MVM PAKS II. ZRT.

IMPLEMENTATION OF NEW POWER PLANT UNITS AT THE PAKS SITE

ENVIRONMENTAL IMPACT STUDY

Submission of missing information based on the order with the reference number of P2D/601/2014

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1 Please demonstrate that the temperature of the receiver water body at any point on the 500 metres section downstream of the discharge point does not exceed the level of 30 ºC during the joint operation of the existing nuclear power plant and the nuclear power plant proposed by the User of the Environment for implementation and during the stand alone operation of the nuclear power plant proposed by the User of the Environment for implementation, as required by item b) 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 (hereinafter referred to as: Discharge Decree).

1.1 Operating control actions reducing the heat load to the Danube in the event of the parallel operation of both the existing and the proposed nuclear power plant units

Operating experiences gained from the currently operating units show that the provisions of Ministerial Decree No 15/2001 (VI.6.) KöM providing for the parameters of the cooling water to be returned and discharged into the Danube which states that the temperature of the receiver water body at any point on the 500 metres section downstream of the discharge point shall not exceed the level of 30 ºC can be met in the case of the cooling water volume associated with the four units operation at high water temperature and low water level.

According to the experiences gained from current operations the temperature of the heat plume measured in the reference profile depends on the amount of cooling water to a lesser extent and it has an impact more on the length of the heat plume downstream. Based on these experiences when the extension of the plant is assessed independently from the existing units, the same extent of temperature reduction can be assumed in the case of a cooling water discharge rate of 132 m^3/s when it is seen in the current situation, in other words after the year 2037 when parallel operation of the current and future units has been concluded, the situation in place at the time being (and up to 2024) will be restored on the Danube.

A key issue is in the operation of the existing and proposed new units the frequency and duration of critically hot days. When the daily temperature maximum values and their duration in the Danube water are assessed, it can be concluded that even when the warming tendencies are taken into account any critical water temperature levels requiring control actions will occur during a few days a year for the proposed 60 years lifecycle of the plant.

Cooling water of the new units is mixed with the cooling water of the existing units when entering the hot water canal and following the mixing phase it is divided into two separate branches and enters the Danube through two distinct structures. A part of the mixed cooling water is introduced into the river will take place at a new entrance point upstream from the current energy dissipation device, through an energy dissipation device. This discharge point will be set up some 200 metres upstream from the current hot water outlet at the Danube 1526.450 river km profile on the right bank. Warmed up cooling water from the existing four units will be discharged at the existing outlet point through the existing energy dissipation structure at the Danube 1526.250 river km profile on the right bank. As a conservative estimate, an inlet temperature of 33 ˚C is taken into account for both discharge points as an initial condition.

Actions to be taken in order to reduce the heat load to the Danube

The proposed monitoring system will follow up the typical temperature of the reference profile above 25 ˚C of Danube temperature, which is the basis for the operator to carry out the required control actions. Reference profile No 1 will be defined 500 metres downstream of the new inlet point, some 300 m from the former discharge point. Reference profile No 2 is the currently existing control profile. Having regard to the model calculations carried out showing the impact of the upstream discharge point to the heat plume of the current units (Chapter 11.9.1.4.1.2 of the EIS), therefore any control action to be taken need to be implemented in the operation of the new units to comply with the temperature limits. Both the Danube river and the cooling water system each and together can be characterised with a large heat storing capacity, consequently their joint inertia is also very large, reacting to changes in parameters and control actions not instantly but over a time lag.

In the event the temperature of the water reached to level of 29 °C in the newly designated reference profile as a result of the increasing background temperature on the Danube, the plant operator will issue a command to carry out the action plan. In parallel to this temperature control of the existing old reference profile and its compliance with the 30 °C temperature limit must be ensured. Actions related to this obligation are identical in the case of the existing and the new units, in other words it may happen that control actions will be taken for both the existing and the new units in parallel. The extent of the control action that is the reduction of loading shall be defined in close cooperation between the operating units, with a view to the nuclear safety of the units, their current operational states and the extent of losses due to outages in production.

Measures in the action plan

Control action Level 1: Exploitation of the built-in pumping reserve capacities:

The two new units are able to deliver their rated output using 60.7 x 2 = 121.4 m^3/s cooling water led through a condenser. Since cooling water pumps do not operate necessarily with their full installed maximum 132 m^3/s capacity, their reserve capacities available provide a safe possibility to meet the needs for electric power on the grid during the critical days by increasing the amount of water circulated on the condenser. With the increased water volume the heat gradient encountered in the condenser and hence, the temperature on the cooling water loop can be reduced.

Control action Level 2: Limiting the production of the operating units.

Reduction of the loads on the unit may keep the temperature of the warmed up cooling water returning to the Danube below the desired 33 °C limit. For this the electrical output of the units must be limited and the load of the nuclear power plant units reduced in a manner which results warming of the water by the heat to be extracted on the condenser only to the desired extent. By the load reduction on the units and reducing the amount of heat extracted on the condenser the rate of warming up of the cooling water will be diminished as a function of the load reduction on the units when the cooling water volume rate of flow on the condenser remains constant. The order of magnitude of load reduction will be 160-180 MW_e/°C, i.e. in order to reduce the outlet cooling water temperature by 1 °C a load reduction of 160-180 MW_e is needed on the electrical output of each unit.

The proposed new blocks will be fit to load-following, therefore they are expected to operate only at partial loads in the first place because of the joining in of renewables during the summer season and favourably priced imports booked for the peak period, which is expected to result in a more beneficial situation in terms of the Danube heat loads.

The application of a supplementary technical solution

Based on a few years' experiences drawn from the parallel operation of the existing and the new units and following the completion of technical and economic analyses the application of wet forced ventilation cooling cell modules operating as peak capacity coolers may be also used in order to comply with the 30 °C temperature limit at the 500 m profile (Chapter 5.3.1.3.3 of the EIS). They may cool hot cooling water to be returned to the Danube either in partial flow or full volume rate of flow pending on the actual temperature of the cooling water. Since it a modular system, it can be installed according to the cooling needs.

The area needed for the installation of the peak coolers is available at the site between the cold water canal and hot water canal. Circulation of the hot water through the peak coolers takes place using a separate pumping station and the cooling cells would be set up in 2x3 arrangement. Installation of the cooling cells could be effectuated in response to the demand predicted from time to time.

Peak coolers operate only during the summer season, therefore neither operational chemical conditioning, nor operational anti-frosting solutions are not necessary. Before and after the operating cycles shock wave chemical cleaning may be accomplished as appropriate. Off summer seasons, when the application of the peak coolers is not necessary, the pumping station and the pipeline system can be drained, conserved and prepared for the operation free winter period.

2 It is necessary to investigate the conjunction range of expected high temperature periods and low water flows on the Danube. The statement made in Section 11.7.4.3. Chapter 11 of the Impact Study saying "the conjunction range is so short in duration that it does not justify the inclusion of the scenarios for extreme low rates of water flow in the Danube for the purposes of heat plume calculations" can not be accepted.

