.5E+10	2.60E+04	5.22E+06	5.96E+05	4.42E+03					
	C	3.5E+10		2.81E+04		6.00E+03					
Cs-134	D	1.8E+10		4.51E+03	6.53E+02	4.80E+02					
	C	1.8E+10									
Cs-137	D	5.6E+09		3.17E+04	1.44E+04	1.62E+04	3.70E+03	8.64E+02			
	C	5.6E+09		3.17E+03							
Ce-141	D	2.5E+12	1.53E+03	1.05E+03							
	C	2.5E+12									
Ce-144	D	2.8E+11		1.77E+04	1.65E+04	3.00E+04	1.93E+03				
	C	2.8E+11				5.59E+03					
Gd-153	D	9.2E+11					6.00E+03	1.14E+03			
	C	9.2E+11									

Released in Danube (D)
Released in Danube – Black Sea Canal (C)

4.1.14.6. Locations for the Discharge of the Waste Waters, Comparison with the Allowable Limits for Discharges

Waste water discharge locations

Warm circulation water and warm service water

The discharge of the warm circulation water including the warm service water, from Cernavoda NPP units, is normally to the Danube and possibly to DBSC- Race 2. For cold seasons, the discharge of a part of the warm water flow is directed to the distribution pool in order to avoid freezing and maintain a minimum 5 ÷ 7 ℃ temperature of the water in the pump station (Ref. 4.1-35).

The slime from the separators in Water Treatment Plant – The discharge is incontinuous and performed by means of the slime discharge pumps, in syphonating bays no. 1 & 2 and then to the NPP effluent.

The neutralized waters from the neutralization tanks in WCTP – The discharge is carried out by means of the pumps in the hyphenating bays no. 1 & 2 and then to the NPP effluent.

The discharge places for the warm circulation and service waters are:

- the Danube – Valea Seimeni;
- DBSC – Race 2 - upstream the hydro power plant;
- Cernavoda NPP intake duct – distribution pool.

Rainfall water drainage

The discharge of the rainfall waters to the system is in the distribution pool of Cernavoda NPP.

The discharge of the waters from flushing the mechanical filters in WCTP is to the rainfall water drainage system. The maximum duration will be three times daily of 45 minutes.

The waters from the overflows from the tanks outside WCTP (raw water, coagulated water, demi water, neutralized water) are discharged to rainfall water discharge system.

Sewage system

The waste waters are transported gravitationally through discharge channels to sewage water pump station 7175-SP 2 located between Unit 3 & Unit 4. Therefrom the waters are pumped to the Valea Cismelei Pump Station of Cernavoda Town.

Allowable discharge limits

a) To the emissary - the Danube or DBSC race 2

With regard to the discharge of the warm effluent from Cernavoda NPP into the Danube or into DBSC – Race 2 and the water recirculation to the distribution pool, from the point of view of the allowable limits, it is mentioned that the values of the physical and chemical indicators should fall in the limits prescribed in NTPA-001/2002 (Standard on the pollutant load limit for industrial and town waters at the discharge to natural receptacles) modified by Government Decision 352/2005 and the limits specified in the water management authorizations that will be issued for Unit 3, respectively 4. At present, it is in force the water management authorization no. 37/20.02.2006 issued for Cernavoda NPP Unit 1.

The liquid radioactive effluents activity must be within DEL approved by CNCAN in the authorization process.

b) To Cernavoda Town Sewage Water System

The quality indices for the waste sewage waters (not contaminated) discharged from Cernavoda NPP to the Town network should meet the allowable limits specified in NTPA-002/2002 (on the requirements for the discharge of waste waters to town sewage networks and to treatment plants), modified by Government Decision 352/2005.

4.1.15. Estimated Impact of Taking Over the Necessary Water Flow for Cernavoda NPP Units 1, 2, 3, 4 and Discharging It

4.1.15.1. Impact on the Danube

Taking a 216 m^3/s flow from the Danube, through the water race 1 and the derivation canal, for supplying the Units 1, 2, 3 and 4, has not significant effects in the Danube downstream reach (water levels above the zero level of the gauge at Cernavoda HS), because of the much higher flow values on the branch Dunarea Veche.

During minimum flows periods (water levels under the zero level of Cernavoda SH), taking over an important fraction from the reduced flow existing on the Dunarea Veche branch in such situations, results in the water level reduction on the downstream sector. If the effluent from the four NPP units would not be discharged in the Danube, the water level decrease on the downstream stretch would be up to 40 - 50 cm. The effluent discharge to the Danube brings this decrease to 10 - 15 cm on Dunarea Veche in the Cernavoda area.

The water depth reduction (Ref. 4.1-7) increases the existing navigation difficulties during low waters. The alluvial deposits favored by the flow speed reduction can result in undesirable morphological effects in some river channel areas. Water intake implications for the downstream users (the irrigation system Seimeni) can also appear due to the water level decrease at the intake points.

The water restitution in Danube makes these effects very reduced, even during low waters, occurring only on a few km length sector, between the DBSC intake and the Cernavoda NPP effluent discharge section.

4.1.15.2. Impact on the DBSC Race 2

The cooling water discharge in the water race 2 of DBSC during periods with very low flow on the Danube can assure the necessary water volumes for the users from this water race. This contribution is important, especially if the flows used by various consumers are close to those envisaged in the DBSC design, reaching total values that could be difficult or impossible to be taken from the Danube during minimum flows.

If the effluent from Cernavoda NPP is evacuated to DBSC race 2, this discharge would have some favorable effects:

- savings at the Complex Pumping Station on the diversion canal, which is used to supply water race 2 when the Danube water level is below the water race 2 level;

- supplying water to water race 2 in case of difficulties at the Complex Pumping Station;
- allowing the generation of electric power in the hydropower stations located on the NPP discharge circuit and the hydropower stations at Agigea;
- increasing the water replacement rate in water race 2 and, as a result, the reduction of some undesired phenomena (mentioned in Chapters 4.1.20 and 4.1.23) due to some usual situations which are sometimes encountered within this water race;
- avoidance of freezing in the DBSC race 2.

4.1.15.3. Impact on the DBSC Race 1 and on the Derivation Canal

When DBSC was designed, the alluvial volume transported by the water taken from the Danube was considered, taking into account the requested maximum water flow for the users, including Cernavoda NPP with five units. Under these conditions an average alluvial amount coming from the Danube was estimated to be about 200 000 m^3/year. The evolution of the alluvial deposition in the DBSC intake area, that could also influence the water intake coefficient to the DBSC, is controlled for permanent insurance of the navigation conditions, by dredging works (Chapter 4.1.9.4). Such works have already been performed in some periods at the DBSC intake and in race 1, and also in the derivation canal, increasing the water taking over capacity during low waters on the Danube.

The DBSC water race 1, the derivation canal and the distribution basin were sized for higher flows than those necessary for the Units 1, 2, 3 and 4 simultaneous operation, starting from the needs of all the users. Therefore, it is expected that the flowing speed increase on this route by Units 3 and 4 operation will not result in additional erosion of canal sides and will not result in difficulties for navigation.

As regards eventual effects on aquatic fauna, it is remarked that the water flow speed values in water race 1, in the derivation canal and in the distribution basin are not higher than the usual water flow velocities on the Danube and therefore they are not excessive so that to transport the fish. This route does not offer various habitat conditions, as those existing on the Danube. Therefore, it is not likely to occur significant adverse effects on fish population. The fact that during the pumping station sieve periodic cleaning just small amount of fish were found, is a further argument for this assessment. The sieve observations, during the maintenance operations, will allow the control of this aspect and to gather data to confirm this conclusion.

A study was performed during a year, starting from June 2004, for qualitative and quantitative monitoring of the macrobiota remaining on the filtering sieves at the NPP intake, and of the ichtyoplankton and microbiota (phytoplankton and zooplankton) in the flowing water (Ref. 4.1-25). This study allowed to assess the aquatic organisms entrainment and impingement effects in the water intake area.

The obtained results show that entrainment and impingement had a minimum negative impact on the populations in the aquatic environment.

The configuration of the DBSC water intake from Dunarea Veche was designed so that water taking over do not generate strong streams and do not perturb significantly water flow directions in the main stream on this branch. Under these conditions, water taking over has not a strong entrainment effect. Water taking over towards the DBSC race 1 has not effect on the aquatic organisms populations from areas on Dunarea Veche upstream or downstream the intake.

The Cernavoda NPP discharges a fraction of its effluent into the upstream part of the water intake basin during some periods in the cold months of the year. This heated water flow has the purpose to prevent frazil ice entrance to the pumps and to ensure an adequate temperature of water according to the technical requirement for the power plant circuits. The time intervals of partial effluent recirculation depend on the Danube water temperature.

At Unit 1, the fraction of the effluent recirculation during the cold period was between 30 % and 70 %, being most frequently of about 50 %. The recirculation circuit at Cernavoda NPP is sized for a flow of 100 m^3/s representing almost 50 % of the total flow of Units 1, 2, 3 and 4.

The recirculated flow (heated water) is taken by the Cernavoda NPP pumps, through the distribution basin, after it mixes with the flow coming through the derivation canal (water with lower temperature).

Taking into account the recirculation impact assessment for the case of Unit 1 and 2 (Ref. 4.1-12) and the similar proportion for four units of heated water mixing with cold water coming from the Danube, the partial recirculation of the cooling water to the NPP intake canal is not expected to have any negative impact on the derivation canal or in the DBSC race 1.

4.1.16. Estimated Impact on Ground Water. Prevention Measures.

The groundwater circulation and level in the main buildings area at Unit 3, respectively at Unit 4, are controlled through the realization of a shielded drained enclosure (Chapter 4.1.11) at each unit. The shielding structure has the role to avoid the diffusion into the groundwater of eventual leaks during the operation period of Units 3 and 4. Moreover, the groundwater level in the enclosure is maintained at inferior levels in comparison with external groundwater, by a drainage system. Thus, the groundwater flowing from inside to outside through eventual breaks of the shielding structure is avoided. The dosimetrically controlled waters are discharged through a collector in the rainwater sewage. In case of accidental contamination, their discharge in the receptor is stopped until the causes are detected and removed.

For preventing effects from some buildings or installations on groundwater, the design includes drainage systems: at the reactor building, around the spent fuel bay, and at the auxiliary service building.

The eventual effects on groundwater by infiltration in the soil of chemicals, oils or fuel leaks (in normal or abnormal operating regime) are prevented or reduced by collecting and discharge measures and procedures.

The proper transport, handling, storage, collecting and management, according to the specified procedures and regulations in force, will avoid groundwater pollution by the used substances and materials or wastes.

The groundwater pollution possibility due to the accidental infiltration of radioactive or non-radioactive products in the groundwater is reduced to minimum through the taken measures. The permanent radiological control makes possible to discover eventual accidental losses and removal of their causes.

In the conditions shown in Chapter 4.1.1, the Cernavoda NPP operation does not influence the deep groundwater quality.

4.1.17. Estimated Thermal Impact of the Effluent from Units 1, 2, 3, 4 on the Branch Dunarea Veche

The impact of the Cernavoda NPP effluent thermal load is assessed having in view the following aspects (Ref. 4.1-12, 4.1-14, 4.1-15):

- influence of the temperature increase in the effluent on water temperature in the receptor;
- the heated water influence on physical and chemical processes in the receptor, with effects on dissolved oxygen concentration;
- the heated water influence on some biochemical processes with effect on the indicators biochemical oxygen demand, chemical oxygen consumption, nitrates, nitrites and ammonium, total phosphorus;
- influence on biocenosis components.

The results of estimating the effluent influence on water temperature on the branch Dunarea Veche contribute to the support for assessments in the next chapters. The existing regulations in Romania and the Water Framework Directive 2000/60/EC were taken into account, as well as criteria of some international organizations (Ref. 4.1-21).

4.1.17.1. Thermal Impact of the Units 3 and 4 Effluent on the Danube

The heated water flow from the Units 3 and 4 is small compared to the average multi-annual monthly flows on the Dunarea Veche branch. In the discharge downstream neighbor area vertical mixing occurs, and then the thermal plume develops gradually, with decreasing temperature difference.

The water temperature distribution along the branch Dunarea Veche, downstream the effluent discharge was estimated by calculation for characteristic hydrological and meteorological conditions.

The effluent thermal effect estimation by mathematical modeling is based on calculation methods applied in this field (Ref. 4.1-15). The mathematical models used for calculating water flow parameters and water temperature distribution consist of the shallow water equations of free surface water flow on the sector downstream the discharge, together with the continuity equation, and the two-dimensional heat transfer equation in the horizontal plane resulting by integrating over water depth the general heat transfer equation. These models take into account the main local conditions of the riverbed (irregular channel shape) and mixing process, using cross-section profiles and hydrological data. Heat loss by various phenomena and processes is taken into account, but water temperature variation under average values of the meteorological parameters is small during the short time while water flows a few kilometers downstream the discharge section. The depth-integrated heat transfer equation has a structure that include terms corresponding to the mentioned processes:

$$h\left(\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}\right)=\frac{\partial}{\partial x}\left(h\varepsilon_x\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(h\varepsilon_y\frac{\partial T}{\partial y}\right)+\frac{E}{\rho c_P}$$

(h - water depth, T - water temperature, x - longitudinal coordinate, y - transversal coordinate, u - longitudinal flow velocity, ε_x - longitudinal heat transfer coefficient, ε_y - transversal heat transfer coefficient, E - heat transfer from air to water through the unit area, ρ - water density, c_P - specific heat coefficient).

The model is able to provide estimations of the effluent thermal effect along the right bank of the river, under various particular conditions, as shown below by comparisons of calculation results with measurement results.

For estimating the effluent thermal effect in characteristic situations, monthly values were used for water levels, flows, water temperature and meteorological parameters, as well as the values of the Units 3 and 4 effluent parameters. For winter months, with monthly average water temperature under 5 °C, a recirculated flow of 50 % of the total cooling water flow was considered. Figures 4.1.17.1-1 to 4.1.17.1-12 show estimations of the thermal plume extension along the Danube branch Dunarea Veche. Water temperature increase is presented by calculated isotherms.

The results obtained for all the months indicate that, under the effect of the effluents from two NPP Units, a water temperature increase of 3 °C is anticipated to occur within the initial vertical mixing area and beyond it in some situations, along the river right part. A water temperature increase of 2 °C occurs at the right bank on a longer distance than in the case of Unit 1, but the influenced area is still small. This is a small variation of the water temperature in comparison with the natural temperature variations on the lower Danube from a year to another, every month (Figures in Annex A.4.1.2). In most part of each cross-section on Dunarea Veche downstream the effluent, the natural thermal regime of the Danube water is not modified.

The fact that the thermal impact on Dunarea Veche of the Units 3 and 4 effluent occurs in limited area is also shown by the results of the measurement and estimations about the Unit 1 effluent (Ref. 4.1-13, 4.1-14, 4.1-15).

The temperatures in the Unit 1 effluent and in the water source were measured by CNE PROD (Ref. 4.1-14). The measured effluent temperatures are within the limits established by the regulation NTPA 001 (Government Decision 352/2005) for waste waters discharge into surface waters and by the Water Management Authorization issued by the waters authority for the Cernavoda NPP.

The local specific conditions on the Danube do not allow fast mixing of the effluent over the cross section, as remarked during the field campaigns. Downstream the Unit 1 effluent discharge, there is an initial vertical mixing area along the right bank, and then the thermal plume (Figure 4.1.17.1-13) extends gradually in the branch cross section. The observations on the Danube and the measured temperatures during the Unit 1 heated water discharge show that the thermal plume can be identified along distances of kilometers.

The data measured both in periods with usual hydrological and meteorological conditions and also during time intervals with extreme conditions provide results regarding the effluent thermal influence in the area downstream the discharge, in various situations encountered in the years 2001, 2003, 2004, 2006. Extreme hydrological conditions were encountered during the summer and autumn of 2003 when extremely low flows occurred (including the absolute minimum water flow recorded at the Cernavoda HS). Higher water levels than the average ones occurred in April and May 2004. Very low water temperatures were encountered in January and February 2004, and high water and air temperatures during the summer in 2001 and 2003.

Figures 4.1.17.1-14 to 4.1.17.1-23 provide an overall view of the thermal effect due to the effluent from one NPP unit, along the right bank of the Dunarea Veche branch. The values in the figures are average temperatures over water depth. The figures present the Danube water temperature measured upstream the effluent and values measured in the effluent and in several sections downstream. For a better view of areas with water temperature increase along the river right side, the figures include also isotherms obtained by calculation.

The data sets obtained in all seasons show that along the initial vertical mixing area, water temperature increase due to the effluent becomes lower than 3 °C in most situations, and the corresponding transversal area is much less than a quarter of the branch cross section area.

Further downstream, the water temperature differences due to the Unit 1 effluent decrease under 2 °C at a distance of about 2 km in most situations. During partial recirculation of the effluent, although the flow discharged from one unit into Dunarea Veche is smaller, the results in figures show that the effect downstream is not very different.

The results of water temperature measurement indicate that the Unit 1 effluent water mixing process in the river is practically finished in the area at km 285 - 283 on Dunarea Veche, as regard the thermal effect. The mixing degree of the effluent from one NPP unit in the Danube water was estimated by comparing the water temperature values measured across the branch in several sections. The results are shown in Figures 4.1.17.1-24 to 4.1.17.1-27 for average river water levels, low flow, high flow, and during heated water recirculation.

4.1.17.2. Cumulated Thermal Impact of the Effluents from the Units 1, 2, 3, 4 on the Danube

The physical and chemical parameters of the discharged water from Units 1, 2, 3 and 4 are similar to the case of one unit, the differences coming from the increased effluent flow. The total design water flow discharged from Units 1, 2, 3 and 4 is 216 m^3/s, in comparison to 108 m^3/s from two NPP units. For winter months, with monthly average water temperature under 5 °C, a recirculated flow of 100 m^3/s from the total cooling water flow wads considered.

The effluent temperature increase above the source water is envisaged to be similar as for Unit 1.

Estimated temperature distributions along the branch Dunarea Veche are presented in Figures 4.1.17.2-1 to 4.1.17.2-12. The figures show, by calculated isotherms, the longitudinal decrease of the temperature in the thermal plume, in situations corresponding to average Danube flows (e. g. January, July), high flows (e. g. April), and low flows (October). The isotherms show the longitudinal extension of the areas at the right bank with water temperatures higher than the average temperatures upstream on the Danube.

Due to the effluent flow value (four times the flow value from one NPP unit), the cumulated thermal effect of the effluent of Units 1, 2, 3 and 4 on the branch Dunarea Veche is spatially larger, but the temperature in the discharge section is about the same as in case of one unit. Along the branch, the effluent influence occurs at longer distances, because of the effluent flow value. In the existing conditions on the Danube, the envisaged temperatures of the NPP effluent are within the limit of 35 °C, established by NTPA 001 (Government Decision 352/2005). The branch transversal section part influenced by the effluent with 3 °C increase can be generally up to a quarter, in conditions of multi-annual average monthly flows on the Danube (flow values larger than 1500 m^3/s, Table 4.1.2.1-1).

The thermal and chemical monitoring program, together with the environmental management system of the Cernavoda NPP will be useful for the effluent effects control and receptors water quality protection.

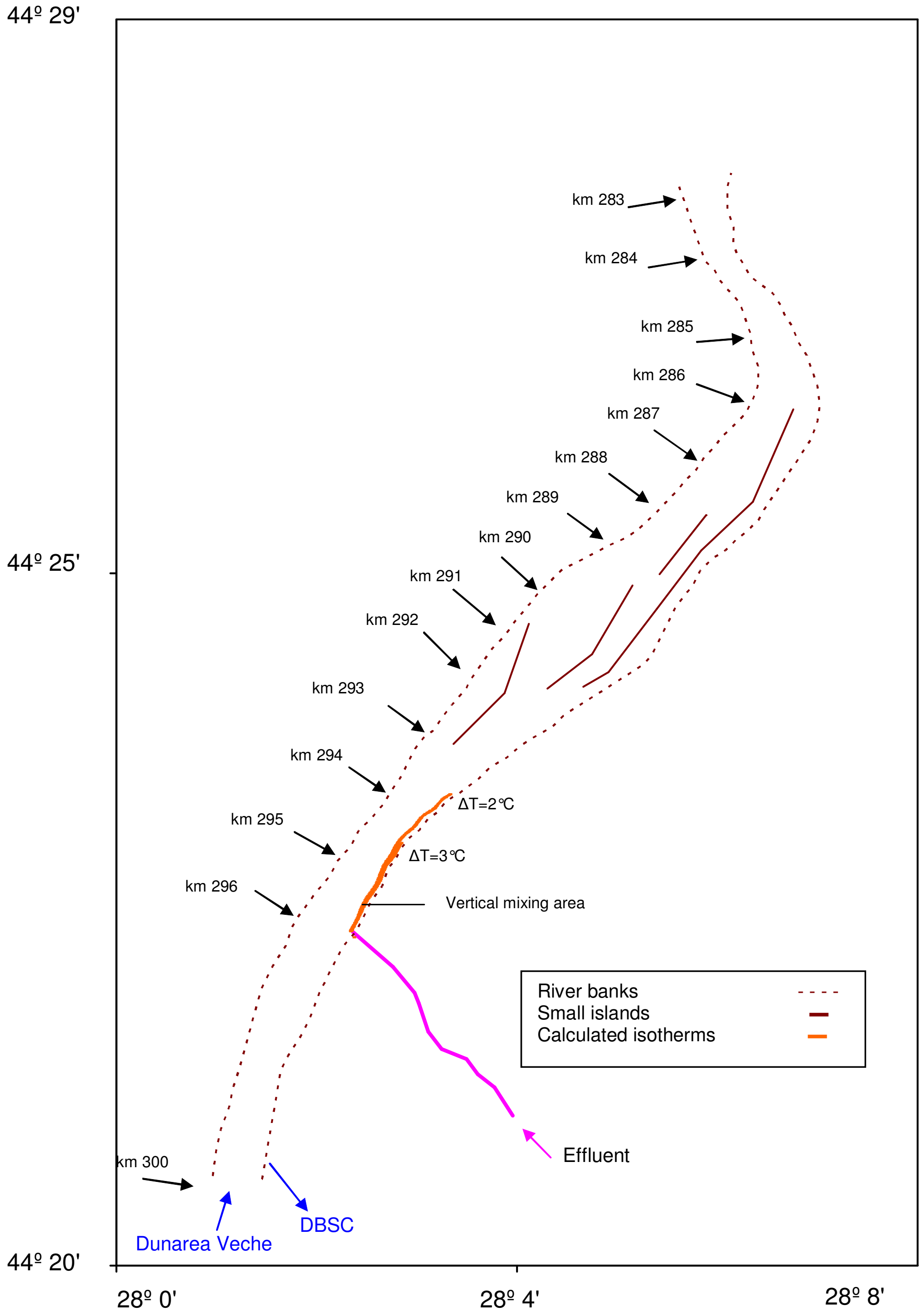

Figure 4.1.17.1-1. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in January (recirculation)

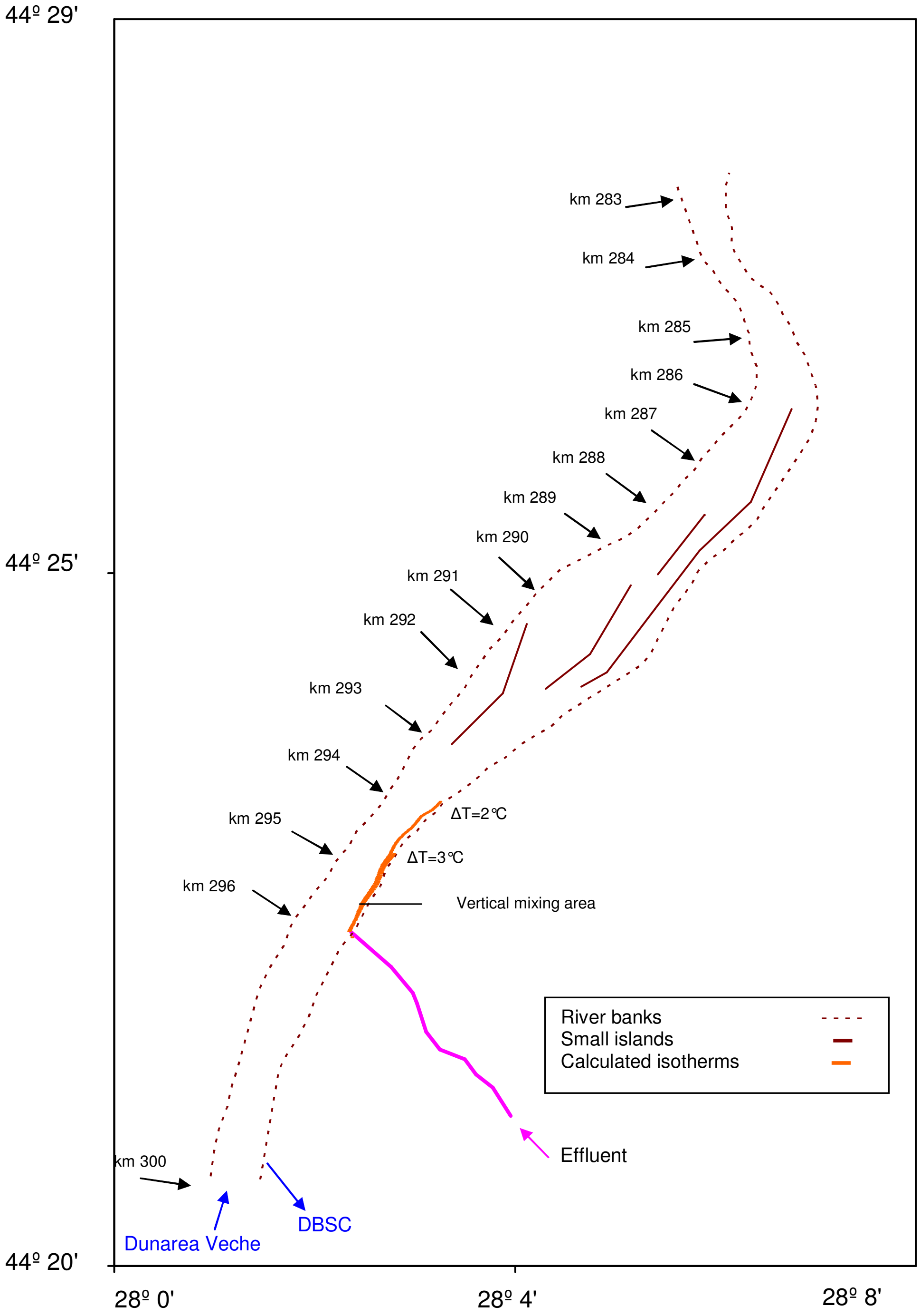

Figure 4.1.17.1-2. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in February (recirculation)

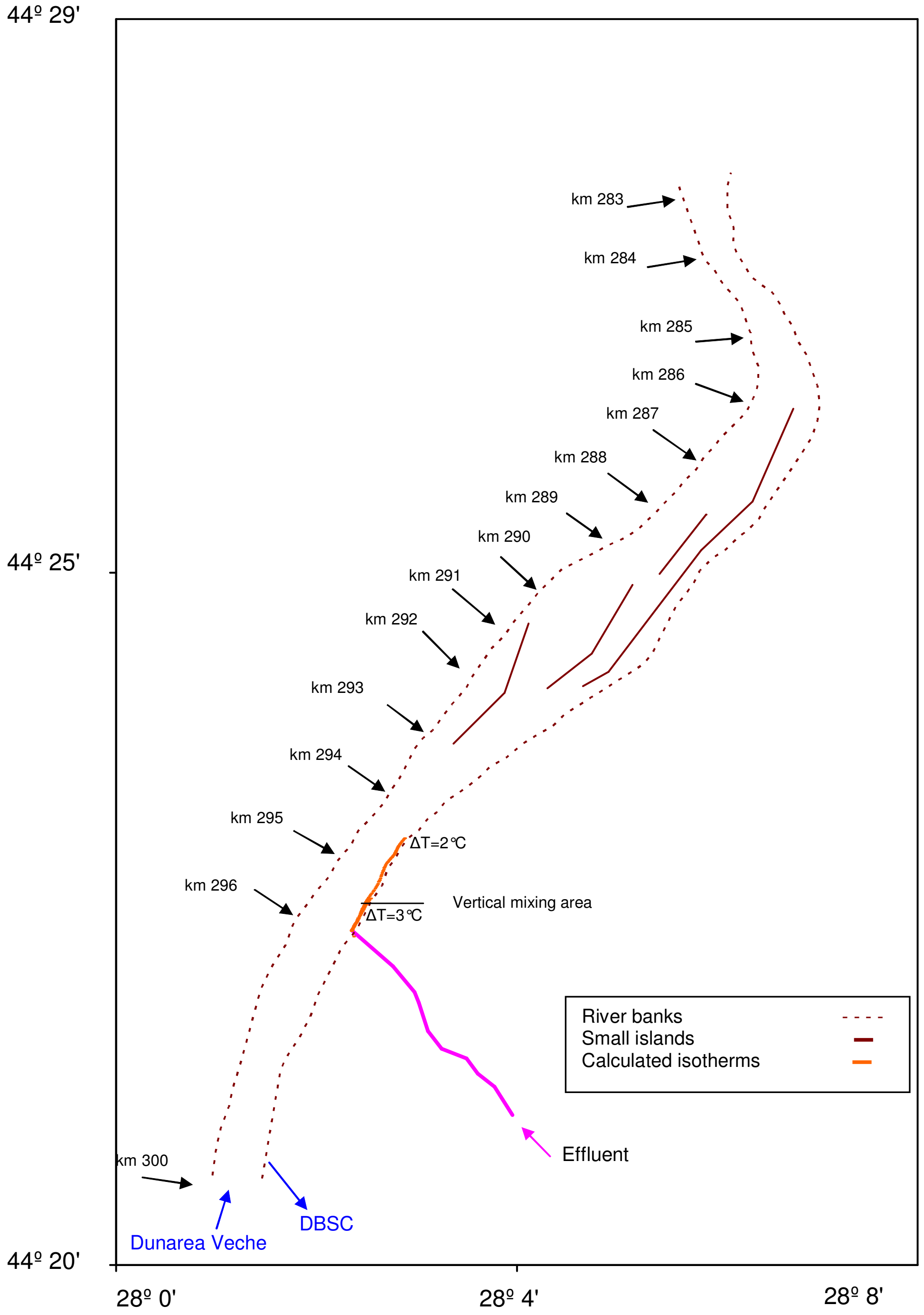

Figure 4.1.17.1-3. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in March (recirculation)

