MVM PAKS II. ZRT.

IMPLEMENTATION OF NEW POWER PLANT UNITS AT THE PAKS SITE

ENVIRONMENTAL IMPACT STUDY

CLARIFICATION OF FACTS

based on the order with the reference number of 35700/4299-4/2015

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1 Reviewing the contents of the EIS from the water protection perspective, the provisions laid down in paragraph (1) Article 10 of Ministerial Decree No 15/2001. (VI. 6.) KöM on the radioactive discharges into the air and water during the application of nuclear power and their control were taken into account. Accordingly, appropriate information has been obtained for both the maximum temperature rate of the hot water discharges (heat gradient); and the background water temperature (in a distance of 500 m from the inlet point). When these requirements are met, the impact on the Danube river will not change substantially. In order allow control and management of the impacts a monitoring system measuring the parameters at the reference point (points) was found to be advisable. Access to the findings presenting the impact on the water quality and ecological status of the Danube, obtained in the course of the operation of the monitoring system must be ensured for the directorate as the asset manager of the Danube River.

Measurement of the quantitative and qualitative parameters of the cooling water used for the purposes of cooling the units of the new nuclear power plant (water level, water flow, water temperature) takes place at the section following the level adjusting weir before it is mixed with the cooling water of the currently operated nuclear power plant units, using metering equipment designed with an appropriate degree of certainty and redundancy.

Temperature measurement of the mixed cooling water originating from the existing and proposed nuclear power plant units will take place in two reference profiles. Reference profile No 1 is situated in a distance of about 500 metres from the new inlet point and some 300 metres from the old inlet point. Reference profile No 2 is the control profile which is in existence at the time being.

2 Based on the written material the temperature of the discharged cooling water can be adjusted to meet the limits included in the respective requirements in a number of ways (load reduction of units, blending of cold cooling water, additional cooling). Compliance was demonstrated with the use of models set up for the River Danube. A 3D OpenFOAM model was completed for the three kilometres section from the inlet point (1527-1524 river km) and an approximately ~93 km long quasi three dimensional CORMIX model, which was fit to the OpenFOAM model. According to Chapter 11.6.3.2 of the document dealing with the modelling of the Danube the studies were conducted by taking into account a number of different heat load states, which is likely to be encountered during the proposed development project. Critical heat load states were modelled by taking into account a Danube water flow of 1500 m3/s. Extremes are expected to grow during the climate change and therefore it is found to be justified to investigate the temperature impacts on the Danube water at low water stages below 1500 m3/s volume rate of flow (and in particular at around 1000 m3/s flow rates).

The trends in the annual duration levels of the volume rates of flow expected in the future design states (such as in the year of 2032 and 2085) calculated with a view to the climatological scenarios were presented in the EIS during periods of water temperature above the given water temperature of the Danube as shown in the tables below:

Q/T	T_{Danube} [°C] – 2032.										
Q_{Danube} [m³/s]	20 °C	21 °C	22 °C	23 °C	24 °C	25 °C	26 °C	27 °C	28 °C	29 °C	30 °C
Q < 800	5.62	4.58	3.48	2.47	1.48	0.85	0.37	0.17	0.05	0.00	0.00
Q < 900	7-34	5.97	4.57	3.24	1.92	1.09	0.51	0.22	0.07	0.01	0.00
Q < 950	8-28	6-71	5.14	3.62	2.14	1.22	**0.57**	**0.25**	0.08	0.01	0.00
Q < 1000	9-22	7-45	5.70	4.00	2.35	1.35	0.63	0.28	0.08	0.01	0.00
Q < 1100	11.10	8-85	6-66	4.69	2.76	1.54	0.69	0.31	0.10	0.01	0.00
Q < 1200	12.91	10.34	7-80	5.44	3.21	1.75	0.80	0.37	0.10	0.01	0.00

Q/T	**T_{Danube} [°C] – 2032.**										
Q_{Danube} [m³/s]	**20 °C**	**21 °C**	**22 °C**	**23 °C**	**24 °C**	**25 °C**	**26 °C**	**27 °C**	**28 °C**	**29 °C**	**30 °C**
Q < 1300	14.96	11.97	9-06	6-34	3.77	2.03	0.94	0.45	0.13	0.01	0.00
Q < 1400	17-36	13.82	10.46	7-32	4.38	2.33	1.08	0.50	0.15	0.01	0.00
Q < 1500*	19-79	15.76	11.94	8-30	4.99	2.65	1.25*	0.56*	0.19	0.02	0.00
Q < 1600	22.34	17-75	13.40	9-31	5.54	2.94	1.38	0.63	0.22	0.03	0.01
Q < 1700	24.94	19-75	14.80	10.29	6-11	3.23	1.52	0.68	0.24	0.03	0.01
Q < 1800	27-75	21.93	16-25	11.26	6-72	3.53	1.66	0.73	0.26	0.04	0.01
Q < 1900	30.70	24.16	17-89	12.33	7-32	3.85	1.83	0.82	0.28	0.04	0.01
Q < 2000	33.86	26.63	19-69	13.45	8-06	4.28	2.09	0.94	0.32	0.07	0.02
Q < 2100	36-98	29-00	21.37	14.61	8-71	4.64	2.26	1.00	0.34	0.08	0.02
Q < 2200	40.10	31.34	23.05	15.70	9-33	4.98	2.42	1.10	0.40	0.09	0.02
Q < 2300	43.35	33.83	24.76	16-72	9-98	5.38	2.59	1.17	0.43	0.09	0.02
Q < 2400	46-57	36-21	26.32	17-69	10.54	5.69	2.71	1.25	0.47	0.10	0.02
Q < 2500	49-47	38-40	27-76	18-64	11.01	5.94	2.80	1.28	0.47	0.11	0.02
Q < 2600	52.69	40.75	29-37	19-64	11.53	6-21	2.95	1.34	0.48	0.11	0.02
Q < 2700	55.42	42.79	30.79	20.52	12.00	6-47	3.06	1.39	0.51	0.12	0.02
Q < 2800	58-10	44.89	32.18	21.36	12.47	6-73	3.16	1.45	0.52	0.12	0.02
Q < 2900	60.51	46-56	33.35	22.02	12.83	6-94	3.27	1.49	0.53	0.12	0.02
Q < 3000	62.86	48-31	34.58	22.85	13.35	7-18	3.38	1.54	0.55	0.12	0.02
Q < 3100	64.71	49-67	35.47	23.39	13.71	7-34	3.45	1.56	0.55	0.12	0.02
Q < 3200	66-56	51.01	36-37	23.96	14.05	7-50	3.52	1.59	0.56	0.12	0.02
Q < 3300	68-18	52.17	37-04	24.33	14.26	7-62	3.57	1.61	0.57	0.13	0.02
Q < 3400	69-39	53.08	37-68	24.72	14.46	7-71	3.61	1.63	0.58	0.13	0.02
Q < 3500	70.37	53.72	38-12	25.02	14.61	7-80	3.65	1.63	0.58	0.13	0.02

Table 2-1: The average number of days in any one year in the year of 2032 when a given (T) temperature is exceeded and below a volume rate of flow (Q) exist on the Danube River (T_{Danube}=26.38 °C) – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

Q/T	**T_{Danube} [°C] - 2085.**										
Q_{Danube} [m³/s]	**20 °C**	**21 °C**	**22 °C**	**23 °C**	**24 °C**	**25 °C**	**26 °C**	**27 °C**	**28 °C**	**29 °C**	**30 °C**
Q < 800	11.60	10.17	8-66	6-94	5.25	3.65	2.22	1.13	0.52	0.22	0.07
Q < 900	14.60	12.76	10.86	8-67	6-47	4.52	2.67	1.39	0.63	0.29	0.10
Q < 950	16-23	14.16	11.945	9-53	7-06	4.90	2.90	1.50	**0.68**	**0.31**	0.11
Q < 1000	17-85	15.55	13.03	10.38	7-64	5.27	3.12	1.61	0.73	0.33	0.12
Q < 1100	21.37	18-47	15.38	12.16	8-97	6-29	3.74	1.94	0.88	0.38	0.14
Q < 1200	25.13	21.66	18-02	14.12	10.37	7-21	4.31	2.26	1.01	0.45	0.17
Q < 1300	28-93	24.78	20.50	16-07	11.80	8-13	4.81	2.52	1.11	0.50	0.18
Q < 1400	32.79	27-99	23.12	18-11	13.28	9-06	5.38	2.81	1.28	0.58	0.21
Q < 1500*	37-01	31.48	25.98	20.30	14.84	10.07	5.93	3.09	1.43*	0.63*	0.22
Q < 1600	41.51	35.24	29-00	22.54	16-32	11.02	6-47	3.33	1.51	0.67	0.23
Q < 1700	46-18	39-12	32.05	24.80	17-94	12.09	7-12	3.61	1.64	0.71	0.24
Q < 1800	51.04	43.16	35.19	27-22	19-57	13.11	7-67	3.90	1.77	0.80	0.28
Q < 1900	55.46	46-71	37-93	29-16	20.91	13.95	8-13	4.13	1.88	0.84	0.29
Q < 2000	59-87	50.33	40.74	31.29	22.38	14.90	8-62	4.37	2.00	0.88	0.30
Q < 2100	64.26	53.91	43.50	33.30	23.72	15.73	9-09	4.58	2.07	0.92	0.30
Q < 2200	68-32	57-10	46-00	35.16	24.98	16-46	9-48	4.78	2.13	0.94	0.32
Q < 2300	72.51	60.43	48-55	37-10	26.19	17-21	9-94	5.02	2.24	0.99	0.34
Q < 2400	76-14	63.41	50.81	38-70	27-22	17-81	10.29	5.20	2.30	1.01	0.35
Q < 2500	79-56	66-13	52.88	40.25	28-27	18-44	10.63	5.36	2.39	1.06	0.36
Q < 2600	82.96	68-85	55.04	41.75	29-28	19-14	10.99	5.53	2.48	1.10	0.38
Q < 2700	85.95	71.23	56-92	43.10	30.17	19-64	11.24	5.67	2.53	1.11	0.39
Q < 2800	88-38	73.18	58-47	44.26	30.97	20.11	11.52	5.82	2.58	1.14	0.39
Q < 2900	90.40	74.82	59-75	45.17	31.57	20.51	11.76	5.93	2.64	1.17	0.40
Q < 3000	92.47	76-52	61.05	46-13	32.23	20.90	11.95	6-02	2.65	1.17	0.40
Q < 3100	94.23	77-89	62.09	46-86	32.72	21.16	12.09	6-09	2.68	1.19	0.41
Q < 3200	95.84	79-17	63.04	47-52	33.18	21.46	12.23	6-15	2.71	1.20	0.42

Q/T	**T_{Danube} [°C] - 2085.**										
Q_{Danube} [m³/s]	**20 °C**	**21 °C**	**22 °C**	**23 °C**	**24 °C**	**25 °C**	**26 °C**	**27 °C**	**28 °C**	**29 °C**	**30 °C**
Q < 3300	97-00	80.03	63.69	48-01	33.50	21.66	12.33	6-19	2.73	1.20	0.42
Q < 3400	98-02	80.84	64.31	48-51	33.84	21.84	12.44	6-26	2.75	1.22	0.42
Q < 3500	98-89	81.54	64.86	48-90	34.07	22.00	12.51	6-29	2.77	1.23	0.42

Table 2-2: The average number of days in any one year in the year of 2085 when a given (T) temperature is exceeded and below a volume rate of flow (Q) exist on the Danube River (T_{Danube}=28.64 °C) – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

It can be seen from the tables that in the event of the design background temperature levels on the Danube (2032: T=26.38 °C, 2085: T=28.64 °C), the duration of the volume rate of flow of 1500 m³/s on the Danube on an annual basis remains below the average rate of 1 days/year. In these periods it can be achieved by technical measures such as back loading of the power plant that the 30 °C temperature limit could be ensured in the reference profile.