2.1 CONJUNCTION OF HIGH WATER TEMPERATURE AND LOW RATE WATER FLOWS

The results of the calculations for the Q/T duration of design background temperature on the Danube, plus the conditional duration distribution generated by the Q,T generator and determined from the data measured on current state of affairs are contained in the tables below (Table 2-1, Table 2-2).

Q/T	**T_{Danube} [ºC] 2014 - T_Danube = 25.61ºC – current state, from Q,T data**										
Q_{Danube} [m³/s]	**20 ºC**	**21 ºC**	**22 ºC**	**23 ºC**	**24 ºC**	**25 ºC**	**26 ºC**	**27 ºC**	**28 ºC**	**29 ºC**	**30 ºC**
Q<800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q<900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q<950	**0.07**	0.07	0.04	0.04	0.00	**0.00**	**0.00**	0.00	0.00	0.00	0.00
Q<1000	0.14	0.14	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q<1100	0.30	0.30	0.24	0.24	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Q<1200	1.30	1.22	1.14	1.00	0.70	0.08	0.00	0.00	0.00	0.00	0.00
Q<1300	2.46	2.27	1.86	1.57	0.97	0.19	0.00	0.00	0.00	0.00	0.00
Q<1400	3.86	3.57	2.81	2.24	1.38	0.43	0.00	0.00	0.00	0.00	0.00
Q<1500	5.76	5.16	3.84	2.84	1.59	**0.49**	**0.00**	0.00	0.00	0.00	0.00
Q<1600	8.30	7.19	5.32	3.73	1.95	0.65	0.00	0.00	0.00	0.00	0.00
Q<1700	11.38	9.78	7.30	4.62	2.30	0.84	0.11	0.00	0.00	0.00	0.00
Q<1800	14.49	12.19	9.00	5.38	2.57	0.89	0.11	0.00	0.00	0.00	0.00
Q<1900	17.81	14.51	10.38	5.86	2.78	0.89	0.11	0.00	0.00	0.00	0.00
Q<2000	21.81	17.35	12.24	6.65	2.84	0.89	0.11	0.00	0.00	0.00	0.00
Q<2100	25.68	20.11	13.57	7.08	2.97	0.89	0.11	0.00	0.00	0.00	0.00
Q<2200	29.51	22.92	15.41	7.81	3.16	0.95	0.11	0.00	0.00	0.00	0.00
Q<2300	32.49	25.05	16.54	8.35	3.22	0.95	0.11	0.00	0.00	0.00	0.00
Q<2400	35.05	26.32	17.08	8.49	3.22	0.95	0.11	0.00	0.00	0.00	0.00
Q<2500	37.30	27.32	17.59	8.59	3.32	0.97	0.11	0.00	0.00	0.00	0.00
Q<2600	38.62	27.86	17.73	8.62	3.32	0.97	0.11	0.00	0.00	0.00	0.00
Q<2700	40.16	28.65	18.05	8.73	3.38	0.97	0.11	0.00	0.00	0.00	0.00
Q<2800	41.24	29.22	18.27	8.78	3.41	**0.97**	**0.11**	0.00	0.00	0.00	0.00
Q<2900	42.41	29.78	18.46	8.78	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3000	43.16	30.05	18.54	8.78	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3100	44.00	30.43	18.62	8.81	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3200	44.62	30.62	18.70	8.84	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3300	45.14	30.78	18.73	8.84	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3400	45.57	31.00	18.78	8.84	3.41	0.97	0.11	0.00	0.00	0.00	0.00
Q<3500	45.73	31.03	18.78	8.84	3.41	0.97	0.11	0.00	0.00	0.00	0.00

Table 2-1: Conditional duration distribution of the current state based on measured Q, T data

Q/T	**T_{Danube} [ºC] 2014 - T_Danube = 25.61ºC – generated current state**										
Q_{Danube} [m³/s]	**20 ºC**	**21 ºC**	**22 ºC**	**23 ºC**	**24 ºC**	**25 ºC**	**26 ºC**	**27 ºC**	**28 ºC**	**29 ºC**	**30 ºC**
Q<800	0.37	0.23	0.14	0.08	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Q<900	0.42	0.26	0.16	0.09	0.05	0.02	0.01	0.00	0.00	0.00	0.00
Q<950	**0.79**	0.53	0.34	0.20	0.12	**0.06**	**0.03**	0.01	0.01	0.00	0.00
Q<1000	1.15	0.79	0.51	0.31	0.18	0.09	0.04	0.01	0.01	0.00	0.00
Q<1100	2.81	1.98	1.31	0.80	0.46	0.23	0.10	0.04	0.02	0.01	0.00
Q<1200	5.20	3.72	2.46	1.49	0.84	0.42	0.19	0.08	0.03	0.01	0.00
Q<1300	8.05	5.76	3.82	2.31	1.27	0.64	0.28	0.11	0.04	0.01	0.00
Q<1400	11.15	7.97	5.27	3.17	1.74	0.87	0.37	0.15	0.06	0.02	0.00
Q<1500	13.93	9.93	6.57	3.94	2.15	**1.08**	**0.46**	0.18	0.07	0.02	0.00
Q<1600	16.54	11.78	7.79	4.67	2.54	1.27	0.53	0.22	0.08	0.02	0.01
Q<1700	19.04	13.54	8.94	5.36	2.91	1.46	0.61	0.25	0.09	0.03	0.01
Q<1800	21.62	15.35	10.11	6.04	3.27	1.64	0.69	0.28	0.10	0.03	0.01
Q<1900	23.96	16.98	11.18	6.66	3.61	1.79	0.76	0.31	0.11	0.03	0.01
Q<2000	26.00	18.41	12.09	7.19	3.87	1.92	0.81	0.33	0.12	0.03	0.01
Q<2100	27.89	19.74	12.93	7.68	4.14	2.05	0.86	0.35	0.13	0.04	0.01
Q<2200	29.70	21.01	13.75	8.16	4.39	2.17	0.92	0.37	0.14	0.04	0.01
Q<2300	31.43	22.21	14.51	8.60	4.62	2.28	0.96	0.39	0.14	0.04	0.01
Q<2400	33.09	23.39	15.27	9.04	4.86	2.38	1.01	0.40	0.15	0.05	0.01
Q<2500	34.65	24.48	15.97	9.44	5.07	2.49	1.06	0.42	0.15	0.05	0.01
Q<2600	36.20	25.55	16.68	9.86	5.28	2.59	1.10	0.44	0.16	0.05	0.01
Q<2700	37.65	26.56	17.34	10.25	5.48	2.69	1.15	0.45	0.17	0.05	0.02
Q<2800	39.03	27.54	17.98	10.63	5.68	**2.78**	**1.19**	0.47	0.17	0.06	0.02
Q<2900	40.36	28.47	18.58	11.00	5.87	2.87	1.22	0.48	0.17	0.06	0.02
Q<3000	41.61	29.36	19.19	11.36	6.06	2.96	1.25	0.49	0.18	0.06	0.02
Q<3100	42.81	30.22	19.76	11.69	6.24	3.04	1.29	0.50	0.18	0.06	0.02
Q<3200	43.91	30.99	20.27	12.01	6.41	3.12	1.32	0.51	0.19	0.06	0.02
Q<3300	44.93	31.73	20.75	12.30	6.57	3.20	1.35	0.52	0.19	0.06	0.02
Q<3400	45.88	32.40	21.19	12.56	6.71	3.27	1.38	0.53	0.19	0.06	0.02
Q<3500	46.79	33.05	21.61	12.82	6.85	3.33	1.41	0.54	0.19	0.06	0.02