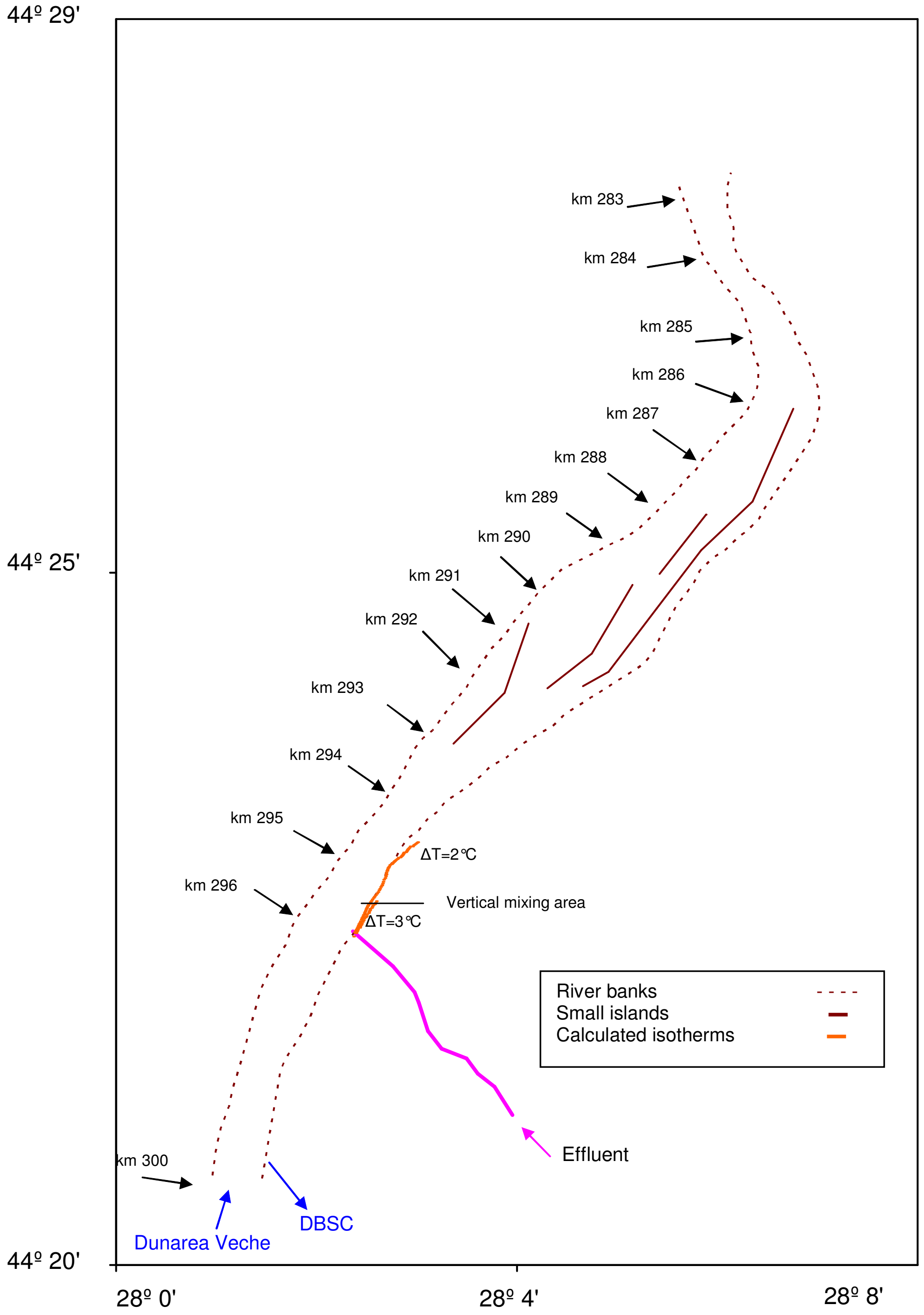

Figure 4.1.17.1-4. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in April

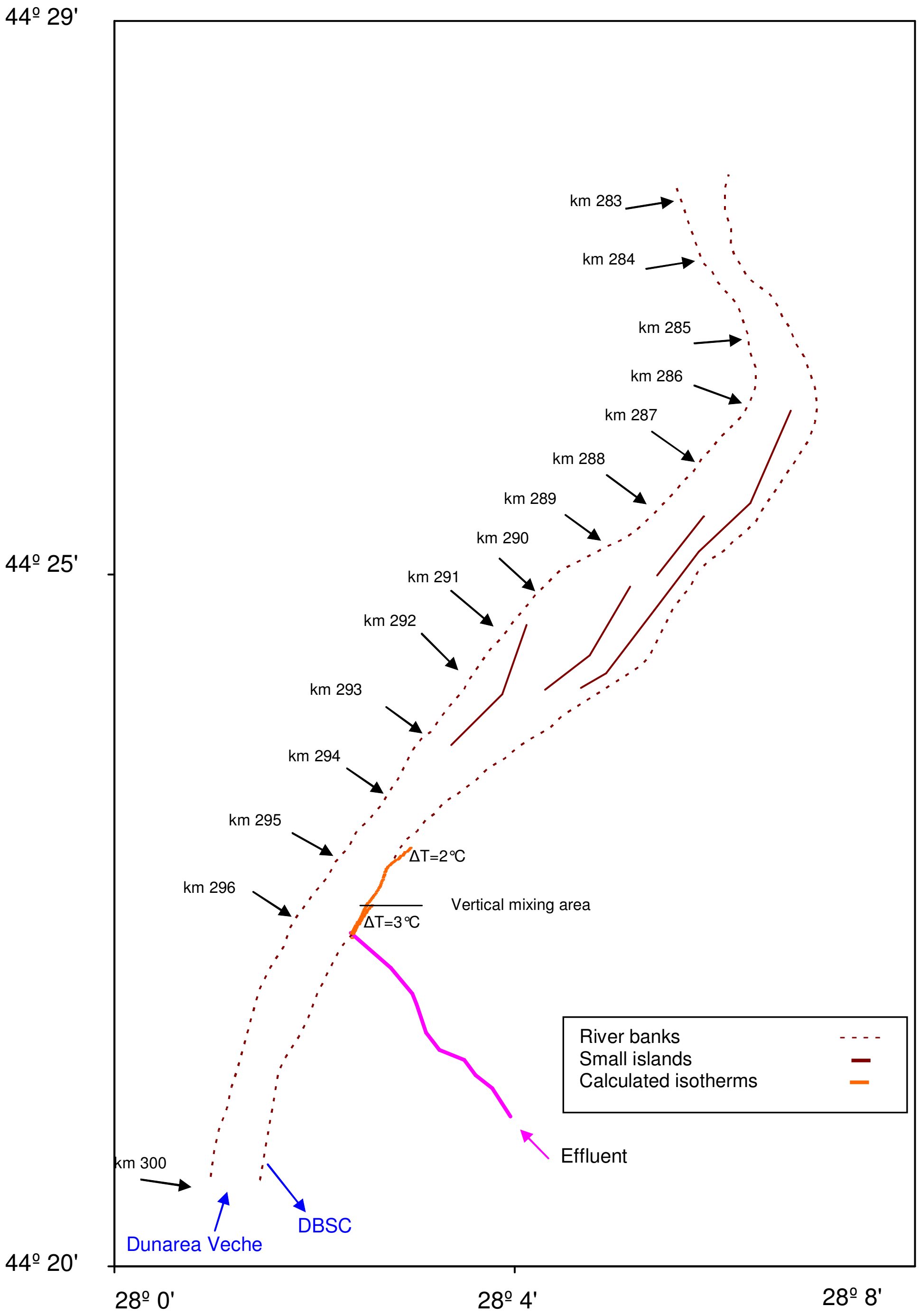

Figure 4.1.17.1-5. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in May

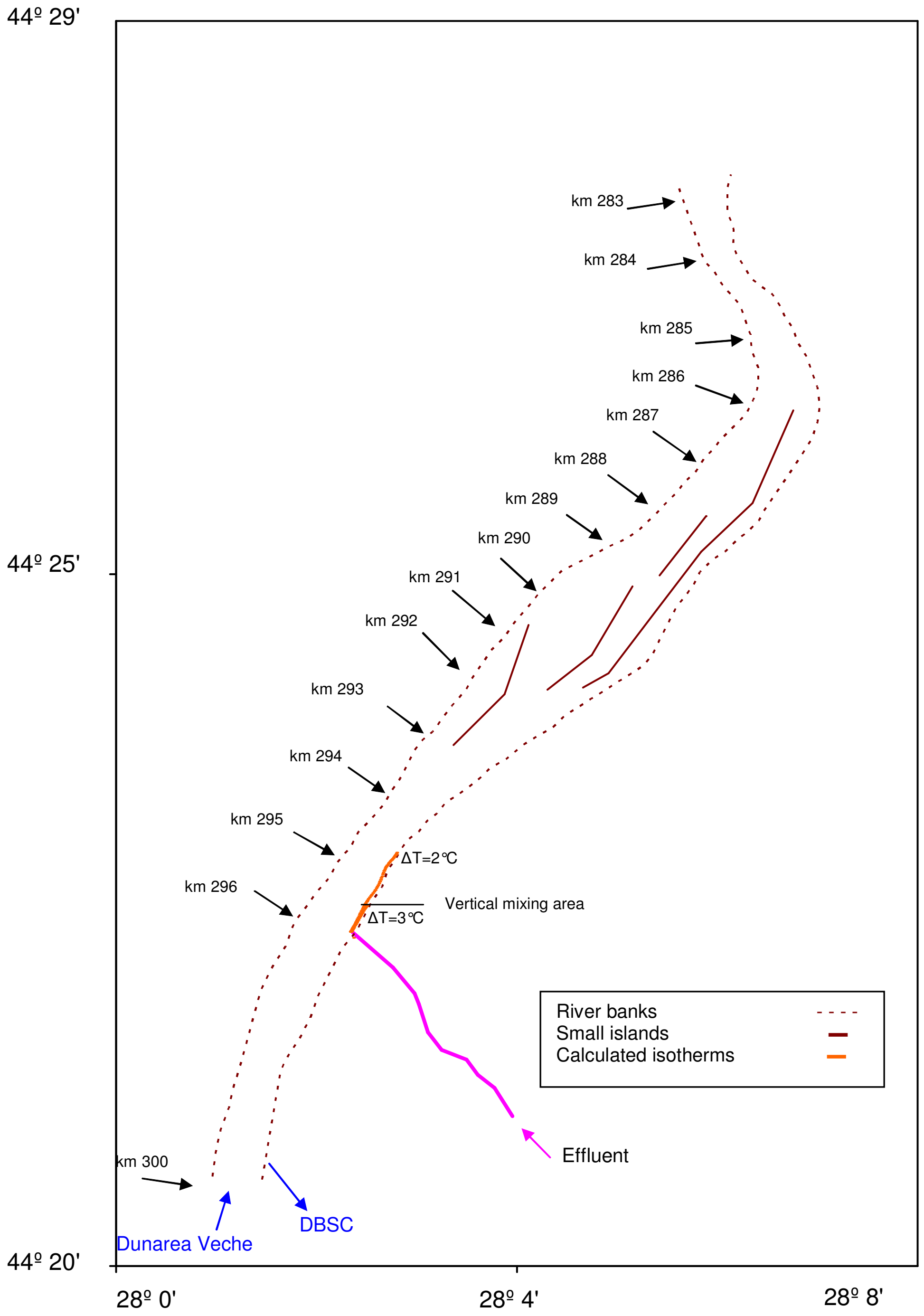

Figure 4.1.17.1-6. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in June

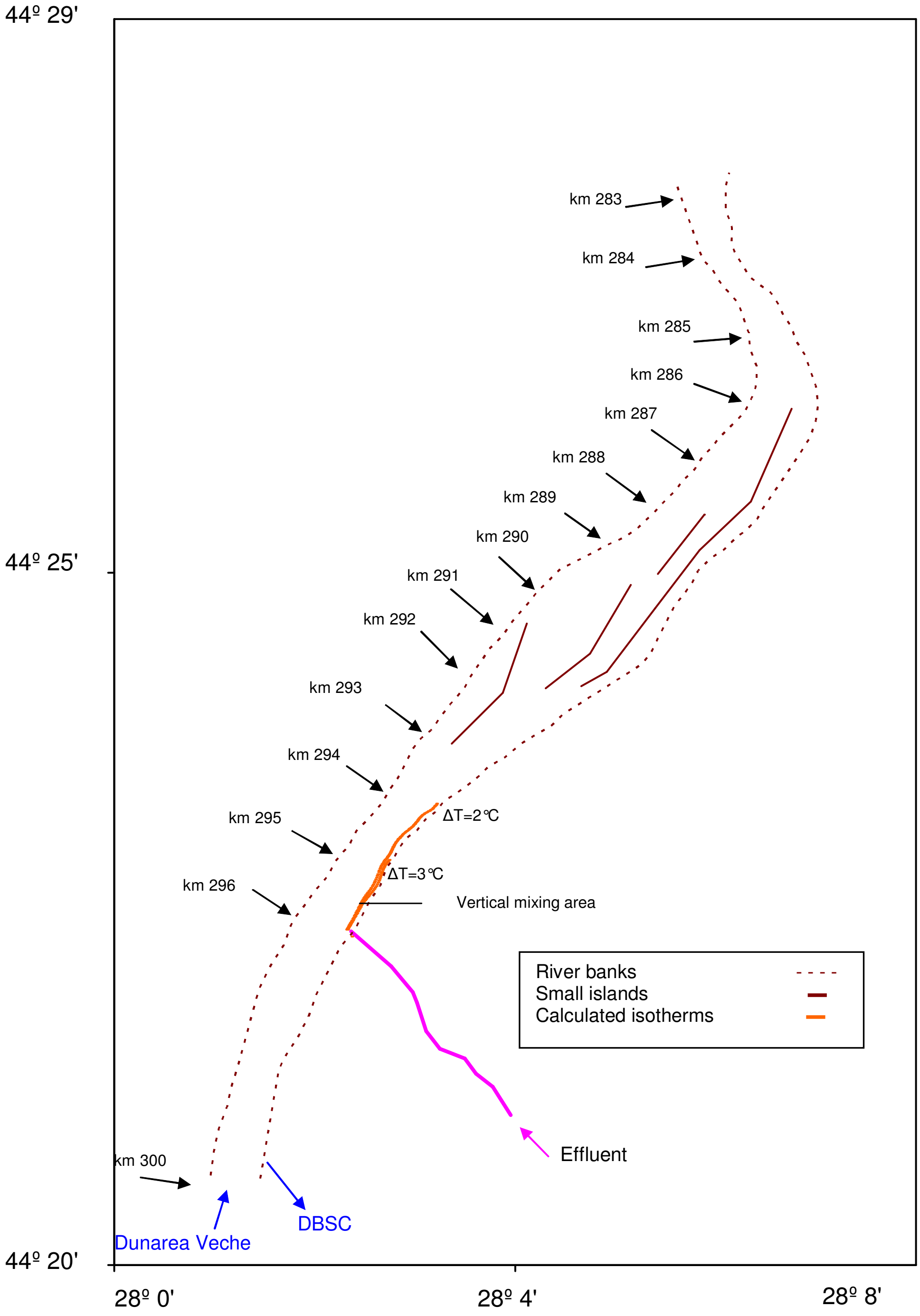

Figure 4.1.17.1-7. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in July

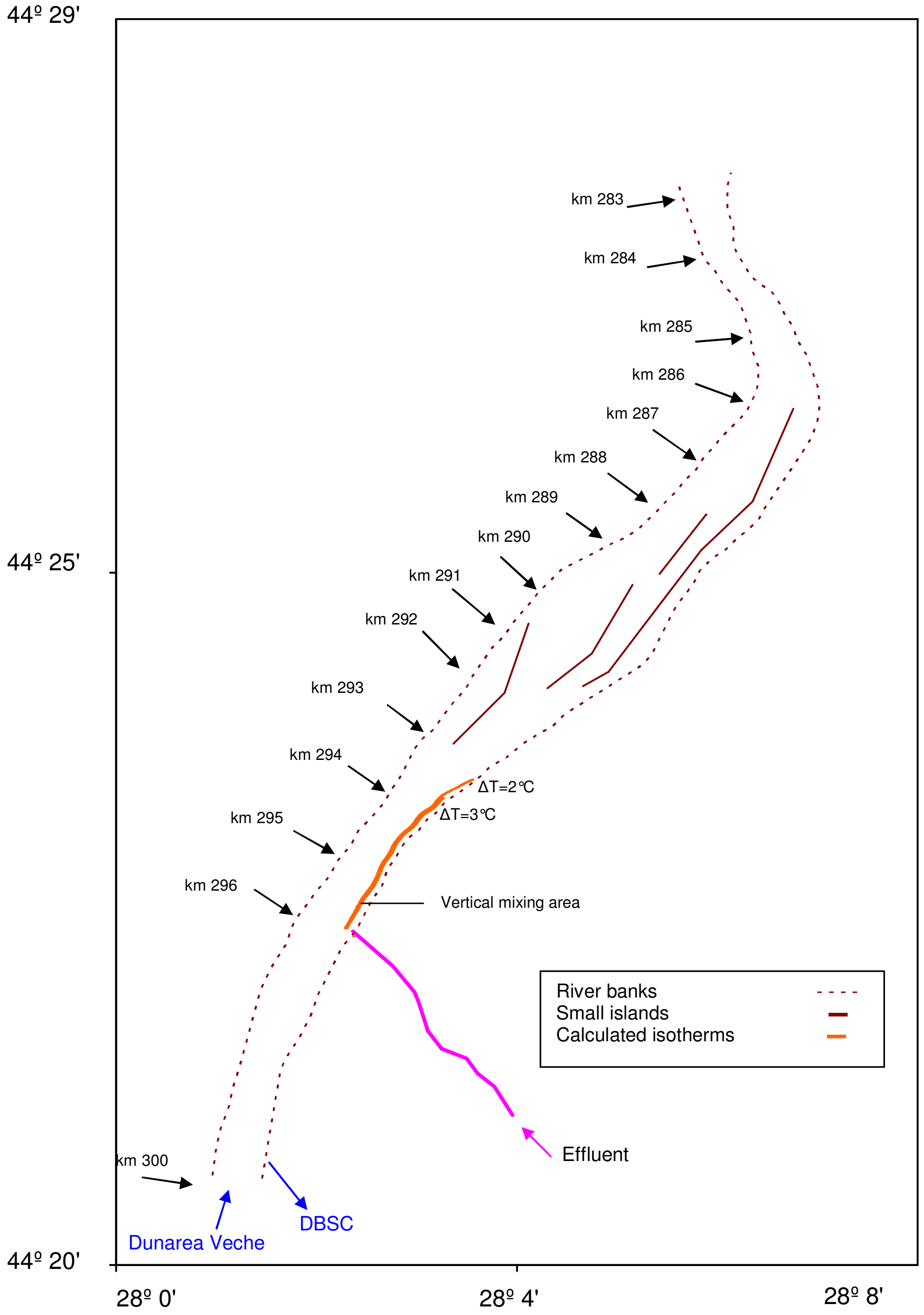

Figure 4.1.17.1-8. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in August

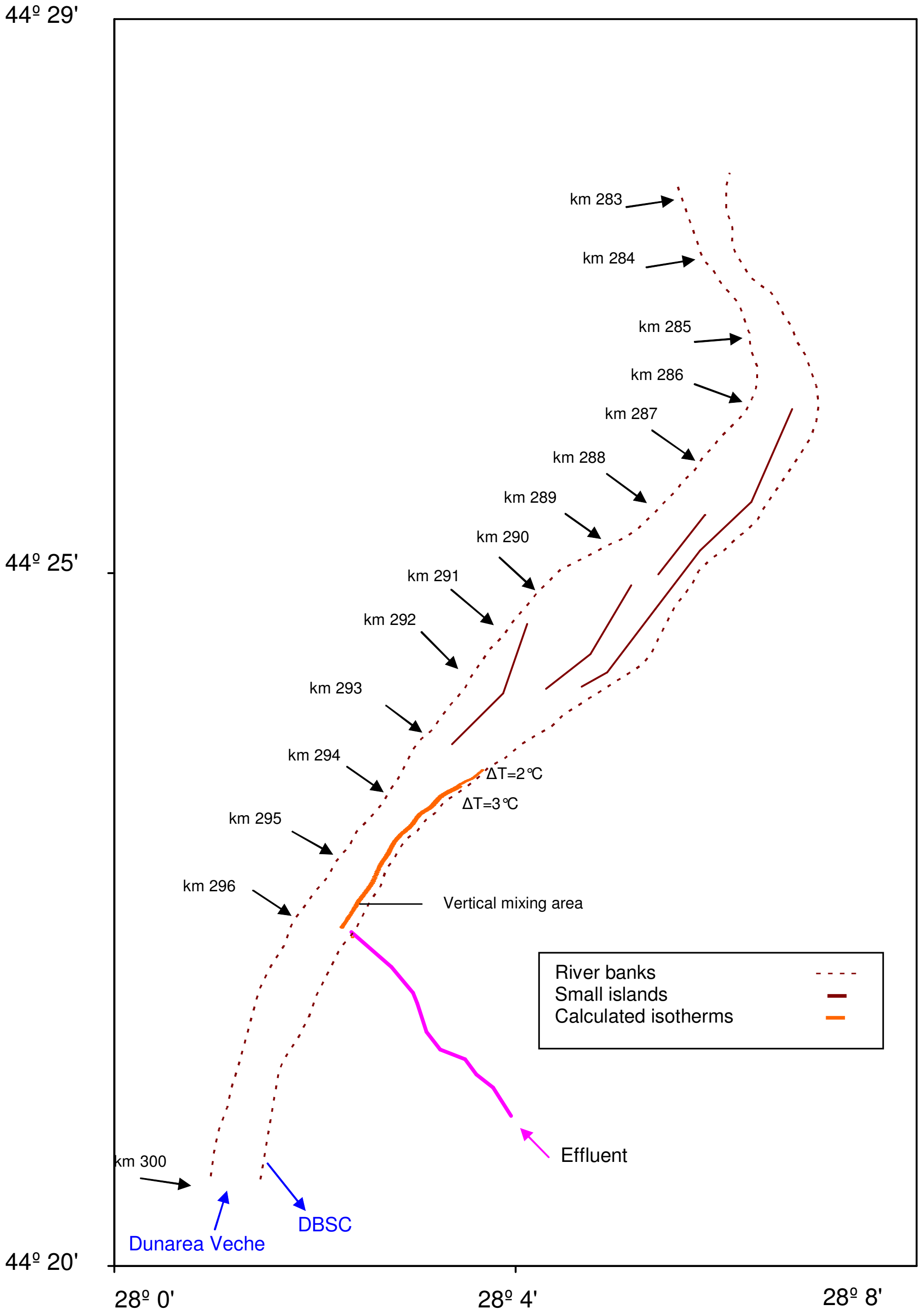

Figure 4.1.17.1-9. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in September

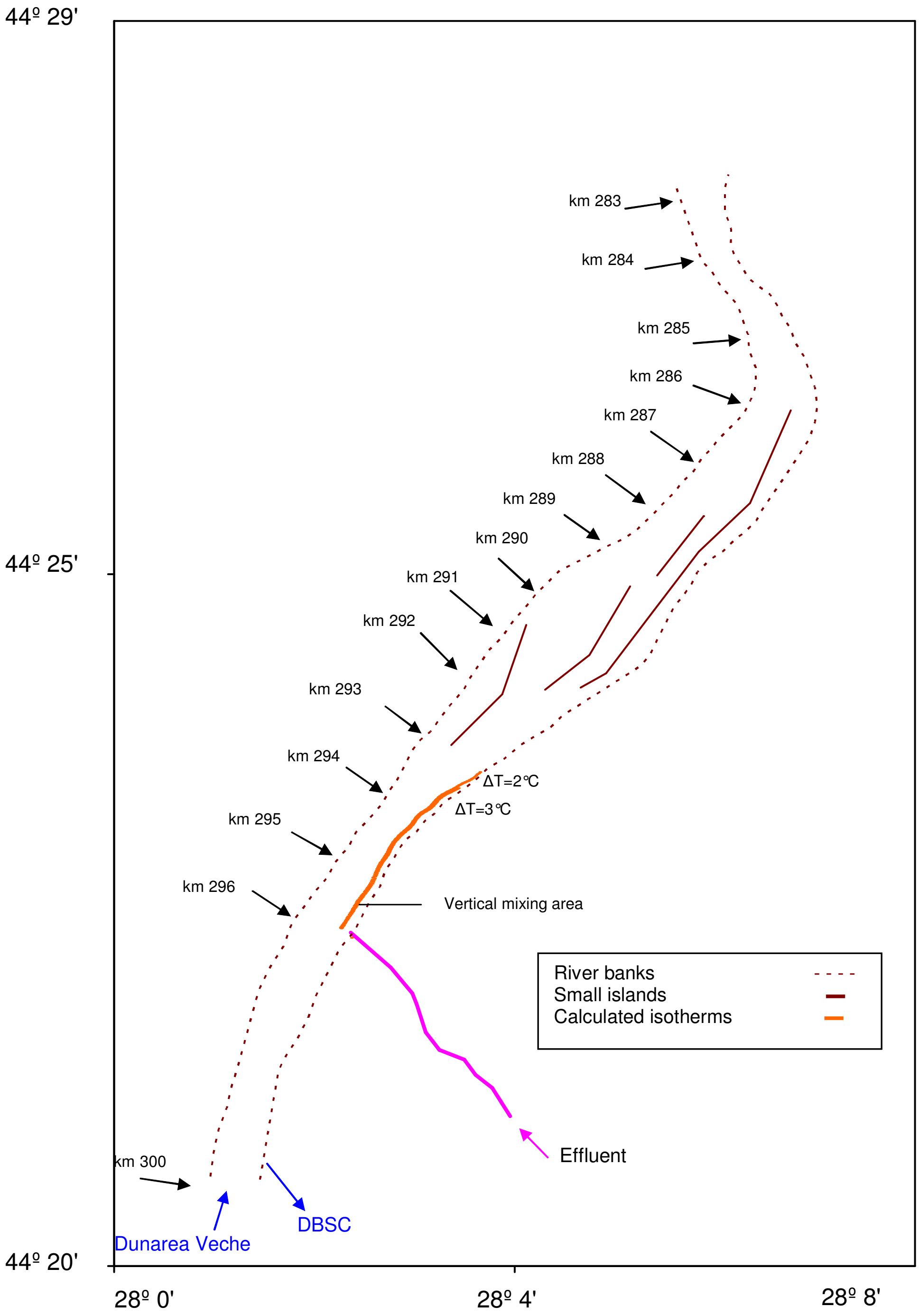

Figure 4.1.17.1-10. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in October

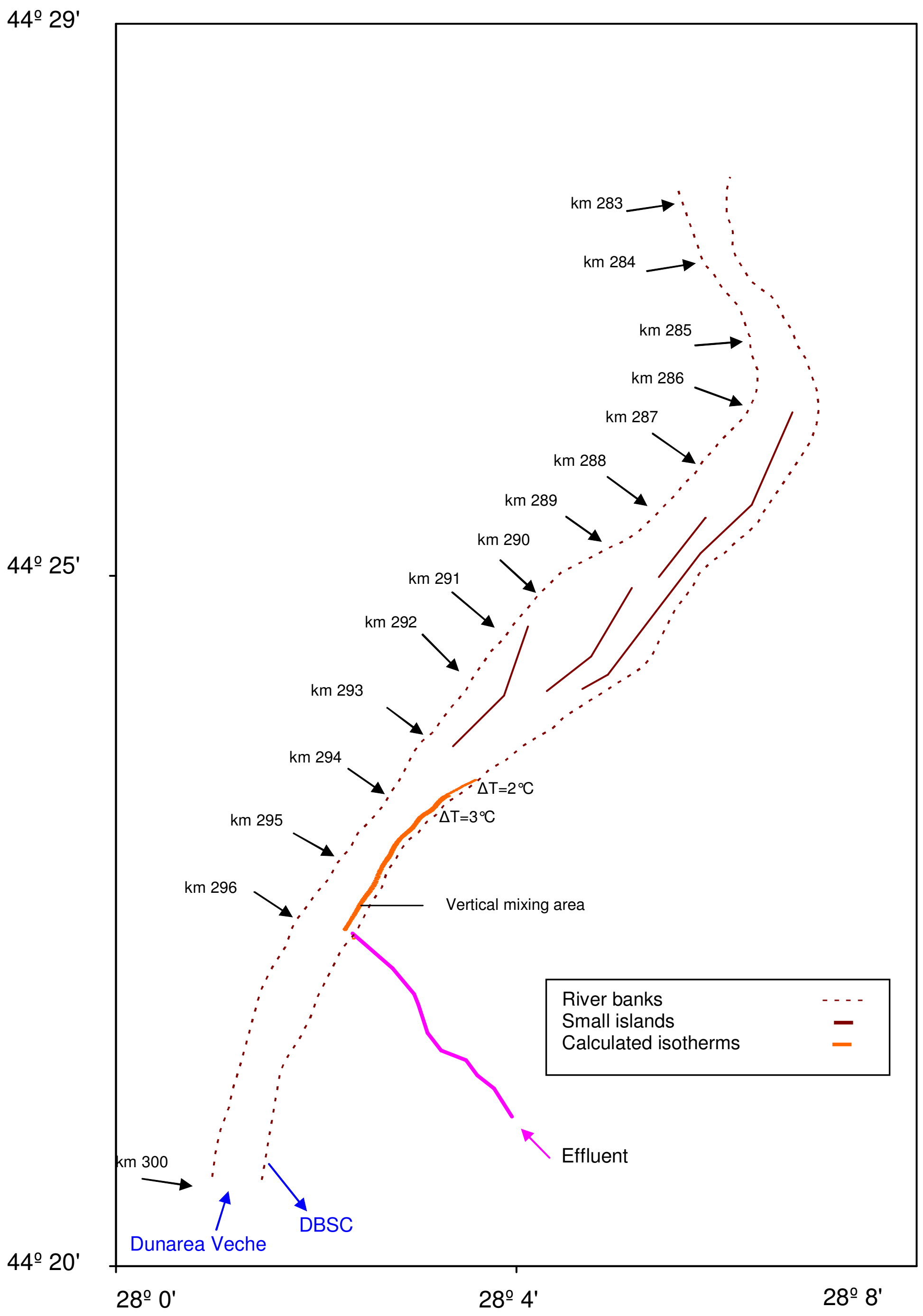

Figure 4.1.17.1-11. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in November

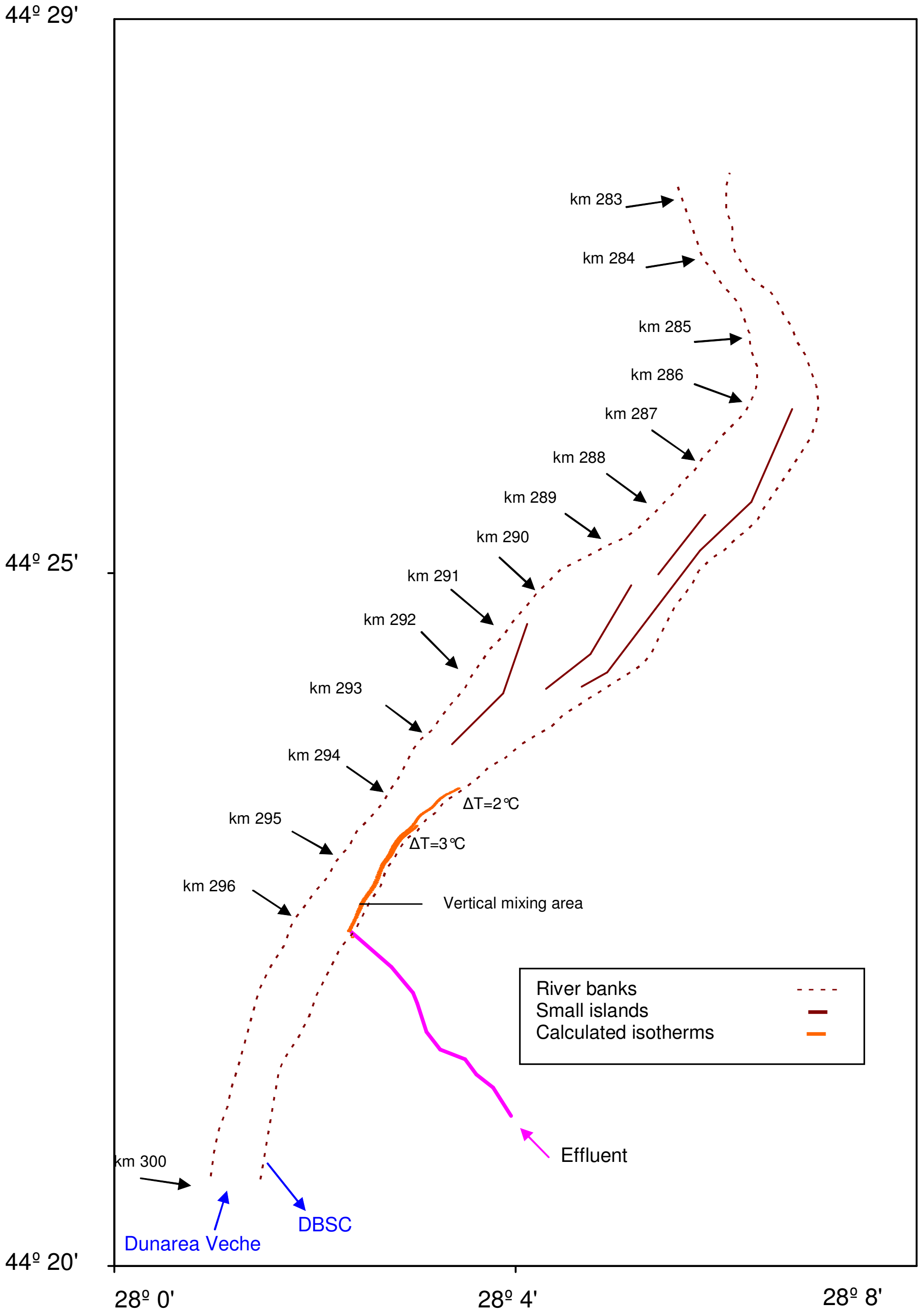

Figure 4.1.17.1-12. Calculated isotherms due to the effluent from the NPP Units 3 and 4, under average conditions in December (recirculation)

Figure 4.1.17.1-13. Thermal plume limit at water surface (effluent from Unit 1)

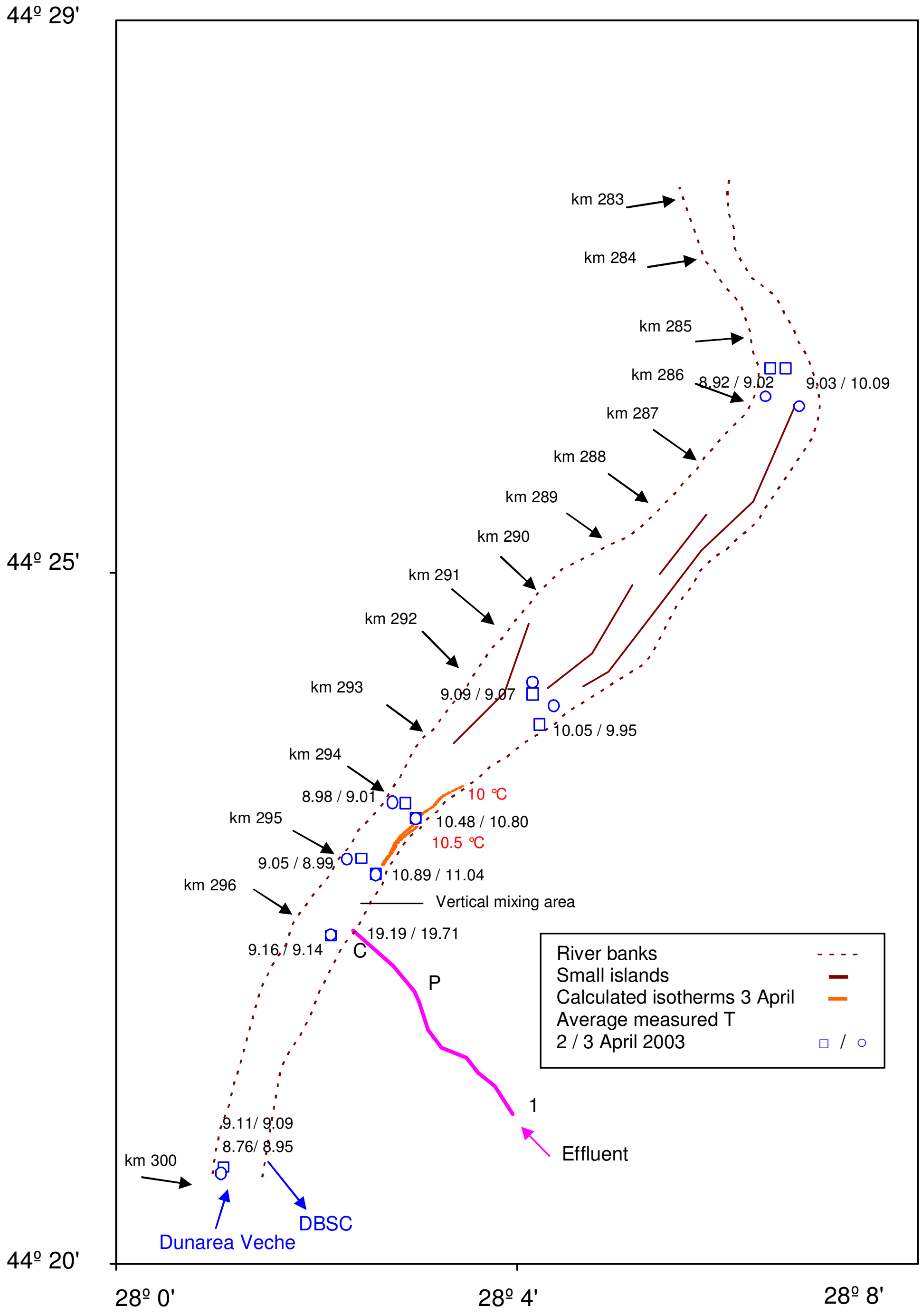

Figure 4.1.17.1-14. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in April 2003 (average water level)

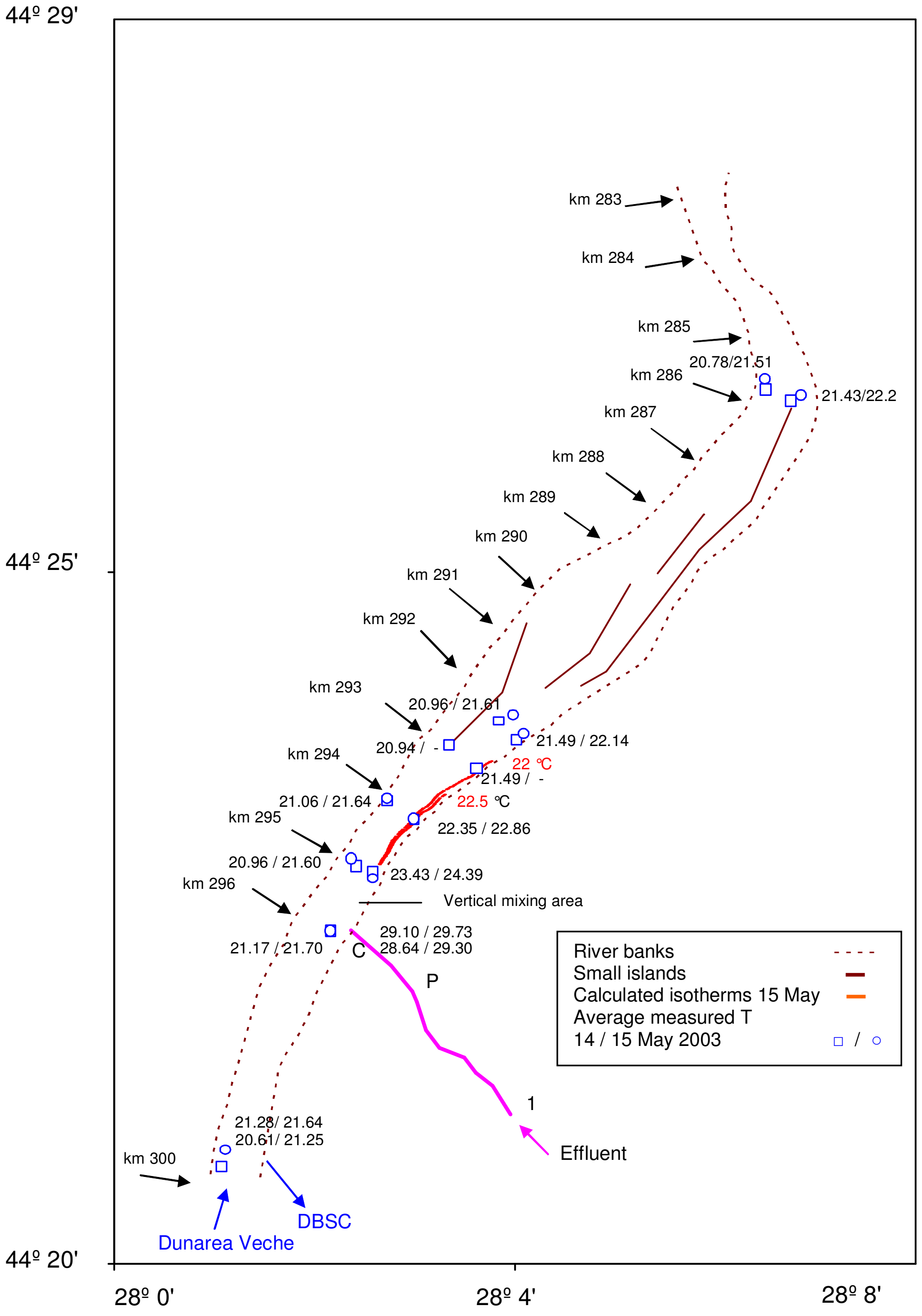

Figure 4.1.17.1-15. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in May 2003 (average water level)