Since the design temperature range in the Danube occurs only below a volume rate of flow of 2800 m³/s, the maximum length of the duration and persistence of potentially necessary measures have been determined on the basis of the violation duration of the water temperature associated with the Danube water volume rate of flow of Q = 2800 m³/s referred to above so that temperature below 30 °C could be ensured in the reference profile.

<u>Quotation from the EIS</u>:

<u>“Expected duration and length of exceeding the 30 °C limit value in the +500 m reference profile:</u>

Table 11.9.1-4 summarises the variations of the calculated maximum Danube water temperatures in the moderate states in the control profile (+500 m) and the duration of exceeding the 30 °C limit value calculated from the climate model. The duration of the Danube flow rate below 1500 m³/day is about 1 day/year in the case of the Danube background water temperature (26.38 °C) taken as a basis (see in the chapter entitled: „Current and expected future trends in the water temperature of the Danube” No 11.7.4), but for the sake of safety the higher duration levels associated with the 2800 m³/s discharge were taken into account.

The range of limit violation which must be handled by intervention measures	**Moderate state (2014.)**		**Moderate state (2032.)**	
	8 [°C] heat gradient	**33 [°C] hot water discharge**	**8 [°C] heat gradient**	**33 [°C] hot water discharge**
Maximum background Danube water temperature expected [°C]	25.61 [°C]		26.38 [°C]	
Calculated maximum Danube water temperature [°C]	26,11 [°C]	26,36 [°C]	24,31 [°C]	25,11 [°C]
Calculated time of overshoot, duration [day]	0.2 [day/year]	0.1 [day/year]	13 [day/year]	7 [day/year]

Table 2-3: Length and duration of exceeding the limit value (2032.) – Paks Power Plant + Paks II.

<u>Expected duration and length of exceeding the 30 °C limit value in the +500 m reference profile:</u>

Table 11.9.1.-5 summarises the variations of the calculated maximum Danube water temperatures in the moderate states in the control profile (+500 m) and the duration of exceeding the 30 °C limit value calculated from the pessimistic climate model (DMI-B2 PRODUCE).

The duration of the Danube flow rate below 1500 m³/day is about 1 day/year in the case of the Danube background water temperature (26.38 °C) taken as a basis (see in the chapter entitled: „Current and expected future trends in the water temperature of the Danube” No 11.7.4), but for the sake of safety the higher duration levels associated with the 2800 m³/s discharge were taken into account.

The range of limit violation which must be handled by intervention measures	Moderate state (2014)		Moderate state (2085.)	
	8 [°C] heat gradient	33 [°C] hot water discharge	8 [°C] heat gradient	33 [°C] hot water discharge
Maximum background Danube water temperature expected [°C]	25.61 [°C]		28.64 [°C]	
Calculated maximum Danube water temperature [°C]	26,11 [°C]	26,36 [°C]	23,81 [°C]	25,23 [°C]
Calculated time of overshoot, duration [day]	0.2 [nap]	0.1 [day/year]	40 [day/year]	20 [day/year]

Table 2-4: Length and duration of exceeding the limit value (2085) – Paks II in stand alone operation

Possibilities to avoid exceeding the limit value:

- post cooling, with the installation of a post cooling system (hot water discharge maximum 33 °C instead of a 8 °C heat gradient),
- power reduction,
- unit shut down, or unit maintenance.

Additionally, 3D heat plume calculations were also completed for the moderate heat load states (in the years 2014, 2032 and 2085, respectively) taking a Danube water flow of 950 m³/s as a basis.

*For the purposes of calculating the Q/T duration of the design Danube water background temperatures the tables generated in XLS (**see: Annex No 2: 2_Melleklet_Tartossagok_Q_T**) for 2014 on the basis of the measured daily Q data in the period from 1965 up to 2013 (Dombori watermark post) and measured daily T values (Paks watermark post) of MAHAB. Maximum durations of exceeding of values here were determined by correlation with the annual average duration values associated with water rates of flow below 2800 m³/s and the design background water temperature on the Danube (25.61 °C; 26.38 °C and 28.64 °C). Namely, compliance with the 30 °C limit in the first reference profile situated 500 m downstream from the proposed new discharge point and in the second reference profile found 500 m downstream of the existing discharge point can only be ensured by reducing the heat gradients with power reduction of the power plant. Estimated maximum durations of maintaining these heat gradients calculated with the climatic model of 1.8 °C/100 years average global climate warming based on generated duration figures (the maximum being estimated with the average duration associated with the 2800 m³/s volume rate of flow) are as follows:*

- *In 2014 (8 °C heat gradient) - maximum estimated duration at 25.61 °C: 2 days/year,*
- *In 2032 5.47 °C heat gradient - maximum estimated duration at 26.38 °C: 3 days/year,*
- *In 2085 2.46 °C heat gradient – maximum estimated duration at 28.64 °C: 2 days/year.*

3 Please note that the Danube section concerned was given a moderate ecological status qualification during the status assessment of the National River Basin Water Management Plan (NRBMP) (due to the fish and macro zoo categories). In line with the water framework directive of the EU, the NRBMP set the goal to bring waters into a good ecological status and keep them there, which objective should be taken into account and adhered to in the course of the present procedure.

This issue is covered by Chapter 12 of the EIS in details.

4 According to Chapter 4.4.1.3 of the Environmental Impact Study documentation (Paks EIS _1__8.pdf) water temperature of the extracted and discharged water and, provided that the Danube water temperature is higher than 25 °C, the temperature of the Danube water is measured at a distance of 500 metres from the discharge point. However, the detailed description of the measurement points is not included in the documentation (profile, location within the profile, depth). "The Environmental Impact Study does not mention the measurements of water level, water flow and water temperature installed at the hot water channel since the year of 2005 as part of the current monitoring system and it does not evaluate the experiences derived from the data measured there in accordance with the proposed development project.

Calibration was completed for the most critical self-check measurements made on 10 August 2013 based on the protocol drawn up there (which, in turn, was based on the Danube water temperature monitoring results in the temperature monitoring rules of the Paks Nuclear Power Plant approved by and known to the water management authority.

At this time (10 August 2013) the water temperature of the Danube cold water channel (CWC) at around noon was: 26 °C. The mouth of the hot water channel (HWC) was maximum 33.6 °C, at 500 metres downstream maximum 29.4 °C (4.2 °C cooling). Heat plume average was also calculated for the upper layer (28 °C), in the width of the measurement route.

Model calculations for calibration provided the following results: calculated maximum was 29.6 °C, which is 0.2 °C more than the measured value, in other words the heat plume modelling was completed for the sake of safety.

(On 10 August 2013 24.8 °C water temperature was measured at Paks (Danube 1531.3 river km) early in the morning at 7 o'clock), Danube flow rate: Dombori: 1490 m^3/s, Dunaújváros 1530 m^3/s.)

No possibility was open to take over the monitoring data and the original data had to be used as initial data.

5 Chapter 5.3 deals with the possible solutions for cooling. The conclusion of the study is the use of a fresh water cooling systems. This part of the documentation also contains the needs for the capacity extension of the cold water channel (hereinafter referred to as cold water channel) and the need for developing the hot water channel (hereinafter referred to as hot water channel) (cross section extension). Taking into account the water speed and pavement in the channel, the cross section extension on the hot water channel means in our view a significant amount of extra risk affecting adversely the operating safety when Paks I is operated.

Upon the establishment of the currently operating nuclear power plant units the cold and hot water channels were designed for the water supply necessary to the currently existing four VVER-440 units and two additional VVER-1000 units, which means a total flow rate of 220 m^3/s, while under the current conditions condenser cooling water requirement is maximum 100 m^3/s.

During the cross section extension of the hot water channel the separations, diversions narrowing the cross section profile of the channel are designed not the exceed one third of the full cross section in each stage of the potentially required work phases.

The water volume less than designed and the limitations on the extent of the channel narrowing ensure that even during the works less than the rated flow rate will be formed in the hot water channel. A primary consideration for the scheduling of the works is that the extension works of the hot water channel never limited the safety and safe operating schedule of the Paks Nuclear Power Plant.

6 It was mentioned in the study that "in the event the water temperature on the Danube River exceeds 25 °C, additional cooling solutions may become necessary", but no quantitative data are provided to the extent and technical solution thereof. It is mentioned in Chapter 5.3.3 the kind of cost and benefit ratios are associated with the various additional cooling methods and with occasional load reduction of the power plant, and it is declared that load reduction was an economic solution. In this documentation however it is also mentioned that the extent of the load reduction of the power plant can be maximum 50 % of nominal load and not more than maximum 250 times within any one year (Page 120, Chapter 6.2.1., Table 6.2.1-1). It is not stated in the documentation, for how many days and to which extent load reduction must be ordered due to the overloaded Danube cooling water.

Load reduction of the power plant when the water temperature of the Danube is too high for the purposes of cooling (>25 °C) means a slow and gradual change of load, accounting for not more than a couple of percentages of load alterations, that can be accomplished at any time, almost without restrictions on the number of occasions on an annual basis. The change of load mentioned above from the rated 100% up to 50% or back refers to the load changes encountered during keeping the operation schedule of the plant as it is designed for a maximum number of times of 250 annually and may only happen when the use of the power plant follows the operation schedule.

The trends in the annual flow duration levels expected in the future moderate states (such as in the year of 2032 and 2085) calculated with a view to the climatological scenarios were presented in the EIS during periods of water temperature above the given water temperature of the Danube as shown in the tables below:

Table 11.7.4-3 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2032 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

Table 11.7.4-4 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2085 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

It can be seen from the tables that in the event of the moderate background temperature levels on the Danube (2032: T=26.38 °C, 2085: T=28.64 °C), the duration of flow of 1500 m³/s on the Danube on an annual basis remains below the average rate of 1 days/year. In these periods the 30 °C temperature limit in the reference profile could be ensured by technical measures such as power reduction.

For the sake of safety, the expected ordering of load reduction operation will be effectuated under the following conditions as seen from the data presented in the EIS:

In the chapter **11.9.1.4.1.2.** entitled Description of the design state in 2032 (Paks Power Plant + Paks II jointly):

"Expected <u>duration and length of exceeding the 30 °C limit value in the +500 m reference profile:</u>

Table 11.9.1.-4 summarises the variations of the calculated maximum Danube water temperatures in the moderate states in the control profile (+500 m) and the duration of exceeding the 30 °C limit value calculated from the climate model. The duration of the Danube flow rate below 1500 m³/day is about 1 day/year in the case of the Danube background water temperature (26.38 °C) taken as a basis (see in the chapter entitled: „Current and expected future trends in the water temperature of the Danube" No 11.7.4), but for the sake of safety the higher duration levels associated with the 2800 m³/s discharge were taken into account.

The range of limit violation which must be handled by intervention measures	Moderate state (2014.)		Moderate state (2032.)	
	8 [°C] heat gradient	33 [°C] hot water discharge	8 [°C] heat gradient	33 [°C] hot water discharge
Maximum background Danube water temperature expected [°C]	25.61 [°C]		26.38 [°C]	
Calculated maximum Danube water temperature [°C]	26,11 [°C]	26,36 [°C]	24,31 [°C]	25,11 [°C]
Calculated time of overshoot, duration [day]	0.2 [day/year]	0.1 [day/year]	13 [day/year]	7 [day/year]

Table 6-1: Length and duration of exceeding the limit value (2032.) – Paks Power Plant + Paks II.