Table 2-2: Conditional duration distribution of the current state based on generated Q, T data

The table for 2014 was prepared 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 overshoot durations 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 downsizing the heat gradients with reduction of the power plant load.

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 The temperature impacts of the cooling water introduced into the Danube on the water of the river have to be assessed for low water stages of the Danube (heat plume calculations, definition of the impact area). In Section 11.9.1.4. Chapter 11 of the Environmental Impact Study only the design water rate of flow of 1500 m³/s is reckoned with and no other lower levels (~1000 m³/s) were studied. When the expected impacts of climate change are assessed, extreme rates of water flow should also be taken into account.

At the meeting held in conjunction with the authorities concerned on 12 May 2015 the Danube rate of flow of 950 m³/s has been determined as the design level for additional studies as proposed by ADUVIZIG. On this basis heat plume calculations and determination of the impact areas were repeatedly completed.

3.1 HEAT PLUME CALCULATION RESULTS FOR THE 950 M³/S DESIGN RATE OF FLOW ON THE DANUBE

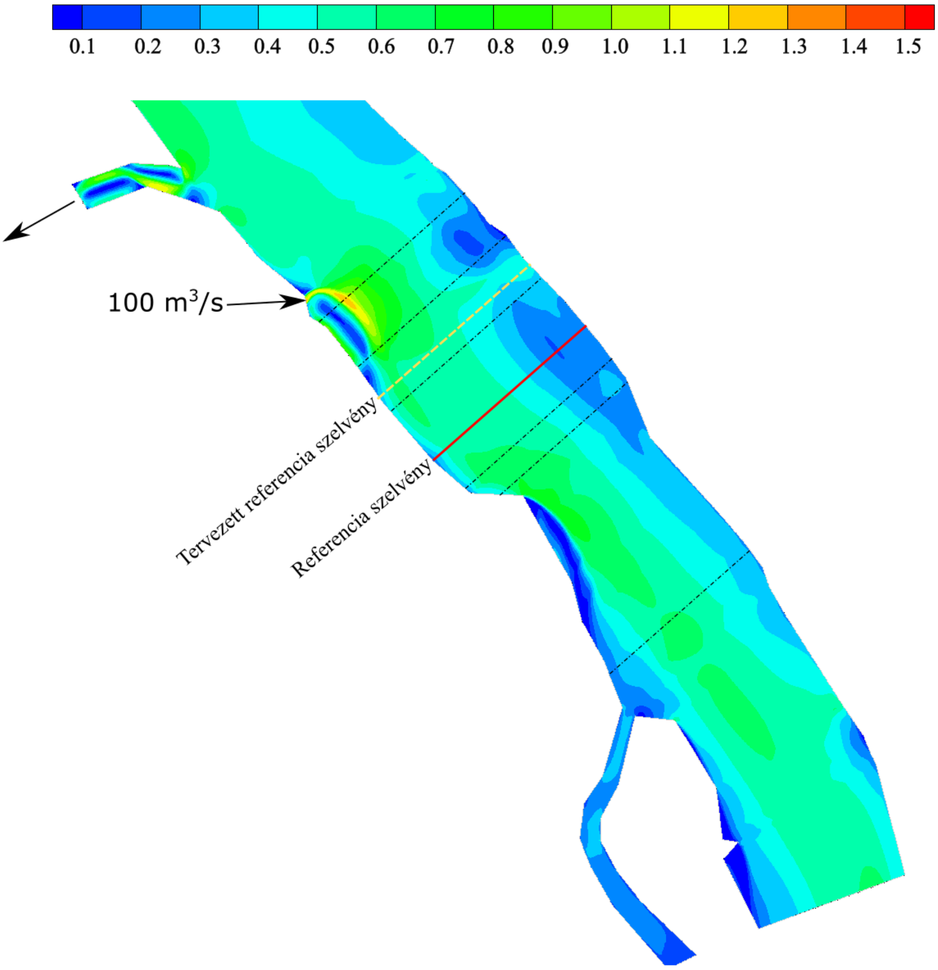
3.1.1 PRESENTATION OF THE DESIGN STATE IN THE YEAR 2014 (PAKS NUCLEAR POWER PLANT STAND ALONE OPERATION)

The assessment of the available time series for water rate of flow and water temperature on the Danube shows that the maximum water temperature level associated with the 950 m³/s rate of flow is 20°C.

From the perspective of the heat plume this a lot more favourable situation than the one presented in the EIS (Q=1500 m³/s, $T_{Danube,max}$=25.61°C). The more favourable situation is developed mainly due to the large temperature difference ($\Delta T_{Danube,max}$=20.00 °C - 25.61 °C = -5.61 °C). As a result the water temperature on the Danube will meet the 30.0 ºC level defined in the Decree in all tested cases.

In compliance with the requirements laid down in order No P2D/601/2014 of the Baranya County Government Office issued on 15 May 2015, the assessment model runs were carried out for high Danube temperature at 950 m³/s rate of flow. It should be noted however that the development of such a combination between water yields and water temperatures is extremely improbable (never observed before, as demonstrated by the measurement data). It can be characterised with a degree of probability approximately 1:100 000 years or higher, and less than 0.1 days/year duration.

The distribution of the absolute value in the flow velocity obtained with the three dimensional (3D) hydrodynamic calculations for the present state is shown on Figure 3-1 in the case of 950 m³/s design volume rate of flow on the Danube (in the year of 2014 the Danube water temperature of 25.61 °C has a duration of nearly 0 days/year when 950 m³/s Danube water yields are considered – see Chapter 11.7.4 of the EIS) and 100 m³/s discharge rate of warmed up cooling water, in the near surface horizontal plane layer (where maximum values of water temperature may be formed).