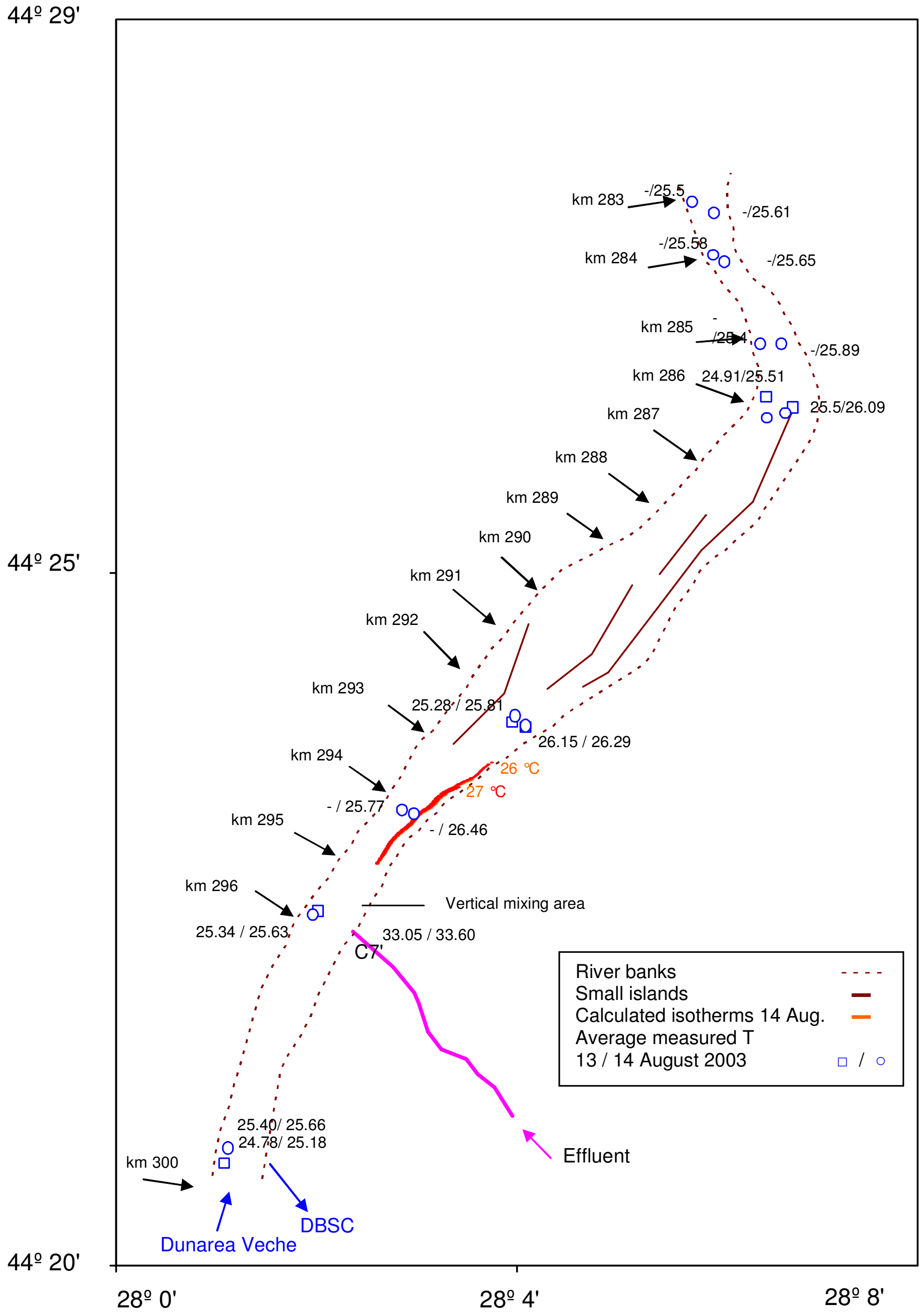

Figure 4.1.17.1-16. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in August 2003 (extremely low water level)

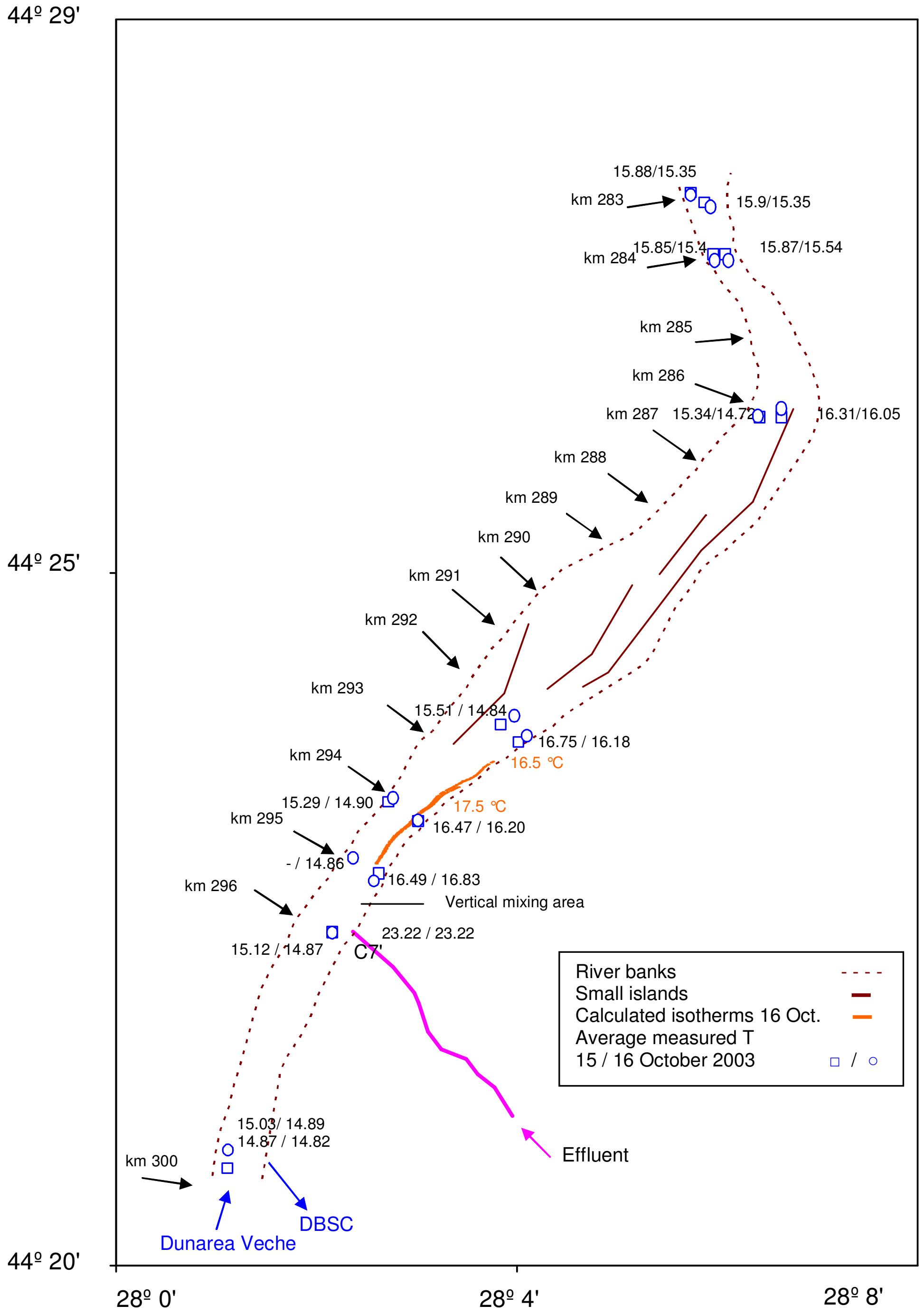

Figure 4.1.17.1-17. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in October 2003 (extremely low water level)

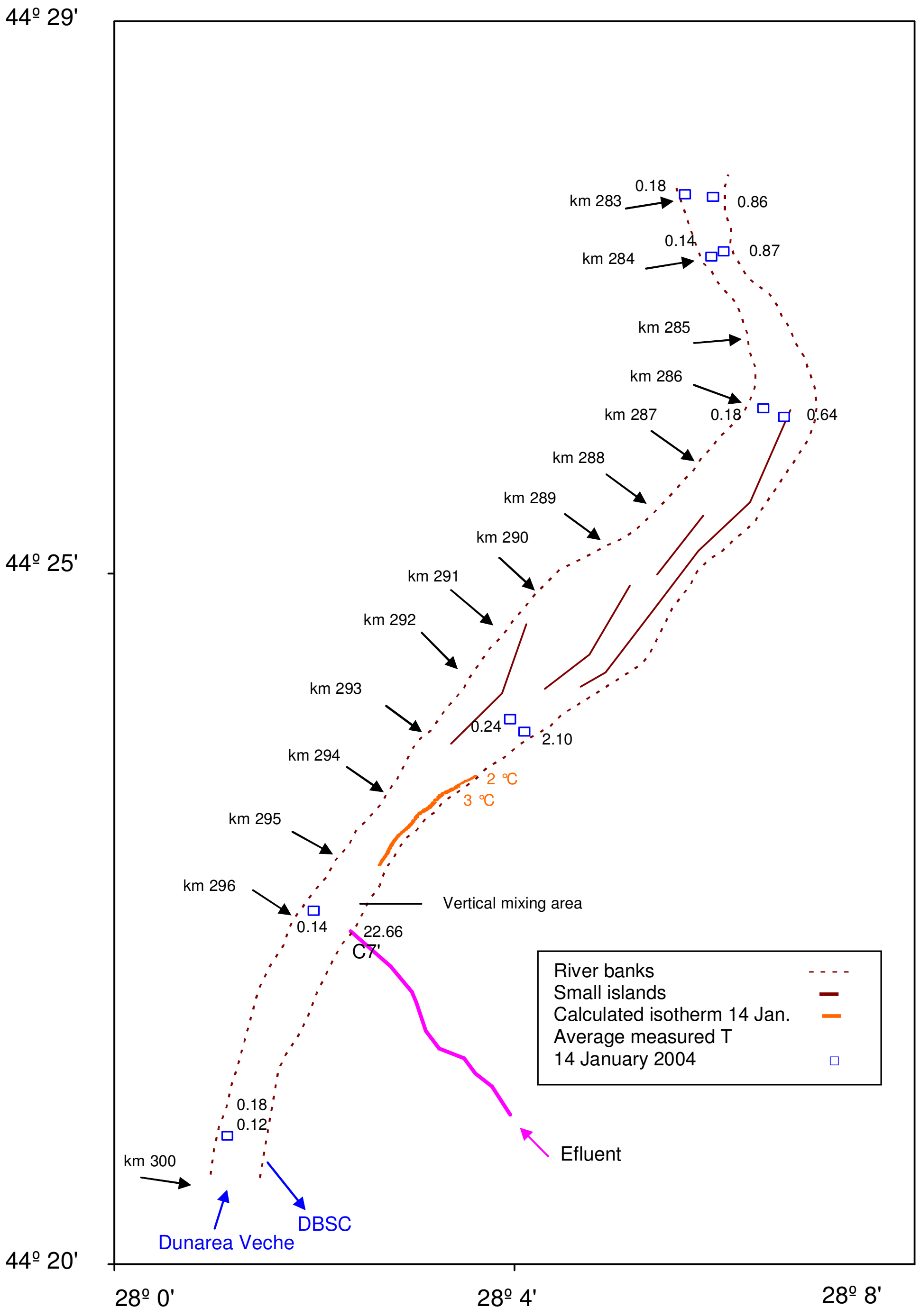

Figure 4.1.17.1-18. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in January 2004 (low water level, partial effluent recirculation)

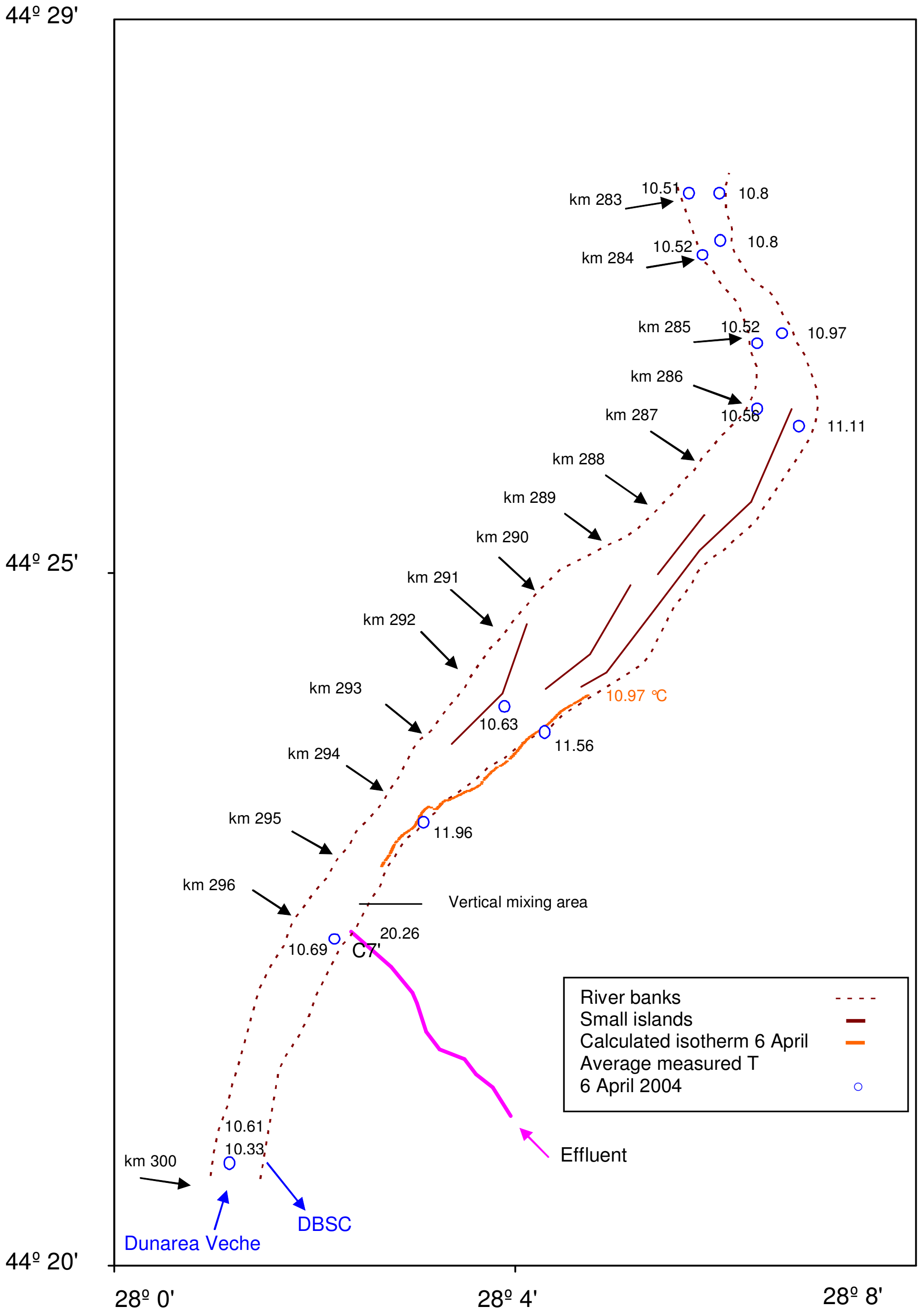

Figure 4.1.17.1-19. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in April 2004 (high water level)

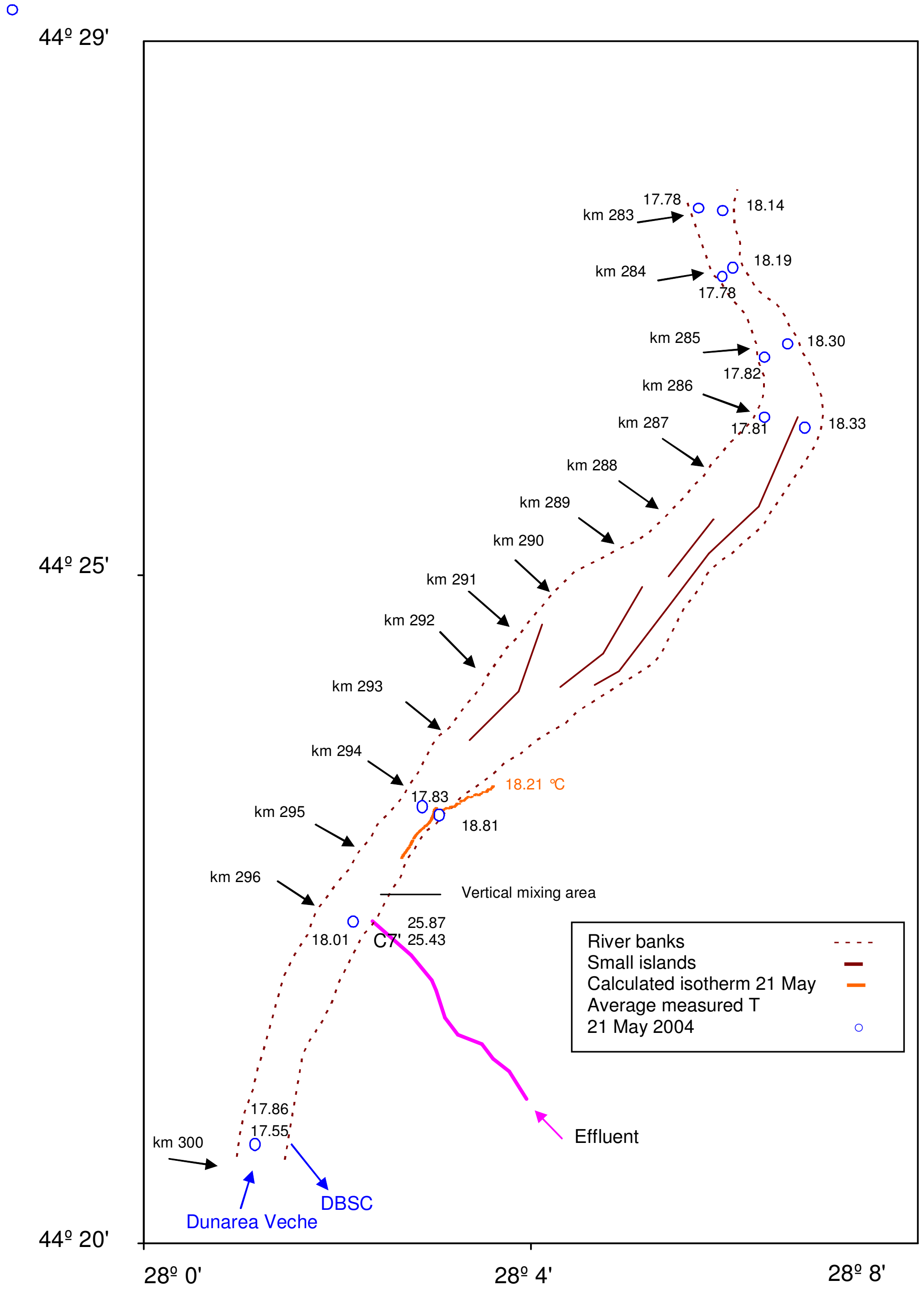

Figure 4.1.17.1-20. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in May 2004 (high water level)

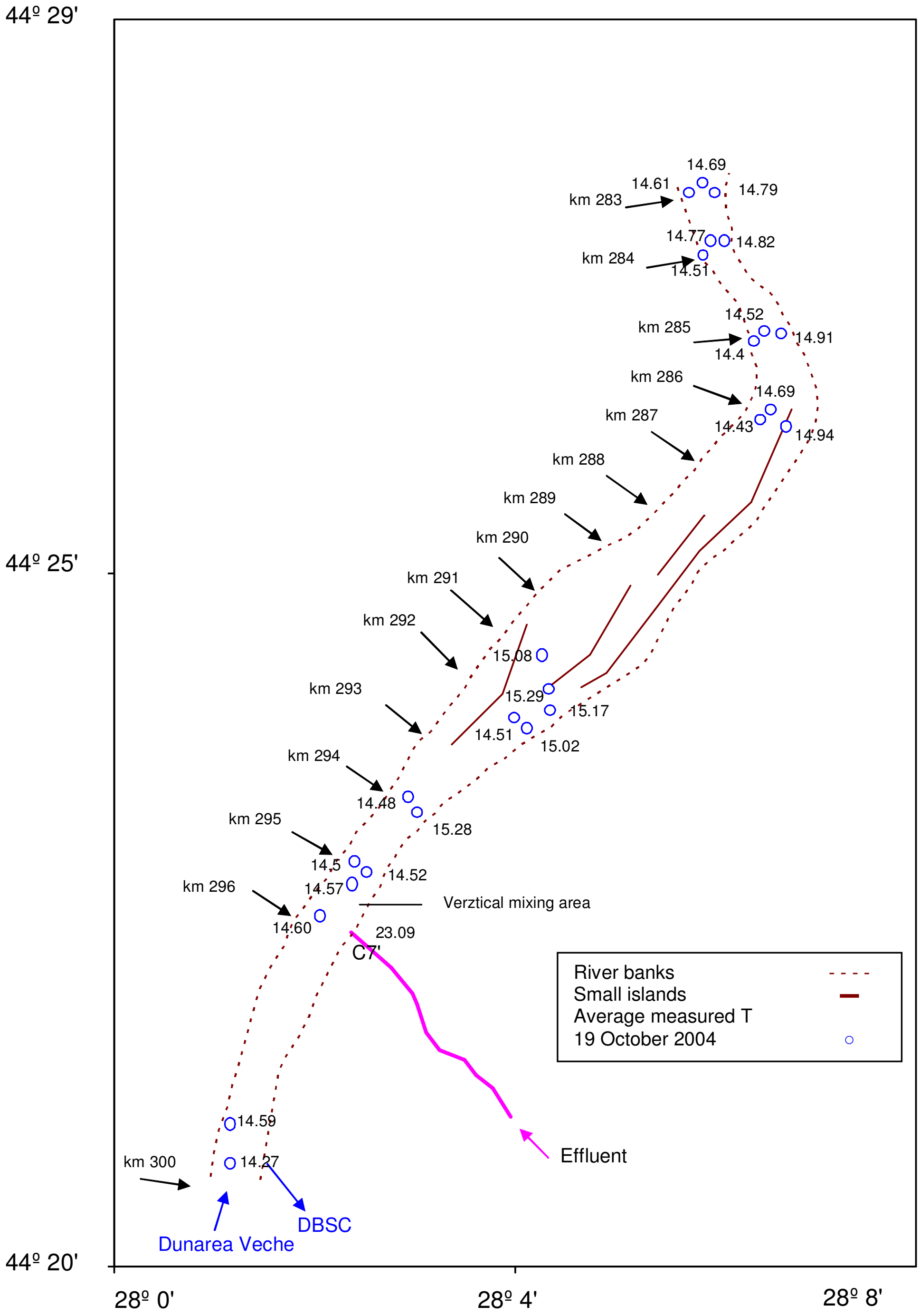

Figure 4.1.17.1-21. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in October 2004 (average water level)

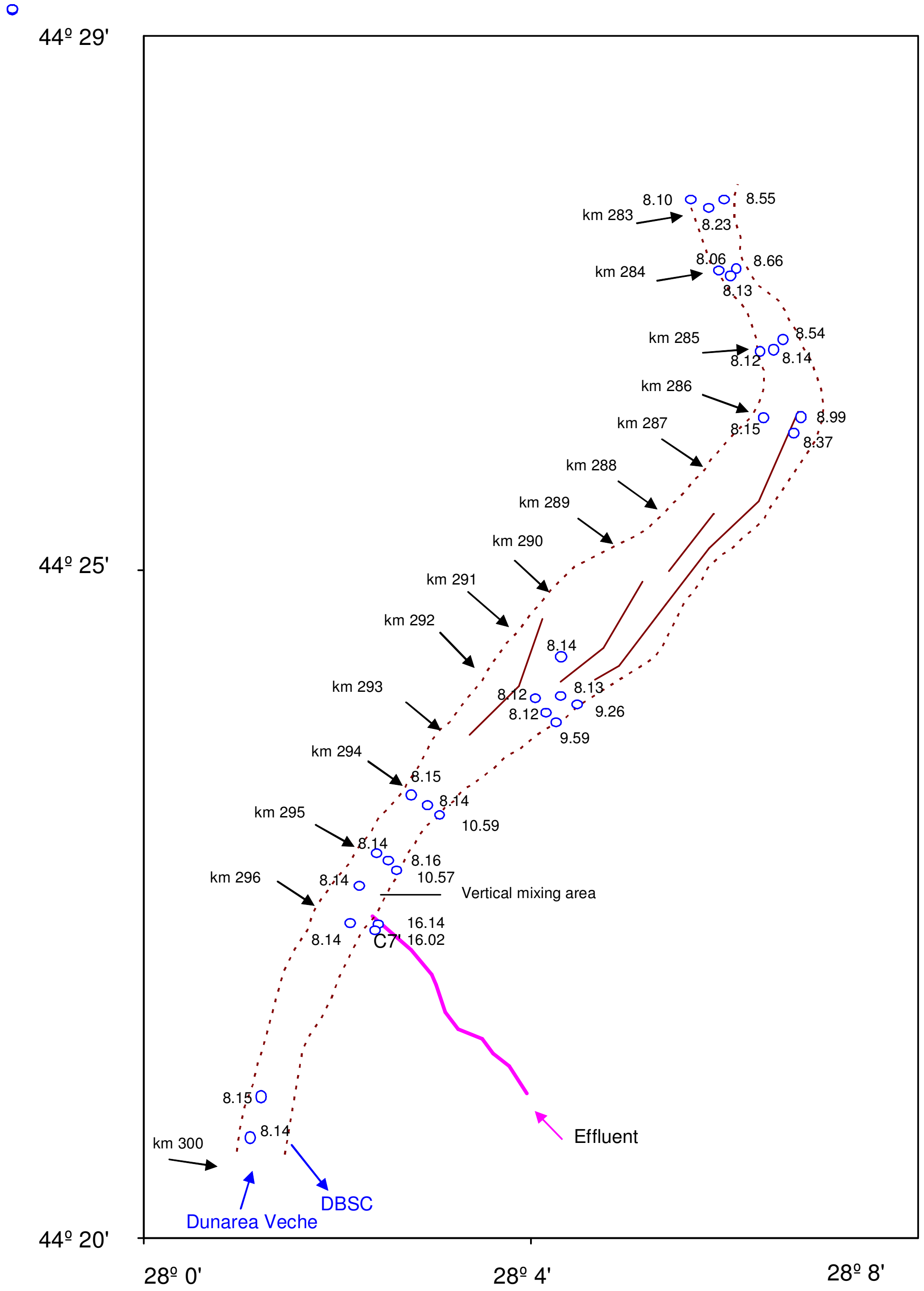

Figure 4.1.17.1-22. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in November 2004 (high water level)

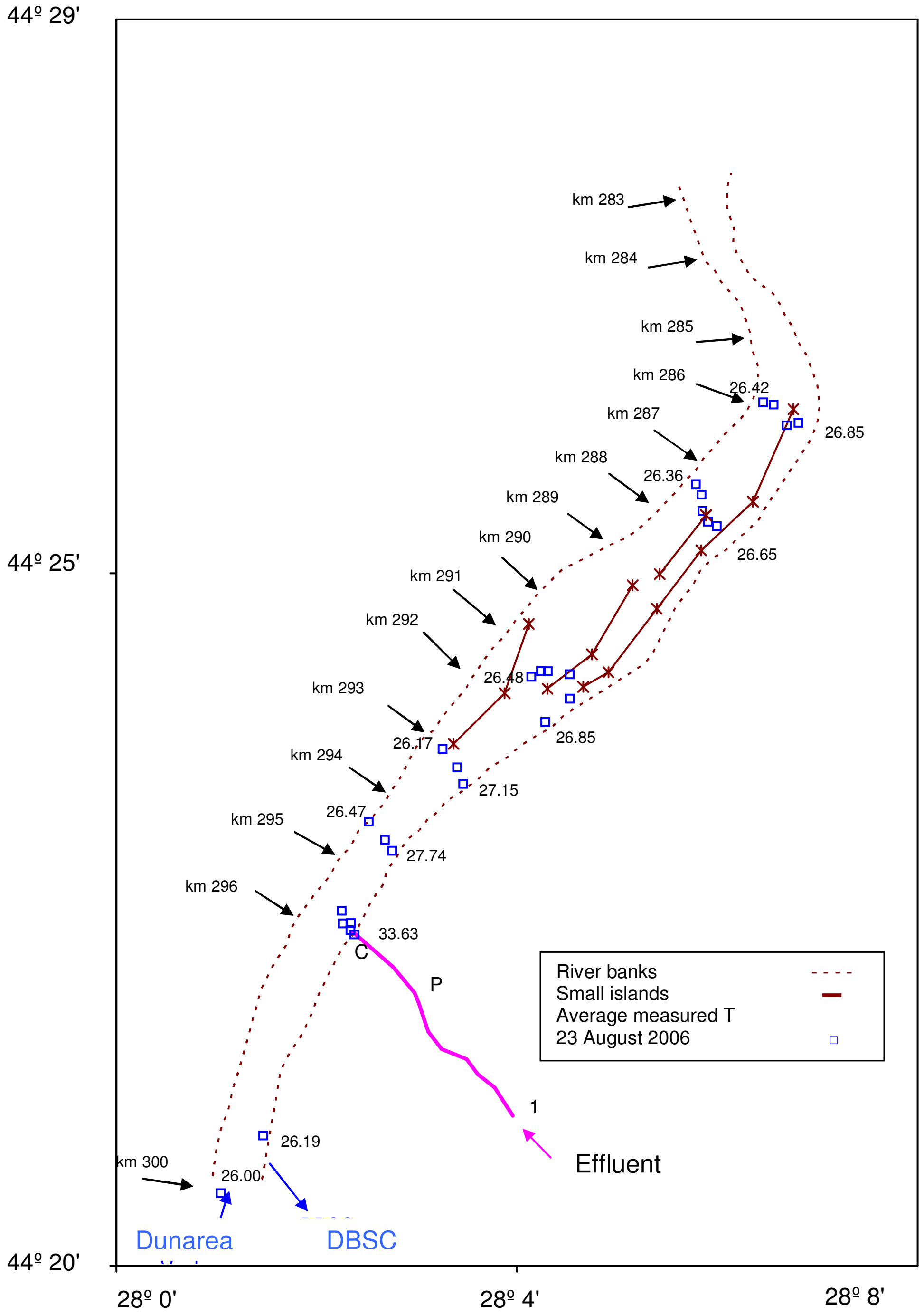

Figure 4.1.17.1-23. Water temperatures on Dunarea Veche, due to the effluent from one NPP unit, in August 2006 (average water level)

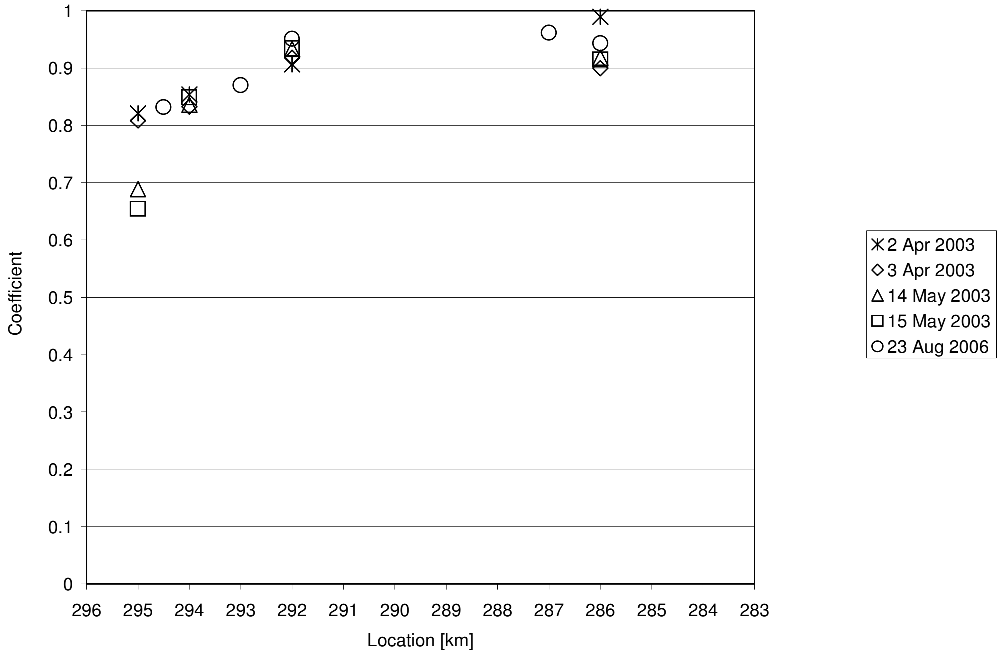

Figure 4.1.17.1-24. Mixing degree of the effluent from one NPP unit, in the Danube water, during average flow values

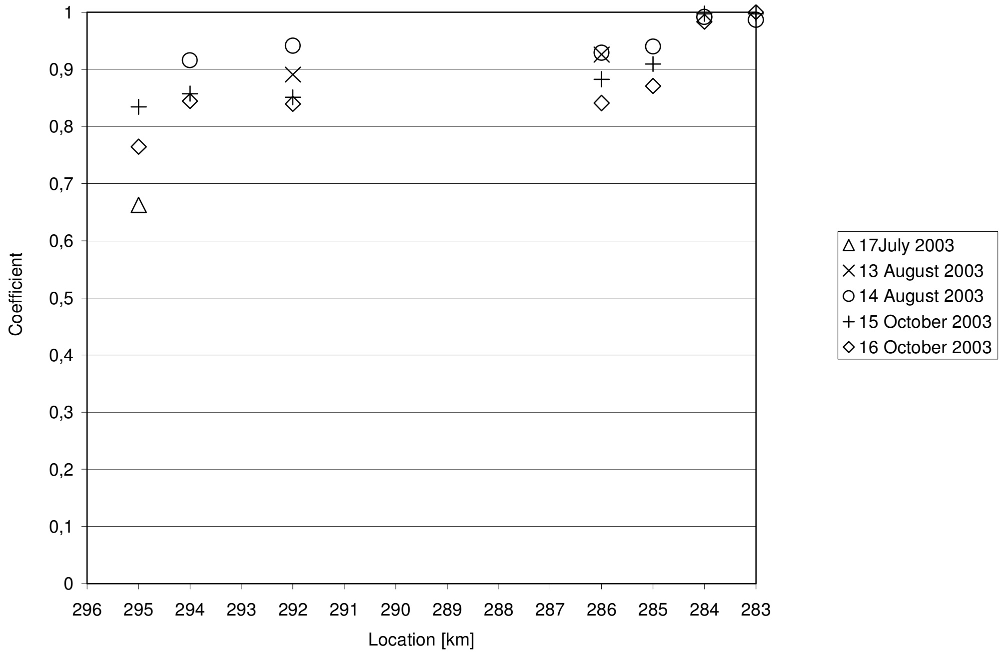

Figure 4.1.17.1-25. Mixing degree of the effluent from one NPP unit, in the Danube water, during low flow values