In the chapter **11.9.1.4.1.3.** entitled Description of the design state in 2085 (Paks II alone):

"Expected duration and length of exceeding the 30 °C limit value in the +500 m reference profile:

Table 11.9.1-5 summarises the variations of the calculated maximum Danube water temperatures in the moderate states in the control profile (+500 m) and the duration of exceeding the 30 °C limit value calculated from the pessimistic climate model (DMI-B2 PRODUCE). The duration of the Danube flow rate below 1500 m³/day is about 1 day/year in the case of the Danube background water temperature (26.38 °C) taken as a basis (see in the chapter entitled: „Current and expected future trends in the water temperature of the Danube" No 11.7.4), but for the sake of safety the higher duration levels associated with the 2800 m³/s discharge were taken into account.

The range of limit violation which must be handled by intervention measures	Moderate state (2014)		Moderate state (2085.)	
	8 [°C] heat gradient	33 [°C] hot water discharge	8 [°C] heat gradient	33 [°C] hot water discharge
Maximum background Danube water temperature expected [°C]	25.61 [°C]		28.64 [°C]	
Calculated maximum Danube water temperature [°C]	26,11 [°C]	26,36 [°C]	23,81 [°C]	25,23 [°C]
Calculated time of overshoot, duration [day]	0.2 [days]	0.1 [day/year]	40 [day/year]	20 [day/year]

Table 6-2: Length and duration of the violation of the limit value (2085) – Paks II in stand alone operation

7 In the study the cooling water requirements of existing Paks I power plant is provided as 100 m³/s, but according to our best knowledge the hot water channel on hot summer days may off-take cooling water at a rate of flow of 120 m³/s just as well. Please therefore collect, process and present the data measured in the cold water channel and in the hot water channel monitoring systems and take into account the findings during any further calculations.

The present water volume of the four operating units is based on Chapter "1.1.2.1. Condenser cooling water system" of the Water rights operating license of the Paks Nuclear Power Plant (No. K6K2409/06 dated on 15 May 2006), and the value is determined as 100 m³/s.

According to the figures listed in Chapter "9.2.3.2 Dimensioning, design information" and in Table 9.2.3-1 of the same chapter in the Final Safety Report the Danube water requirements of the consumers in the condenser cooling water system in the design state is 4 x 25 m³/s.

The 120 m³/s figure mentioned above was the upper measurement limit of the water flow rate measurement facility installed in 2005 on the hot water channel.

8 In Table 6.6.5-1 of Chapter 6.6.5.1 the hydrological foundations of the lowest water level LKV=83.80 metres above Baltic sea level provided for the Danube Paks cross section for the year 2032, and the 83.60 metres above Baltic sea water level calculated from this parameter for the mouth cross section of the hot water channel are doubtful. We disagree with the methodology applied and in our view the calculated values cannot be regarded representative. The expected water levels of River Danube during the proposed lifetime of the cold water channel and the water levels required for operability and their relations compared to each other are not presented.

Out of the water levels mentioned above, the water level of 83.80 metres above Baltic sea level is a predicted lowest water level (mouth water level) expected in the year of 2032 and it is derived from the Paks city watermark post (1531.3 river km) to the nuclear power plant cross section (1527 river km). The other figure, 83.60 metres above Baltic sea level is the water level of the cold water channel measured at the water extraction plant at the time of low water flows and calculated with an average surface decline of 20 cm (embayment water level).

The design water level from which the pumps are able to provide cooling water to the condensers in the water extraction work is at 82.00 metres above Baltic sea level.

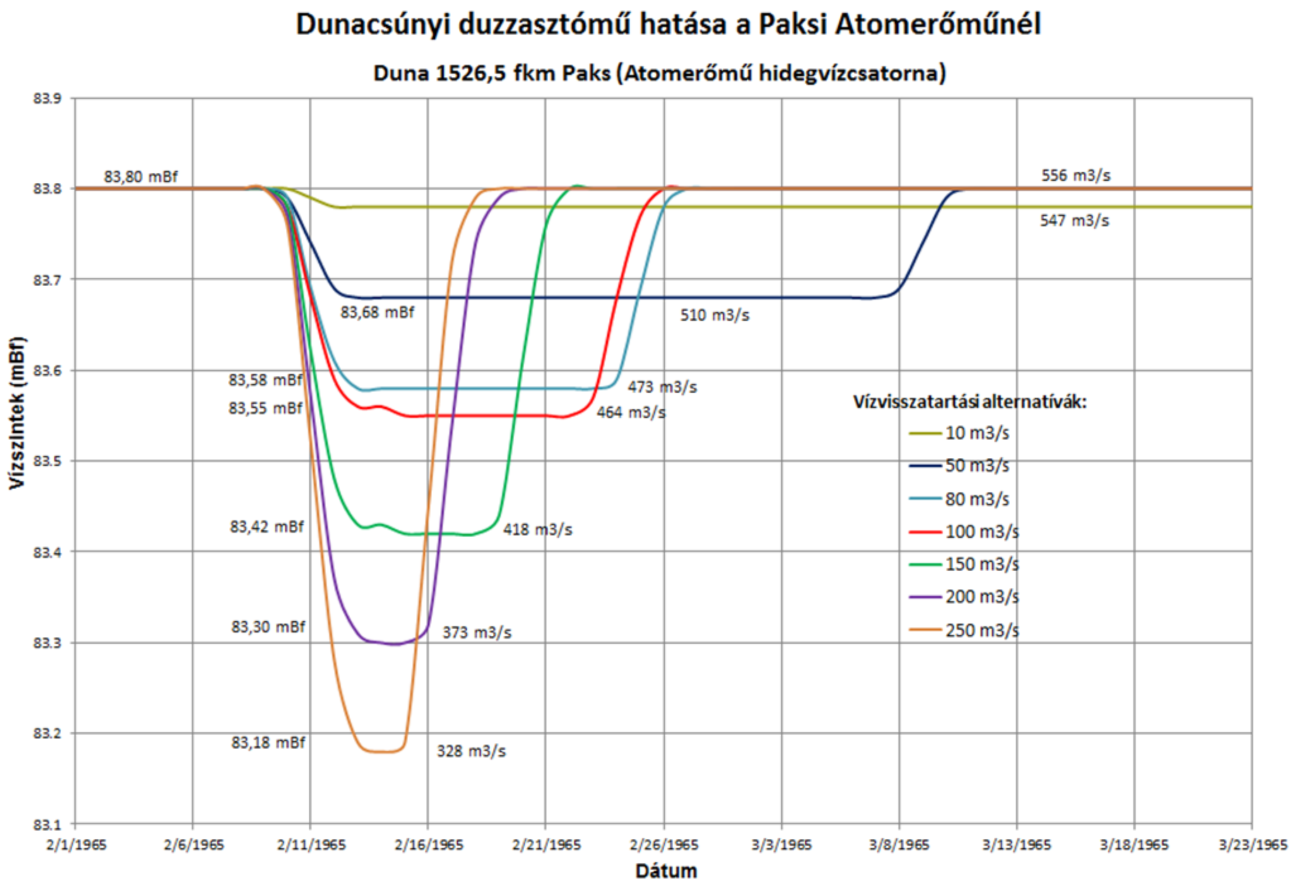
In the period following the year 2032 the required amount of water is gradually decreasing due to the continuous shutting down of units of Paks I, and after 2037 cooling water is needed only for the proposed new units. As a consequence, the joint impact of the reduced need for Danube water and the extended capacity of the cold water channel, due to the result of the sinking Danube River bed bottom the expected lower water levels at the end of the operating period will not limit the delivery capacity of the pumps.

Based on the following figure of the EIS (11.9.2-5.) it can be concluded that the extreme low water level situations recurrent in every 20 000 years occurs in case of the current river bed at approximately ~83.80 metres above Baltic sea level.

When the more pessimistic linear trend is applied to the changes of the river bed, the low water stage river bed of the Danube will sink 1.8 metres below the level of the current river bed bottom by 2090, in other words the expected water level at extreme low water stage is 83.80 metres above Baltic sea level – 1.8 m = 82.0 metres above Baltic sea level. The current bed bottom level on the cold water channel is 81.0 metres above Baltic sea level (it is anticipated to be deepened), while the water extraction threshold of the operating pumps (MJO pumps) is at 83.6 metres above Baltic sea level (for the safety pumps the same is: BQS 83.50 metres above Baltic sea level) in the embayment.

In times of low water stage the surface decline on the cold water channel may be up to 20 cm, associated with a 82.0 metres above Baltic sea level - 0.2 m water extraction threshold, in other words a 81.8 metres above Baltic sea level operational water extraction threshold level would be necessary, which means that the threshold level of the operating pumps needed to be deepened by 1.8 metres (83.6 – 81.8 metres above Baltic sea level).

The particulate composition of the river bed bottom of the Danube across depth is not known however, although this is the factor forming the real river bed sinking trend in the future. The linear trend calculates with a more pessimistic and hence, greater river bed sinking, while the logarithmic trend calculates with the asymptotic slowing down of the sinking in the future, due to reaching of the large particle and not easily eroded gravel bed (more optimistic characterisation). Averaging of the two methods approaches a scenario which is linear in the first half of the forecasting period and will turn to logarithmic – due to reaching of the gravel layer – in the second half.



Legend: Dunacsúnyi duzzasztómű hatása a Paksi Atomerőműnél – The impact of the Cunovo barrage at the Paks Nuclear Power Plant
Duna 1526,5 fkm Paks (Atomerőmű hidegvízcsatorna) – Danube 1526 river kilometres Paks (Nuclear Power Plant, cold water channel)
Vizszint tartási alternativák – Alternatives of water level retention
Dátum – Date
Vízszintek (mBf) – Waterlevels (mBf)

Figure 8-1: The impact of water retention actions charactersied by alternatives of the Cunovo / Gabcikovo barrage system in the low water level periods recurrent in every 20 000 on the security of the water extraction possibilities for the Paks Nuclear Power Plant (Danube, 1526.5 river km)

9 The slope inclination indicated on the cross section sample of the cold water channel on Page 129 of the EIS documentation entitled _1_8.pdf (r=1:4.6) is in contradiction with the value provided in Table 6.6.5-3 (Page 128) which is r=1:4.2.

The slope inclination of the banks on the cold water channel during capacity extension will be shaped in a homogeneous manner at an angle of slope of 1:4.6.

10 There is a discrepancy in the calculations characterising the water delivery capacities related to the proposed covered reinforced concrete channel and channel-conduit bridge presented in Chapter 6.6.5 and the dimensions provided. The dimensions mentioned in the text are as follow: 4 * 3x5 = 15 m^2 wetted cross section channel with a maximum medium profile velocity vk,max = 1.5 m/s. Based on the foregoing the water delivery capacity of the channels is "Omu = 90 mJ/s, while they were supposed to take off 132 m^3/s according to the proposed cooling water requirement.

The flow velocity of the water in the wetted cross section of 4 times 3x5 m on the channel-conduit bridge situated above the cold water channel used to remove the warmed up cooling water is 2.25 m/s, thus it is able to remove the 132 m^3/s rate of flow. In the subsequent new hot water channel section the flow velocity of the water is diminished and due to the available larger flow cross section it takes a level of 1.5 m/s.