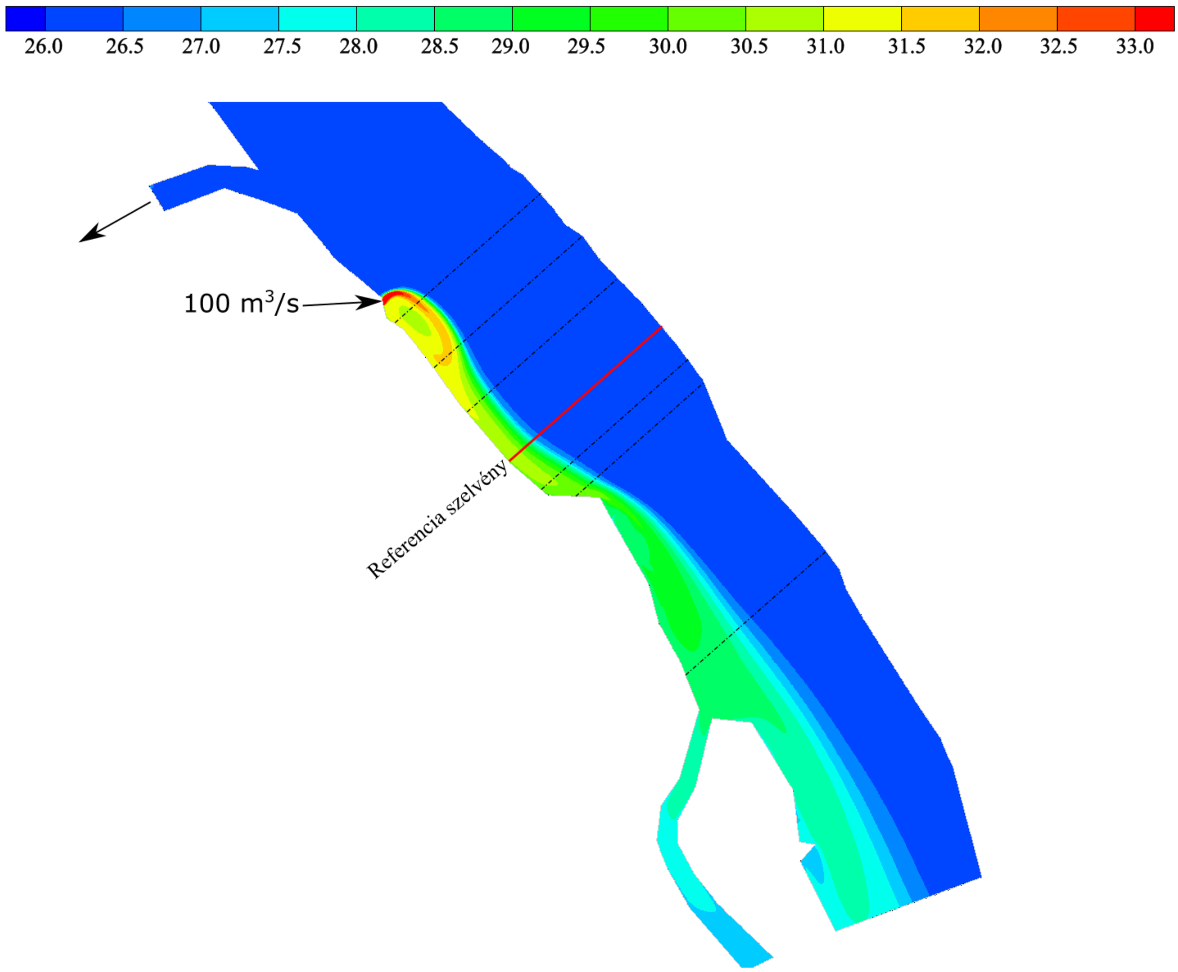


Note: Unit of measurement for the colour code is m/s.

Legend: Tervezett referencia szelvény - Proposed reference section,
Referencia szelvény - Reference section

Figure 3-1: Near surface flow velocity distribution pattern (heat gradient 8 °C) – design state of the year 2014 ($T_{Danube,max}$=25.61 °C, Q_{Danube}=950 m³/s) – Paks Power Plant stand alone operation

Figure 3-2 shows the heat plume of the version calculated with a heat gradient of 8 °C. It can be clearly seen that similarly to the case at 1500 m³/s rate of flow in the Danube the plume is attached to the right bank. Furthermore it can be observed that any more substantial drop of temperature levels occurs – due to the phenomena discussed in the EIS – at the discharge point and at the cross dam, respectively. The phenomena are set forth in details by Figure 11.9.1-40 of the EIS.