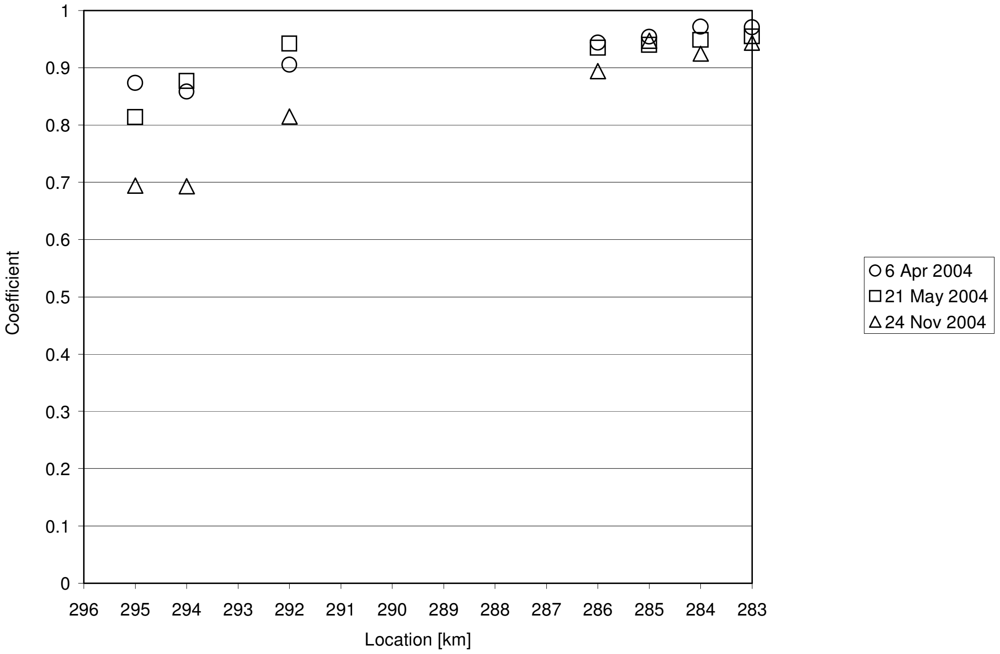

Figure 4.1.17.1-26. Mixing degree of the effluent from one NPP unit, in the Danube water, during high flow values

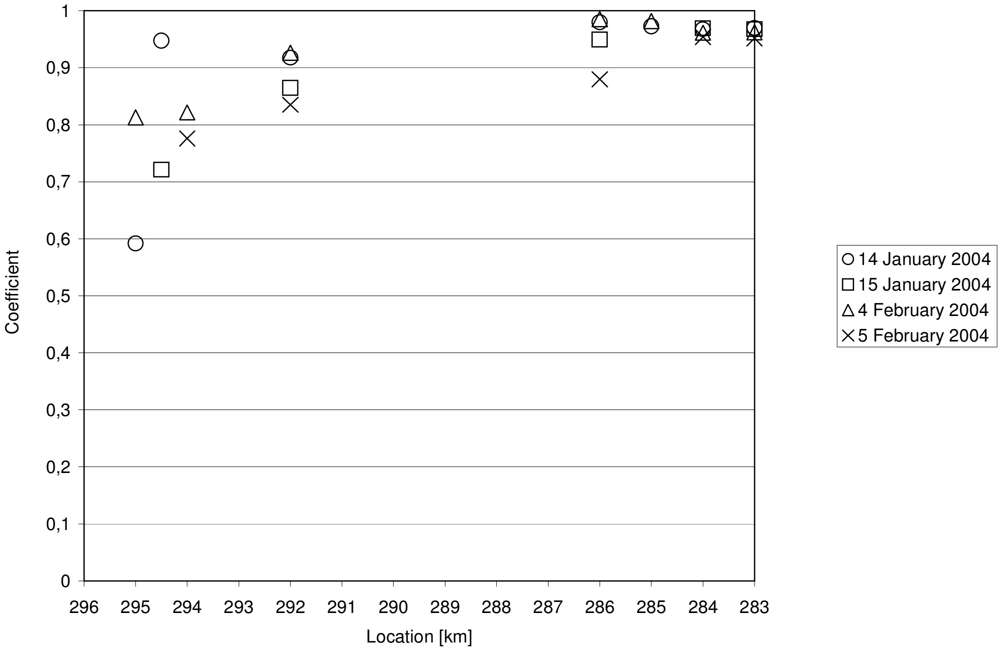

Figure 4.1.17.1-27. Mixing degree of the effluent from one NPP unit, in the Danube water, during heated water recirculation

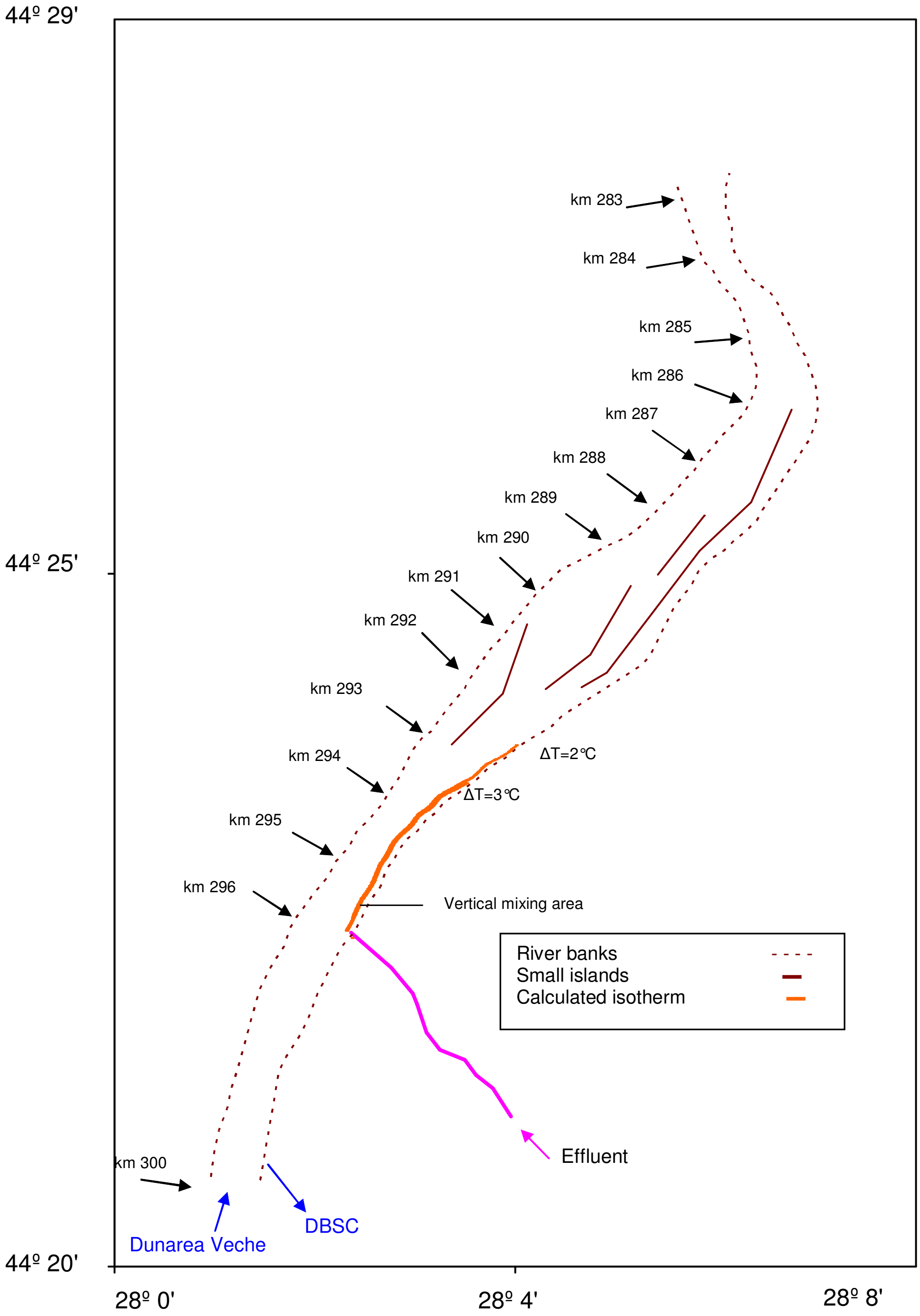

Figure 4.1.17.2-1. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in January (recirculation)

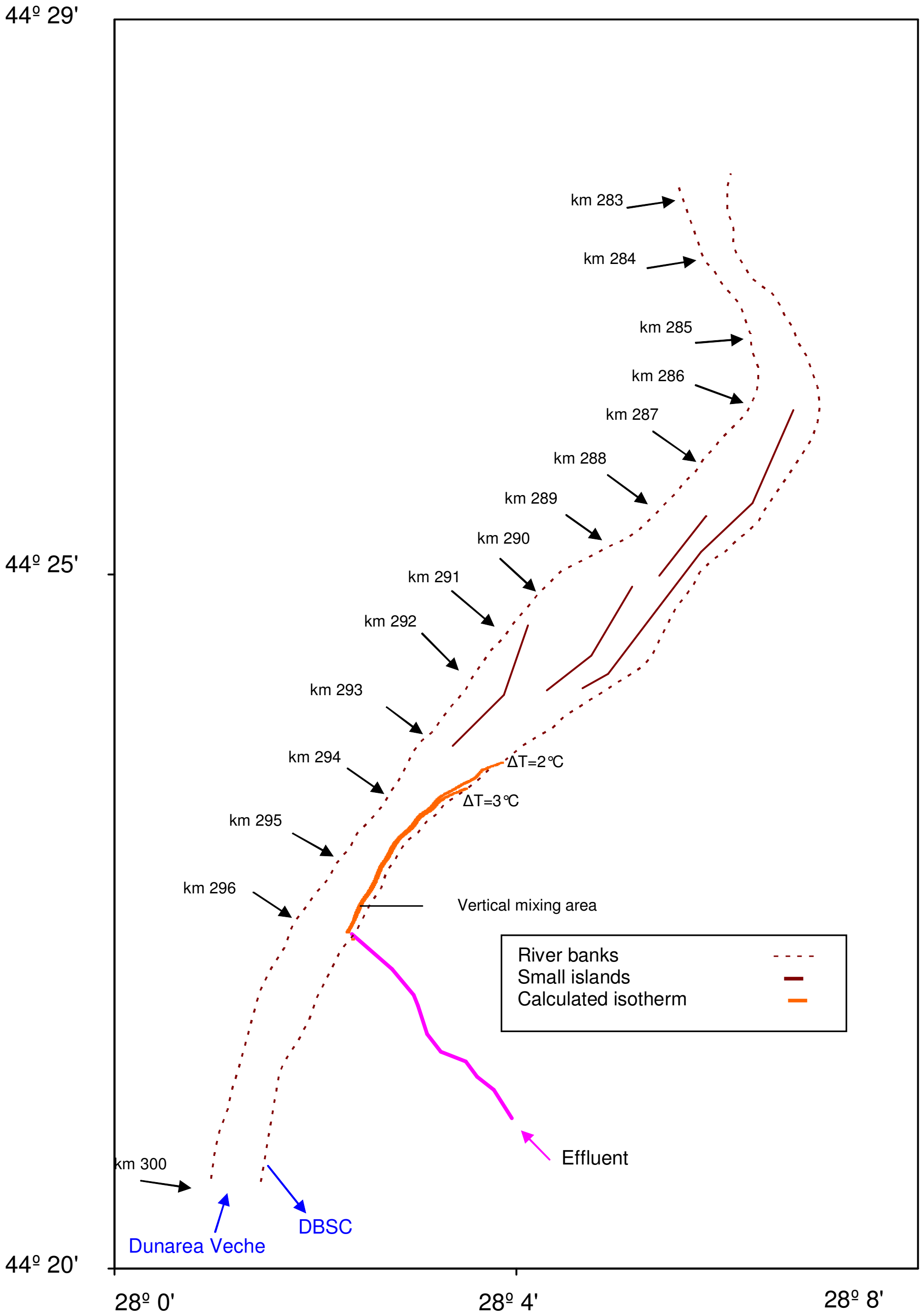

Figure 4.1.17.2-2. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in February (recirculation)

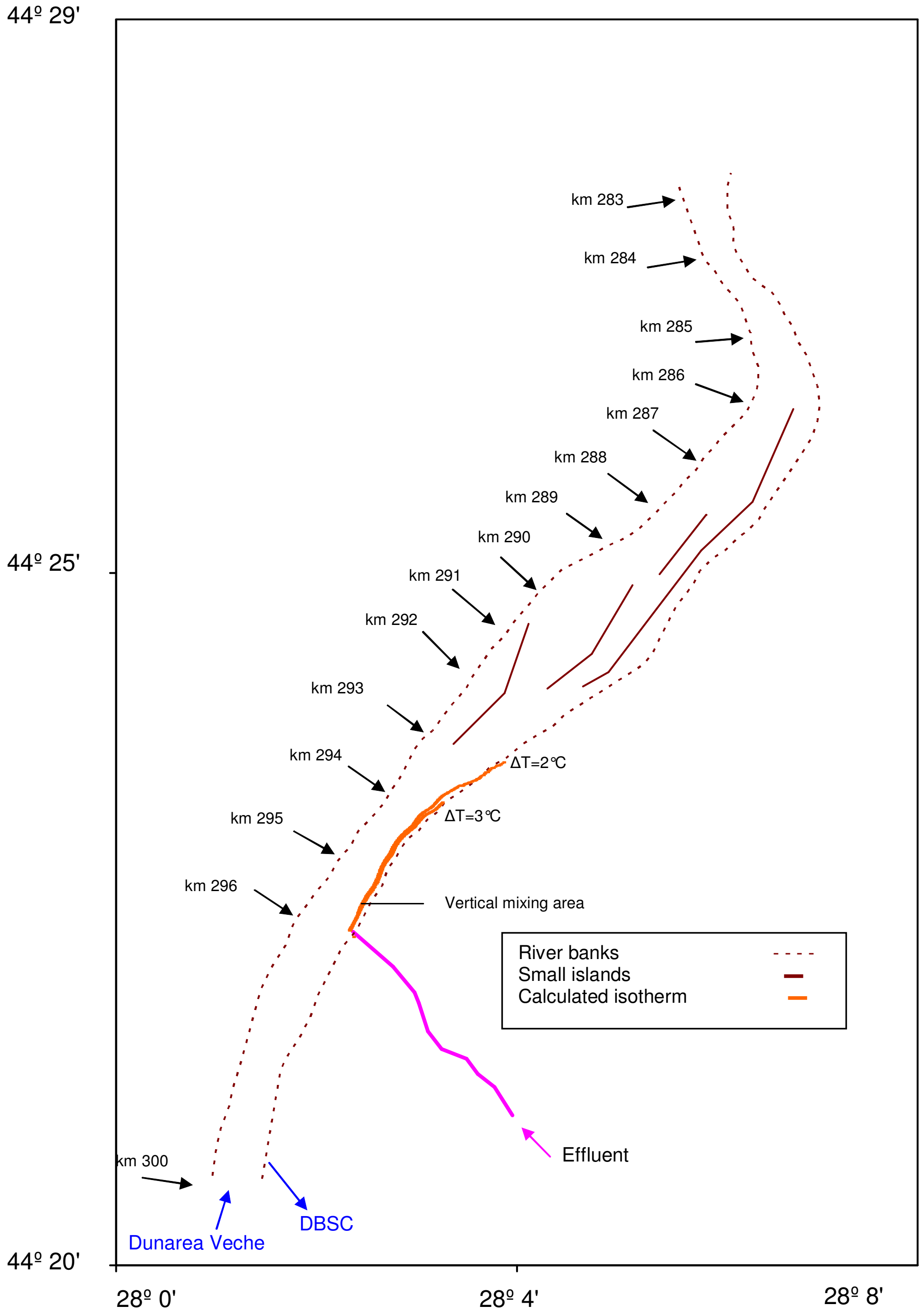

Figure 4.1.17.2-3. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in March (recirculation)

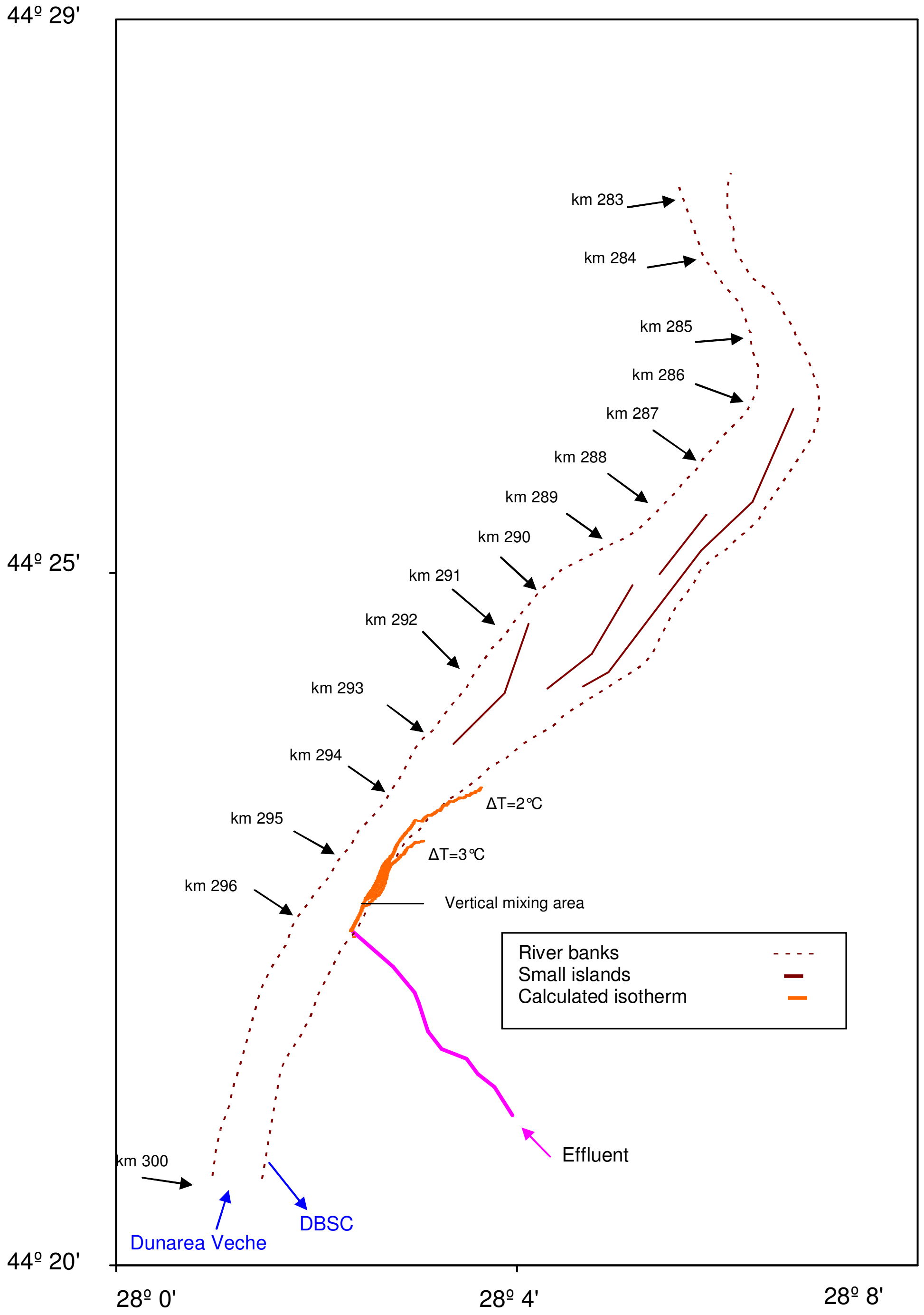

Figure 4.1.17.2-4. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in April

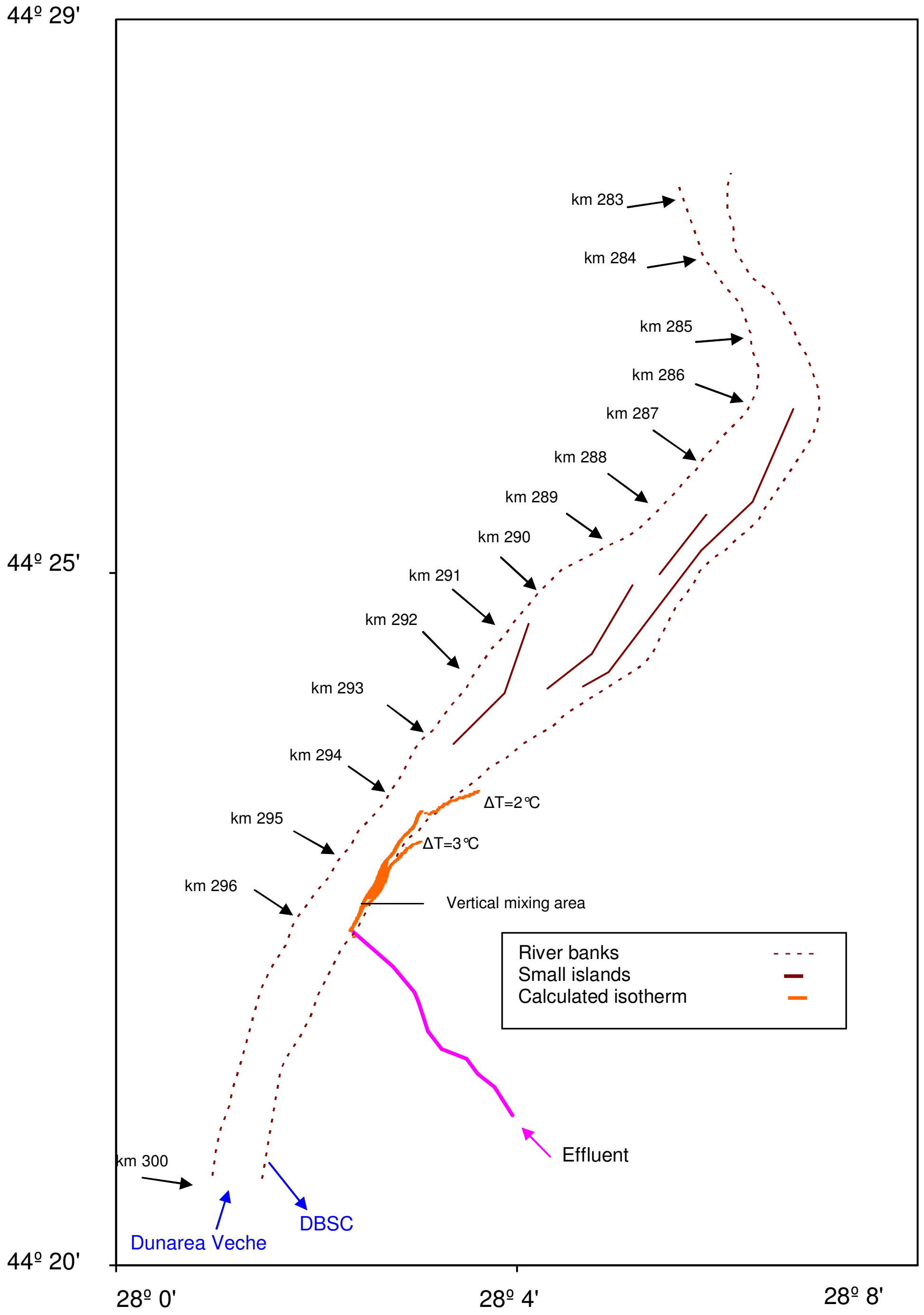

Figure 4.1.17.2-5. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in May

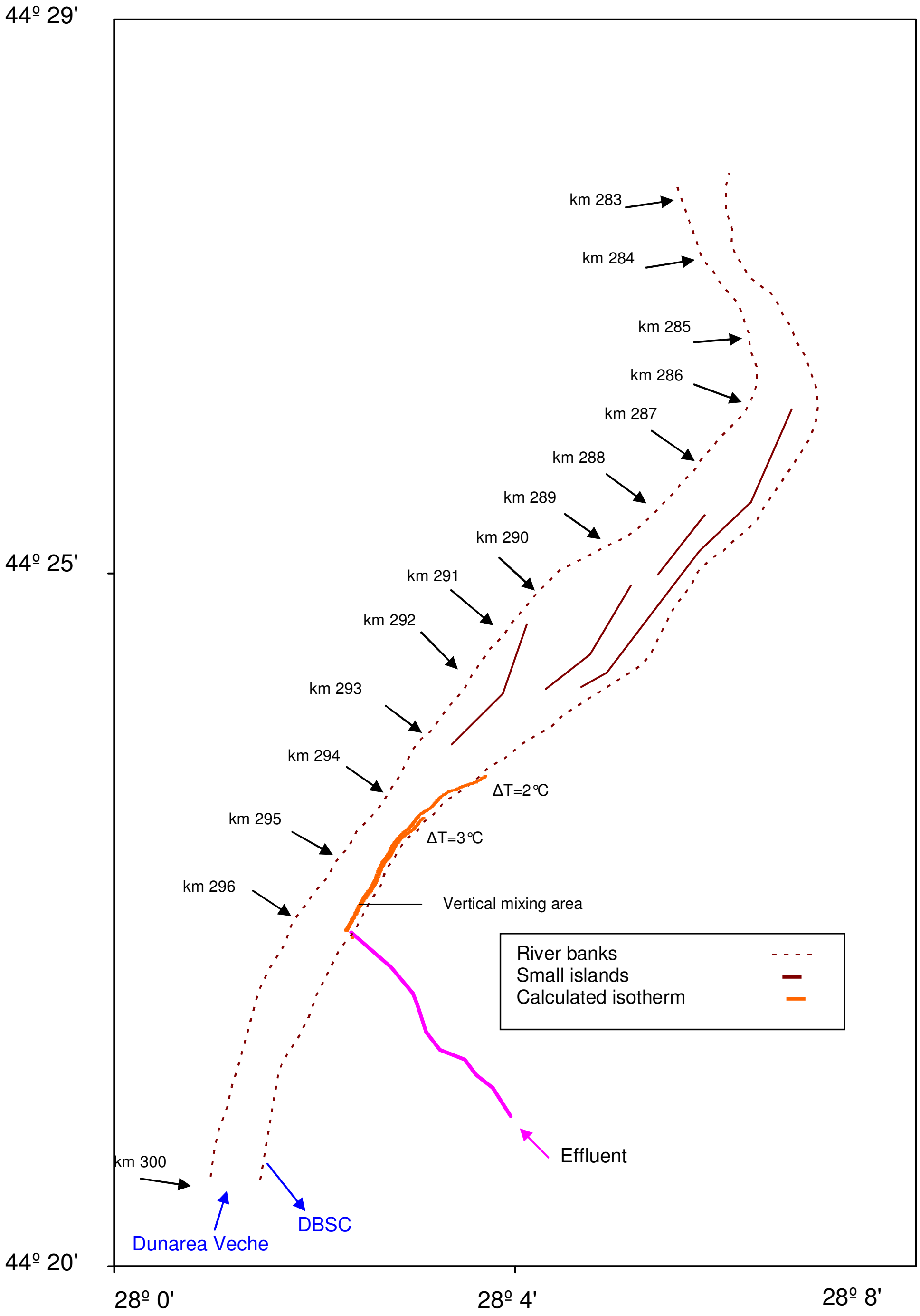

Figure 4.1.17.2-6. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in June

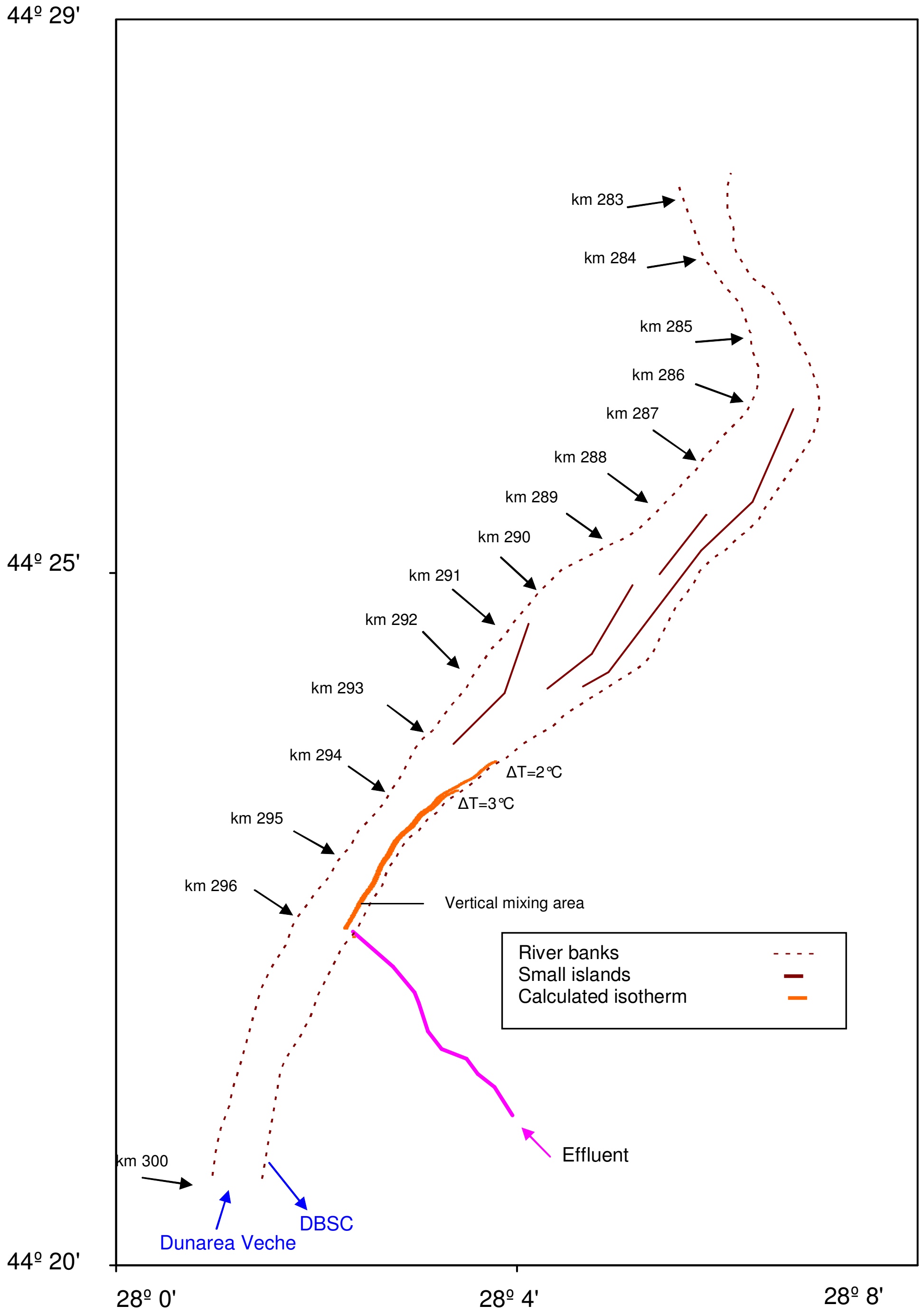

Figure 4.1.17.2-7. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in July

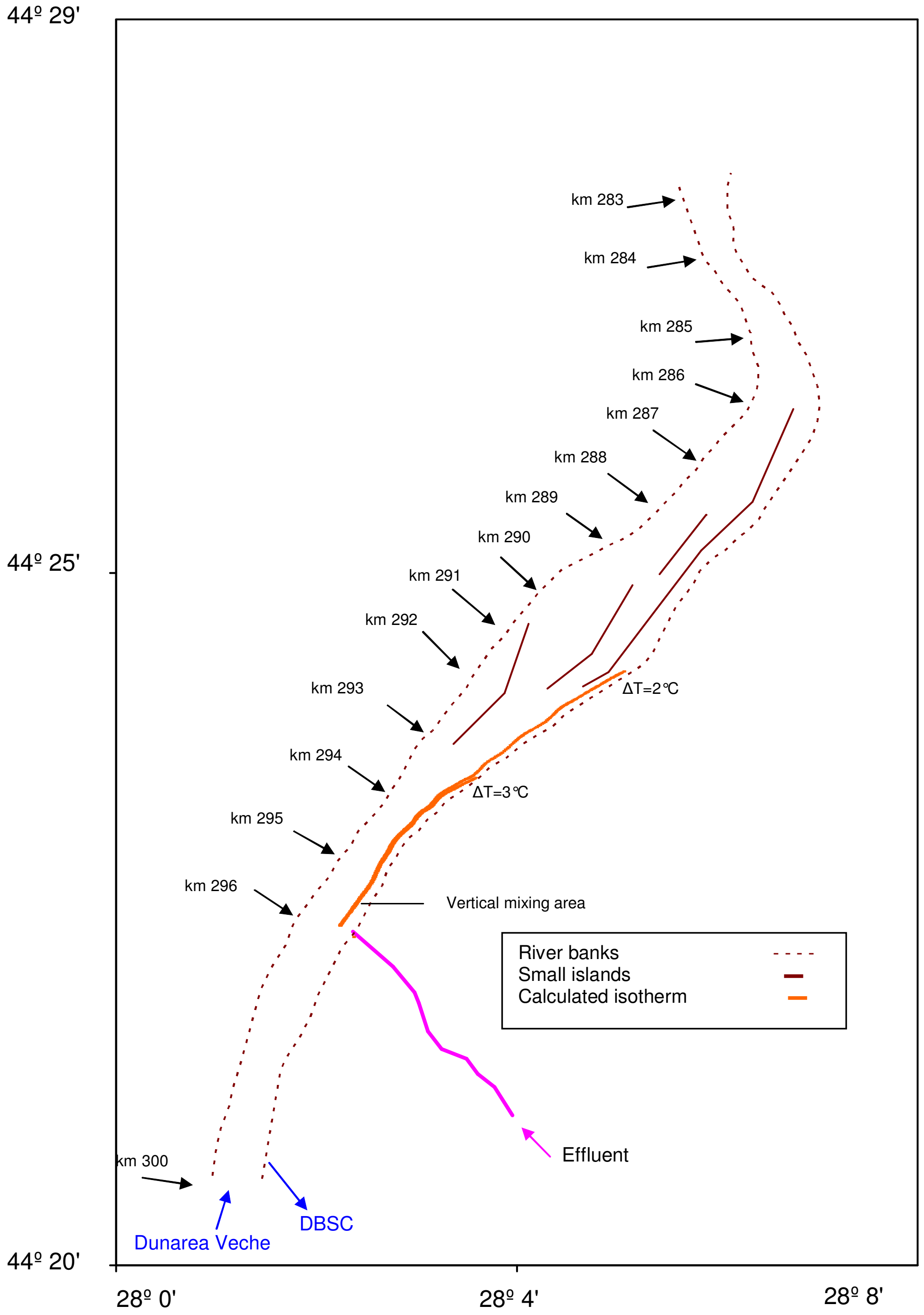

Figure 4.1.17.2-8. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in August

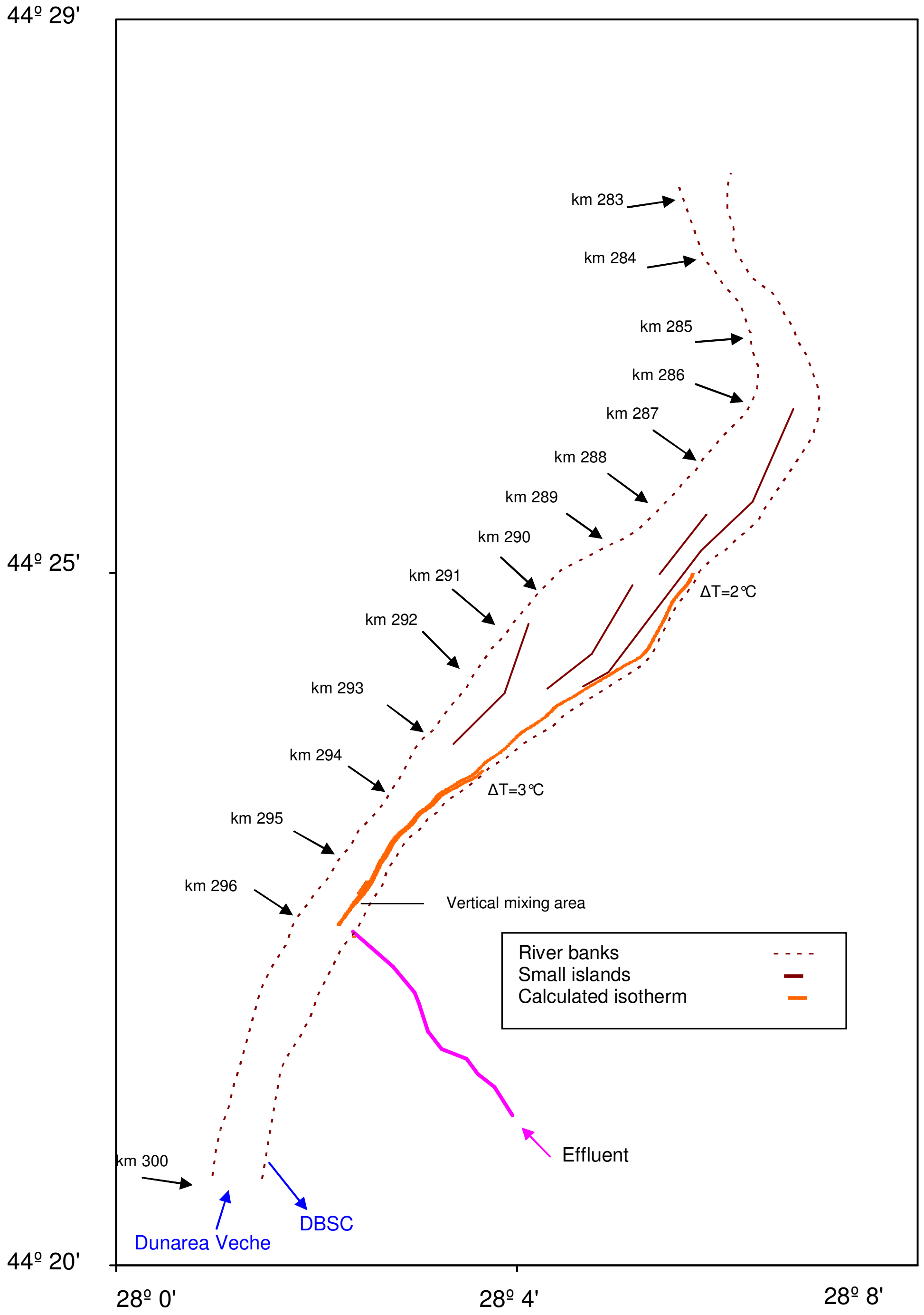

Figure 4.1.17.2-9. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in September