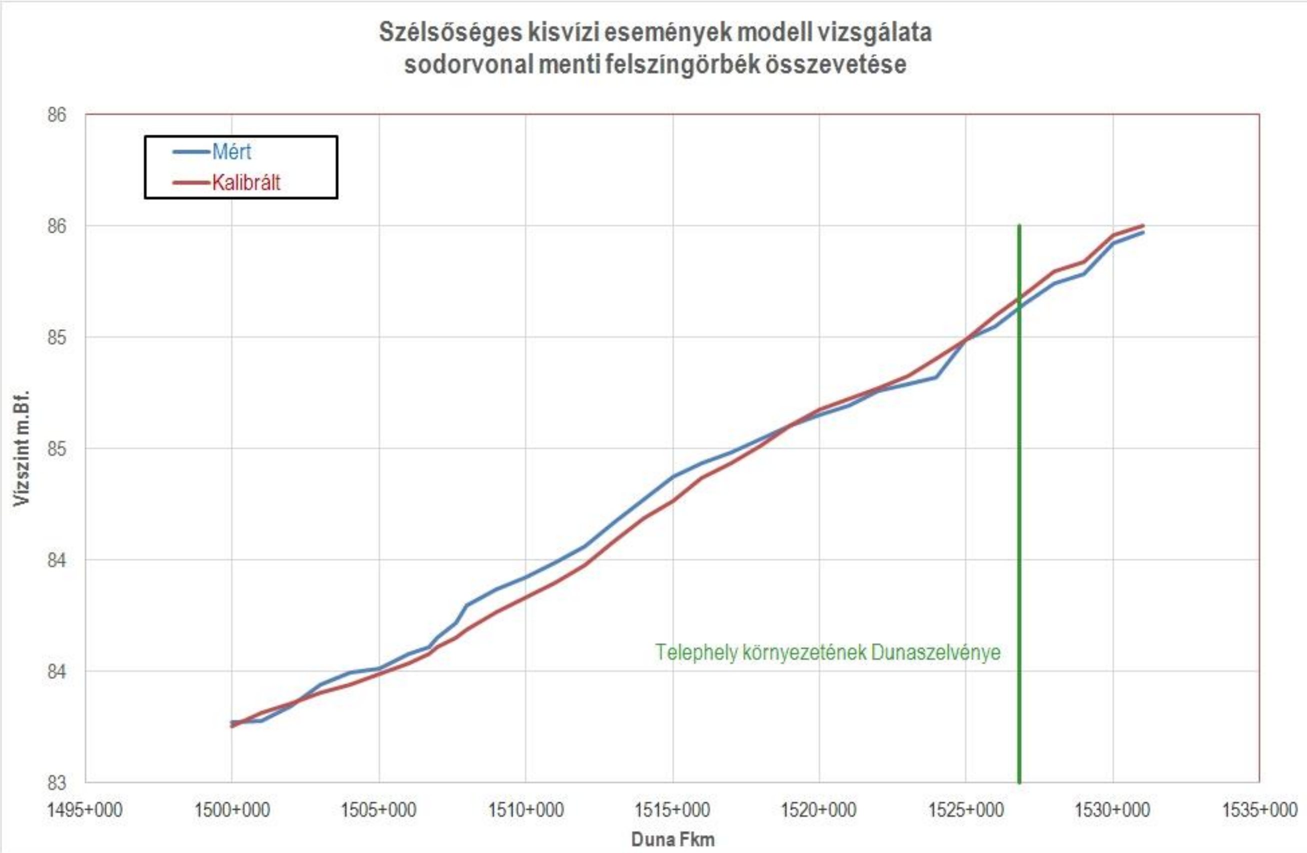
11 The documentation on the modelling River Danube (EIS _II.pdf) states that the low water flow calibration of the computerised hydraulic model was prepared for DB "0" water level. (Table 11.6.1-3 – Page 35). It is not indicated to which period of time the DB "0" water level refers, and that it was not a measured, but calculated, theoretical water level. We think it was necessary to present the connection between the river bed flow constituting the basis for the DB "0" water level taken into account for the purposes of the model calculations and the river bed model prepared for the EIS. Should the assessment basis of the river bed models be different, the morphology changes occurring during the period in between the survey dates may distort the value of DB "0", thus resulting in a faulty low water flow calibration. The correctness of the calibrations to be carried out during modelling must be checked by validation. The documentation does not contain any information on the verification process and its outcome for either high or low water flows.

Calibration of the 2D flow model (proportioning of the river bed roughness factor distribution) was calculated for the high water flow (peaking at Paks in June 2013 at 8790 m^3/s) and water levels, using Danube River bed particulars from the year of 2012. For the areas of different uses initial roughness factors were taken based on the experiences gained from Danube modelling exercises.

Due to a very good concurrence of the calibrated and measured water surfaces, furthermore because the good correlation between surface curve calculated for the low water stage quasi permanent water volume rate of flow measured on the Danube on 6 October 2011 (1242 m^3/s at Paks) and the actually measured water surface the calculations were seen as validation exercises. Study model calculations were carried out using the river bed morphology figures from the year 2012 (source: MVM Paks Nuclear Power Plant), with a volume rate of flow of 579 m^3/s on the Danube. Results are summarised below as a supplement to Chapter **11.6.1.2.3** (Low water stage calibration) of the EIS:

Danube [river km]	Z (measured water level) [metres above Baltic sea level]	Benchmark data
1531+300	85.32	1. Danube-section Danube 1519 – 1530 river km Q = 1242 m³/s Z0_flat = 84.30 metres above Baltic sea level Z_downstream = 84.41 metres above Baltic sea level
1531+000	85.30	
1530+000	85.25	
1529+000	85.16	
1528+000	85.05	
1527+000	84.95	
1526+000	84.86	
1525+000	84.76	
1524+000	84.68	
1523+000	84.61	
1522+000	84.56	
1521+000	84.52	
1520+000	84.48	
1519+000	84.41	2. Danube-section
1518+000	84.33	Danube 1509-1519 river km Q = 1242 m³/s Z0_flat = 83.50 metres above Baltic sea level Z_downstream = 83.64 metres above Baltic sea level
1517+000	84.24	
1516+000	84.15	
1515+000	84.06	
1514+000	83.96	
1513+000	83.89	
1512+000	83.83	
1511+000	83.76	
1510+000	83.70	
1509+000	83.64	3. Danube-section
1508+000	83.57	Danube 1500-1509 river km Q = 1242 m³/s Z0_flat = 83.00 metres above Baltic sea level Z_downstream = = 83.20 metres above Baltic sea level
1507+600	83.54	
1507+000	83.50	
1506+700	83.48	
1506+000	83.44	
1505+000	83.40	
1504+000	83.36	
1503+000	83.33	
1502+000	83.29	
1501+000	83.25	
1500+000	83.20	

Calibration of the 2D flow model developed for the Danube section between 1500 to 1530 river km at low water stages is illustrated on the following figure as a supplement to the EIS (see: ***Annex No 1: 1_Melleklet_Sebessegmezok***).



Legend: Szélsőséges kisvizi események modell vizsgálata sodorvonal menti felszngörbék összevetése – Model analysis of extreme low water flow events, comparison of the surface streamline along the mainstream
Vízszint (mBf) – Water level (mBf)
Duna Fkm – Danube river km
Mért – Measured
Kalibrált – Calibrated
Telephely környezetének Dunaszelvénye – Danube section in the vicinity of the Site

The calculation of the calibrated surface curve included in the EIS (Chapter **11.6.1.2.3: Calibration for low water stages**) (Figure 11.6.1-15 and Table 11.6.1-3) was made for the Danube river bed particulars of the year 2004 and the water yield associated with the surface curve measured by the Danube Commission in 2004 (taking effect in 2006) (1180 m³/s). This and the EIS are to be complemented with the calculation results presented above.

12 Annual trends in low water flows were determined by both linear and logarithmic methods for the purposes of assessing long term changes in the river bed morphology. Their averaging can not be justified from the professional point of view, it is suggested that out of the two methods, use the one that is best verifiable (Table 11.6,4-3).

The particulate composition of the river bed bottom of the Danube across depth is not known however, although this is the factor forming the real river bed sinking trend in the future. The linear trend calculates with a more pessimistic and hence, greater river bed sinking, while the logarithmic trend calculates with the asymptotic slowing down of the sinking in the future, due to reaching of the large particle and not easily eroded gravel bed (more optimistic characterisation). Averaging of the two methods approaches a scenario which is linear in the first half of the forecasting period and will turn to logarithmic – due to reaching of the gravel layer – in the second half.

1D and 2D hydrodynamic calculations were made for the current river bed bottom levels of the Danube, without taking into account an expected river bed sinking in the future. The extent of deepening of the river bed in the future depends on the vulnerability to erosion and particulate composition of the Danube bed across depth. Since this is not known at the time being and the future development of the trend is unknown as well, it would be possible to suggest averaging of the values obtained for river bed morphology changes with the linear (extrapolation of the river bed deepening characterising the recent past to the future) and with the logarithmic (river bed deepening mitigated in the future) trends on the basis of the current information from the professional point of view.

Monitoring of river morphology changes in the operating period – conducted by ADU-VIZIG on an annual basis for Paks Nuclear Power Plant – is suggested to be continued throughout the service period of Paks II. Based on the observations the trends in morphology changes may be determined more accurately – for instance, processing in the annual Final Safety Reports (FSR) the river bed monitoring data, and then making a recommendation on the basis of the assessment for eventually necessary control actions in the later stages of the service period.

Due to lack of information on the particulate composition of the river bed across depth the future development of the trend can not be decided but it can be concluded that of the logarithmic and linear trends investigated the linear trend is dedicated for a larger level of certainty, indicating a higher level of river bed sinking in the future.

Trends in river morphology changes (Chapter 11.6.4.3.3) – quotation from the EIS:

“Expected trends in river morphology changes based on the statistical assessment of the Danube low water levels:

The trends of the river morphology changes are usually concluded from the hydrological statistical analysis of the annual low water levels.

The outcomes of the forecasts for the Paks watermark post profile of the Danube (Danube 1531.3 river km) up to the year 2120 set forth in details at the statistical analysis of the Danube low water stages are summarised in the table below (Table 11.6.4-3):

Expected low water levels in terms of time based on the projection of the trend (Paks watermark post- Danube 1531.3 river km)							
Period of the proposed development project and lifetime extension		***Expected low water levels (lowest annual) in terms of time Z [metres above Baltic sea level]***			***Expected subsidence of low water stages in terms of time ΔZ [m]***		
Year	**Unit operation schedule**	**Linear trend**	**Logarithmic trend**	**Average trend**	**Linear trend**	**Logarithmic trend**	**Average trend**
2013	-	83.78	83.78	83.78	0.00	0.00	0.00
2025	Enter new unit I	83.51	83.74	83.62	-0.27	-0.04	-0.16
2030	Enter new unit II	83.39	83.72	83.55	-0.39	-0.06	-0.23
2032	Exit existing unit I	83.34	83.71	83.53	-0.44	-0.07	-0.25
2034	Exit existing unit II	83.30	83.70	83.50	-0.48	-0.08	-0.28
2036	Exit existing unit III	83.25	83.70	83.48	-0.53	-0.08	-0.30
2037	Exit existing unit IV	83.23	83.69	83.46	-0.55	-0.09	-0.32
2085	Exit new unit I	82.13	83.52	82.83	-1.65	-0.26	-0.95
2090	Exit new unit II	82.02	83.50	82.76	***-1.76***	***-0.28***	***-1.02***
2100	-	81.79	83.47	82.63	-1.99	-0.31	-1.15
2120	-	81.33	83.39	82.36	-2.45	-0.39	-1.42

Table 12-1: Expected low water levels in terms of time based on the projection of the trend (Paks watermark post- Danube 1531.3 river km)

Logarithmic trend fit of the low water levels is an optimistic estimate assuming full stop of the industrial river dredging operations and a declining tendency of their impacts, while the fit of the linear trend can be regarded as a conservative estimate.