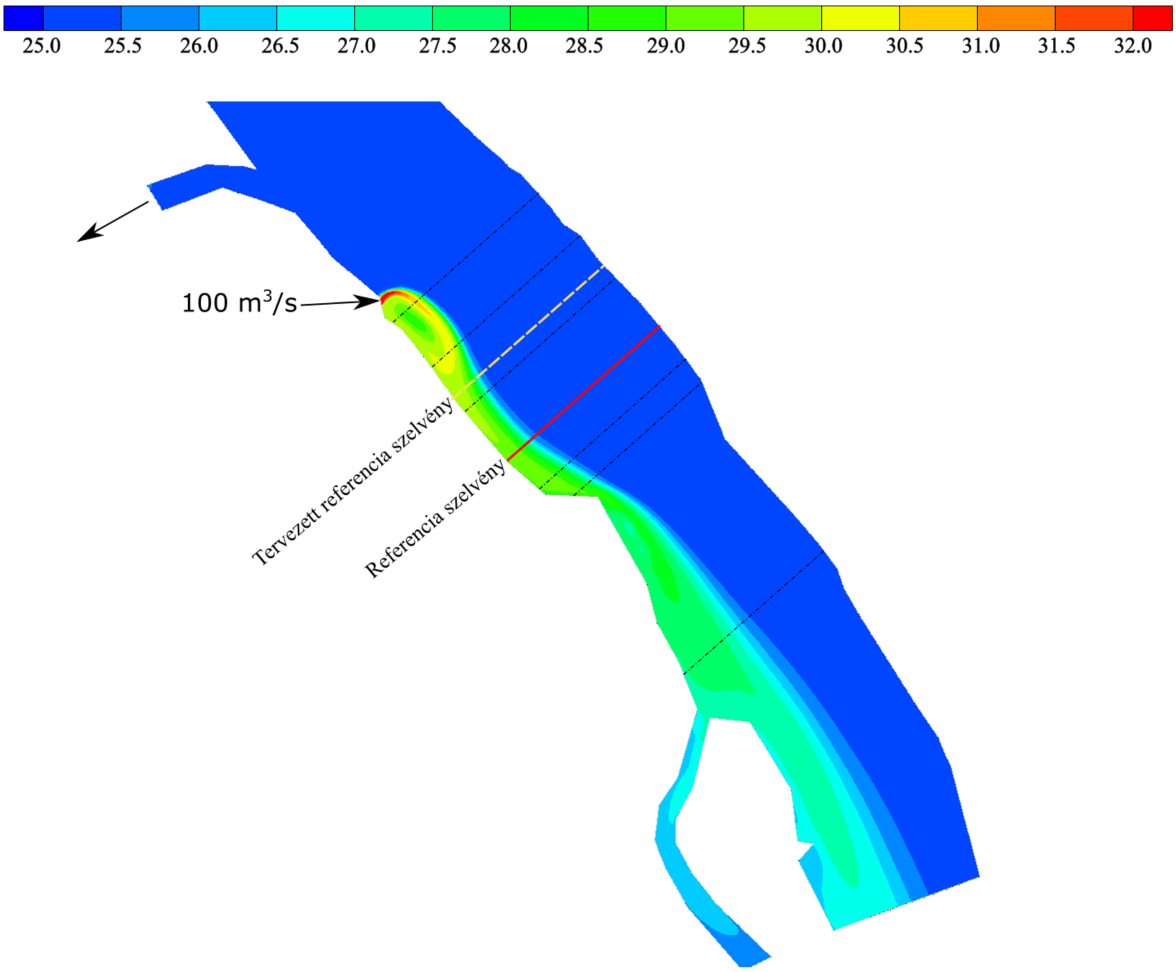


Note: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Referencia szelvény - Reference section

Figure 3-2: Heat plume, 8°C heat gradient – design state of the year 2014 ($T_{Danube,max}$=25.61 °C, Q_{Danube}=950 m³/s) – Paks Nuclear Power Plant stand alone operation

Figure 3-3 shows the heat plume of the version calculated with a hot water discharge of 33 °C.



Note: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-3: Heat plume, discharge at 33°C temperature – state in the year of 2014 ($T_{Danube,max}$=25.61 °C, Q_{Danube}=950m³/s) – Paks Nuclear Power Plant stand alone operation

Figure 11.9.1-40 of the EIS presented the Danube velocity space through the direction and size of velocity vectors, while the temperature was shown on the colouring of the vectors, this way an impression was given all at once on the properties of the flow and the directly associated heat transport.

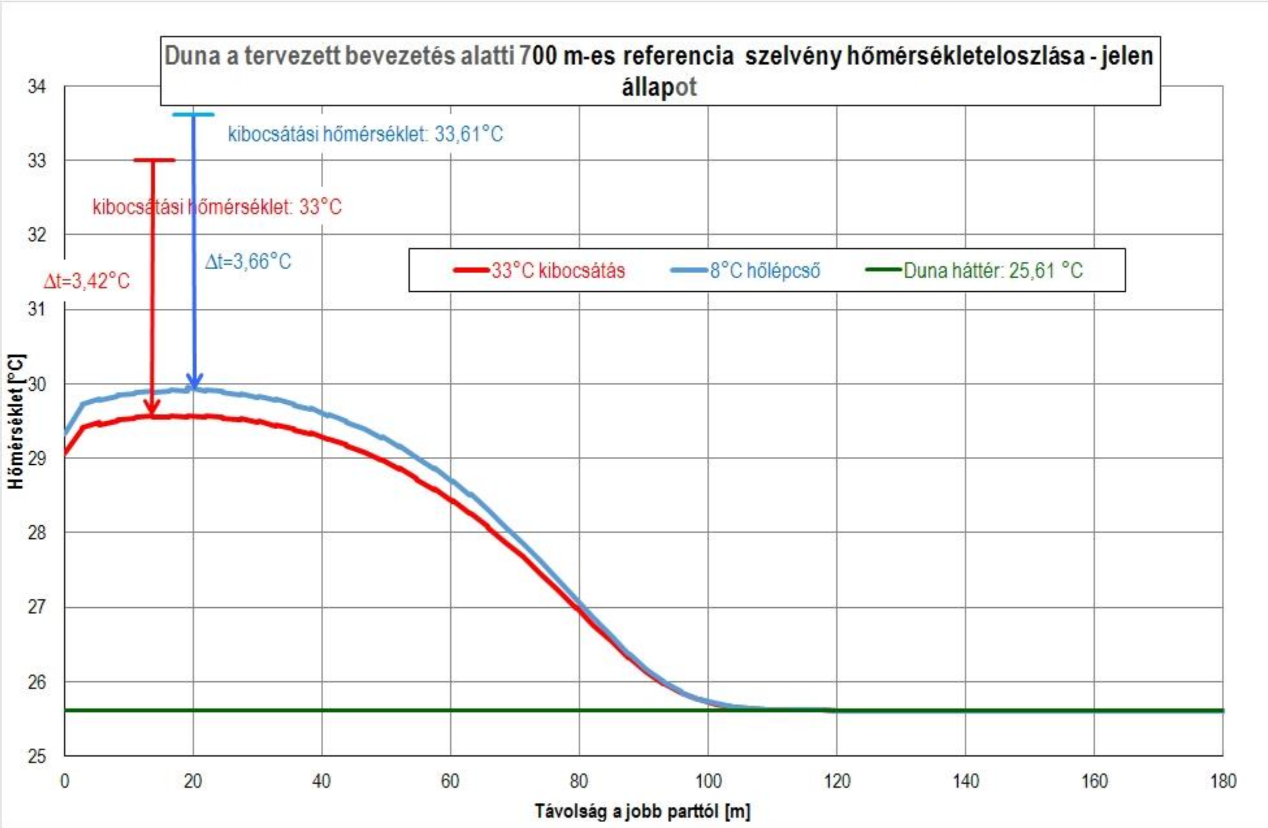
The same way as it happened in the 1500 m³/s scenario, a sudden drop of impetus happens in the environment of the discharge point in the case of the 950 m³/s Danube rate of flow, thus increasing the dissipation of the turbulent kinetic energy. The hydraulic gradient, derived from this variable shows the extent of blending. The rapid turn in direction and shearing force resulting from the speed differences in various layers of the plume favour the formation of eddies. This is the reason why a vortex zone turning clockwise is found in the downstream section of the discharge point maintained by the kinetic energy of the continuously discharged cooling water. Downstream of the zone of eddies next to the right bank at the shallower parts lower velocities are observed which grow towards the main current line. No substantial temperature decline can be experienced downstream in this section. Crosswise dispersion is increased substantially by the spatial inequalities of river bed depth and the break of direction in the plume at the cross dam, therefore temperature decline may be significant at this point. Downstream variations of maximum heat plume temperature also demonstrates that following the initial sudden drop of temperature at the discharge point the next sharp change will occur some 650 metres from the inlet at the cross dam.

It can be concluded based on the temperature distribution measured in the current reference profile that in the current state the 30°C temperature limit can be definitely adhered to with the version operated at a 8°C heat gradient and continuously 33°C discharge temperature even in the case of the expected highest background temperature of the water in the Danube. When a higher heat gradient is applied, the cooling effect is also higher, since the driving force behind equalisation is the temperature differential.

As a result of the 3D blending study the following maximum expected water temperature cross profile is obtained with the design hot water load (100 m³/s discharge, 8 °C heat gradient and 33 °C discharge temperature) to be introduced into the Danube (at 0 days/year duration, 950 m³/s Danube rate of flow), taking the maximum Danube water temperature expected in the year of 2014 as the basis (25.61 °C) in the following maximum water temperature longitudinal profile and in the current reference profile (+ 500 m) (Figure 3-5).