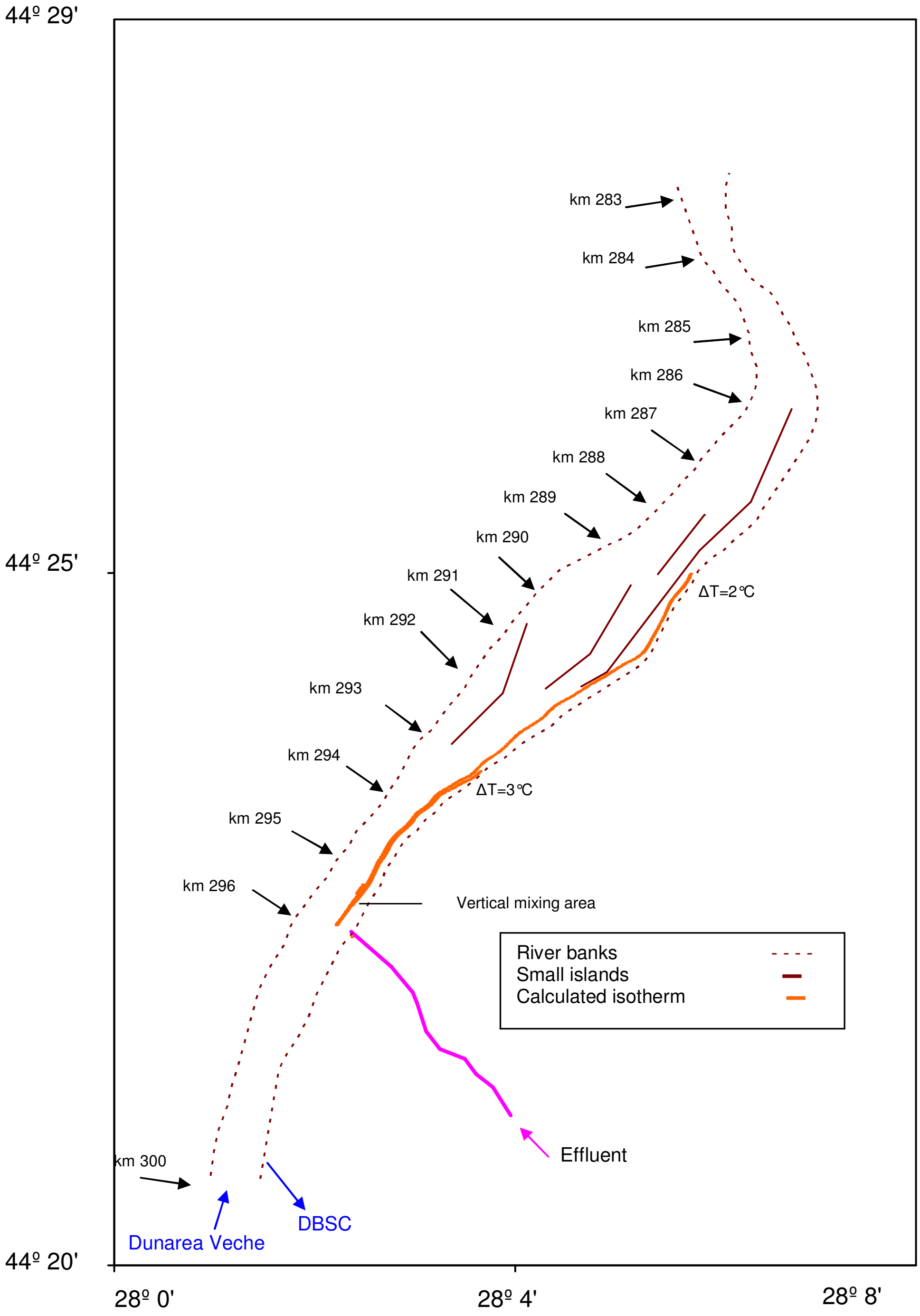

Figure 4.1.17.2-10. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in October

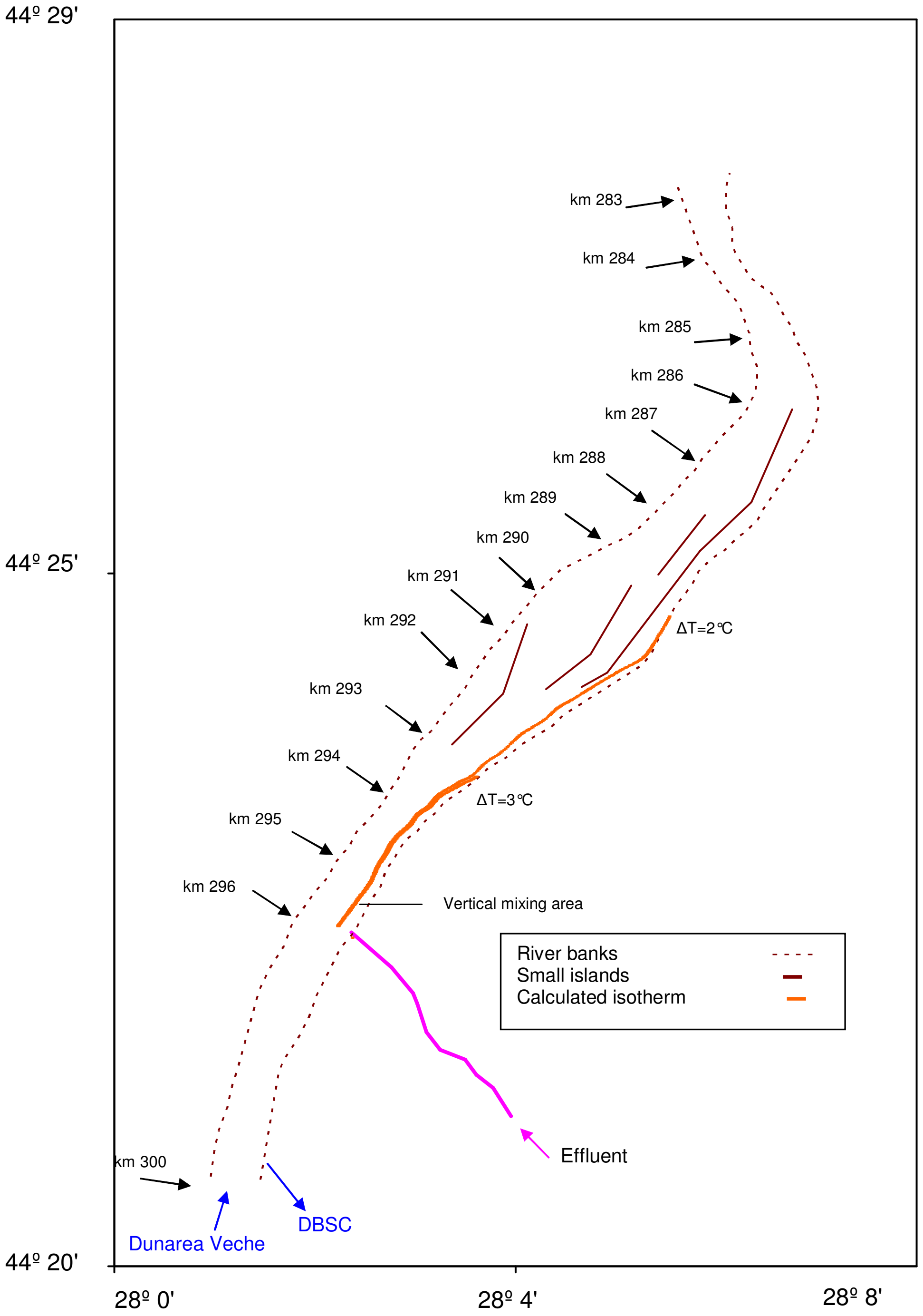

Figure 4.1.17.2-11. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in November

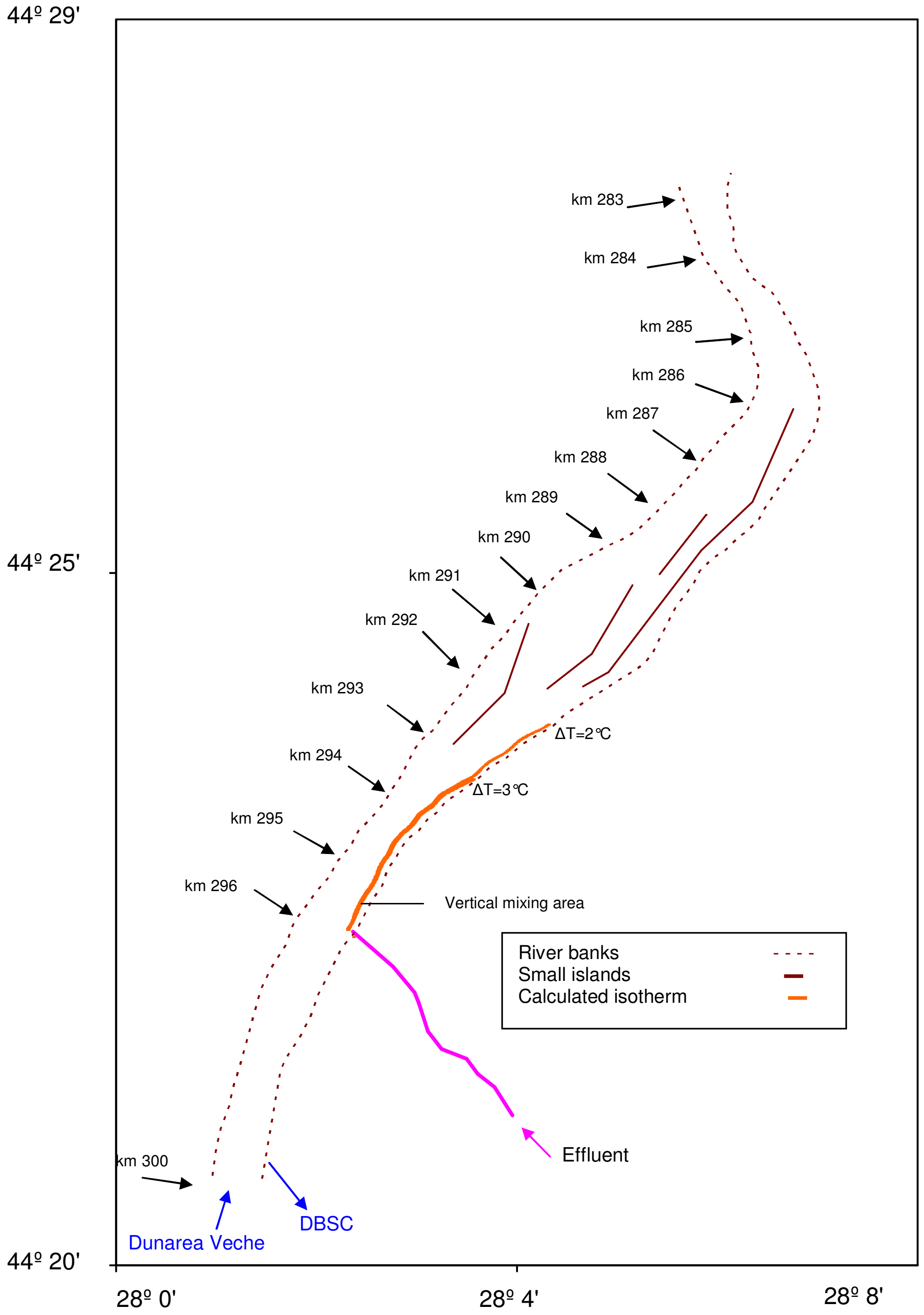

Figure 4.1.17.2-12. Calculated isotherms due to the effluent from the NPP Units 1, 2, 3 and 4, under average conditions in December (recirculation)

4.1.18. Estimated Thermal Impact of Discharging the Effluent from Units 1, 2, 3, 4 into the Race 2 of the Danube Black Sea Canal

The thermal impact of the Cernavoda NPP effluent was assessed having in view the aspects specified at the beginning of Chapter 4.1.17.

4.1.18.1. Thermal Impact of the Unit 3 and 4 Effluent During its Discharge to the DBSC Race 2

Taking into account the thermal load of the effluent from each unit, similar to the Unit 1 effluent, it results that the temperature measurements carried out for the case of Unit 1 and the estimations related to Unit 1 provide an image regarding the separate thermal impact of the Unit 3 effluent, respectively Unit 4 effluent, on the DBSC race 2. The measured data reflect the existing conditions in the respective periods (water flows used from the canal, water flows discharged from Unit 1 into race 2, flows from SPC for water supply of race 2, lock operations, various meteorological conditions).

Figures 4.1.18.1-1 to 4.1.18.1-5 show water temperature values along DBSC and PAMNC, without the NPP effluent, and temperatures due to the effluent from one NPP unit at the end of about one month of discharge to water race 2. From the temperatures measured without the NPP effluent it was found a natural factors influence of the order of 1 °C. It was found that the effluent covered the entire canal cross section. The thermal effect of the effluent from one NPP unit, combined with the influence of the other factors, was of the order of 2 °C at the DBSC race 2 downstream end. The results for the case of the effluent from one unit are compared in Figures 4.1.18.1-6 and 4.1.18.1-7 (where the data measured in two successive days are indicated with different markers) with calculated temperature distributions under average monthly conditions. Two variants of water mixing in cross-sections and heat transfer conditions were taken into account: intense mixing and high heat transfer (results represented by the lower lines in the figures), and respectively slow mixing and low heat transfer (the upper lines in the figures).

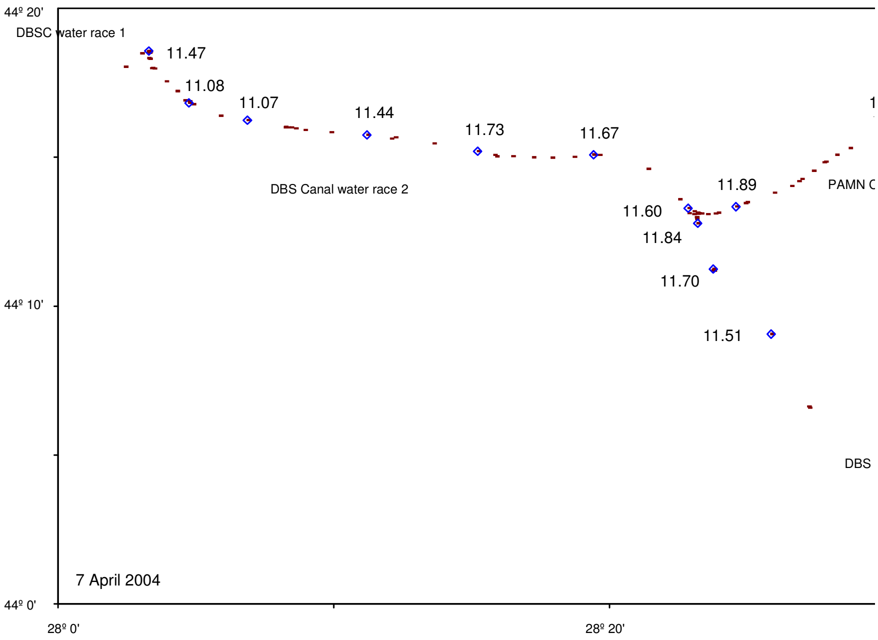

Figure 4.1.18.1-1. Results of water temperature measurement along DBSC and PAMNC in April effluent

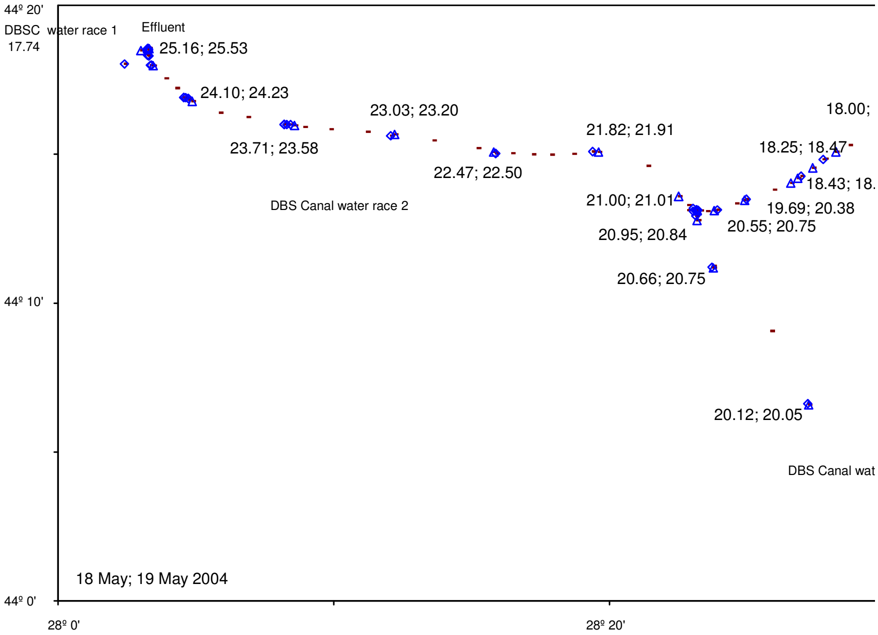

Figure 4.1.18.1-2. Results of water temperature measurement along DBSC and PAMNC in M effluent from one NPP unit

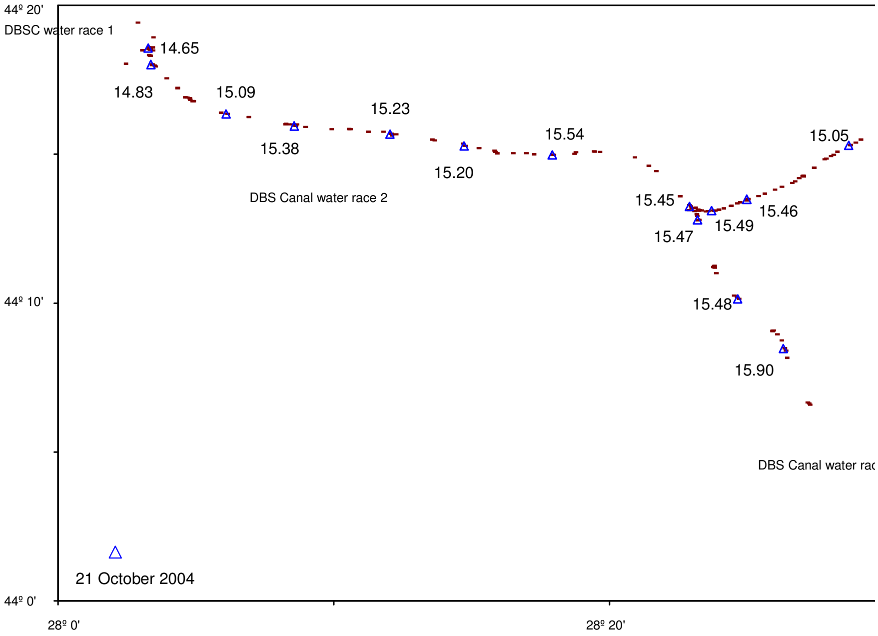

Figure 4.1.18.1-3. Results of water temperature measurement along DBSC and PAMNC in Oct
NPP effluent

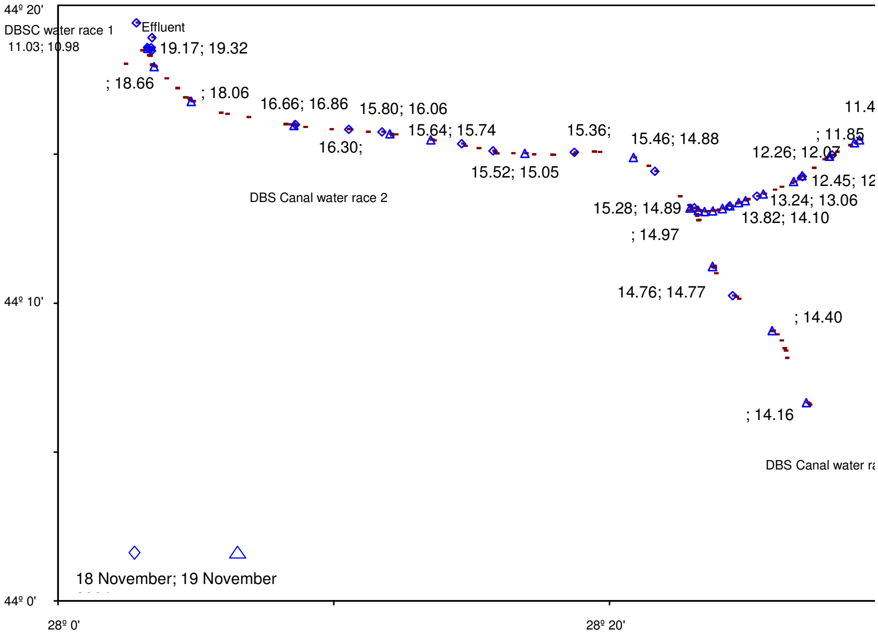

Figure 4.1.18.1-4. Results of water temperature measurement along DBSC and PAMNC in Nover effluent from one NPP unit

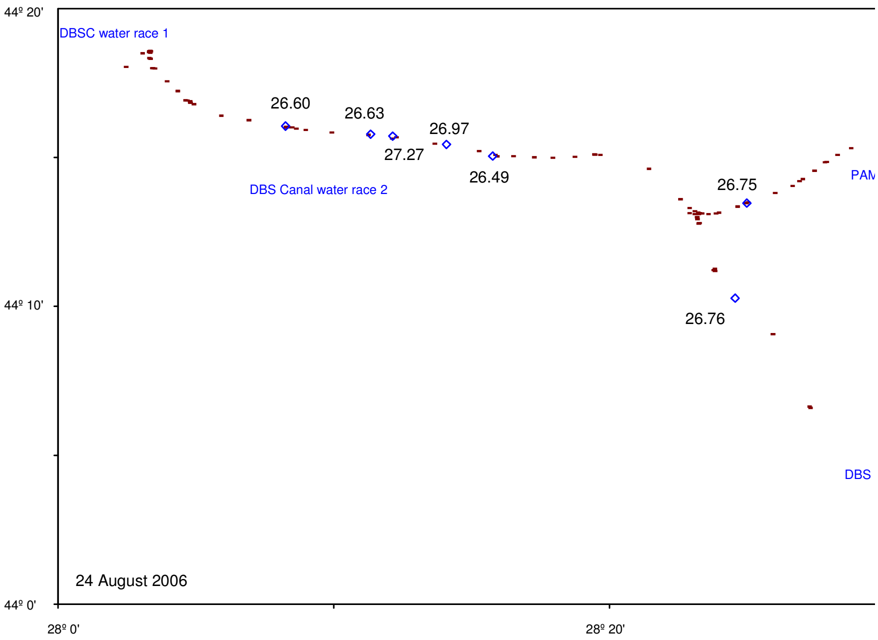

Figure 4.1.18.1-5. Results of water temperature measurement along DBSC and PAMNC in Au
effluent from one

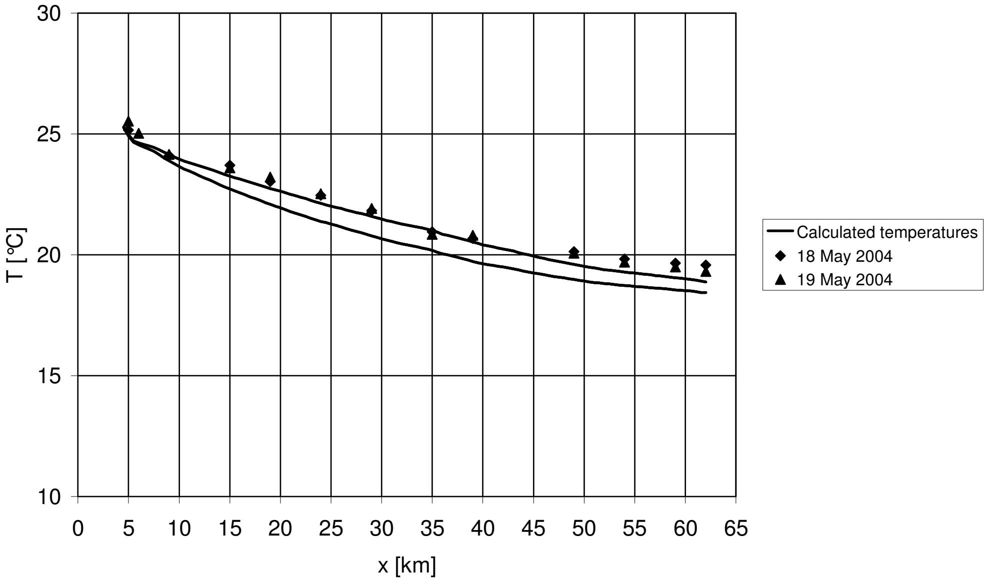

Figure 4.1.18.1-6. Longitudinal view of the water temperature measurement results at 18, 19 May 2004 (markers for two days, effluent from one NPP unit), and temperature distribution estimations by calculation (2 lines, different conditions of water mixing in cross-sections and heat transfer)

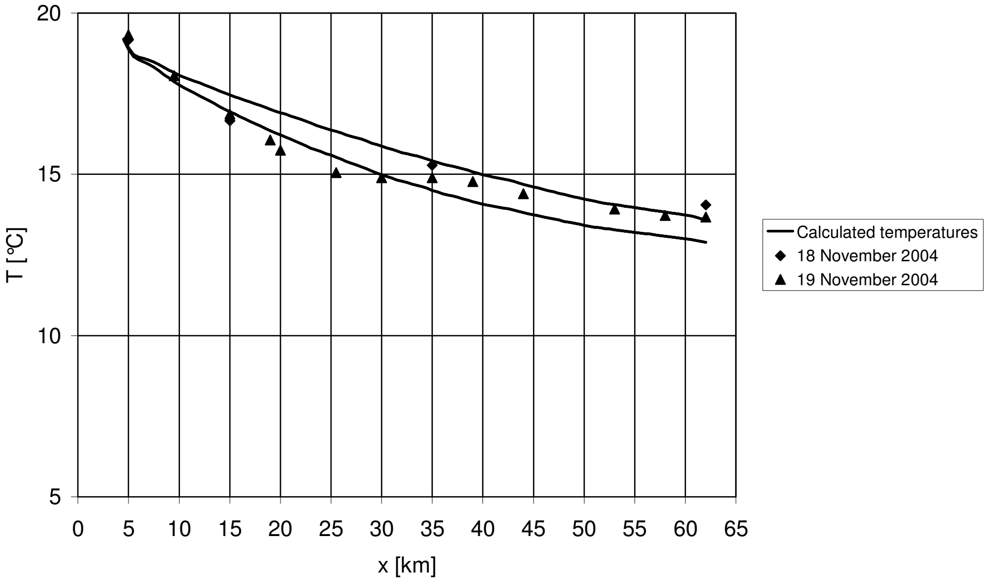

Figure 4.1.18.1-7. Longitudinal view of the water temperature measurement results at 18, 19 November 2004 (markers for two days, effluent from one NPP unit), and temperature distribution estimations by calculation (2 lines, different conditions of water mixing in cross-sections and heat transfer)

Water race 2 of DBSC is usually supplied directly from water race 1 by means of the Complex Pumping Station or gravitationally. The flow value depends on the water users requirements that result in different total values in different months (especially because of the irrigation needs). The heated effluent from Cernavoda NPP mixes with this water flow taken directly from water race 1 where water temperature is practically that in the Danube. The effluent from Units 3 and 4 can supply totally or partially the necessary water volumes for the users existing along DBSC.

The water temperature in the upstream section of water race 2 is the NPP effluent temperature, or it is lower if the effluent mixed with an additional flow taken directly from water race 1 by SPC. Figure 4.1.18.1-8 shows calculated temperature values in the upstream section of water race 2 under the effect of a temperature increase of 7 ℃ in the effluent from U3 and U4, assuming design irrigation consumptions for the average year. The values presented in this figure were obtained by adding the effluent effect to average Danube water temperatures over 10 days intervals in each month.

The temperature values in the upstream section of the water race 2 are less than the limit of 35 ℃ specified by NTPA 001 (Government Decision 352/2005), under usual values of Danube water temperature.

The separate thermal impact of the Units 3 and 4 effluent in characteristic situations was estimated by calculation, in two cases of mixing and thermal transfer conditions (as mentioned above). For winter months, with monthly average water temperature under 5 ℃, a recirculated flow of 50 % of the cooling water flow was considered.

The results indicate expected limits of the Units 3 and 4 effluent thermal effect in DBSC water race 2 (Figures 4.1.18.1-9 to 4.1.18.1-20). Pairs of curves are presented in figures, that show estimated longitudinal temperature distributions starting from three average temperatures over three 10 days intervals in each month.

4.1.18.2. Cumulated Thermal Impact of the Effluents from Units 1, 2, 3, 4 during its Discharge to the DBSC Race 2

Having a temperature similar to the case of one NPP unit, the effluent from 4 units leads to a similar water temperature in the upstream section of the DBSC race 2 during the months without water need for irrigation.

During summer months, the effluent from Units 1, 2, 3, 4 can cover the water requirements for irrigation, without supplementary flow from race 1. The resulting temperatures in the upstream section of race 2 are those of the effluent (Fig. 4.1.18.2-1). In comparison with the case of two units, the thermal impact along race 2 of the effluent from 4 units is given by the higher upstream temperatures in some months (Fig. 4.1.18.1-8, 4.1.18.2-1) and the smaller flow time along the DBSC race 2. Estimations of the thermal impact of the effluent from 4 NPP units are presented in Fig. 4.1.18.2-2 to 4.1.18.2-13, taking into account an effluent temperature increase of 7 ℃ and design water consumption for irrigation in the average year during summer months. For winter months, with monthly average water temperature under 5 ℃, a recirculated flow of 100 m^3/s from the total cooling water flow wads considered.