Based on the table above in summary it can be stated that the following annual low water stage levels and the following estimated subsidence levels of the channel bottom can be expected by the year of 2090, when the second new unit of the proposed Paks II power plant quits:

- *In the case the linear trend is extended: a subsidence of ~1.8 [m] (-2.29 [cm/year]),*
- *In the case the logarithmic trend is extended: a subsidence of ~0.3 [m] (average: -0.36 [cm/year]),*
- *Calculated with the average value of the linear and logarithmic trends: a subsidence of ~1.0 [m] (average: -1.33 [cm/year]).*

13 The use of the morphodynamic model fit for imaging river bed morphology changes and the determination of water level changes based on the evaluation of the calculations results is suggested to study the impact of morphology changes on the low water flows.

The 2D morphodynamic modelling method in the EIS was used for the purposes of determining the extent and extension of local river morphology (this was set as an objective of the EIS). It was shown in the EIS that the 5 years model calculation period was sufficient to predict the expected local changes in river morphology. Since the particulate composition of the river bed bottom is not known with the appropriate accuracy across depth, therefore any conclusion on longer term bottom deepening cannot be permitted from the current data. Although the MFGI (formerly MÁFI) geological profiles available for the purposes of hydrodynamic modelling contain the gravel boundary, but this is not sufficiently accurate and detailed to calculate the morphology processes.

14 The legal environment requires the determination of the extreme water hydrological conditions occurring in every 20 000 years. According to our view the methodology used for this purpose is not sufficiently representative, because the available data sets (water level, water flow rate) that are not sufficiently long for statistical purposes (the necessary length should be the third or fourth of the recurrence period) have been further abbreviated (1965 - 2011). This is merely one third and roughly one half of the water level figures and water flow rate figures available, respectively. The reason why data sets were truncated was inhomogeneity. The trend of water levels is gradually declining which is true for the partial data set, therefore homogeneity of the partial data sets may be demonstrated in numeric terms, yet in reality this is not the case. In our opinion the homogenisation of the entire data sets ought to have been made for the current period and the extreme values to be considered as the design levels determined on this basis, selecting the most appropriate and fitting distribution function (only the fit of three types of cumulative distribution functions were investigated for the data sets). According to the aforementioned arguments we do not agree with the application of the calculated extreme water levels.

This comment questions the predictability of infrequent events, even though it is customary to design flood control works for instance to events (such as water level) recurrent in every 1000 years. According to the statement hidden in the question this cannot be answered on the basis of the approximately 100 year long period of observations.

The indicated necessary length of the data sets of the observations is not properly grounded – that is, no statistical proposition exists which would substantiate, as the question implies, that a third length of the recurrence period would be necessary for the observation data sets (if this would be true, any power plant or other facility implying risks could only be built in several thousand years).
As opposed to the question, the correct statement is as follows: The length of the data set has an influence on the error of estimate/estimation of the parameters in the statistical model and as a consequence, the accuracy of the statistical prediction.

In other words the truncation of the data sets exerts an impact increasing the rate of errors, yet the method is not to be discarded, much rather the errors of the parameters need to be reflected in the final outcome of the statistical model.

However, homogenisation of the entire data set is a thought to be discarded.

Namely, homogenisation is allowed only to be completed for probability variables. Data with high level of auto correction are not probability variables. The probability variables obtained from them by selection such as for instance the trends of annual low or high water flows cannot be forced onto the data set as a whole. In fact, the tendency like variations of any partial data set are not necessarily true for the whole set.

If the proposer tries to execute this trend on daily data, most probably he will not get any significant trend. Namely, the confidence range of the trend slope is increased by the standard deviation of the data set. And this, in turn, is increased as we switch to daily data frequency.

Further justification of data truncation:

"According to the hydrological studies of the more recent period (after 1965) the passing of the floods accelerated in the last few decades due to the impact of the water barrage systems constructed on the Austrian section" (Zsuffa, István: Az ausztriai vízerőmű rendszer hatása a magyar Duna-szakasz árvízvédelmi biztonságára / The impact of the Austrian system of hydropower plants on the flood control safety level of the Hungarian section of River Danube, Hidrológiai Közlöny / Hydrology Bulletin Year 1999, No 1).

In the article cited above the author investigated the trend of passing time of floods encountered since the beginning of regular measurements. The article contains the following explanation:

"Statistical examination of flood levels provides the evidence that in the last few decades the passing time of the floods was shortened as a result of the river training works and barrage system constructions, consequently the cumulative effect of floods is experienced to a lesser extent. The probability distribution of the annual maximum water levels has not changed significantly in the last 50 years, but the duration of the floods was reduced radically at all water levels. This means that although we must reckon with the occurrence of floods causing very high water levels, the appearance however a flood with duration comparable to that in 1965 is less probable."

15 In Chapter 11.7.1.1.2 on modelling, the calculations for the water level drop between the Paks metering station and the cold water channel was presented. The use of the average between the low water flows and high water flows cannot be considered to be correct from the professional point of view henceforward, since the water level drop of the two distinct hydrological states differ from each other significantly. When the design operating states at low water flows are examined, the use of the transformation derived from the water level drop in the case of low water flows is justified.

In order to allow simplification an approach based on watermark connections (between the Paks watermark post and the embayment watermark post of the Power Plant) was used for the purposes of converting levels between the Paks watermark post (1531.3 river km) and the cold water channel (Danube 1527 river km), in order to allow quick and easy to follow projection and transformation of the hydrological statistical results calculated from the data of the Paks watermark post (Danube 1531.3 river km) to the Power Plant profile (Danube 1527 river km). In fact this method is used here only for the provision of information but it was not used to determine the flood levels and low water levels expected in the neighbourhood of the site. For this purpose an accurate 2D hydrodynamic model is used.

It should be noted that at the culmination of the flood in June 2013, the surface drop measured at the high water flow was 24 cm (as opposed to the 27 cm value determined in the EIS as an approximation with the use of the watermark post connection), while the water level drop at low water flow measured in October 2011 (6 October 2011) at 1242 m^3/s flow rate was 32 cm, as opposed to the estimated 27 cm level.

Determination of the site exposure (that is exposure of the site in the Power Plant Danube section to the water levels formed at low water flows and high water flows, in other words at times of natural extremes) was not made according to the watermark post connections, which is considered to be an approximate value only, but by taking the 2D hydrodynamic model calculations used in the EIS as a basis. The hydrological statistical calculations made on the Danube water levels were used for informative purposes only. "Live" calculations were based on the Danube water levels obtained from the hydrodynamic model calculations built on the statistical analysis of the water flows, which did not contain the approximations derived from the watermark post connections any more.

16 We disagree with the method used in Chapter 11.7.1.3.5, because it is dependent on the length of the period involved in the calculations and contradicts to the claim that the probability of the occurrence of an event does not depend on the number of sampling sessions (Figure 11.7.1-23).

As opposed to the implications in the question the probability of an event does not depend on the number of occasions it is observed, and the relative abundance to be obtained by a limited number of observations only approached the probability level of the event – never equals with it.
The methodology presented above – as any trend-analysis – fits a trend function to the data set if a trend can be assumed.
Fitting of the trend function is made using the method of least squares – this is a customary procedure in the execution of the trend analysis.
A trend function does not need to be linear in all cases. How suitable the selected trend function is, can be evaluated by examining the randomness of the remainder. The trend free set of data (the remainder of the trend analysis) must be entirely random and exempt from trends.

The method makes a single probability assumption: the distribution of the remainder is a Gaussian variable, in other words the distance of the remainder from the trend function follows the Gaussian distribution pattern which can be demonstrated by a goodness-of-fit test.

17 We cannot agree with the statement that the flood level determined for a frequency recurrent in every 20 000 years cannot be formed because the current level of the crest on the left bank embankment is lower than this (Chapter 11.7.1.2, Page 79). Flood levels exceeding the current elevation of the embankment crests can be successfully controlled by temporary control works as demonstrated in the past two decades on the river Tisza.

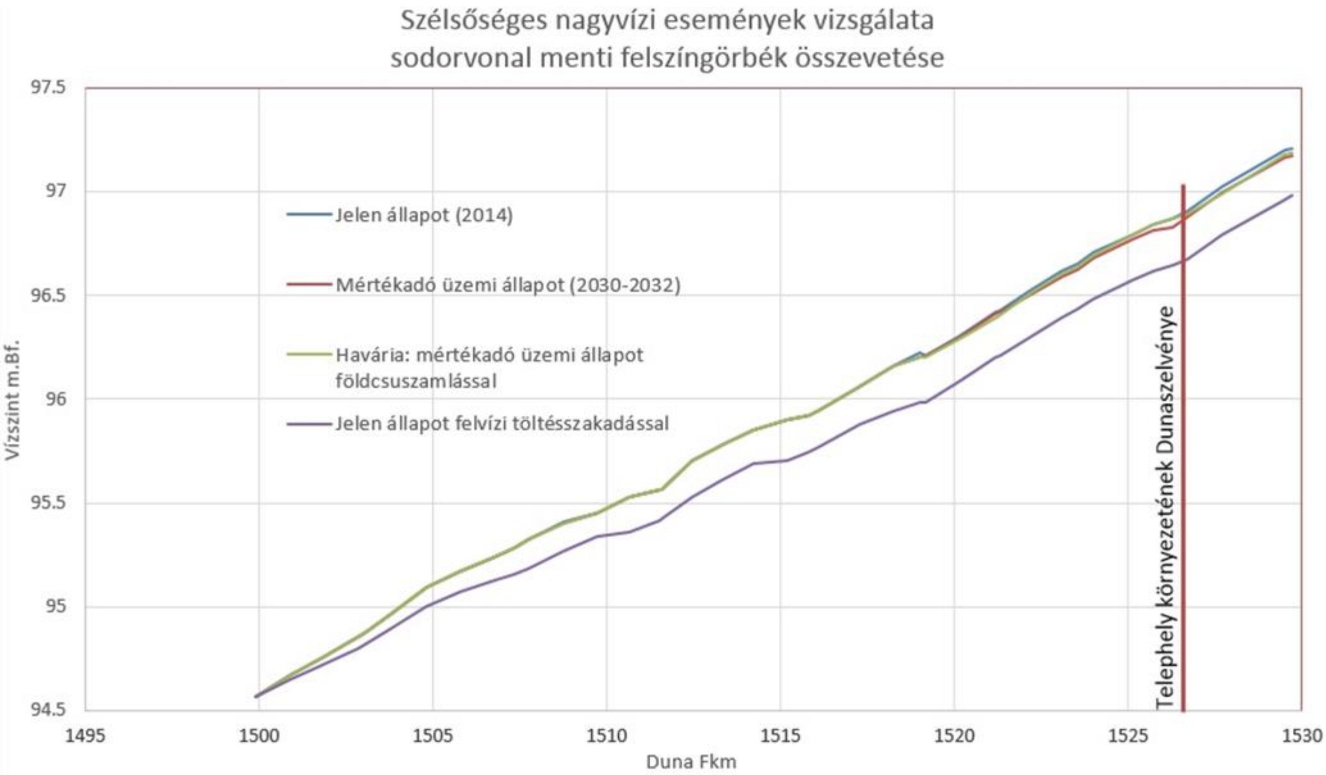
The water surface formed in the case of the water flow on the Danube recurrent in every 20 000 years (14 799 m^3/s) was determined in the EIS using a 2D hydrodynamic model between the 1500 – 1530 river km profiles.

Namely, the current crest levels of the flood control works were elevated along the entire Danube section modelled (Danube 1500 – 1530 river km profiles) so that the water level reducing effect of the water spilling over the embankment crest at the current crest levels of the embankments (in the Power Plant profile the right bank crest level is currently at 96.30 metres above Baltic sea level, on the left bank 95.80 metres above Baltic sea level) were not taken into account.