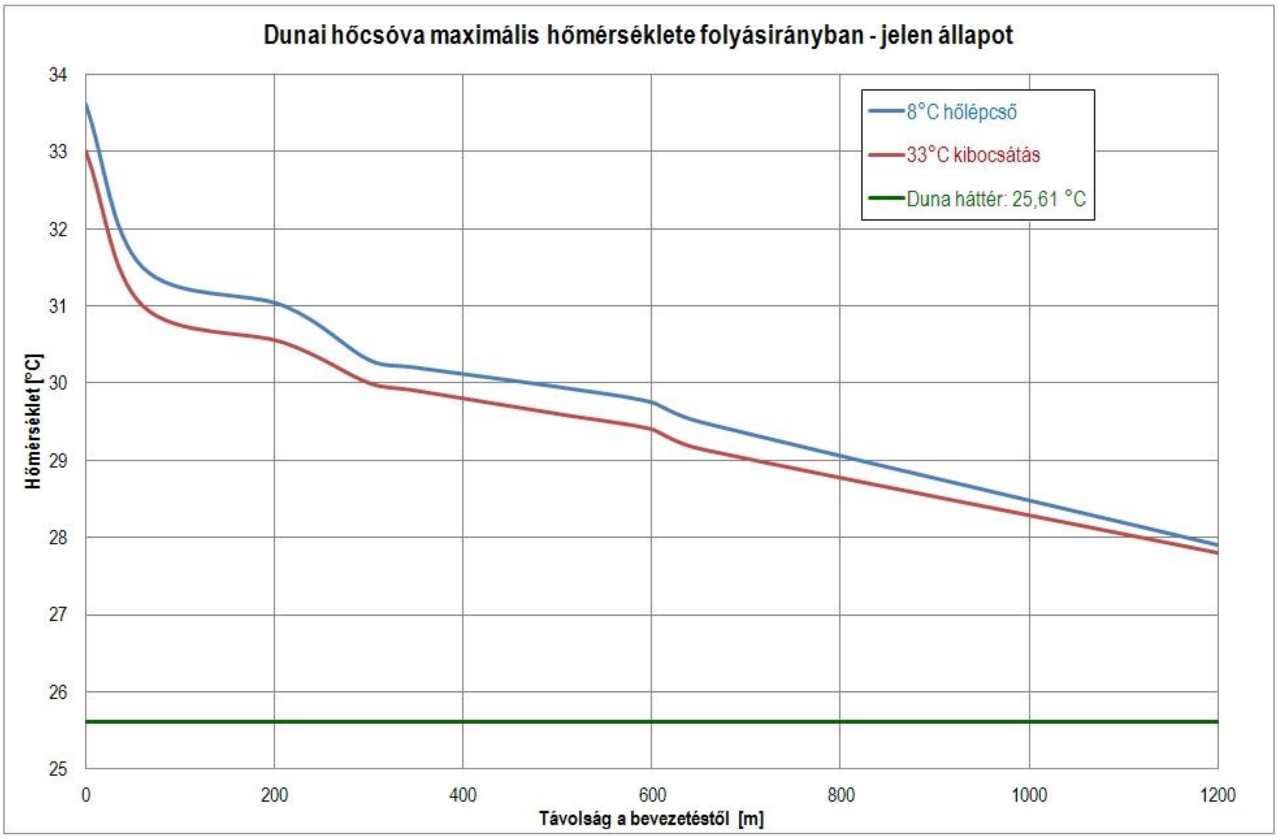
Since a 33 °C temperature hot water discharge means a heat gradient of 7.39 °C (33 – 25.61 °C), which does not depart substantially from the discharge with the 8 °C heat gradient, therefore the maximum water temperature distribution values calculated with the model calculations fall only very slightly short of the results of water temperature distribution calculated with the 8 °C heat gradient.

Comparing the crosswise temperature differentials developing in the current reference profile in the case of 1500 m³/s and 950 m³/s Danube water rates of flow, respectively, it can be concluded that the maximum temperature within the cross profile is increased by approximately 0.5 °C in the event of the lower rate of flow on the Danube. Similar values are obtained for the width of the plume in both cases. Having a view on the trend of temperature maximum values downstream it can be stated that the largest difference between the two versions can be found within 300 m from the discharge point. Flow conditions occurring due to the lower rate of flow cause adverse blending in the nearby zone, however the longitudinal profile of the maximum values shows a similar picture downstream from the bottleneck.



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 700 m-es referencia szelvény hőmérsékleteloszlása – jelen állapot – The temperature distribution of the River Danube at the reference section 700 m downstream of injection point – present condition;
Kibocsátási hőmérséklet: 33,61 °C – Discharge temperature of 33.61 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient,
Duna háttér: 25,61 °C - Background temperature of the River Danube: 25.61 °C

Figure 3-4: Crosswise changes in temperature – state in the year of 2014 ($T_{Danube,max}$=25.61 °C; Danube rate of flow 950 m³/s) – Paks Nuclear Power Plant stand alone operation



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a bevezetéstől [m] - Distance from the injection [m],
Dunai hőcsóva maximális hőmérséklete folyásirányban – jelen állapot – The maximum temperature of the heat plume of River Danube downstream – present condition;
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient,
Duna háttér: 25,61 °C - Background temperature of the River Danube: 25.61 °C

Figure 3-5 Differntial temperature downstream – state in the year of 2014 ($T_{Danube,max}$=25.61 °C; Danube rate of flow 950 m³/s) – Paks Nuclear Power Plant stand alone operation