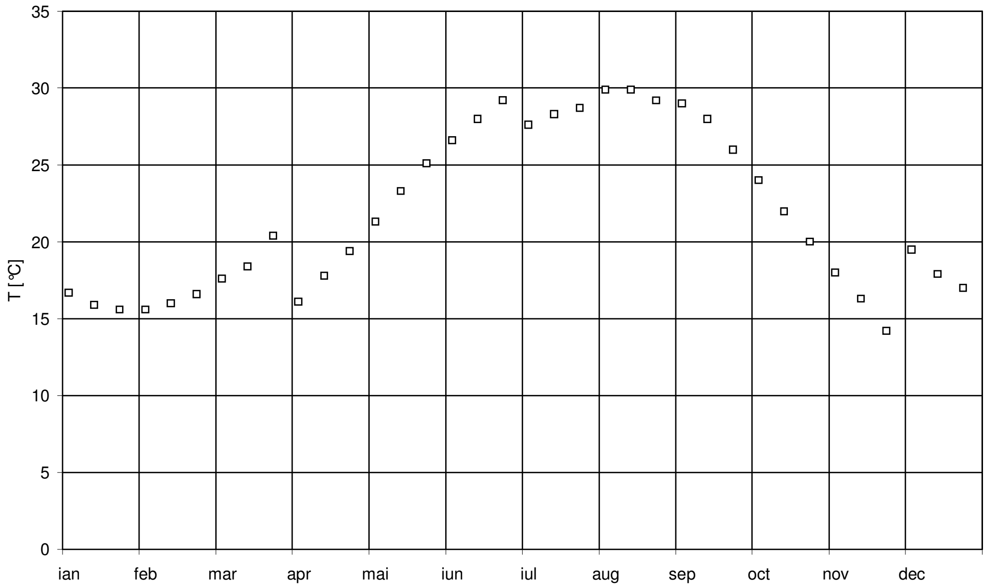

Figure 4.1.18.1-8. Calculated water temperatures in the water race 2 upstream section under the effect of the temperature increase in the effluent from Cernavoda NPP Units 3 and 4 (design water consumptions for irrigation in the average year)

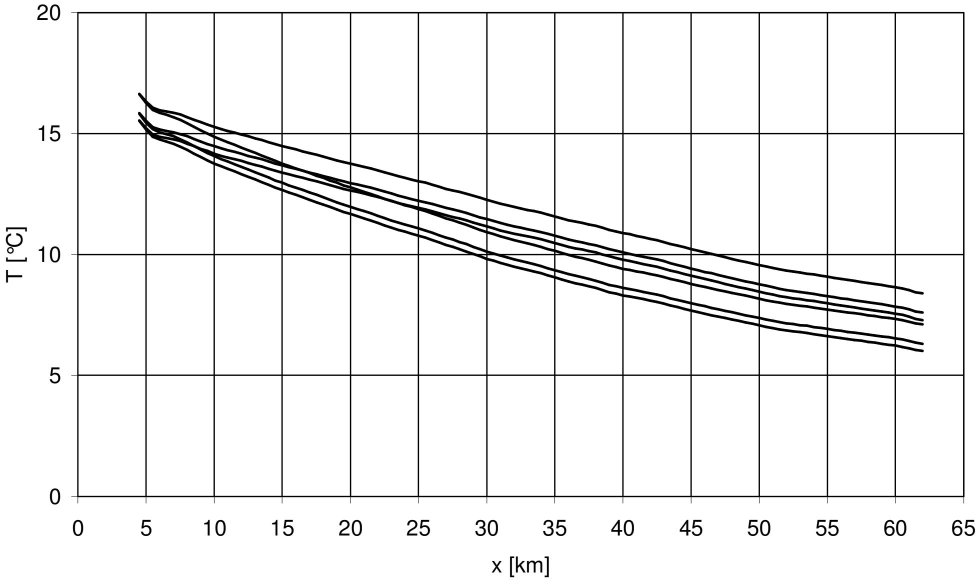

Figure 4.1.18.1-9. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in January (design water consumptions for irrigation in the average year, recirculation)

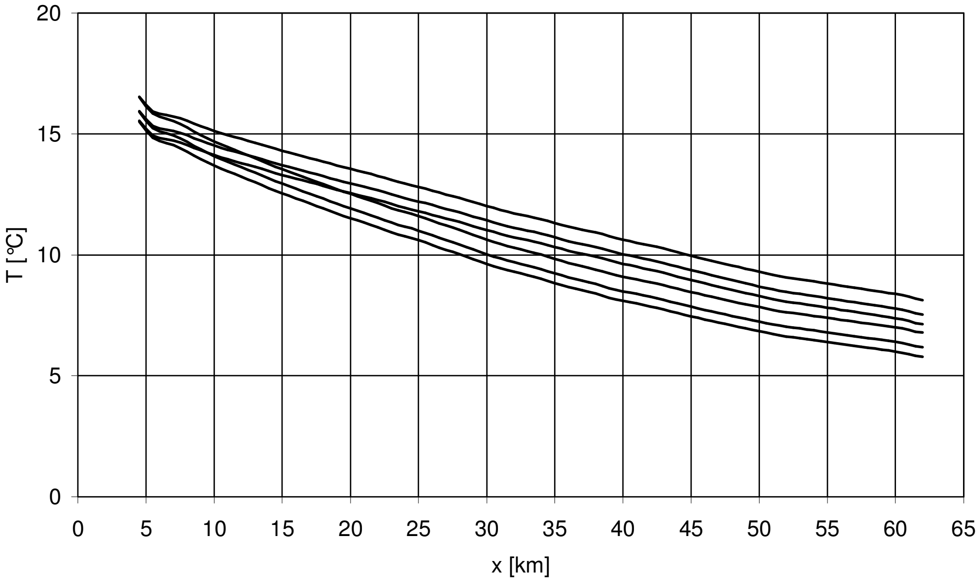

Figure 4.1.18.1-10. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in February (design water consumptions for irrigation in the average year, recirculation)

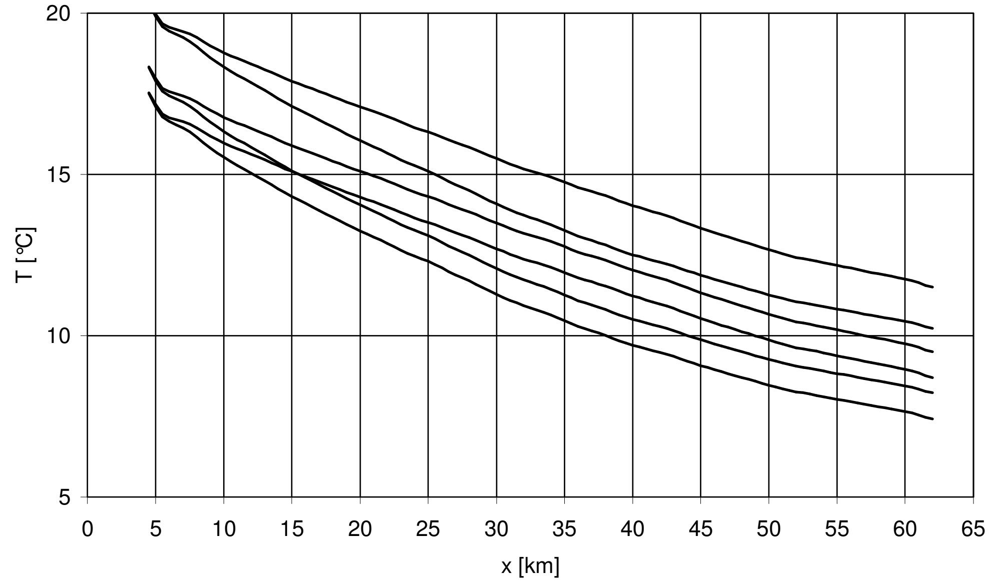

Figure 4.1.18.1-11. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in March (design water consumptions for irrigation in the average year, recirculation)

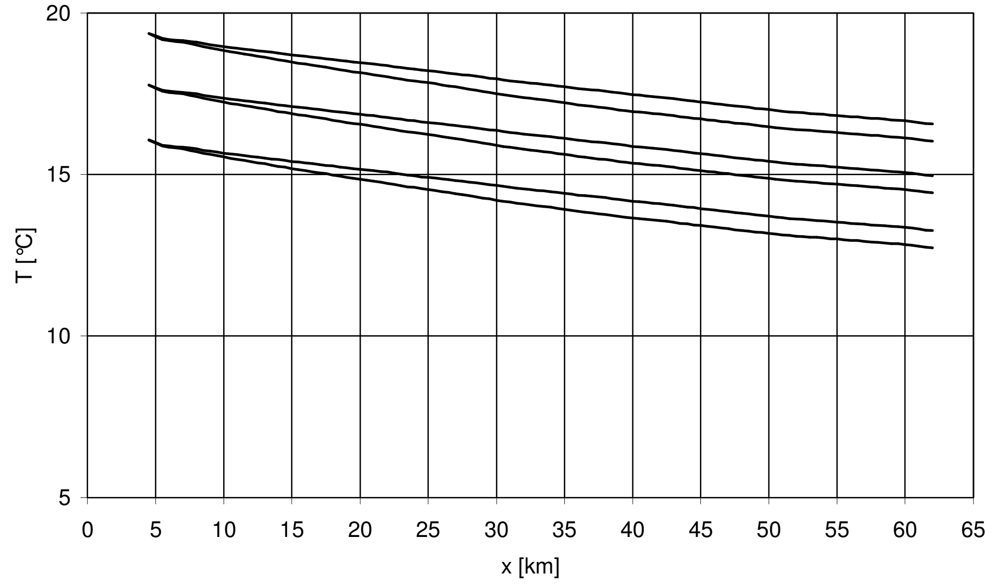

Figure 4.1.18.1-12. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in April (design water consumptions for irrigation in the average year)

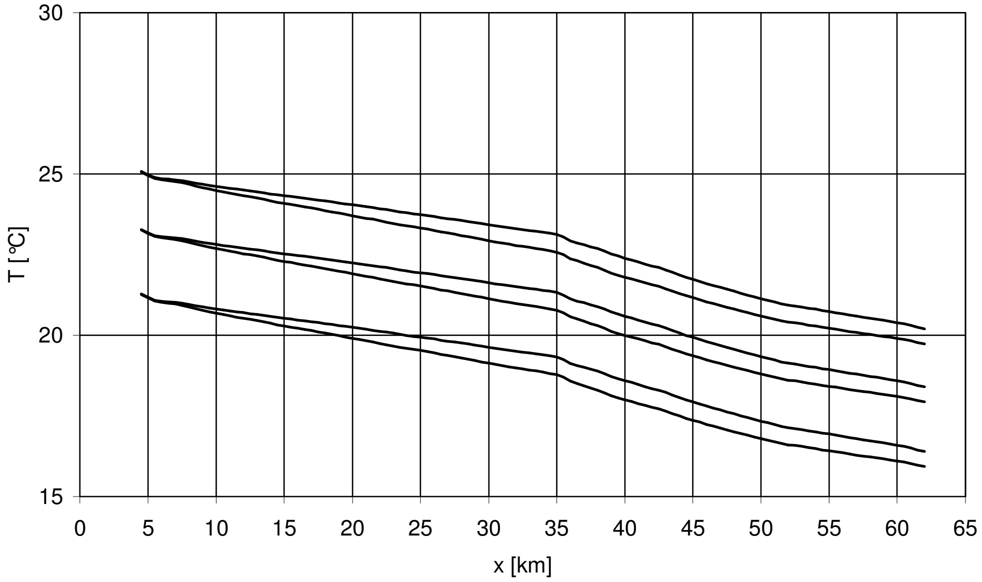

Figure 4.1.18.1-13. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in May (design water consumptions for irrigation in the average year)

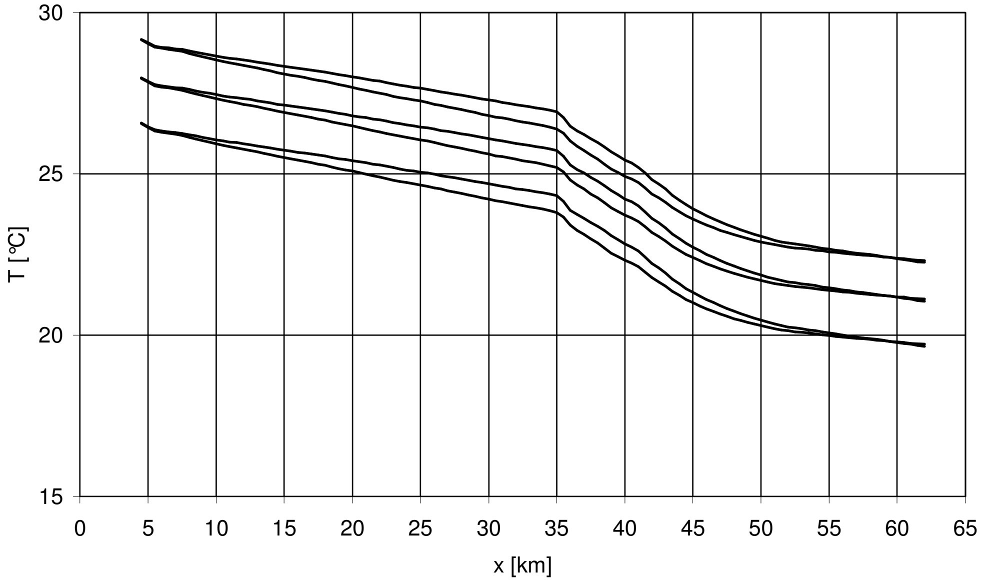

Figure 4.1.18.1-14. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in June (design water consumptions for irrigation in the average year)

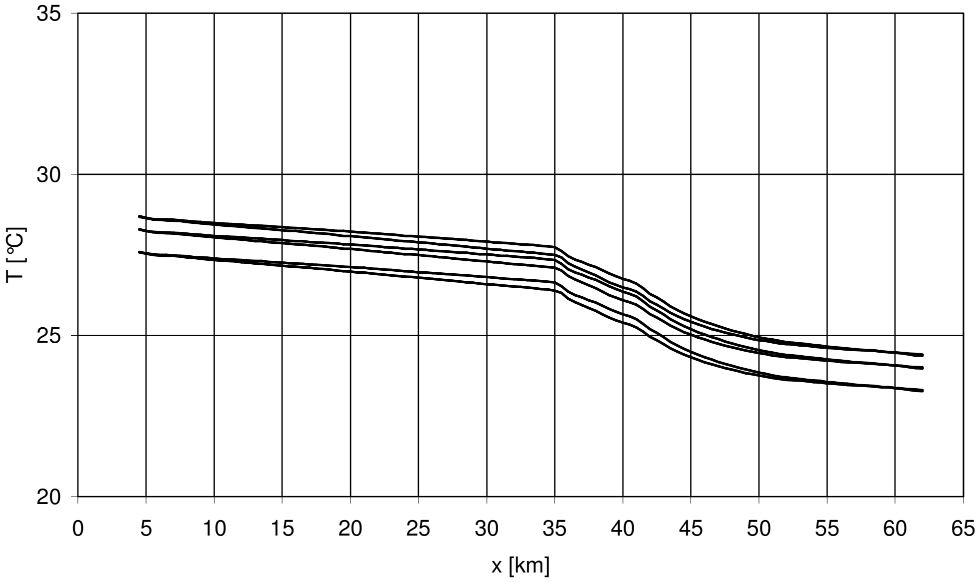

Figure 4.1.18.1-15. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in July (design water consumptions for irrigation in the average year)

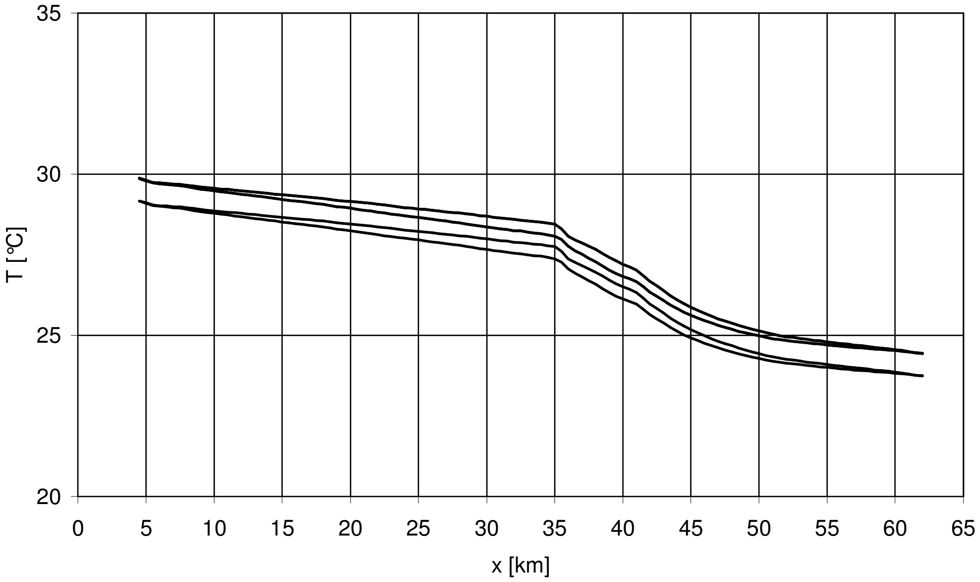

Figure 4.1.18.1-16. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in August (design water consumptions for irrigation in the average year)

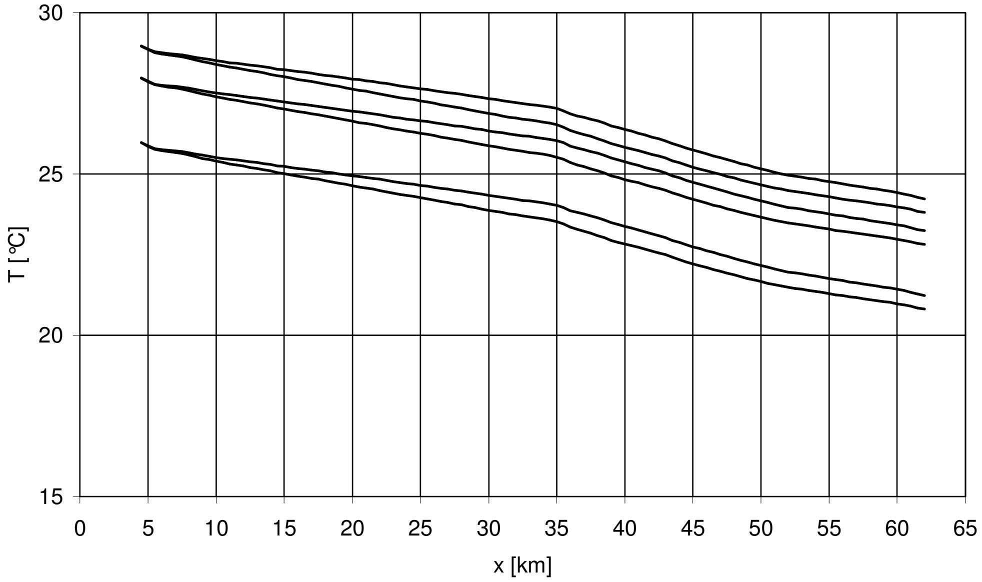

Figure 4.1.18.1-17. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in September (design water consumptions for irrigation in the average year)

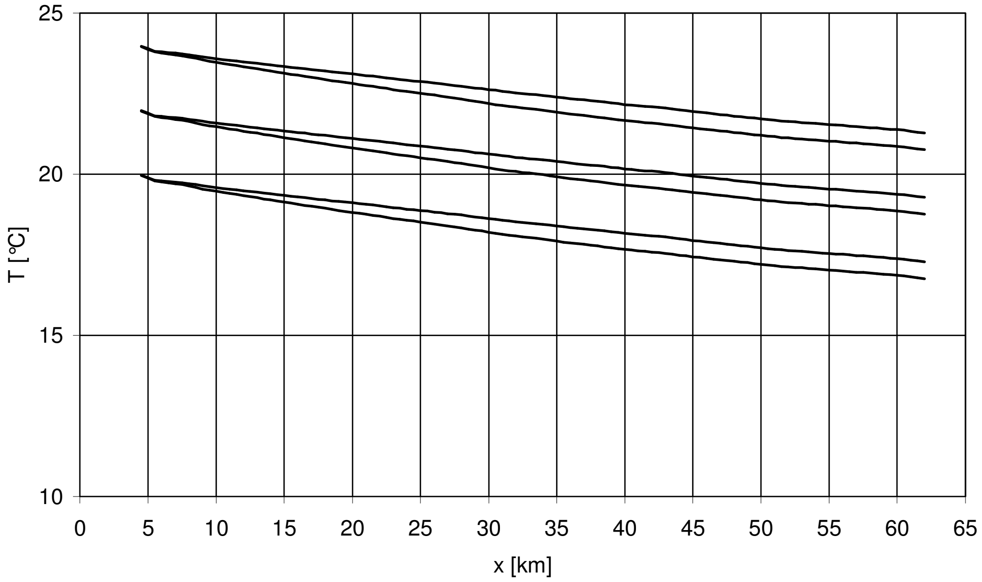

Figure 4.1.18.1-18. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in October (design water consumptions for irrigation in the average year)

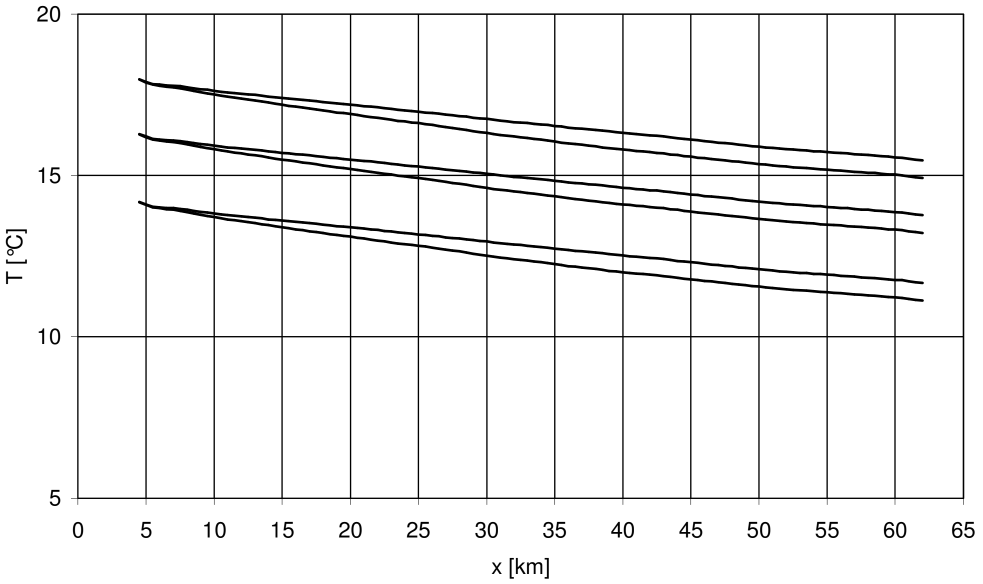

Figure 4.1.18.1-19. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in November (design water consumptions for irrigation in the average year)

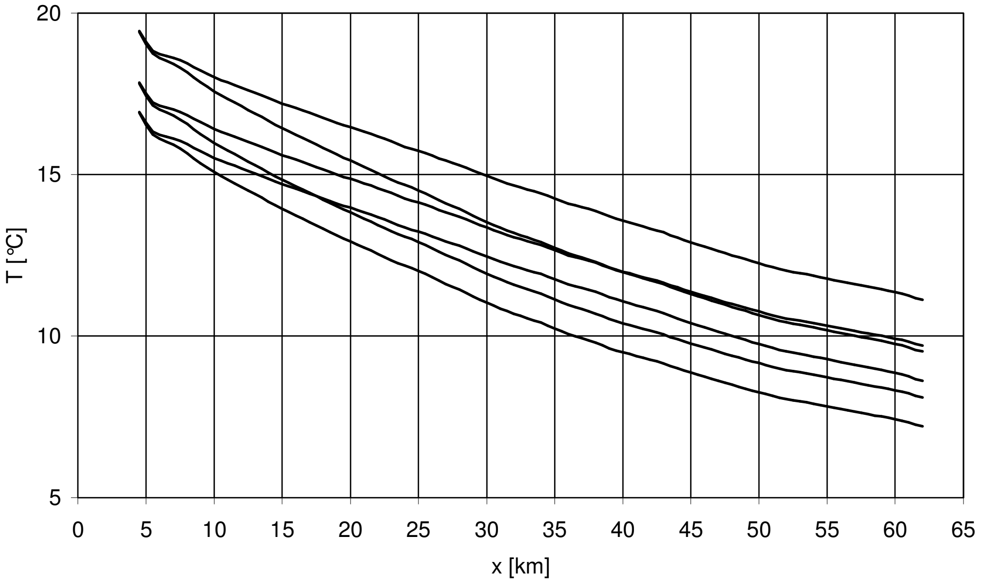

Figure 4.1.18.1-20. Calculated effect of the temperature increase in the effluent from the NPP Units 3 and 4 on the water temperature distribution along water race 2 in December (design water consumptions for irrigation in the average year, recirculation)

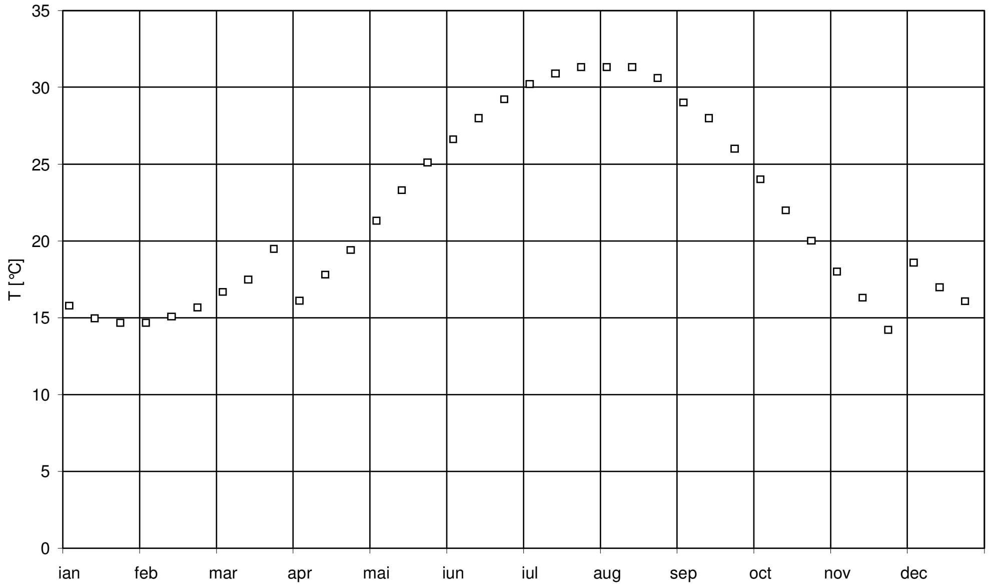

Figure 4.1.18.2-1. Calculated water temperatures in the water race 2 upstream section due to the temperature increase in the effluent from the Units 1, 2, 3 and 4 (design water consumptions for irrigation in the average year)

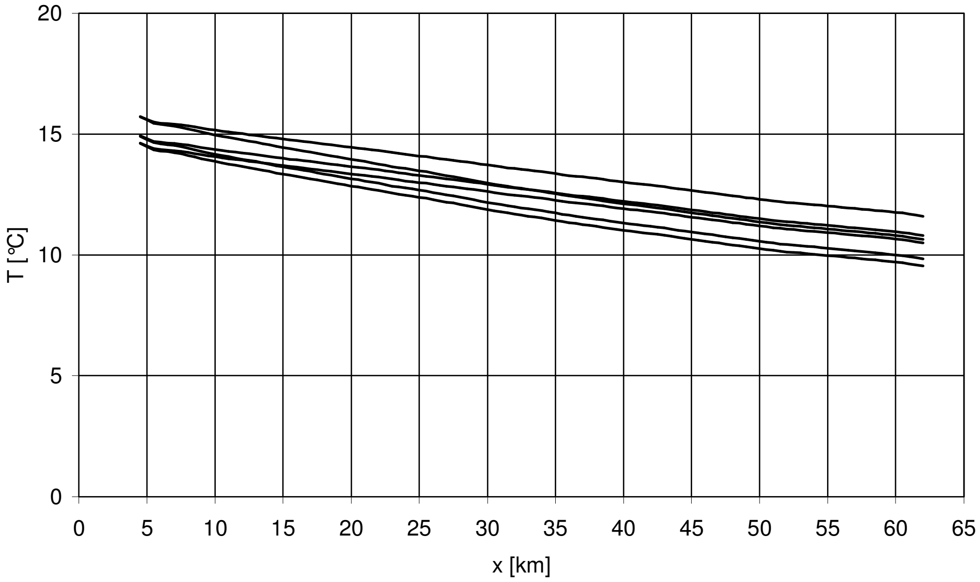

Figure 4.1.18.2-2. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (January conditions, recirculation)

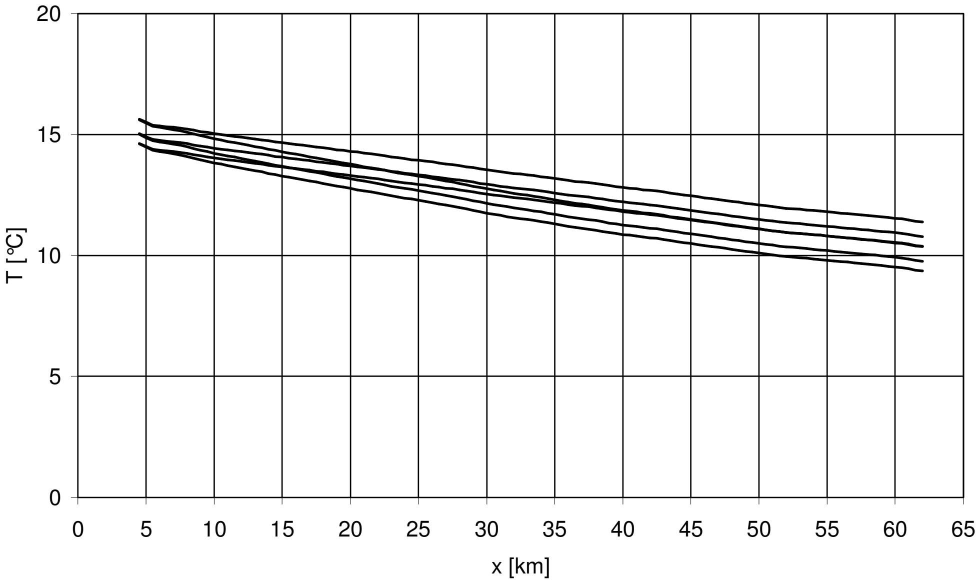

Figure 4.1.18.2-3. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (February conditions, recirculation)

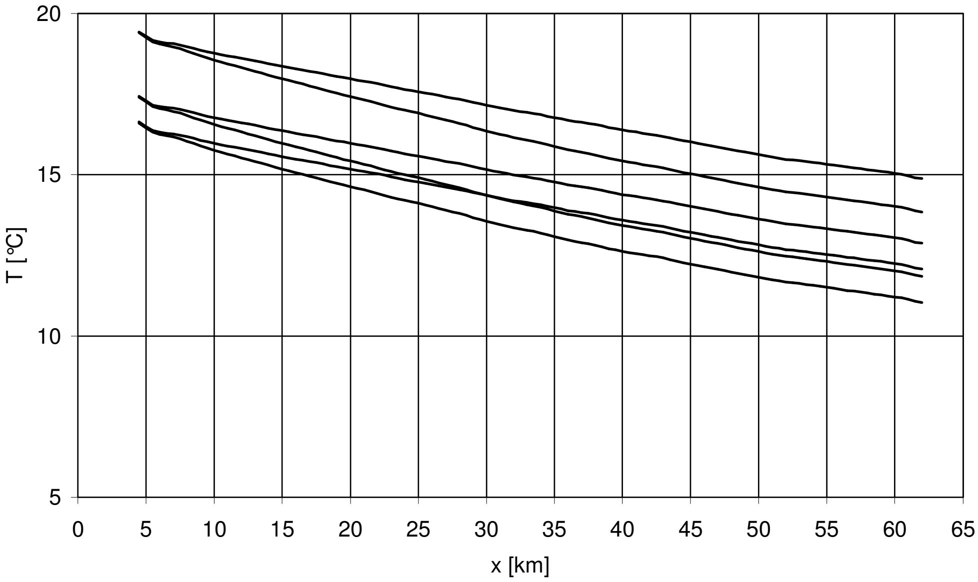

Figure 4.1.18.2-4. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (March conditions, recirculation)

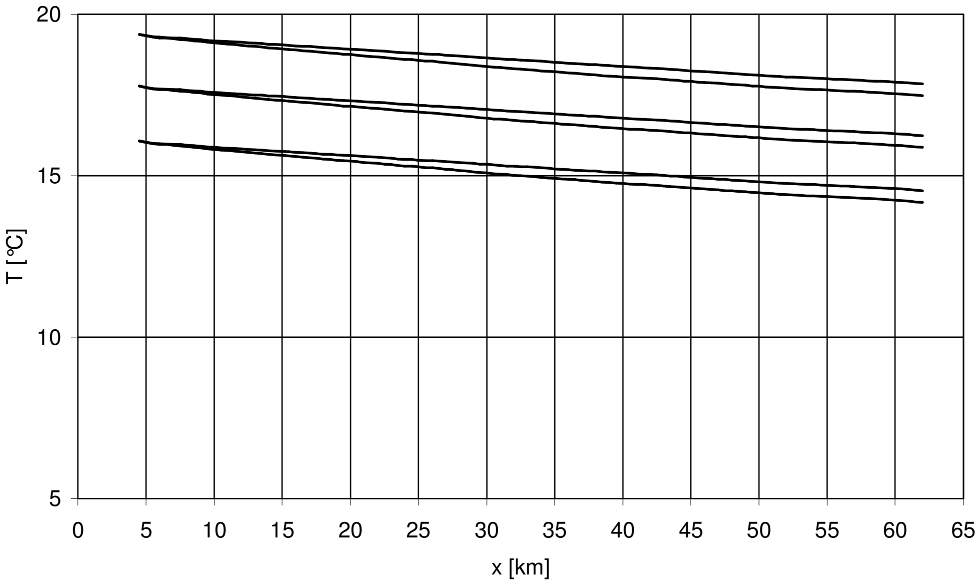

Figure 4.1.18.2-5. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (April conditions)

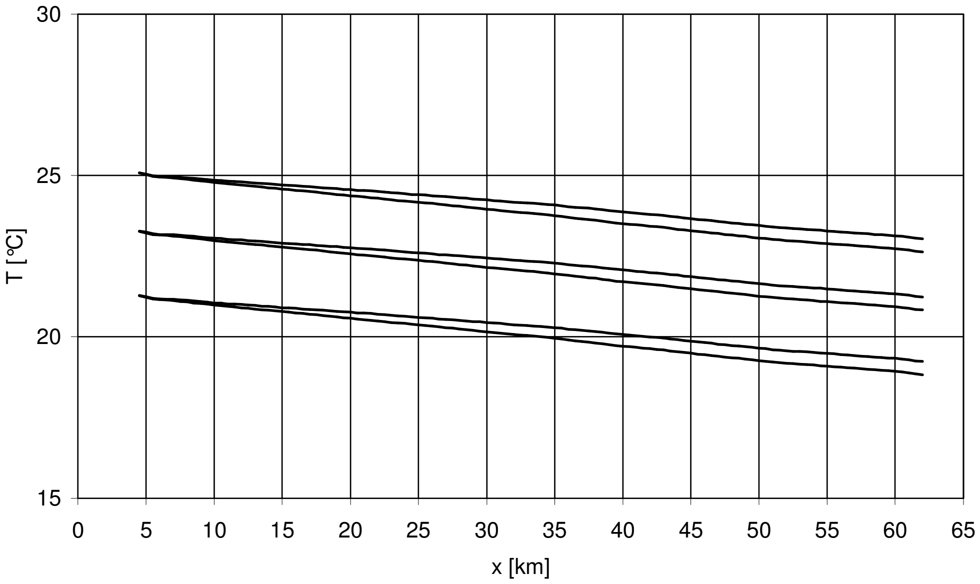

Figure 4.1.18.2-6. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (May conditions)

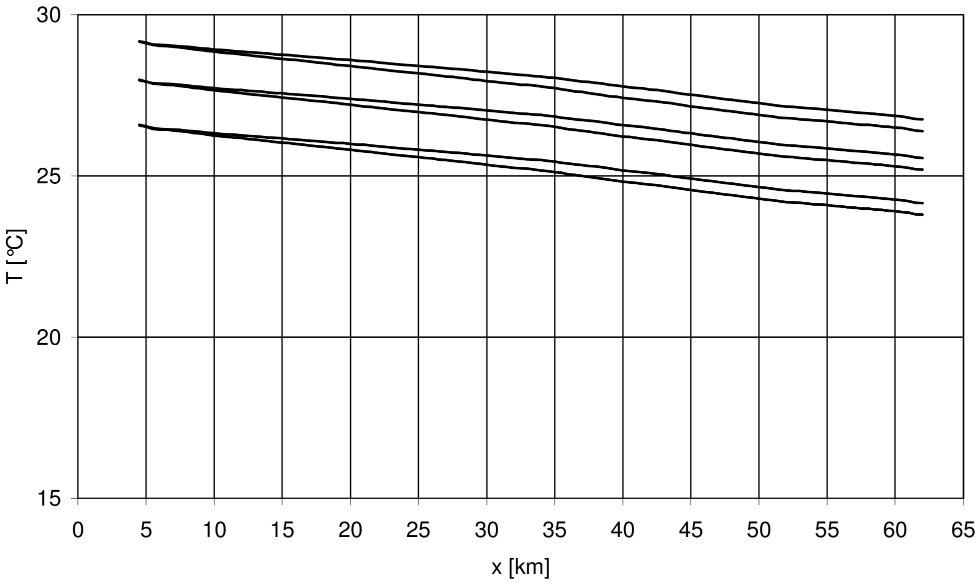

Figure 4.1.18.2-7. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (June conditions)