For the sake of safety, the value of the water flow recurrent in every 20 000 years was not reduced due to the fact that the crest of the flood may be reduced substantially if expected inundations occur on the higher reaches of the Danube.

<u>This consideration is included in the EIS as follows</u>:

"In order to allow more convenient comparison of water surfaces in the individual model variations the water level data of certain water surfaces calculated for the main current line, i.e. the main current line surface curves are illustrated on Figure 11.9.1-9.



Legend: Szélsőséges nagyvizi események vizsgálata sodorvonal menti felszíngörbék összevetése – Investigation of extreme high water events, comparison of surface streamlines along the mainstream line
Vízszint (mBf) – Water level (mBf)
Duna Fkm – Danube river km
Jelen állapot (2014) – Current state (2014)
Mértékadó üzemi állapot (2030-2032) – Moderate operating state (2030-2032)
Havária: mértékadó üzemi állapot földcsuszamlással – Failure event: moderate operating state with landslide
Jelen állapot felvizi töltés szakadással – Current state including the burst of a dam upstream
Telephely környezetének Dunaszelvénye – Section of River Danube in the vicinity of the Site

Figure 17-1: Comparison of main current line profiles of calculated water surface areas (one dimensional surface curve along the main stream) (Danube 1500-1530 river km) in the extreme (Q = 14799 m³/s) flood cases assessed (Paks Power Plant operation, Paks Power Plant operation including the bursting of a dam, Paks Power Plant and Paks II joint operation in moderate state and failure event, respectively)

Based on the model calculation the water level on the Danube culminates at 96.90 metres above Baltic sea level in the event of an extreme flood event (a flood flow rate recurrent in every 20 000 years), under the most unfavourable conditions (for the sake of safety it was assumed that the current flood control works on the Danube are developed in the future and the passing flood can be contained within the embankments with the help of protection measures against floods) in the surrounding of the existing and proposed site.

It is visible that it will not threaten the ground level at 97.00 metres above Baltic sea level of either the existing or the proposed site of the development by static inundation, but provided the wave motion becomes more intensive for whatever reason, it may generate an emergency situation and may affect vulnerable objects on the surface or in the public utility ducts. ***Therefore the vulnerable objects situated close to the surface are recommended to be provided by active protection (parapet wall, etc.), and such protection installed for the proposed development****."*

18 According to Chapter 11.7.4.1 of the documentation on modelling (Page 129, paragraph 5) the mixing-up properties and the maximum temperature of the resulting heat plume do not depend on the rate of flow below the level of 1850 m³/s flow rates. The quantitative substantiation of this claim is not included in the material (the statement is in contradiction with the laws of physics especially considering the fact that the EIS determined the design low water flow rate recurrent in every 20 000 years as 576 m³/s). The extent of cooling during a 500 metres mixing is estimated to be 2 °C on page 142. This is not substantiated by conclusive evidence in figures, but at the same time the maximum Danube temperature needed to maintain the 30 °C required maximum Danube temperature is provided here as 26 °C, with the duration parameters found at the same place. These duration levels are far from being negligible, therefore in our view they absolutely have to be investigated the cases with Danube temperatures higher than 26 °C and flow rates below 1500 m³/s.

"Based on the measurements carried out at low water stages the largest average velocities in the near field zone was observed in the environment of the right bank rather than in the surrounding of the maximum depths. This is a somewhat surprising property in the light of the observations and modelling experienced obtained from other sections of the Danube. The cross directional velocity distributions in the critical (Q_{Danube} < 1850 m³/s) flow rate range remain in their essence unchanged." (BME Department for Water Utility and Environmental Engineering, 2008). In other words, the crosswise dispersion basically determining the mixing conditions in this flow rate range is unchanged, and therefore no significant difference can be observed in the expected temperature distribution patterns, either.

19 Due to the aforementioned circumstances the appointed agent modelled only the hydrological state with a 1500 m³/s volume rate of flow when the heat loads on the Danube were assessed. Intake and outlet sites were not investigated with the required details as a function of the operating period, for instance when the current state was assessed the calculations did not take into account the known actual flows substantiated by measurements but the original design value (100 m³/s). When the changes over time are addressed, the rising water temperature on the Danube originating from the climate change is taken into account, but the extent of water flow rate decrease or increase also in connection with the climate change is not considered in the EIS .

The cooling water maximum of 100 m³/s was received as a baseline figure for design. Calibration of the hydrodynamic and mixing model of the heat plume took place with real measured parameters.

The trends in the annual flow duration levels expected in the future design states (such as in the year of 2032 and 2085) calculated with a view to the climatological scenarios were presented in the EIS during periods of water temperature above the given water temperature of the Danube as shown in the tables below:

Table 11.7.4-3 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2032 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

Table 11.7.4-4 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2085 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

It can be seen from the tables that in the event of the design background temperature levels on the Danube (2032: T=26.38 °C, 2085: T=28.64 °C), the duration of flow of 1500 m³/s on the Danube on an annual basis remains below the average rate of 1 days/year. In these periods it can be achieved by technical measures such as load reduction of the power plant that the 30 °C temperature limit could be ensured in the reference profile.

Impacts from the climate change were assessed for low and high water yields on the Danube (Budapest, Baja) using and advancing a generator. The impact of the climate change is included in the measured data set of water volume rates of flow (approximately 1 °C/100 years for the Earth in geographic and time average). Flow rates at low water stages were somewhat reduced on the basis of the more pessimistic (1.8 °C/100 year, meaning 4 °C/100 years in the environment of the site) climate model results, and the rate of decrease seemed to be negligible for the extreme low water flow rates. This did not justify, either, to examine the development of 1 days/year average duration of the maximum temperature limit violation (at 1500 m³/s).

A Danube water yield generator was also developed within the topic of natural hazards in the characterisation of the site, to take into account the climatological scenarios associated with a higher rate of warming. High water flows generated with the climatological water volume rate of flow generator resulted in lower extreme high water flow rates in the case of climatological scenarios assuming higher rates of warming than in the case of models calculating with lower warming rates.

The generated extreme low water flow rates in the case of climatological scenarios assuming higher rates of warming provided practically the same extreme low water yields as the low water flow rates generated with the climate change models assuming lower warming rates (recurrent in every 100, 1 000, 10 000, 20 000 years, etc.), to put it more exactly the higher warming case provided 1% lower generated flow rate.

In other words the reduction of flow rates in low water stages caused by the climate change does not exceed 1% of the cases assuming a lower rate of warming.

20 We disagree with the statement (Page 132) claiming that maximum temperature and minimum volume flow rates of Danube water have such a short concurring period which is not worth dealing with. Please investigate this quantitatively and furnish evidence to the claim. The statement in the EIS is also challenged by the operating state modelled in the 1500 m³/s Danube volume rate of flow when the Danube water temperature in the 500 metres profile downstream of the discharge site exceeds the maximum temperature limit allowed by the law, 30 °C.

The trends in the annual flow duration levels expected in the future design states (such as in the year of 2032 and 2085) calculated with a view to the climatological scenarios were presented in the EIS during periods of water temperature above the given water temperature of the Danube as shown in the tables below:

> Table 11.7.4-3 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2032 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)
>
> Table 11.7.4-4 gives the average number of days expected annually when the Danube water temperature is exceeded (T) and the (Q) Danube flow rate is not reached in the year of 2085 – DMI (B2 PRODUCE, ΔT_{Earth} = 1.8 °C, between 2000 and 2100)

It can be seen from the tables that in the event of the design background temperature levels on the Danube (2032: T=26.38 °C, 2085: T=28.64 °C), the duration of flow of 1500 m³/s on the Danube on an annual basis remains below the average rate of 1 days/year. In these periods it can be achieved by technical measures such as load reduction of the power plant that the 30 °C temperature limit could be ensured in the reference profile.

In lower flow rates of the duration of temperature violation is reduced substantially (for instance, in the case of 1000 m³/s it is 0.4-0.5 days/year, at 800 m³/s it is approximately ~0.3 days/year).

The limits provided for the reference cross section must be observed during the operation of the power plant, as defined in the water rights establishment licensee decision to be obtained in the future.

In the version presented in the EIS the maximum water temperature of the Danube in the reference profile exceeds the level of 30 °C indeed and in such events action needs to be taken to reduce the heat flux which can be accomplished either by reducing the hot water discharged into the river (shut down of units), or by reducing the water temperature of the discharged flow (load reduction of the plant).

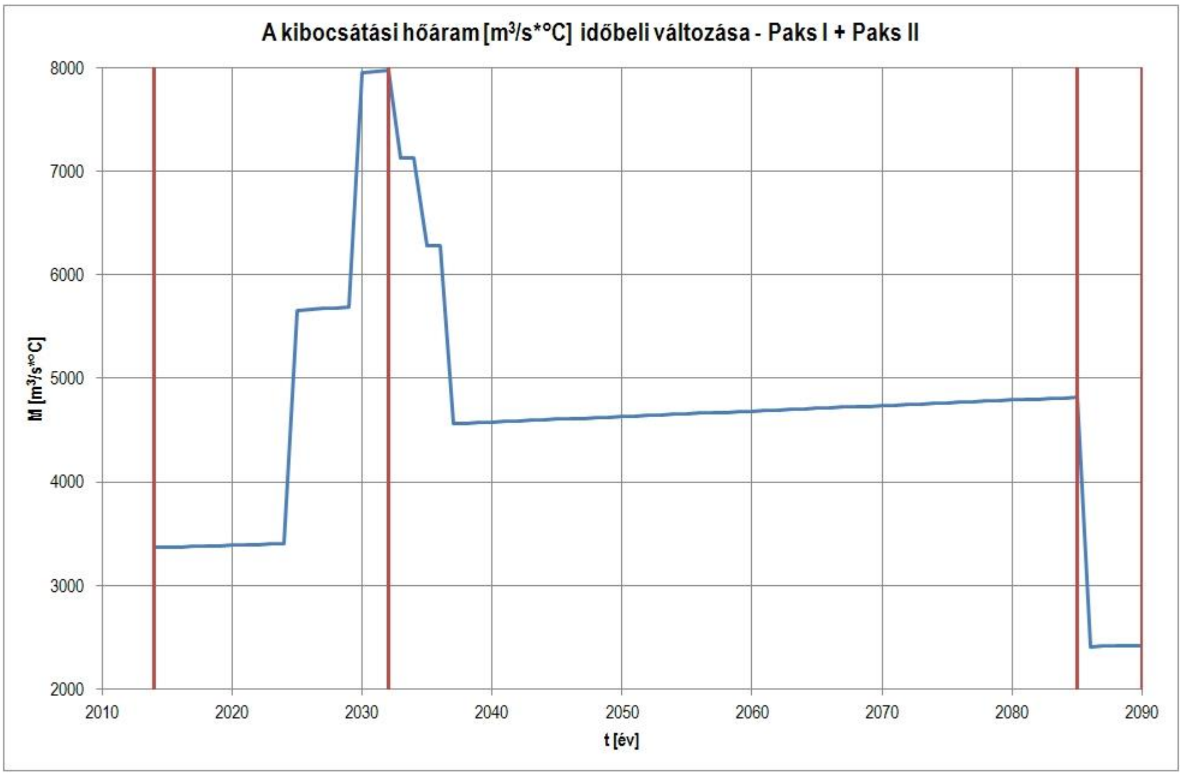
21 The statement in the documentation on the modelling (Page 140), states that the drop of flow in the hot water channel over time has a greater impact than the increase of the Danube water temperature derived from the climate change is not demonstrated by modelling, it should be supplemented. The Table in the beginning of Chapter 11.7.4.5.2 justified the extension of heat load studies to both various extreme Danube water flow rates on time horizons, since from the perspective of the aquatic life a very short term violation of the temperature limit may have a significant impact.