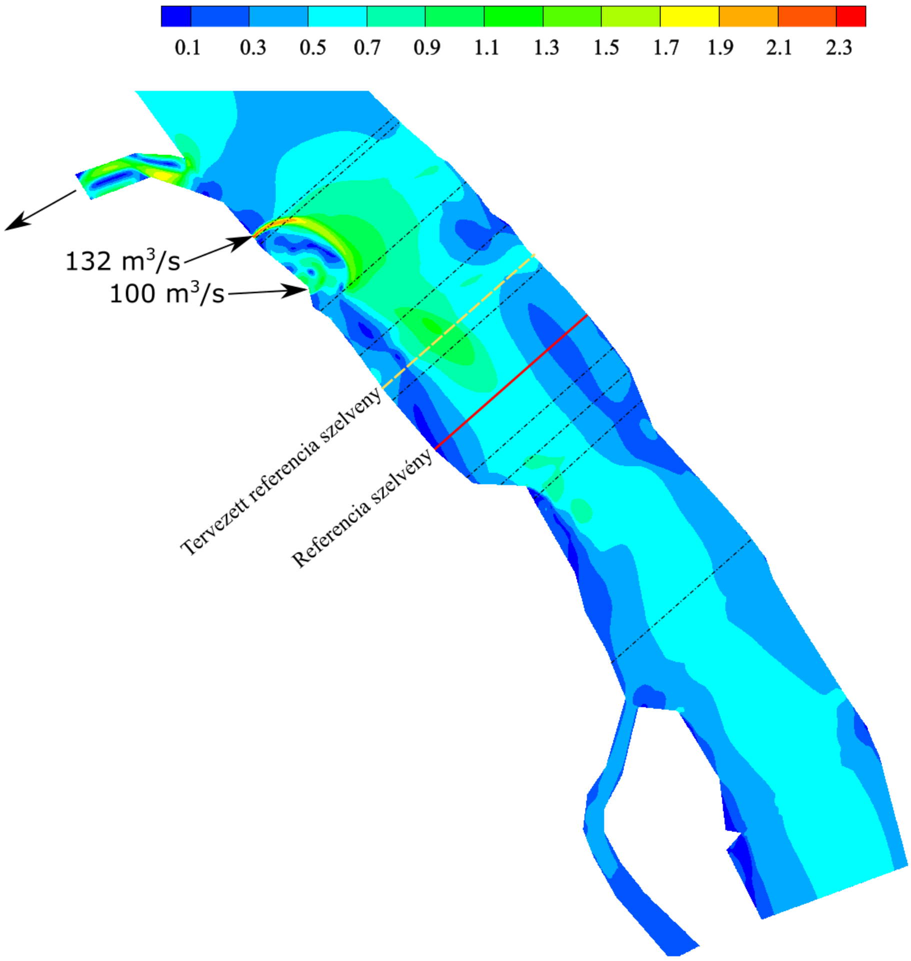
3.1.2 CHARACTERISATION OF THE DESIGN STATE IN THE YEAR OF 2032 (JOINT OPERATION OF PAKS NUCLEAR POWER PLANT + PAKS II)

The joint operation of Paks Nuclear Power Plant and Paks II plant results in a cooling water load to the Danube discharged jointly but at separate locations. Flow and heat transport simulations studies the impact of joint loads using 3D hydrodynamic and heat transport models.

The background water temperature of the Danube associated with the rate of flow at 950 m³/s is 20.77 °C.

From the perspective of the heat plume this a lot more favourable situation than the one presented in the EIS (Q=1500 m³/s, $T_{Danube,max}$=26.38 °C). The more favourable situation is developed mainly due to the large temperature difference ($\Delta T_{Danube,max}$=20.77 °C - 26.38 °C = -5.61 °C). As a result the water temperature on the Danube will meet the 30.0 ºC level defined in the Decree in the proposed reference profile.

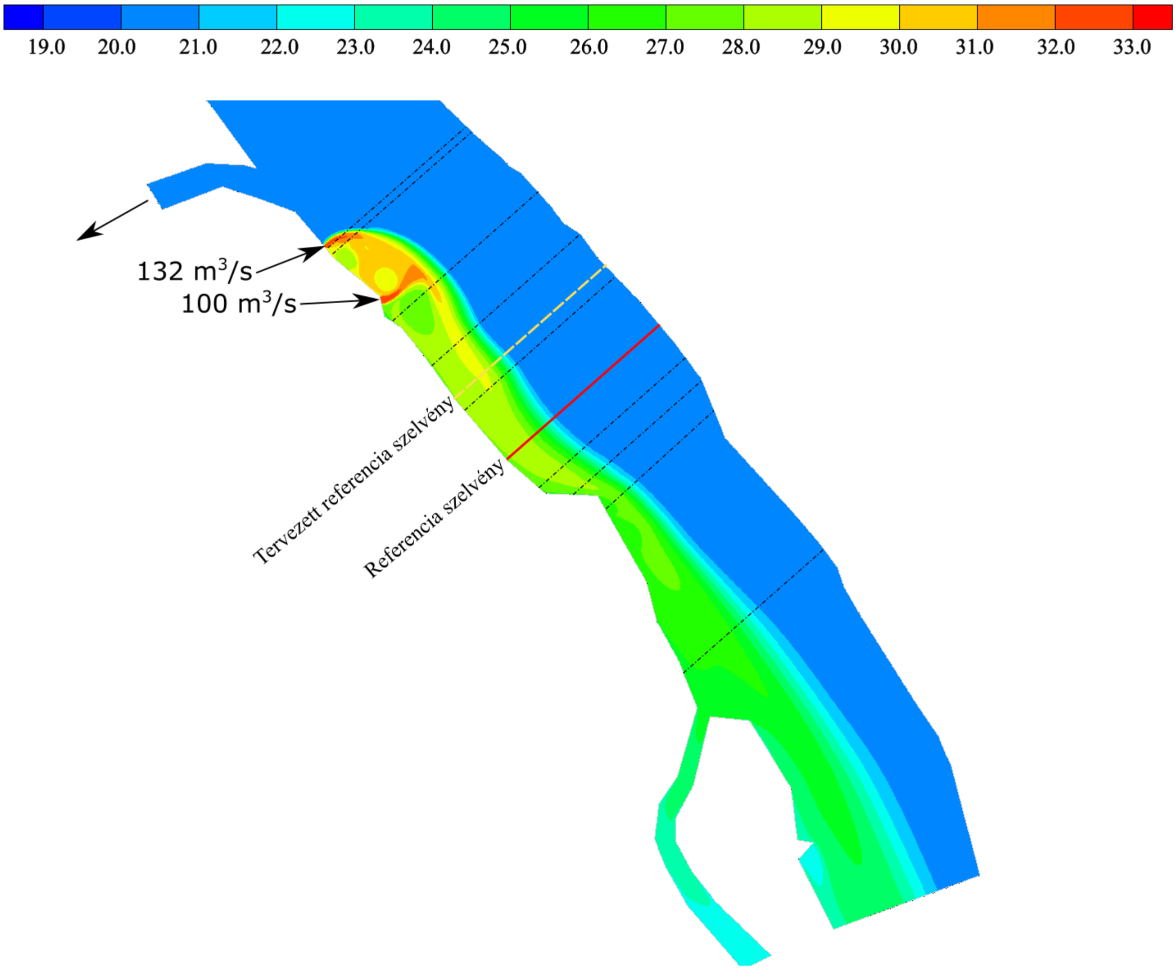
The distribution of the absolute value in the flow velocity obtained with the three dimensional (3D) hydrodynamic calculations carried out for the state in the year 2032 is shown on Figure 3-6, while the formation of the heat plume is seen on Figure 3-7.



Note: Unit of measurement for the colour code is in m/s.