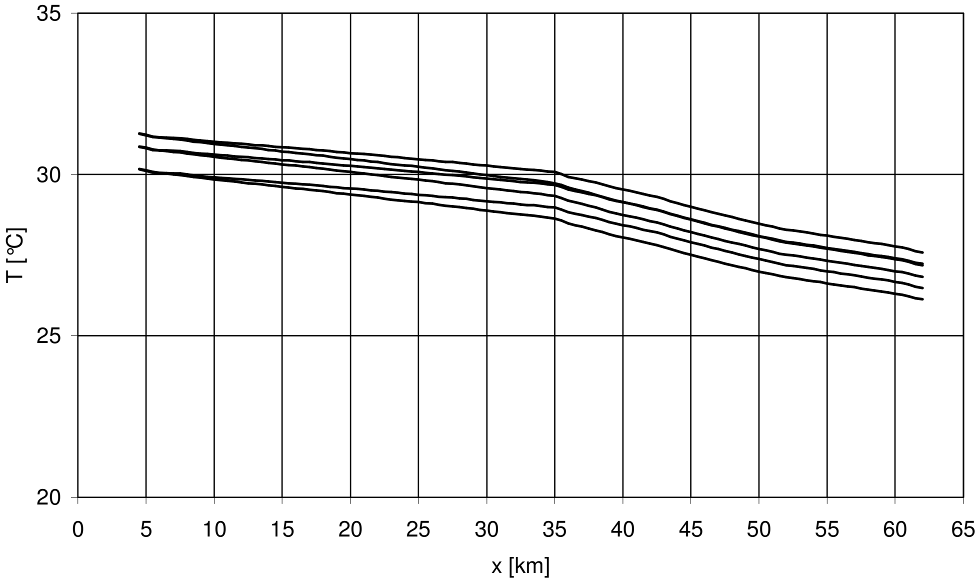

Figure 4.1.18.2-8. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (July conditions)

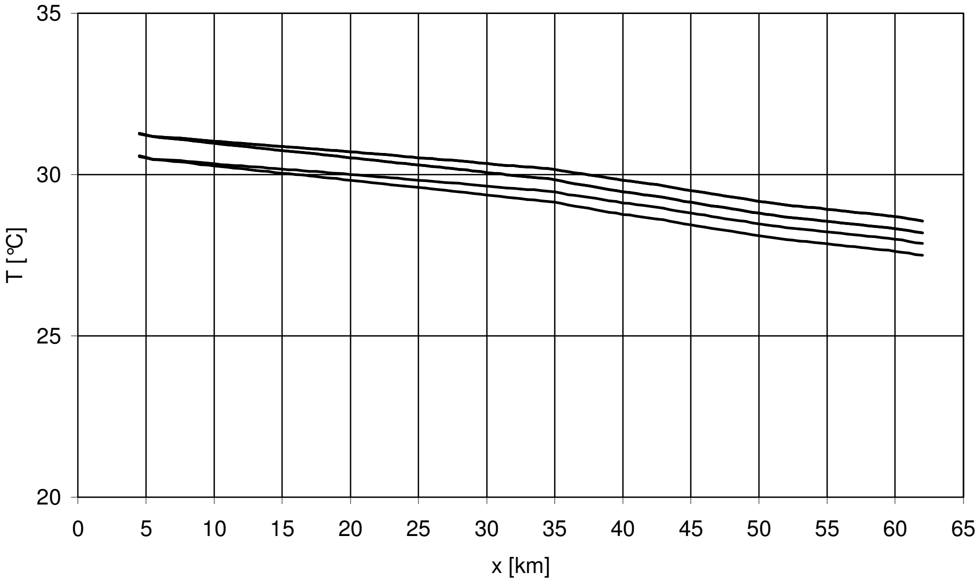

Figure 4.1.18.2-9. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (August conditions)

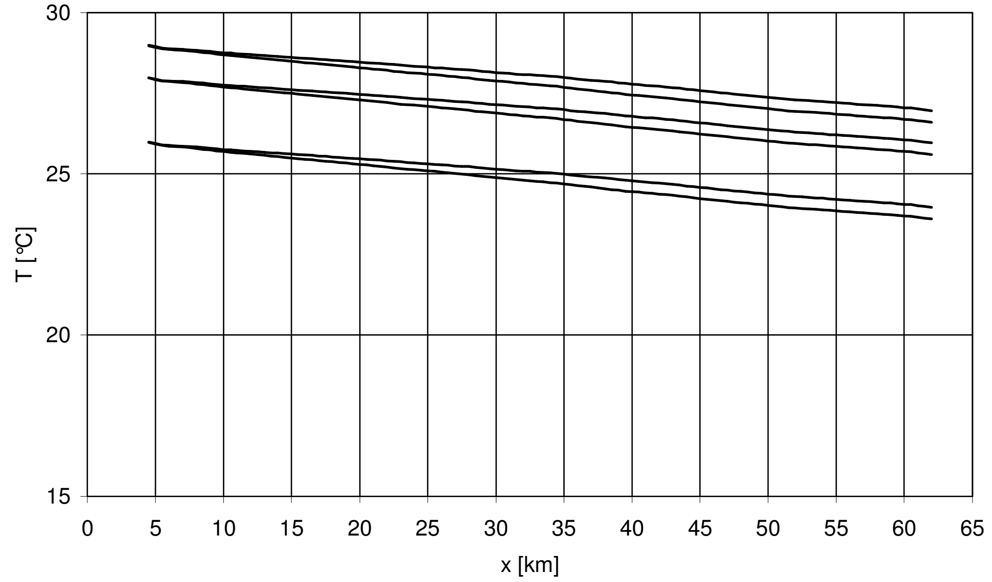

Figure 4.1.18.2-10. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (September conditions)

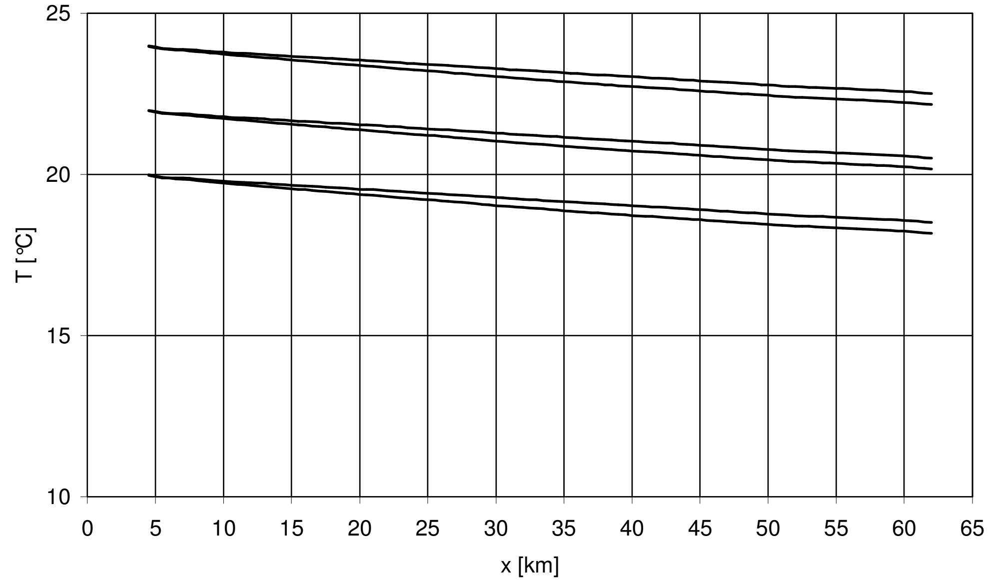

Figure 4.1.18.2-11. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (Octomber conditions)

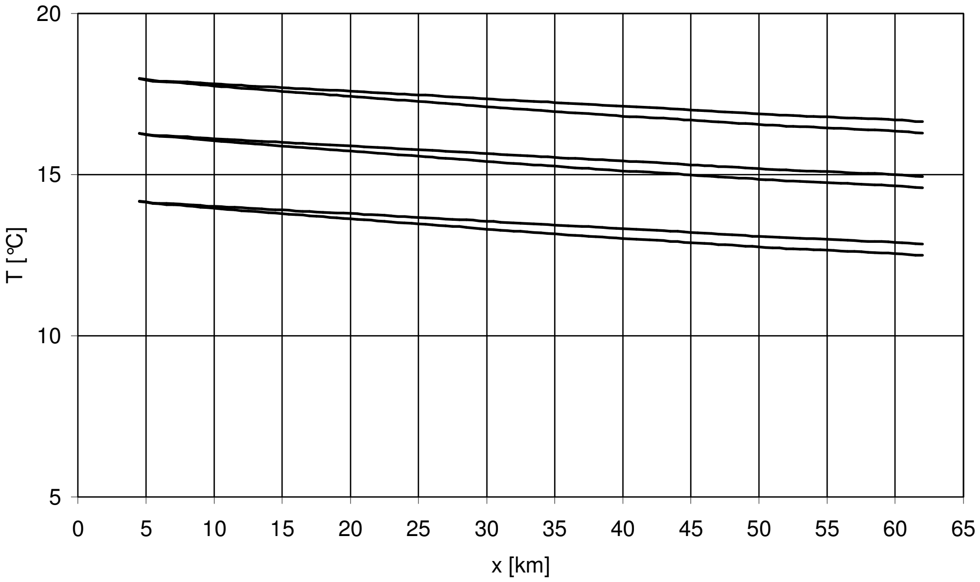

Figure 4.1.18.2-12. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (November conditions)

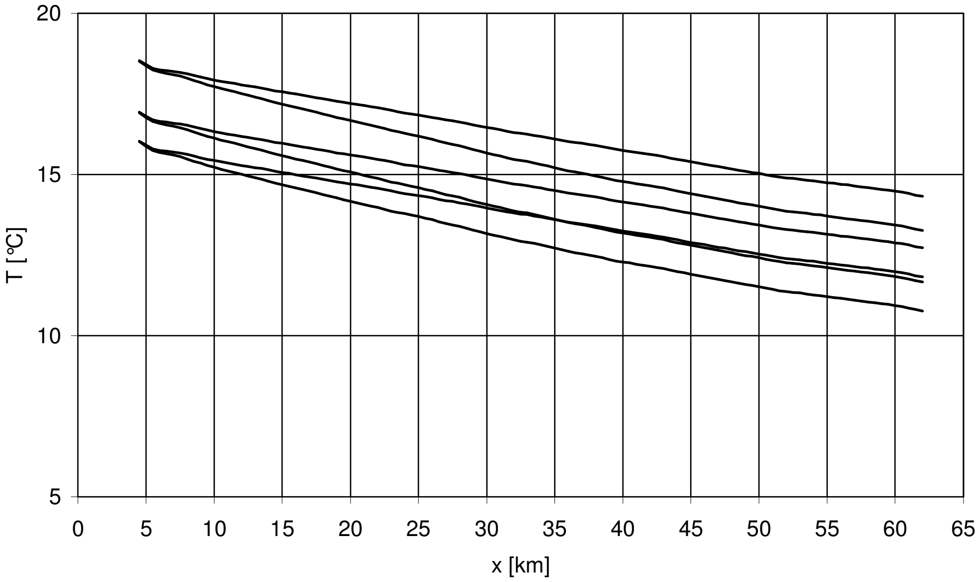

Figure 4.1.18.2-13. Calculated water temperatures in the race 2, under the effect of the effluent from the Units 1, 2, 3 and 4 (December conditions, recirculare)

4.1.19. Estimated Impact of the NPP Effluent on Danube Water Quality Indicators

The data obtained during the campaigns in 2001, 2003, 2004 and 2006, that were presented in the Chapter 4.1.3, are useful for assessing the impact of the effluent from one NPP unit and provide information for the case of two or more units.

The analyzed quality indicators included physical parameters, oxygen regime indicators, nutrients, dissolved ions, and also specific substances used by Unit 1 during normal operation. These parameters are relevant for assessing potential effects of the NPP effluent discharge on water quality and aquatic environment state.

The separate impact of the Units 3 and 4 effluent on the Danube branch Dunarea Veche can be assessed taking into consideration these data.

The Units 3 and 4 effluent has the chemical loads from the Danube water and an increased temperature in comparison with the water source. It includes also some waste waters from the NPP. The waste waters discharged from the water treatment station are those that come from decantation (sludge), from ionic filters regeneration and washing water from the mechanical filters. The water treatment station is equipped with a system for neutralizing the waste waters resulted from the regeneration process, equipment washing, floor, etc. The volumes and the discharge conditions for these waters are specified in section 4.1.14.4. In the cooling water the concentrations of the chemical substances (calcium, magnesium, natrium, chloride, sulfates) and of the suspended matter from STA reduced very much (Table 4.1.14.5-2). The water from neutralizing tanks of STA is discharged only after the pH value control, carried out on the neutralizing pump discharge line, as well as in the laboratory. The discharging valves are opened only if the pH value is inside the permitted limits for discharging. It results from the above that the discharges from the water treatment station in the heated effluent and further in the receptor have no significant impact. The impact of specific substances (hydrazine, morpholyne, cyclohexilamine) in the effluent is examined in Chapter 4.1.21.

Figures 4.1.19-1 to 4.1.19-8 provide an overview of the whole set of values obtained for some relevant indicators in all sections during the campaigns. The values have normal variations from a time interval to another and from a point to another, as it is usual in the Danube.

The dissolved oxygen concentrations are in most cases within the quality classes I and II, indicating that the Danube water is well oxygenated.

The values of the indicators are around those in the upstream section, within class II in most cases. Some temporary exceeding values are determined by the existing conditions and pollution sources in the Danube hydrographic basin.

CNE-PROD takes regularly water samples from the effluent, in a section (the Seimeni bridge) before the discharge into Dunarea Veche. The water source quality is also monitored taking water samples from a section (the NPP bridge) at the entrance to the NPP water intake basin. The results are reported to the waters authority.

Figures 4.1.19-9 and 4.1.19-10 show examples of average values obtained by CNE-PROD in the quarters of 2001 and 2003, compared with results of the campaigns of ICIM in those years. All the values in the figures are obviously at about the same level in the effluent as in the water source (coming from the Danube).

The measured values are below the limits specified in the Water Management Authorization and in NTPA 001.

An important quality indicator for the aquatic organisms and for water self-purification is the dissolved oxygen. Its concentration is influenced by various phenomena and processes at the interface with the air and inside the aquatic environment. One of the factors is water temperature. Table 4.1.19-1 presents the dissolved oxygen saturation concentrations (Ref. 4.1-22, 4.1-12) at various water temperatures, in ideal conditions, without oxygen production or consumption.

Table 4.1.19-1. Oxygen concentrations in water at various temperatures, without oxygen production or consumption

Water temperature (^{0}C)	0	5	10	15	20	25	30	35	40
Dissolved oxygen at saturation (mg/l)	14.6	12.8	11.3	10.2	9.2	8.4	7.6	7.1	6.6

The water temperature increase due to the effluent occurs only in a rather small area compared to the river channel width. The temperature differences, both measured and calculated, are within a range of a few degrees and therefore the table above shows that they have not any significant effect on the oxygen concentration. The fact that the oxygen regime is not significantly influenced by the effluent, is confirmed by the sets of measured values during the field campaigns. Furthermore, the solubility limit at 35 ^{0}C is above the limit of quality class II, 7 mg/l.

The variation of the values of some chemical indicators (dissolved oxygen, nitrogen, phosphorus, organic matter) depends also on the phytoplankton biomass variation (influenced by water temperature). The results of the biological analyses of the water samples taken during the field campaigns showed that the total phytoplankton biomass was within the Danube river characteristic limits, as well as in the case of the chemical indicators. Therefore, the chemical indicators were not modified because of the water temperature.

The analyses of the chemical indicators did not find any significant changes of their values on the branch Dunarea Veche due to the Unit 1 effluent. Therefore, it is assessed that the impact of the Units 3 and 4 effluent on Danube water quality indicators will be insignificant.

If the effluent comes from four units, its temperature difference over the Danube water temperature and its chemical concentrations are expected to be similar to the case of one NPP unit. The substances concentrations in the effluent are at the same level as in the Danube water. Only the flow value will be larger, four times. Therefore, the thermal impact will occur at a longer distance (Chapter 4.1.17), but it will be local along the right bank of the river. Based on the results of the thermal effect estimation and of the studies on the Danube, it is assessed that the cumulated impact on water quality indicators, of the effluent from Units 1, 2, 3 and 4 will not be significant.

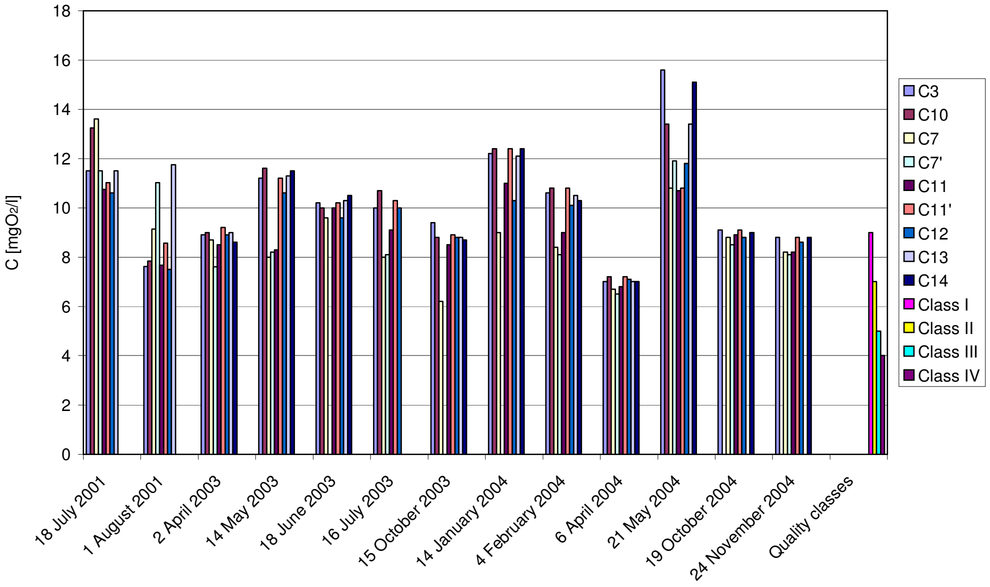

Figure 4.1.19-1. Values of the dissolved oxygen on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

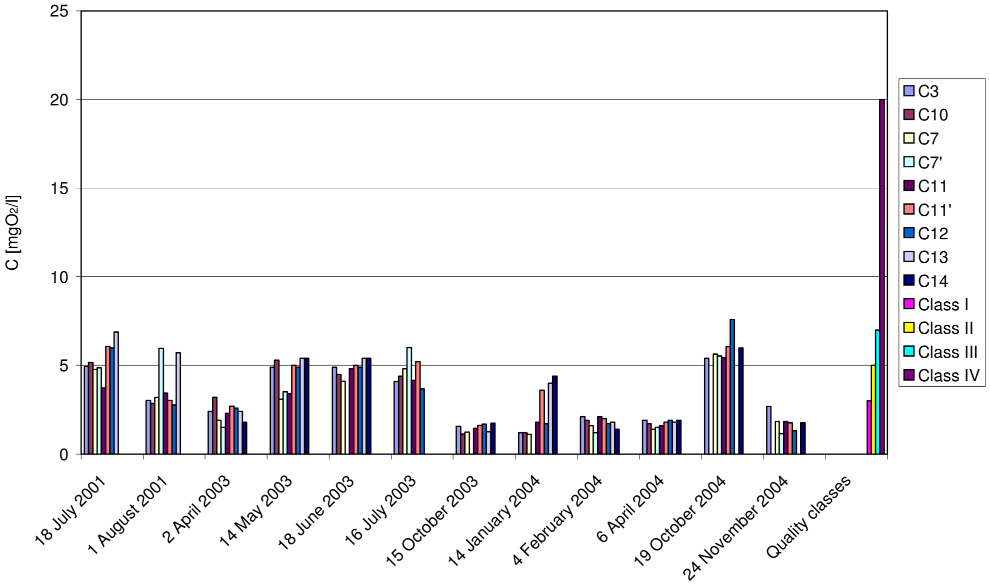

Figure 4.1.19-2. Values of the BOD$_5$ indicator on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

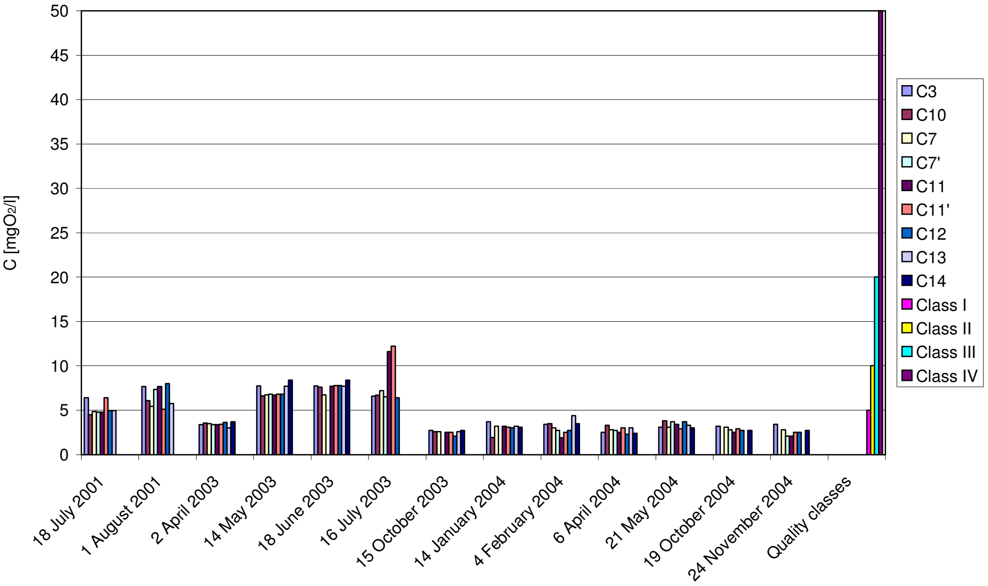

Figure 4.1.19-3. Values of the COD-Mn indicator on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

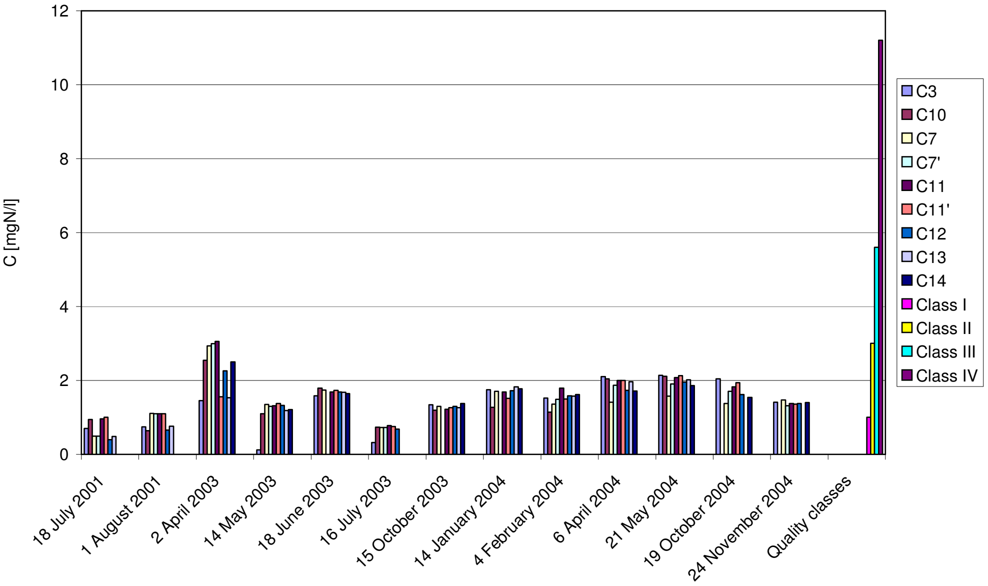

Figure 4.1.19-4. Nitrates concentrations on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

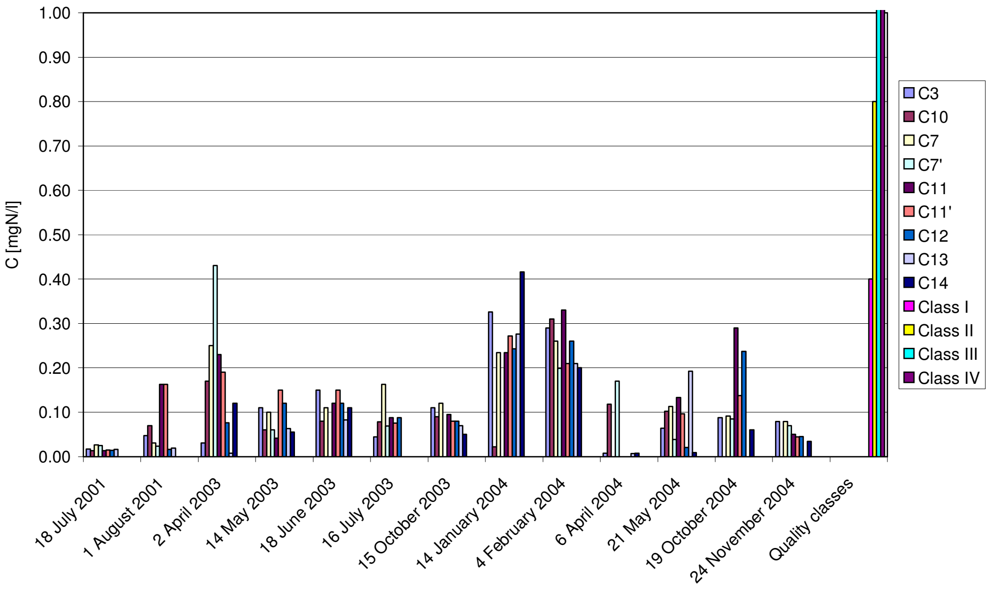

Figure 4.1.19-5. Ammonium concentrations on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

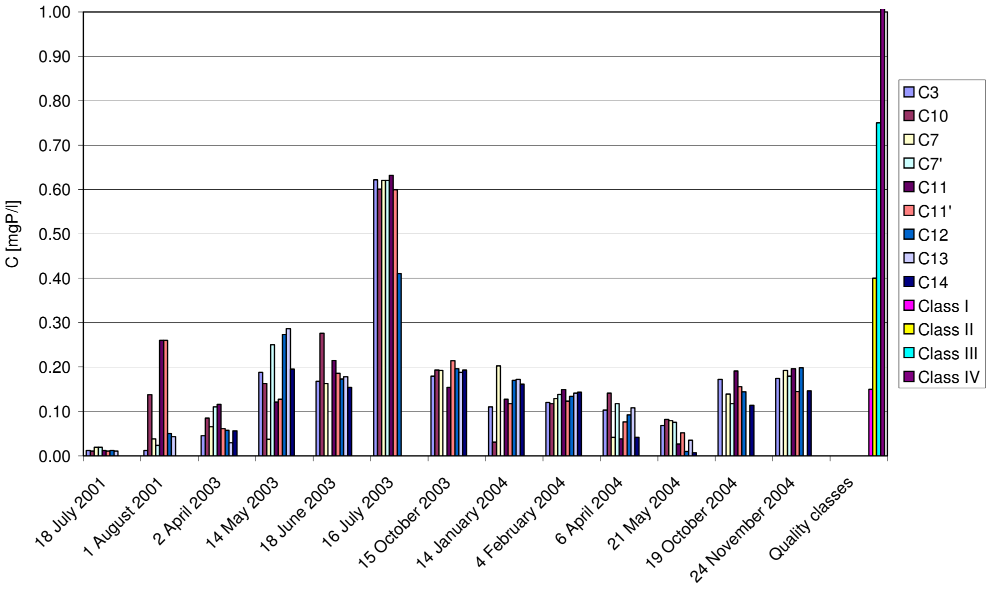

Figure 4.1.19-6. Total phosphorus concentrations on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

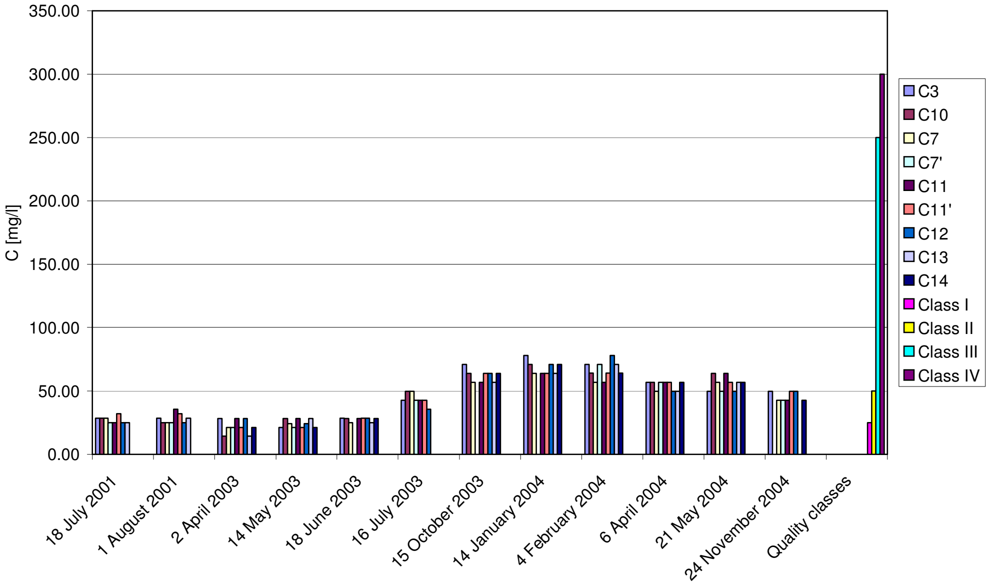

Figure 4.1.19-7. Chlorides concentrations on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

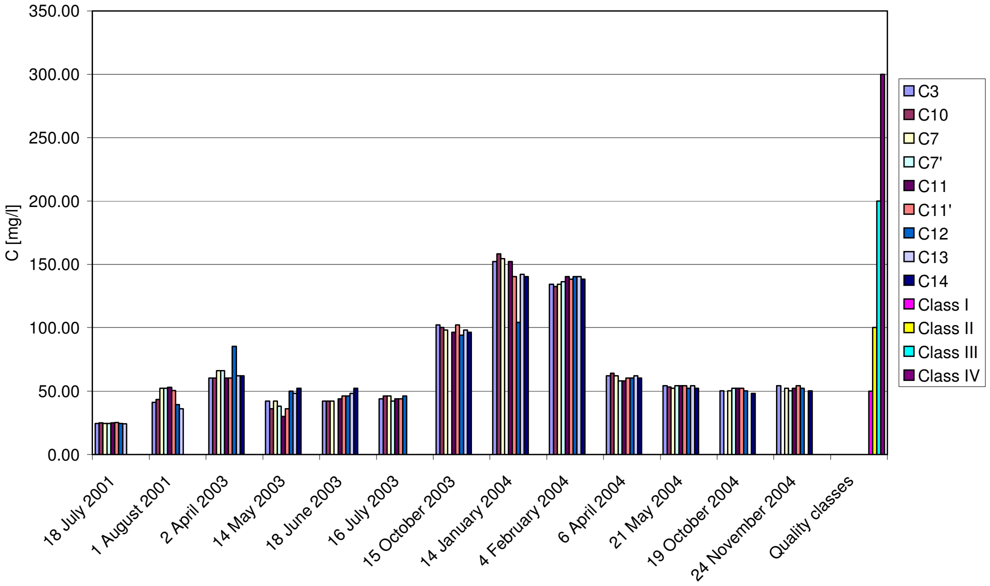

Figure 4.1.19-8. Calcium concentrations on Dunarea Veche, upstream and downstream the NPP effluent discharge section (from one unit)

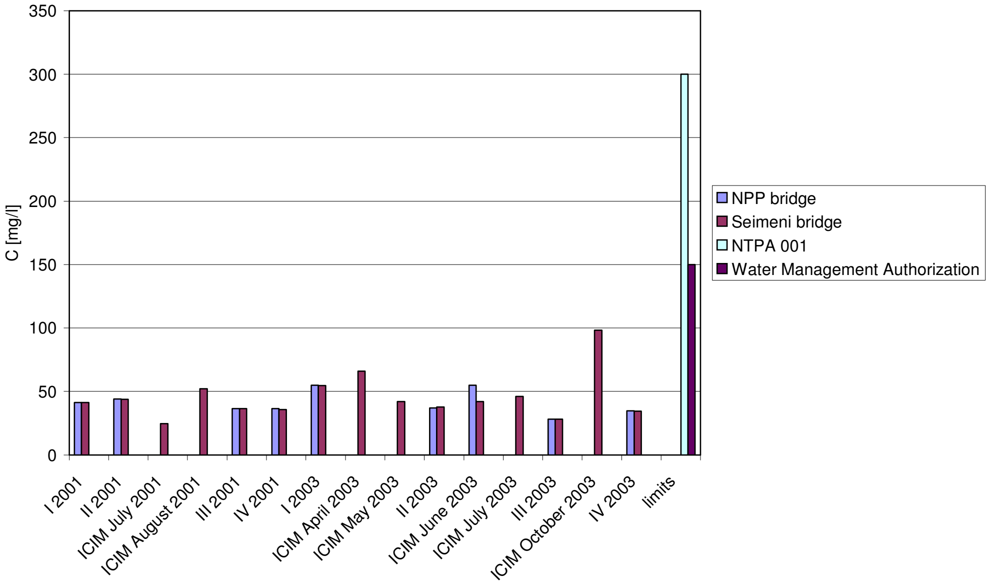

Figure 4.1.19-9. Calcium concentrations measured by CNE-PROD and ICIM in the heated effluent from Unit 1

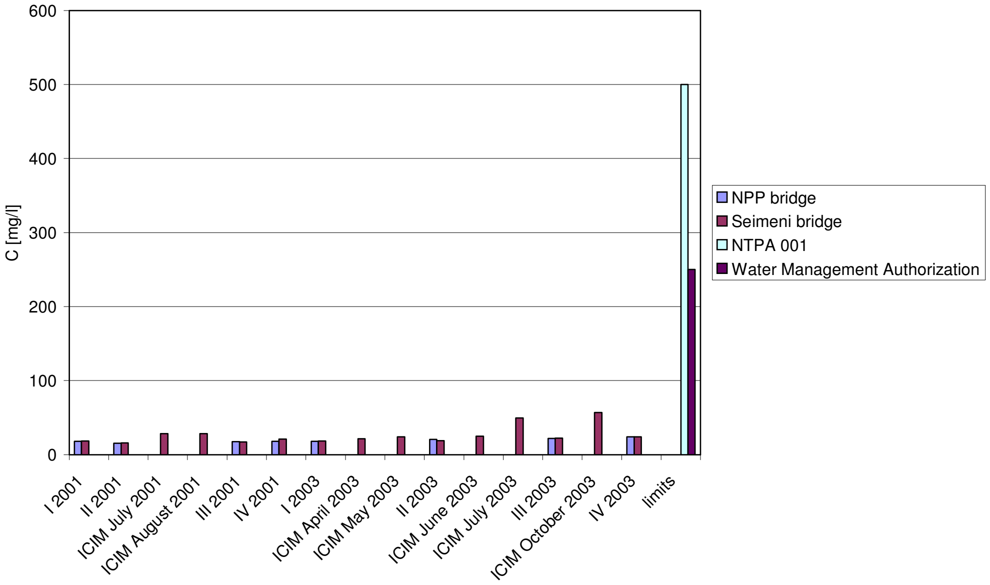

Figure 4.1.19-10. Chloride concentrations measured by CNE-PROD and ICIM in the heated effluent from Unit 1

4.1.20. Estimated Impact of the NPP Effluent on Quality Indicators in the DBSC Water

The effects on DBSC water quality of the effluent discharged from one Cernavoda NPP unit was studied during several campaigns on DBSC and PAMNC, as shown in Chapter 4.1.6. The results are relevant for assessing the separate impact of the Unit 3 effluent or Unit 4 effluent discharge into DBSC race 2.