Maximum riparian temperature is described by the following analytical correlation, where **M = T** [°C] **x q** [m³/s]:

$$T_{m.h}^{parti} = \frac{M}{h\left(\pi D_{y,1} v_x x\right)^{\frac{1}{2}}} exp\left(-\frac{v_x}{4D_{y,1}x} y^2\right)$$

M – heat flux, on which maximum water temperature depends in a linear manner,
q –hot water flow rate, changes over time (**q** = **q**(t)),
T = $\mathbf{T_{Danube,max}}$ **+ ΔT**, temperature of the discharged water (**ΔT**: heat gradient), changes over time (**T** = **T**(t)).
$T_{Danube,max}$ **= 25.61 °C + 0.04 [°C/year] x (t – 2013), t = 2014. 2015……, 2090 (year).** $T_{Danube,max} = T_{Danube,max}(t)$.

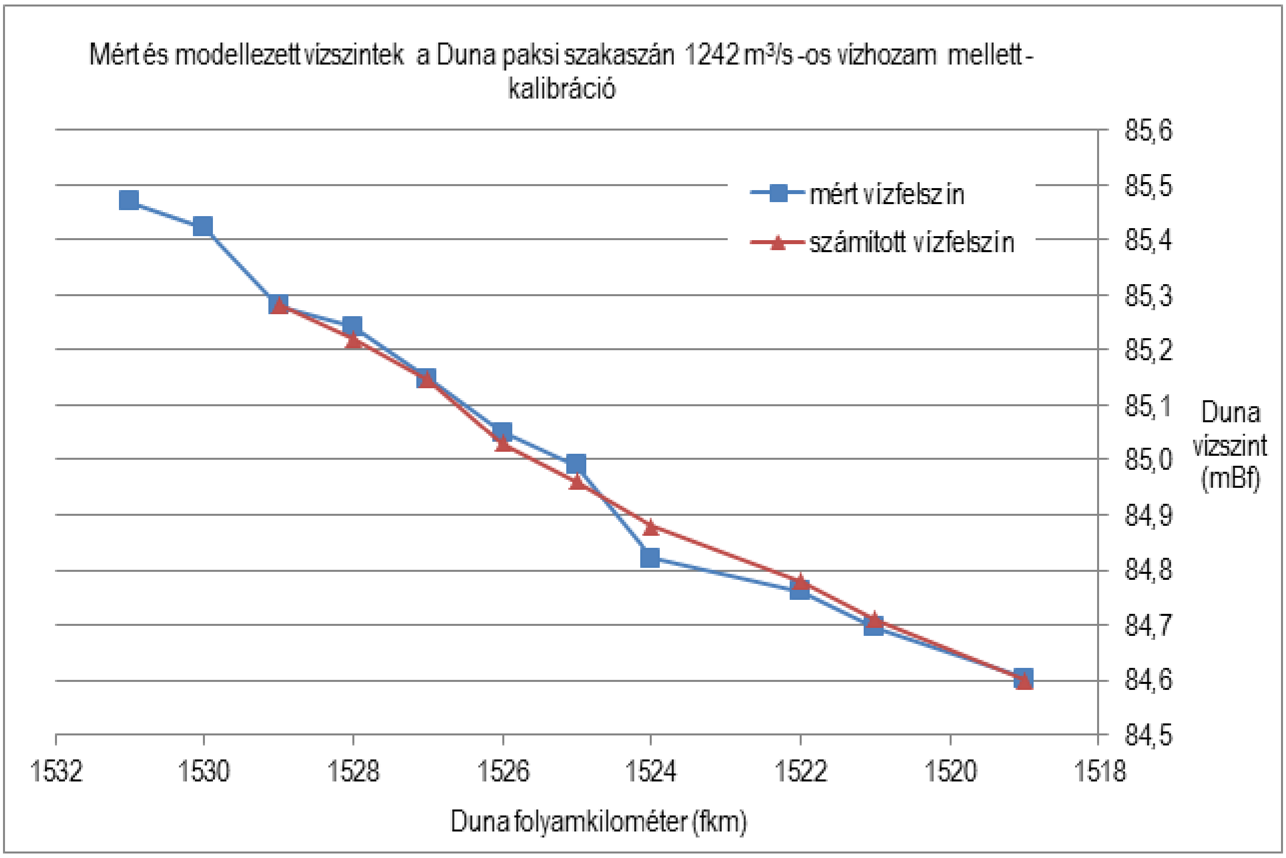
According to this, the design heat flux discharge is as follows (maximum levels are encountered in the years of 2032 and 2085):
Please find attached in XLS format as well (see ***Annex No 3: 3_Melleklet_mertekado_hokibocs*** – name of the file: ***Valasz_Melleklet_2_Hoaram.xls***).



Legend: A kibocsájtási hőáram [m³/sec*°C] időbeli változása – Paks I – Paks II - Changes in discharge heat flux as the function of time [m³/s*°C] – Paks I and Paks II
M [m³/sec*°C] – M [m³/sec*°C]
t [év] – t [year]

22 Only two figures were found about the examination of the flow conditions in Chapter 11.8.1.2. The impact of the erection of Paks II on the flow space and river morphology changes in the Danube, which contain the depth integrated flow fields associated with a flow of 2300 m/3s on the Danube and a water extraction/flow rate of 100 m3/s. The EIS does not contain any such results from series of tests which would have applied higher level of water use and lower levels of Danube flow rates, although the design state for the purpose of navigation would be represented by extreme low water flows and the highest levels of water use throughout the operation period.

The 2D flow calculations have been completed taking into account the nearly permanent surface curve and water flow rate of (1242 m³/s) measured on 6 October 2011:

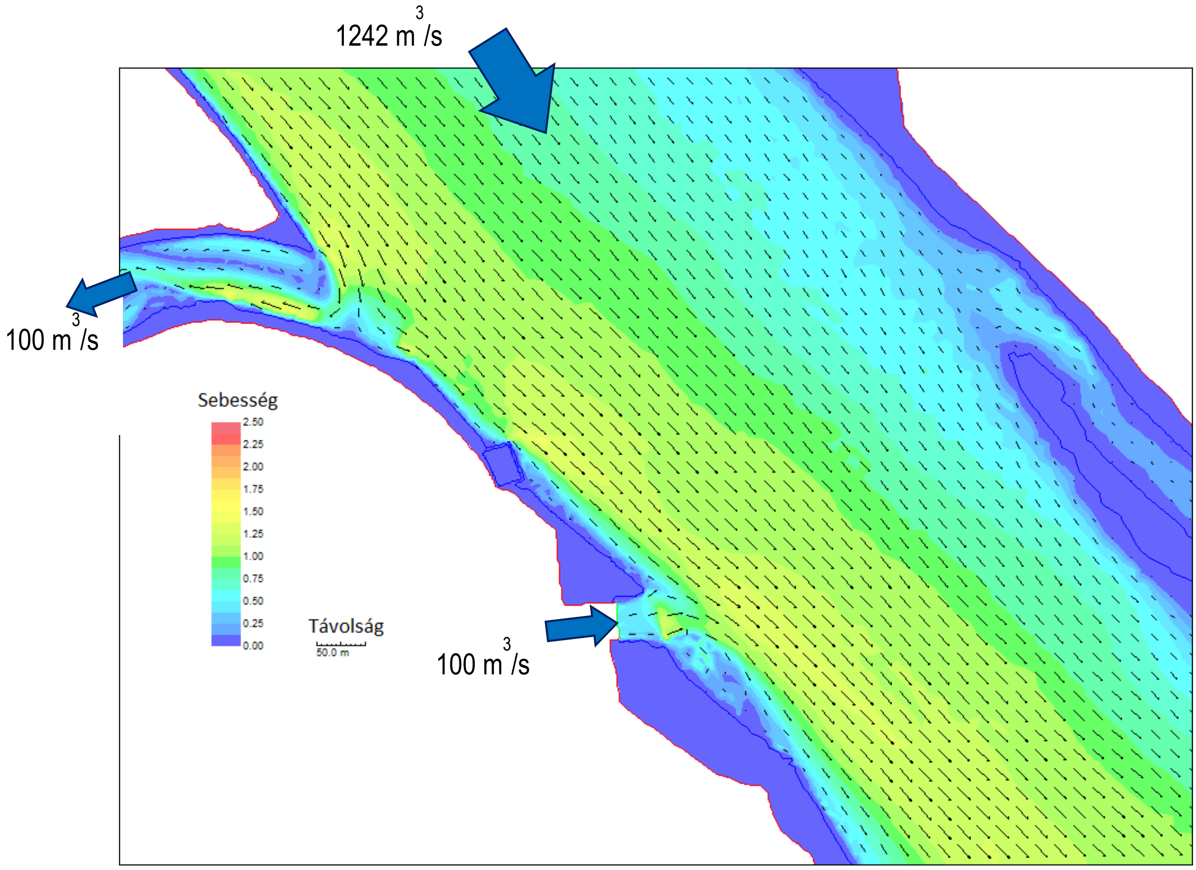


Note: Danube water level unit of measurement: m

Legend: Mért és modellezett vízszintek a Duna paksi szakaszán 1242 m³/s-os vízhozam mellett - kalibráció – Measured and modelled water levels on the Paks Danube section at 1242 m³/s flow rates - calibration
Duna folyamkilométer (fkm) – Danube River kilometre
Duna vízszint (mBf) – Danube water level (mBf)
Mért vízfelszín – Measured water surface level
Számított vízfelszín – Calculated water surface level

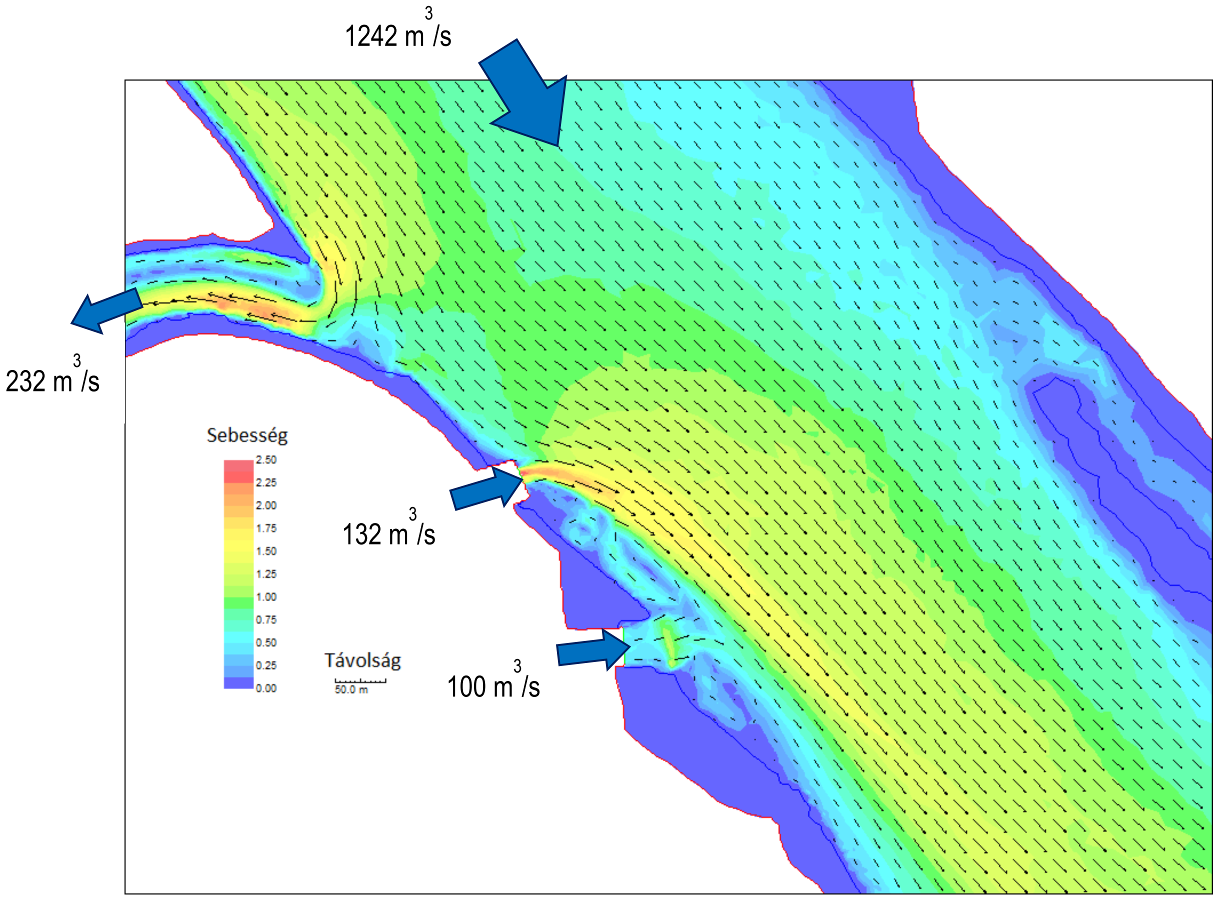
Figure 22-1: Calibration of the River2D model for 1242 m³/s Danube flow rate

Flow rate calculations and evaluation were made for these water yield (100 + 132 m³/s, etc.) versions (see the report entitled “The state of the Danube river bed and river wall”, dated on 11 April 2014). See the following figures:



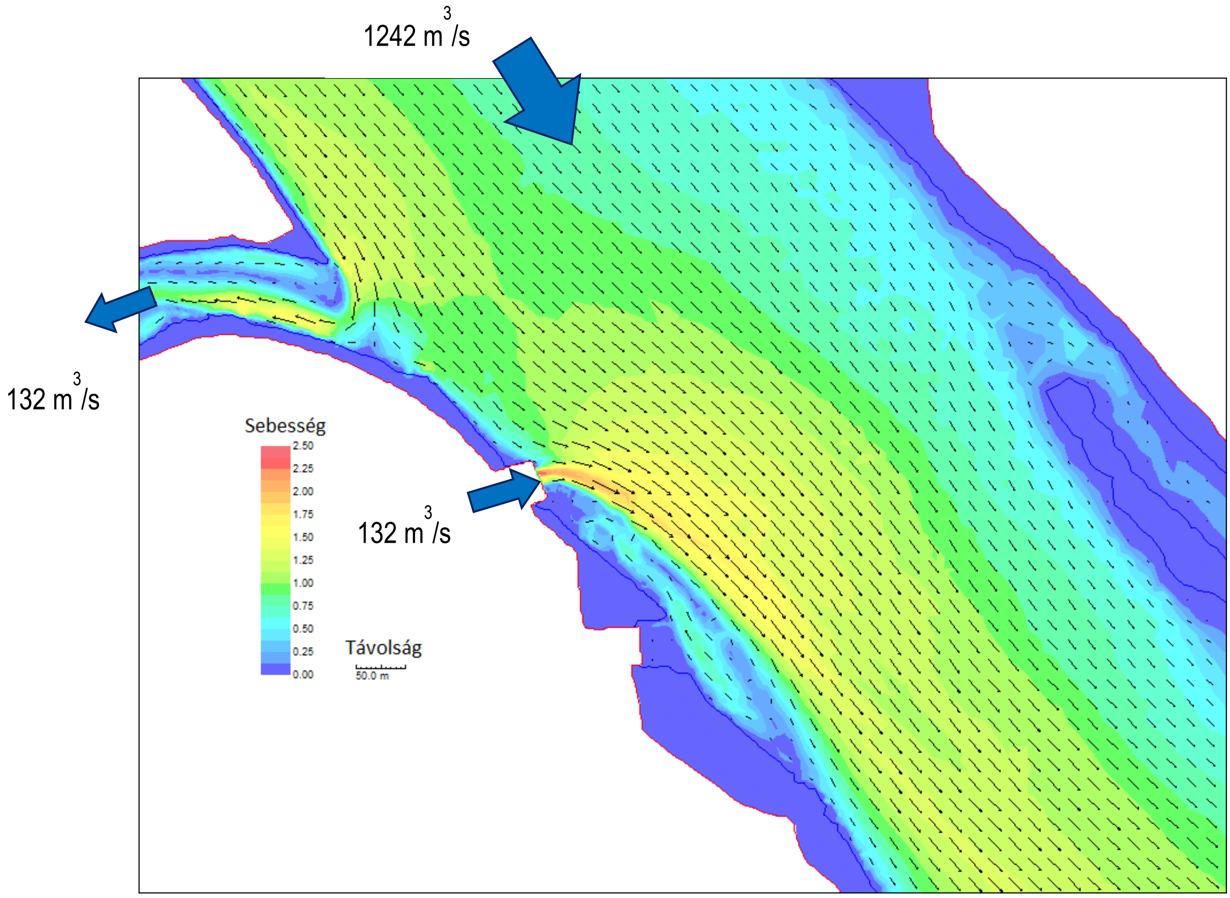
Note: unit of measurement on the colour code is m/s
Legend: Sebesség – Speed
Távolság – Distance

Figure 22-2: Modelled flow velocity field in the environmental of the cold water channel and hot water channel mouth at 1242 m³/s Danube flow rate and 100 m³/s cold water extraction rate (current state)



Note: unit of measurement on the colour code is m/s
Legend: Sebesség – Speed
Távolság – Distance

Figure 22-3: Modelled flow velocity field in the environmental of the cold water channeland hot water channel mouth at 1242 m³/s Danube flow rate and 232 m³/s cold water extraction rate (state of affiars in the year of 2032)



Note: unit of measurement on the colour code is m/s
Legend: Sebesség – Speed
Távolság – Distance

Figure 22-4: Modelled flow velocity field in the environmental of the cold water channeland hot water channel mouth at 1242 m³/s Danube flow rate and 132 m³/s cold water extraction rate (state of affiars in the year of 2085)

The (2D depth integrated) velocity fields which can be calculated in the design states of the years 2014, 2032 and 2085 associated with the 950 m³/s and 1100 m³/s Danube volume rates of flow for cooling water flow rates of 100 m³/s, 232 m³/s, 132 m³/s are attached hereby (see: ***Annex No 1: 1_Melleklet_Sebessegmezok***), indicating the borderlines of the current navigation route.

Based on the figures it can be stated that riverside flow conditions will change to a slight extent in the surrounding of the water extraction and water discharge site on the Danube on the right hand bank of the Danube in the moderate situation expected in the future upon the decrease of the Danube volume rate of flow (1100 and 950 m³/s) (232 m³/s cooling water extraction and hot water discharges, respectively, in 2032). Since however the width of the navigation route is substantial even at low water stages, and the navigation depth is available along the entire ship channel, it seems to be expedient to move away from the river bank a little towards the inner side of the Danube water space which is not influenced any more (maximum approximately 50 m) in order to avoid potentially non desirable drifting. Less intensive shipping traffic is expected at low water stages since further reaches of the Danube can not always be navigated in these periods. The expected riparian flow direction change will diminish from 2032 with the exit of the currently operating units of the power plant, and from 2037 (132 m³/s cooling water extraction and hot water discharges, respectively) will become similar to that experiences at the time being.

23 Modelling took place with static flow rates when the river morphology changes were investigated taking into account a 5 year service period. We disagree with this methodology, please model river bed morphology changes for a longer period of time and present it using the variable Danube water rates of flow modelling the real hydrological conditions.

The impact of major flood waves on river morphology changes was investigated. A permanent year was studied using the measured actual non-permanent set of data on flow rates and with the average approximately 2300 m³/s average flow rate in 2010. It was seen that the morphological changes were more prominent in the case of the permanent calculation because the flood wave does not cause any substantial movement of the river bed, but at the same time the sinking of the bed bottom in low water stages is more moderate than in the times of medium water stages. This was the basis on which the more adverse impact was considered, in other words the decision was made for the sake of safety.

24 Based on the operating states presented in Chapter 11.9.1.4 of the modelling documentation and the set of figures showing the impacts it can be concluded that the following occurs in the case of a Danube flow rate of 1500 m³/s:

a. heat loads on the Danube exceed the legal limits,
b. such anomalies are expected to occur in the flow conditions which have an adverse impact on navigation (which can be concluded from the figure on velocity distribution since no figure presenting the directions of the flow was published),
c. with the technical solution selected the mixing of the heat plume in the Danube does not occur throughout several tens of kilometres, and in certain operating states it can even be measured at the border.

Answers:

a) In the version presented in the EIS the maximum water temperature of the Danube in the reference cross section exceeds the level of 30 °C indeed and in such events action needs to be taken to reduce the heat flux which can be accomplished either by reducing the hot water volume discharged into the river (shut down of units), or by reducing the water temperature of the discharged flow (load reduction of the plant).

b) The EIS set the calculation of the spatial distribution of the heat plume (its impact area) as the primary goal in order to reveal conditions for compliance with the effective laws and regulations. Negative impacts on navigation may be mitigated and improved with appropriate control actions. It is expedient to avoid the area next to the discharge site where the heat plume enters the river from the hot water channel. Further up impacts are attenuated and the water depth may still be fit for safe navigation.

c) During the design period (2030 to 2032) a hot water rate of flow ranging up to 232 m³/s flows into the Danube when all units are in service. In such a period the impact area is indeed approximately ~11-12 km long, the duration of which is maximum 1 day on the basis of the multiple years data sets and furthermore it can be concluded that the crosswise migration of the impact area can be found near the right bank of the Danube. Any temperature increase outside of the impact area in the Danube water body is irrelevant with respect to the aquatic life in the Danube.

25 It is not clear from the documentation whether or not the recuperation power plant designed on the existing hot water discharge point with the existing energy dissipation structure that holds the water rights establishment license is to be constructed and thus, two recuperation plants will be operated on the hot water discharge site. In the event plants are constructed on both discharge sites, their mutual impact on each other and on the environment, respectively, must be investigated.

Seeing the protracted designing and licensing procedures it can be assumed that the recuperation power plant that already holds a water rights establishment permit - designed for the existing hot water channel will not be implemented. MVM Paks II. Zrt. intends to establish not a recuperation power plant at the northern branch of the hot water channel but an energy dissipation structure which is designed to improve the mixing of cooling water. This is a facility which uses the potential energy derived from the level differences of the hot water channel and the Danube to improve the mixing of the hot water discharged instead of the production of electricity. Based on a subsequent, later analysis and decision making process the conversion of this structure into a recuperation power plant can be implemented as a separate, independent investment project. Consequently, there is no issue of two recuperation power plant operating simultaneously, and therefore it is not necessary to investigate their mutual impacts on each other and on the environment.

26 The consequences of the impacts expected to be experienced as a result of water intake and hot water discharge during the investment period must be tackled, and the stability of the river bed must be secured with the use of the appropriate control structures. The necessary water management facilities must be design with due and thorough workmanship by describing and using the modelling results, under which the extremes of the velocity distributions formed in the environment must be presented. Our directorate, as the operator of the high water stage river bed of the Danube River held exclusively in state property offers the designers the opportunity of continuous consultations during the preparation of the design plans."