Water quality in these canals is under the effects of the Danube water chemical loads and the received waste waters. The specific water motion situation causes a high residence time that is important for physical and chemical processes in the aquatic environment and their relationship with biocenosis components.

In addition to physical indicators, the relevant chemical parameters for assessing potential effects of the NPP effluent discharge on the DBSC water race 2 aquatic environment are the oxygen regime indicators, the nutrients and the dissolved ions. The assessment regarding the specific substances in the effluent is presented in Chapter 4.1.21.

Figures 4.1.20-1 to 4.1.20-8 show comparisons among the sets of results obtained during the campaigns in 1999, 2001, 2004 and 2006 with the Unit 1 effluent in water race 2 (May 1999, May 2004, November 2004) and without the effluent in water race 2 (March and September 1999, July and August 2001, April and October 2004, August 2006).

The values of the dissolved oxygen concentration are within the quality classes I and II. The water in the DBSC and PAMNC is well oxygenated mainly due to the natural conditions. The biochemical oxygen demand (BOD_5) values were within quality class II in most cases, with some exceeding values.

The nutrients (nitrates, ammonium, phosphorus) were found with values within quality class II with some exceeding concentrations indicating higher loads from the Danube and from the waste water sources existing along water race 2. These loads represent a nutritive support for phytoplankton growth (observed during summer in 1999 and 2001).

The water quality indicators values obtained by ICIM and CNE-PROD for the effluent were within the limits specified by NTPA 001 and the Water Management Authorization issued for CNE-PROD.

The effluent thermal and chemical loads effects were assessed by examining the DBSC water indicators values under its influence, in comparison with existing values in the absence of the effluent. Figure 4.1.20-1 shows that the dissolved oxygen values depend mainly on the natural conditions in various periods. The other indicators values are determined especially by the concentrations in the Danube water and by sources (other than the NPP effluent) existing along the DBS Canal. The results of the campaigns indicate that the water temperature increase in the DBSC water race 2 due to the effluent from one NPP unit had not any apparent direct effect on the values of the chemical indicators. The dissolved oxygen (important for biochemical processes, water quality and aquatic organisms) had usual values, within the quality classes II and I.

The data sets taken into consideration (with the effluent flowing along race 2) were obtained during spring and autumn. Under the highest Danube water temperatures during summer, the effluent thermal effect can favor phytoplankton growth with potential influence on some chemical indicators. Actually, the influence of the increased water motion along water race 2 has also to be considered. The phytoplankton growth that occurred naturally in some periods without the effluent effect was temporary and the aquatic ecosystem state returned back to the usual situation after the water temperature decreased. Aquatic vegetation was also observed in some stretches of race 2.

The effluent discharge from two or more NPP units in water race 2 changes the water motion regime from a quasi-stagnant water body to a slowly flowing water stream. This change helps the water replacement in the DBS Canal reducing much the water residence time. The increased water circulation is expected to be favorable for water quality.

On the basis of the direct impact data mentioned above and the estimated thermal effects, it can be assessed that the separate impact of the Units 3 and 4 effluent will occur mainly on water temperature distribution as shown in Chapter 4.1.18. The effluent is not expected to change the water quality class as regards the dissolved oxygen or to have a notable direct effect on other quality indicators. Only some temporary indirect effects are possible sometimes, during the warm season, due to algal growth.

The cumulated effect of the effluents from Units 1, 2, 3, 4 is higher (chapter 4.1.18) on water temperature. The dissolved oxygen values are expected to remain in the quality class II (Table 4.1.19-1). The chemical concentrations will be similar, so that direct effects on water quality chemical indicators are not expected. During the warm season, the thermal effect can lead to higher temperatures favoring algal growth and biochemical reactions in the aquatic environment, that can influence some water quality indicators. Therefore, the cumulated effluent influence on the water quality in the DBS Canal is more intense during some periods. However, the effluent causes faster water motion and replacement in water race 2, with shorter residence times that are in favor of water quality.

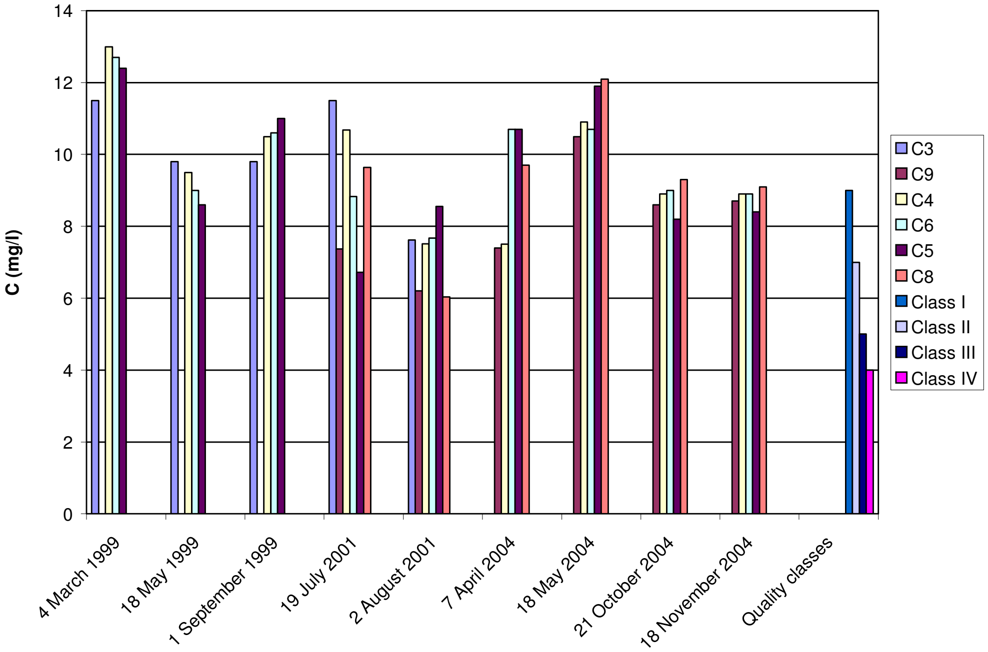

Figure 4.1.20-1. Values of the dissolved oxygen in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

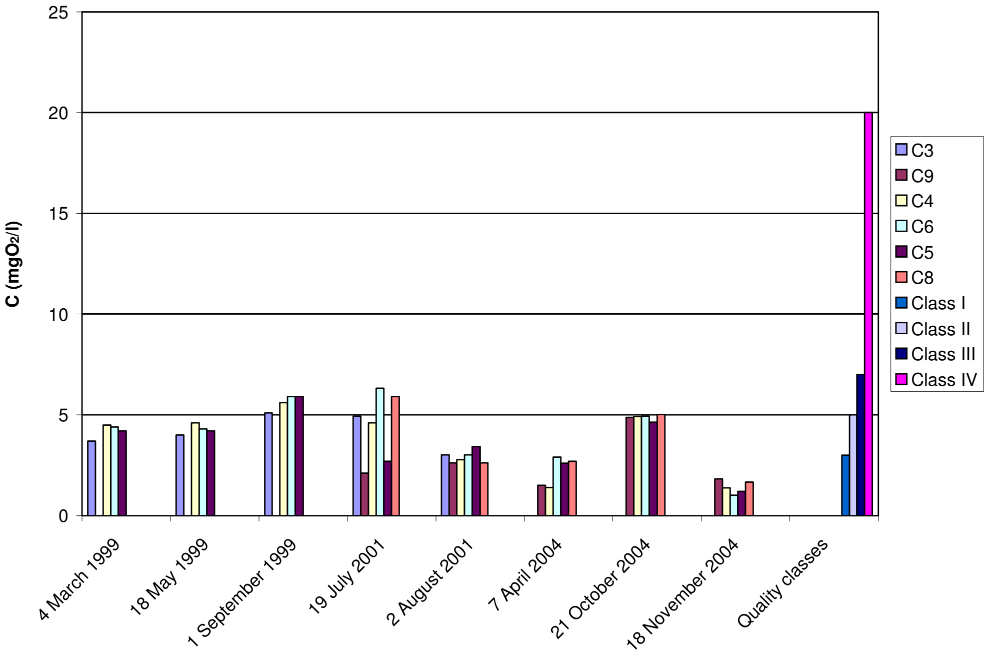

Figure 4.1.20-2. Values of the BOD_5 indicator in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

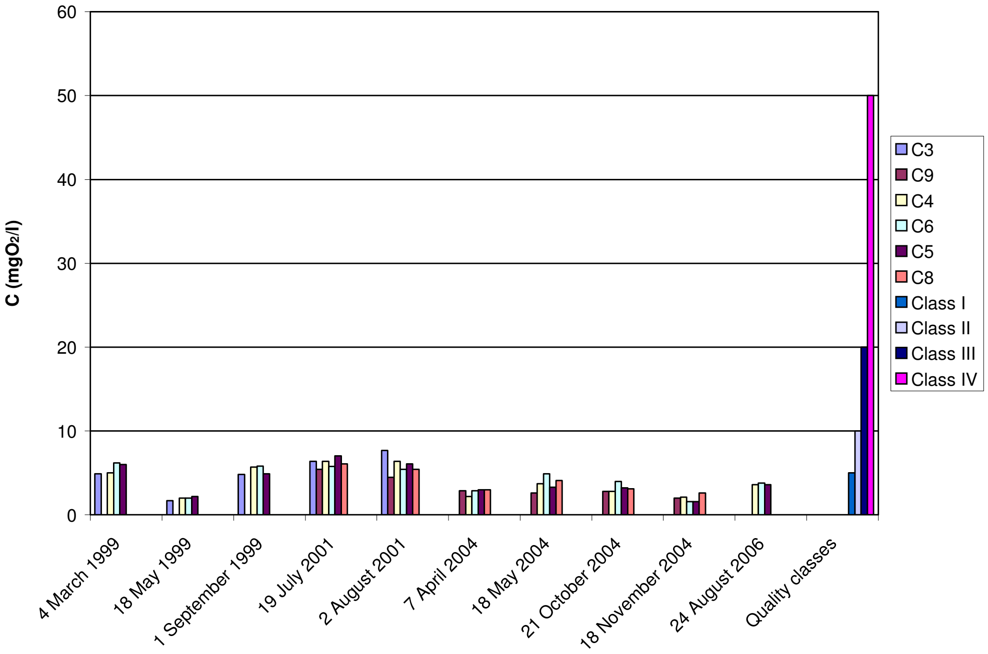

Figure 4.1.20-3. Values of the COD-Mn indicator in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

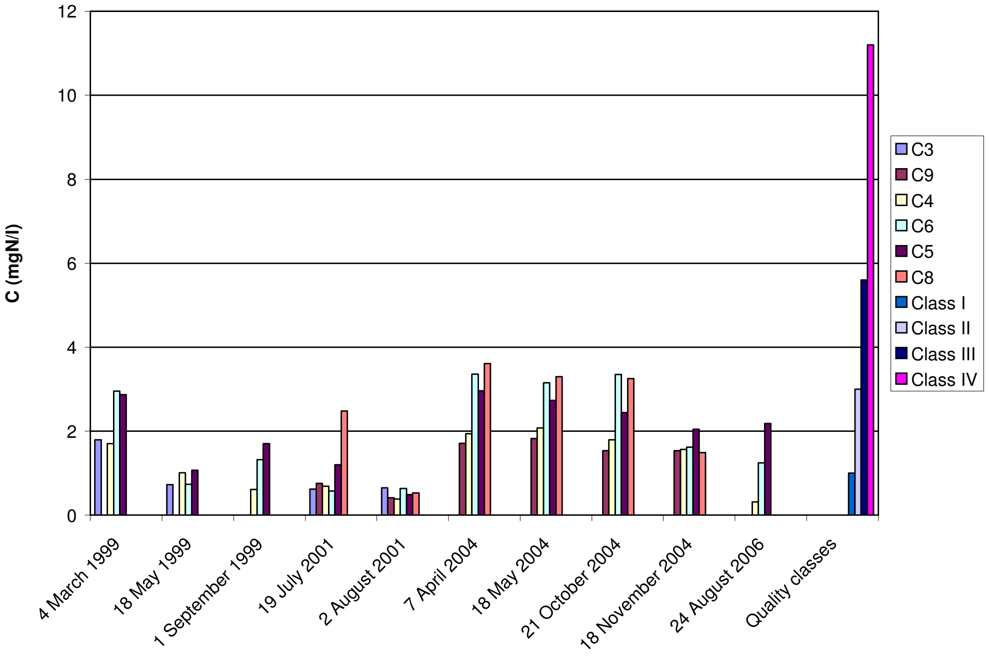

Figure 4.1.20-4. Values of the nitrates in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

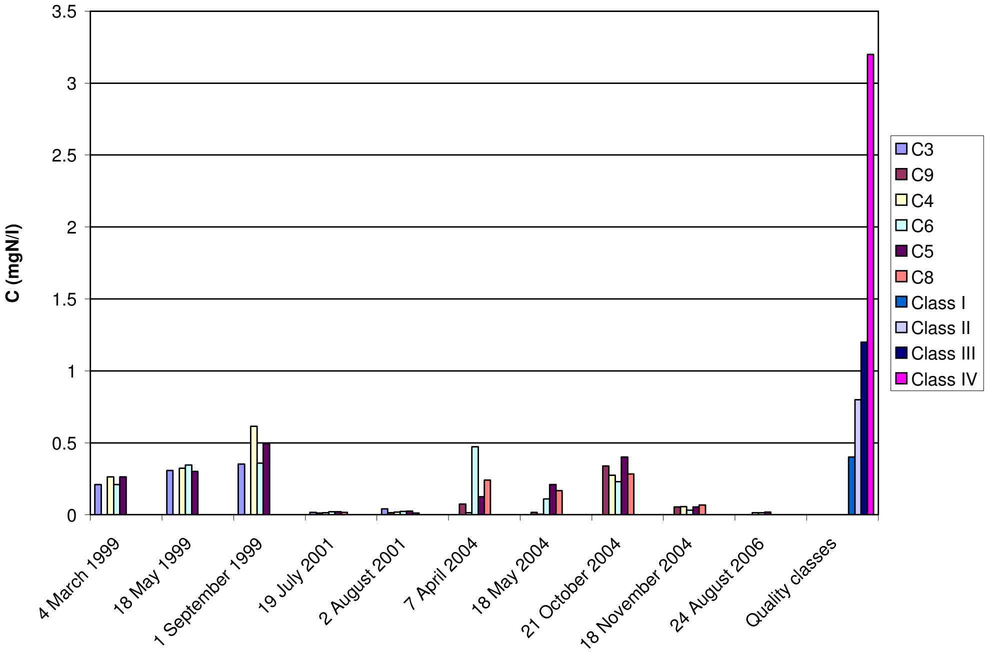

Figure 4.1.20-5. Values of the ammonium in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

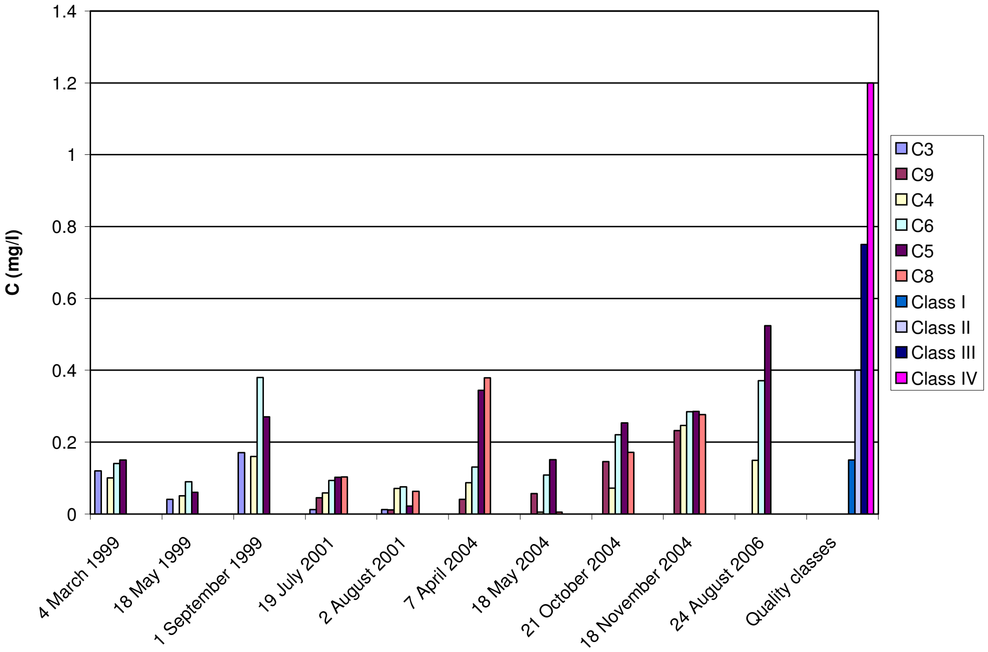

Figure 4.1.20-6. Values of the total phosphorus in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

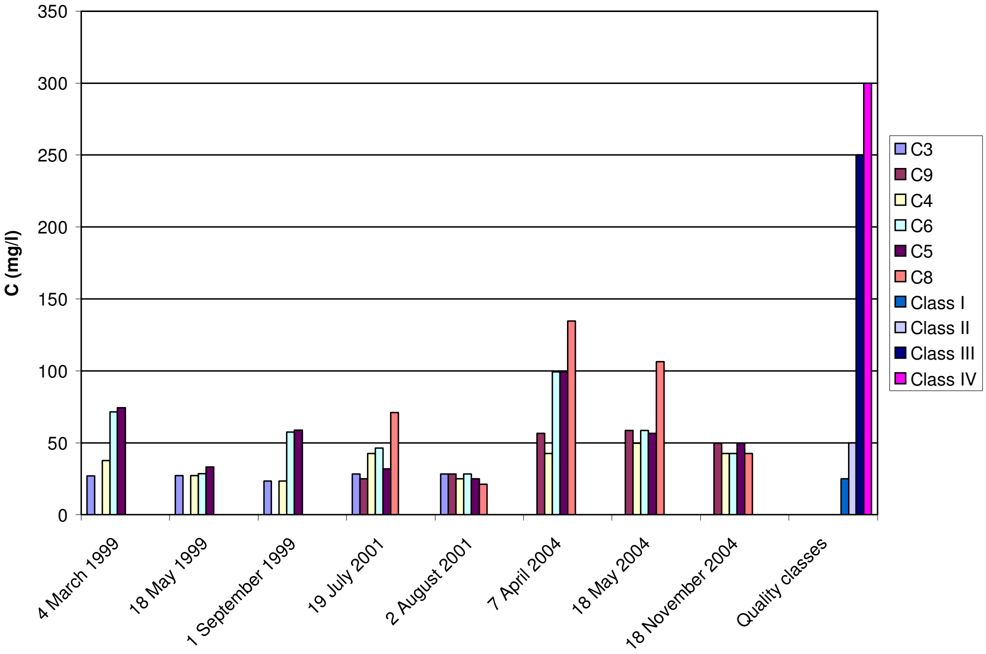

Figure 4.1.20-7. Chlorides concentrations in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

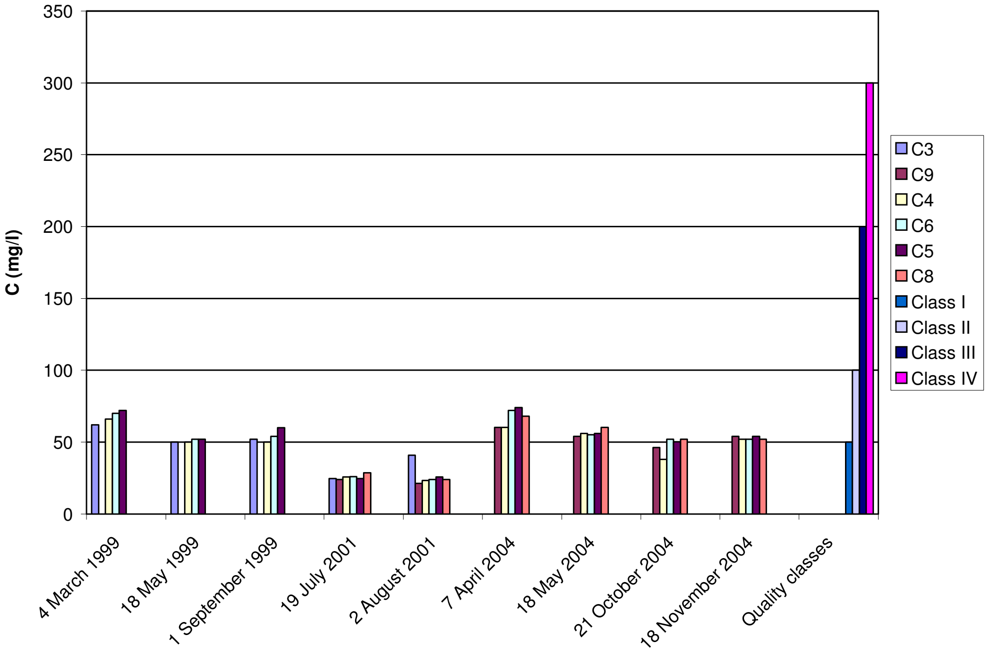

Figure 4.1.20-8. Calcium concentrations in sections of the DBS Canal water race 2 and the PAMN Canal, with and without the effluent from one NPP unit

4.1.21. Influence of Specific Chemical Substances in the NPP Effluent on Water Quality in the Danube or DBSC

The Units 3 and 4 effluent contains some specific chemical substances that are used currently during normal operation, as shown in previous chapters.

Among these, hydrazine is used as reducing agent, in order to prevent the corrosion induced by the dissolved oxygen. The hydrazine reacts with the oxygen, resulting nitrogen, and under certain conditions the hydrazine is decomposed, resulting ammonia and nitrogen. Morpholine is used for the control of the pH value in certain circuits of cooling systems with demineralised water, in order to reduce the corrosion effect. Another substance used during normal operation is cyclohexilamine.

The chemical analyses of water samples from Cernavoda NPP effluent, from the Danube and DBSC, carried out by ICIM and by CNE PROD (regularly) within its own monitoring program, did not show detectable values for hydrazine, morpholine and cyclohexilamine in the Unit 1 effluent or in the receptor water.

Having in view that the hydrazine existing in the water can lead by chemical transformations to increase in the ammonium content, the concentration of ammonium and its equilibrium with ammonia were also examined during the studies on the Danube and the DBSC. The results indicated that the ammonium values were within usual limits in the Danube and DBSC, without showing any increase because of eventual hydrazine decomposition.

Taking into account concentrations of these substances in the Units 3 and 4 effluent similar to those in the effluent from the Unit 1, and the results mentioned above, it is estimated that the influence of these substances will be similar, without effect on water quality indicators.

From the Units 1, 2, 3, 4 the total used quantities of these substances are bigger, but the concentrations in the effluent are similar because the total flow value is four times larger. Therefore, the concentrations resulting in the receptor will continue to be below the detection limits as in the case of one unit.

Keeping these substances concentrations below the allowed limits and monitoring them will ensure conformity with the regulations for surface waters quality protection.

The limits for specific substances in the effluent are established on the basis of specialized studies according to the legislation.

4.1.22. Estimated Impact of the NPP Effluent on Flora and Fauna in the Branch Dunarea Veche

The impact of the Cernavoda NPP effluent from Units 1, 2, 3 and 4 on the biocenosis in Dunarea Veche is estimated starting from the studies regarding the influence of the Unit 1 effluent.

During several studies (Ref. 4.1-12, 4.1-13, 4.1-14), the aquatic environment quality was analyzed on the basis of both biological results and the physical and chemical indicators. From the biological point of view, the Danube water quality characterization has been carried out based on the study of the qualitative composition (taxonomic groups, species, dominant forms) and quantitative composition (density, density abundance, biomass, biomass abundance) of the planktonic organisms populations.

The phytoplankton and zooplankton organisms in the Danube upstream and downstream the effluent discharge section were found with naturally varying values according to the seasonal conditions. Both within and without the thermal plume, the values found by means of the water samples are comparable. They are influenced by the nutrients carried by the Danube from a lot of sources, the nearest being the Cernavoda Town sewage (at the right bank of the branch Dunarea Veche). The nutrients load from this source will be controlled by a waste water treatment plant.

Downstream the effluent it was found a similar range of values as upstream in the Danube. Therefore, the results obtained for the phytoplankton and zooplankton during the campaigns carried out by ICIM do not show an influence due to the effluent.

Many planktonic organisms found in the water samples are bioindicators of water load with biodegradable organic matter. For example, in the autumn of 2004, 14 bioindicator species were found including 3 in the oligosaprobic category, 9 in the beta-mezosaprobic category and 2 in the alfa-mezosaprobic category. Therefore, it is appreciated that the Danube water is within the beta-mezosaprobic category. It can be assessed that the effluent from two NPP units does not influence negatively water quality and the biocenosis on Dunarea Veche.

At this moment, the ecological state of the studied Danube sector was not affected by the Unit 1 effluent thermal and chemical loads. This is also due to the Danube physical characteristics in the studied area, the flowing velocity and the large flow values, which assure rapid water homogenization.

Taking into account the estimated impact of the Cernavoda NPP effluent (after the Units 3 and 4 commissioning) on water temperature and water quality physical and chemical indicators, as well as the low level of specific substances in the effluent and the much higher Danube flow, it is expected that the effluent influence on biocenosis components will not be significantly different.

Future monitoring activities on the Danube and also the regular analyses carried out by the Cernavoda NPP after Unit 2 commissioning and after Units 3 and 4 commissioning, will provide further field data to confirm in time the effluent quality within the admitted limits and the absence of some negative effects from the Units 1, 2, 3 and 4 effluent on the biocenosis in the Danube.

4.1.23. Estimated Impact of the NPP Effluent on Flora and Fauna in the DBSC Race 2

The effects on water quality and biocenosis, of the Cernavoda NPP effluent discharge from one unit into the DBSC race 2 for periods of one month, were studied (during spring and autumn) in 1999, 2004 and 2005.

The biological analyses comprised determinations of the qualitative composition (taxonomic groups, species, dominant forms) and quantitative composition (density, density abundance, biomass, biomass abundance) of the phytoplankton and zooplankton.

The primary productivity varies in the DBS Canal and PAMN Canal water from season to season, depending on several factors (including the nutrients concentration).

The phytoplankton and zooplankton in these canals were studied with and without the NPP effluent in the DBSC water race 2.

The phytoplankton biomass and the evolution of other aquatic organisms vary annually depending on the particular conditions during each year and growing sometimes more when the conditions are favorable. The measured biomass values reflect the existing different growth in different years.

In all the control sections, the correlation between the biotic component and abiotic component analyses results was taken into consideration for water quality assessment from the biological point of view. Most of the bioindicators species found in the water of the DBSC and PAMNC belonged to the beta-mezosaprobe category, and a few species belonged to the alfa-mezosaprobe category. Depending on the values of the quantitative biological indicators (phytoplanktonic density and biomass), on the bioindicator species presence and on the structure of the entire biocenosis, the DBSC and PAMNC water was biologically within the β-mesosaprobe category. Specific to this category, high dissolved oxygen quantities are present in the water, the organic load is reduced, the self-purification process is advanced, the organic matter mineralization is almost finished. A general characteristic of the organisms in the β-mesosaprobe category aquatic environment, is the high degree of sensibility to the dissolved oxygen concentration decrease and to the pH variations.

Algal growths were observed in water race 2 in some warm periods, favored by the natural factors, in the absence of the NPP effluent. The water temperature values have even in the absence of the effluent, important variations during the year, and from a year to another, favoring sometimes phytoplankton development over the usual limits, with influences on the canal water quality.

The water temperature increase in the upstream section of DBSC water race 2 due to the Units 1, 2, 3 and 4 effluent is similar to the case of one unit during winter, spring and autumn (when additional flows from race 1 are not necessary for covering water consumption from race 2), but water temperature is increased on longer distances in DBSC.

The temperature in the supplying water source for DBSC (the Danube) can be higher during June-September, when the average multi-annual monthly values at the DBSC water intake are between 20.7 - 24 ºC, and the average monthly temperature maximum values are between 23.6 - 26.7 ºC. Even the minimum monthly average temperature values are 22.1 ºC in July and 22.0 ºC in August. The water temperature increase could modify the life cycle of aquatic organisms in DBSC.

Under conditions of high water temperature at the DBSC intake, and low supplementary flow into the canal, taking into account the available natural amount of nutrients in the water race 2, water temperature increase could lead to algal development. Large algae development, if it occurs, can lead, in time, to consequences on some biotope chemical components (for example, high oxygen consumption) and some quality indicators that are important for water use (especially source for drinking water treatment). When water temperature returns to normal values (in autumn), the biocoenosis recovers in time.

In order to prevent some undesirable effects, the water temperature and other parameters monitoring will be necessary in some periods, during and after the Units 1 and 2 effluent discharge into DBSC water race 2. Later, after Units 3 and 4 commissioning, the effects of the effluent from Units 1, 2, 3 and 4 on the DBSC aquatic environment will have to be monitored. The DBSC water state monitoring will be performed within the surface waters state analysis by the water management authorities, according to the existing regulations. The obtained data will allow the environmental protection and water management authorities to establish the solution for the NPP effluent discharge (into the Danube or into the DBSC race 2) in the very warm periods, taking into consideration all the important aspects.

4.1.24. Estimated Impact of the NPP Effluent on Danube Water Use and on DBSC Water Use

The surface waters in the Cernavoda NPP area are used for navigation, industrial water supply, as water source for drinking water treatment, for irrigation, and commercial and recreation fishing.

Danube is used as a raw water source for drinking water supply for Cernavoda town, the intake being located in a section upstream the confluence of the Danube with Danube - Black Sea Canal (DBSC), and therefore, upstream the effluent discharge section. Also, many towns in Braila County (including 80 % of Braila City inhabitants) use water taken from the Danube via the pumping stations located in Gropeni (about 90 km downstream

Cernavoda NPP) and Chiscani (about 100 km downstream Cernavoda NPP). The villages in the Big Island of Braila and Tulcea County (Daieni, Ostrov, Turcoaica area) use the Danube water without any pre-treatment. The localities downstream Cernavoda are far, beyond the influence of the thermal plume from the Cernavoda NPP effluent.

Along the Danube sector between the NPP effluent discharge section and Harsova, there are water intakes of three irrigation systems. Only the Seimeni irrigation system is supplied from an area relatively influenced by the heated water plume. The effluent influence on water temperature in that area is rather small and it is unlikely to occur negative influences of the thermal factor on the irrigated plants.

Fog occurrence frequency in the Cernavoda area was analyzed on the basis of data sets obtained by the meteorological stations. This phenomenon was examined in specialized studies (Ref. 4.1-7, 4.1-12), in relation to the main relevant factors, including the underlying surface temperature. The heated effluent has an increased surface temperature in comparison to the natural water temperature.

For the area in the neighborhood of the effluent discharge into the Dunarea Veche branch, it was estimated an increase in the fog phenomenon annual frequency by 10 % in the heated water discharge area, due to one or more NPP units. Water temperature increase occurs in a relatively small area on the right part of the river so that the effluent influence on fog frequency is not important. After Unit 2 and Units 3 and 4 commissioning, the fog occurrence conditions in the effluent discharge area and its frequency will be practically the same, but on a longer sector towards downstream. The possibly influenced area on Dunarea Veche is relatively small, on the right side, and the effluent effect is not important.

In the DBSC hydrotechnical system, the intake of the water treatment station on PAMNC is far from Cernavoda, on a canal with slow flow, and the water temperature increase, lower than in the upstream race 2 section, will be diminished by mixing with cold water from underground.

As regards the impact on the water intake for the existing irrigation systems along race 2, the water transport long distances significantly reduce the thermal factor impact on the systems.

As in the case of the discharge to the Danube, it was estimated that the effluent could lead to an increase of fog phenomena annual frequency with about 10 % (with some seasonal variations) at the upstream end of the DBSC race 2. During the discharge of the Units 1, 2, 3 and 4 effluent into DBSC, water temperature increase could favour fog occurrence on a longer downstream sector. The effluent effect on fog occurrence diminishes with the distance increase from the heated water discharge section, in any season.

4.1.25. Measures for Impact Mitigation and Prevention

Radioactive Liquid Effluent Control

The liquid effluent activity is measured with the Liquid Effluent Monitor (LEM). The LEM is located in the S/B basement and consists of:

- An adequately shielded detection unit (the detectors), installed in the monitored liquid effluent area;
- A signal processor/microprocessor with specified input/output;
- A logic/sequential control unit, which will also include LEM states monitoring;
- A separated display unit which will be placed in the monitored discharge area;
- Operational additional/display/indication panels.

The LEM ensures the following functions:

- Display and indications about the measured parameters and monitoring of the status at any given moment;
- Communication and input/output control signals to the Radioactive Liquid Waste system control panel, to automatically stop the discharge when a set point is exceeded;
- An output signal for continuous recording of data on a recorder.

The set point is established considering that all measured activity is due to the most restrictive isotopes (Cs-137, Co–60). The detector has sufficient sensitivity to activate the alarm and terminate the pump out the liquid radioactive waste before approximately 0.1 % monthly DEL has been released.

Sampling is automatically stopped when a liquid radioactive waste tank discharge is carried out. A sample taken from the discharged effluent is sent to the Health Physics Laboratory for detailed quantitative analysis using a Ge (Li) multichanal gamma spectrometer. Thus the quantity of gamma emitting radionuclide in the liquid radioactive effluent can be accurately determined. The sample is also analysed for tritium and C-14 using the liquid scintillation counting technique.

By construction, the LEM is provided with background compensation facilities.

The LEM fulfils the following requirements:

- Constant monitoring of all discharged liquid wastes, by continuous representative sampling;
- Permanent recording and display on demand of activity concentration in the discharge channel, as a function of time;
- Determines the total activity released daily and monthly by integration function of time and flow rate;
- Detection and measurement of the liquid effluent gamma radiation and indication of measured activity;
- Permanent availability for detection and measurement of activity, whether there is pumping or not;
- Detection and measurement of activity in real time;
- Receives inputs and provides outputs/interlocks which will close a pumping sequence in certain cases such as for unfavorable operating conditions or monitor unavailability/failure;
- Provides an input signal to another panel (Radioactive Liquid Waste System panel) to close the discharge valve in cases when the detected activity concentration or total activity are higher or equal to the set point;

- Provides a high activity alarm in the MCR;
- Provides an analogical input signal to the recorder, which corresponds to the sample net activity concentration (Ci/m^3).

Representative samples for further laboratory analyses are taken by a device separated from the LEM.

Mitigation Measures Regarding the Non-Radiological Impact

The measures for preventing or diminishing the effects on groundwater and surface waters were described in Chapters 2 and 3, and also in previous sections of Chapter 4.

Water Accidental Chemical Pollution Prevention Measures

The accidental pollution prevention measures will be taken according to the requirements of the legislation.

Moreover, the operation and maintenance procedures will be strictly applied at Unit 3 and 4, with the purpose to prevent any causes of accidental pollution. The installations and equipments will be verified periodically, the substances and wastes management will be rigorous, and the personnel training will include accidental pollution prevention topics.

The absence of accidental pollution of waters during the activities at Unit 1 shows the effectiveness of the measures and procedures applied within the Cernavoda NPP site.

The monitoring activities provide data so that the effluent be kept permanently within the admitted parameters for limiting its impact.

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