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-6: Velocity distribution developed near the surface – design state in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

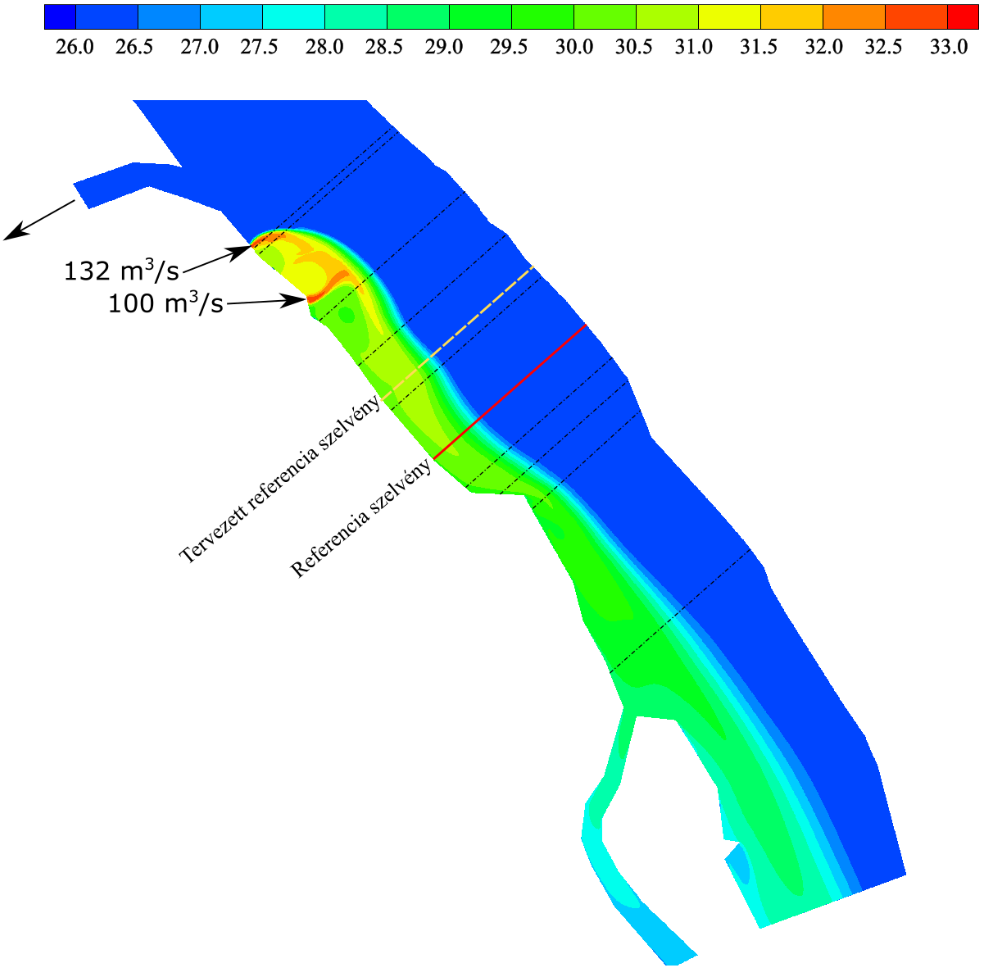


Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-7: Heat plume, in the case of hot water discharge at a temperature of 33 °C – probable state in the year of 2032 ($T_{Danube,max}$=20.77 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

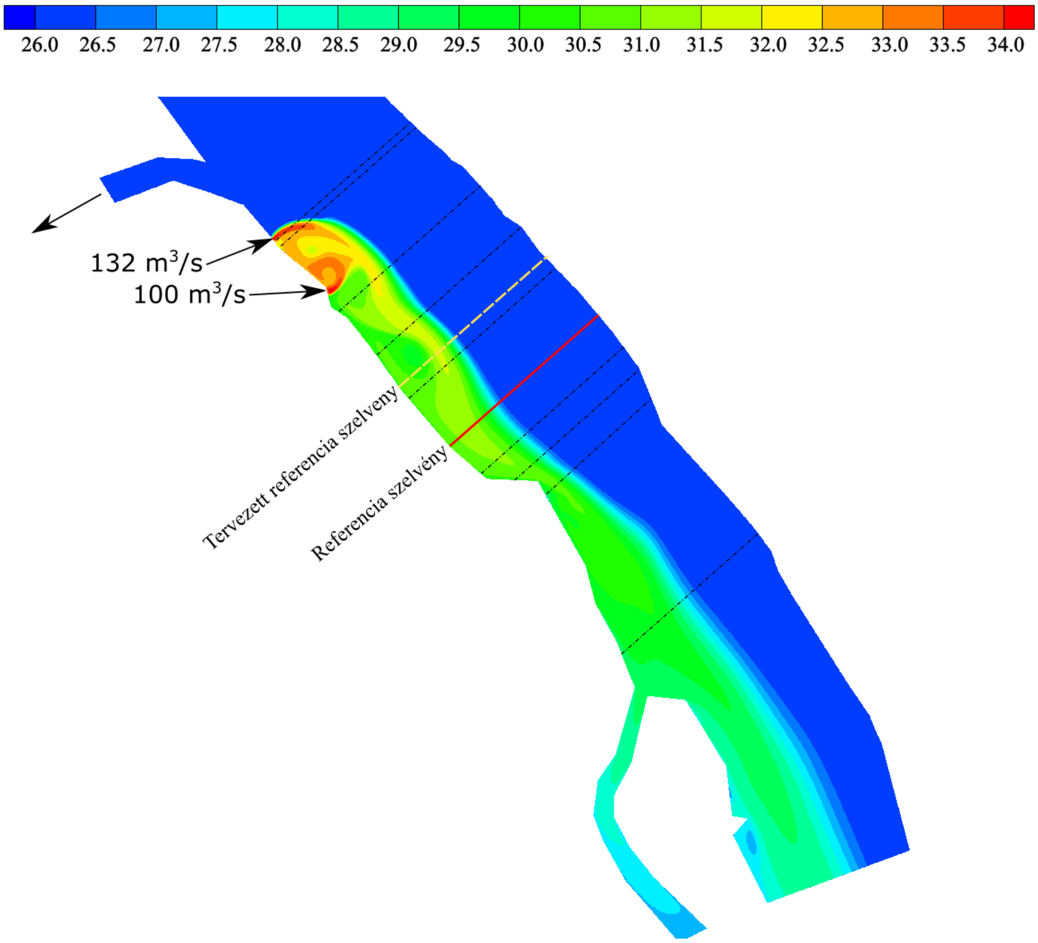
Figure 3-8 and Figure 3-9 show the formation of the heat plume, the nature of flow developing in the neighbourhood of the two respective discharge points and the rapid decline of temperature. Due to the features discussed in the EIS an eddy zone is formed downstream of the discharge point and this tears away a part of the water flowing into the river at the original discharge point downstream and this is the reason why the temperature decline is not homogenous up to the second discharge point. Monotony is eliminated by the three dimensional eddies and the associated secondary flow zones so that extra heat appears at the upstream section of the second discharge point.



Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-8: Heat plume, in the case of hot water discharge at a temperature of 33 °C – design state in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

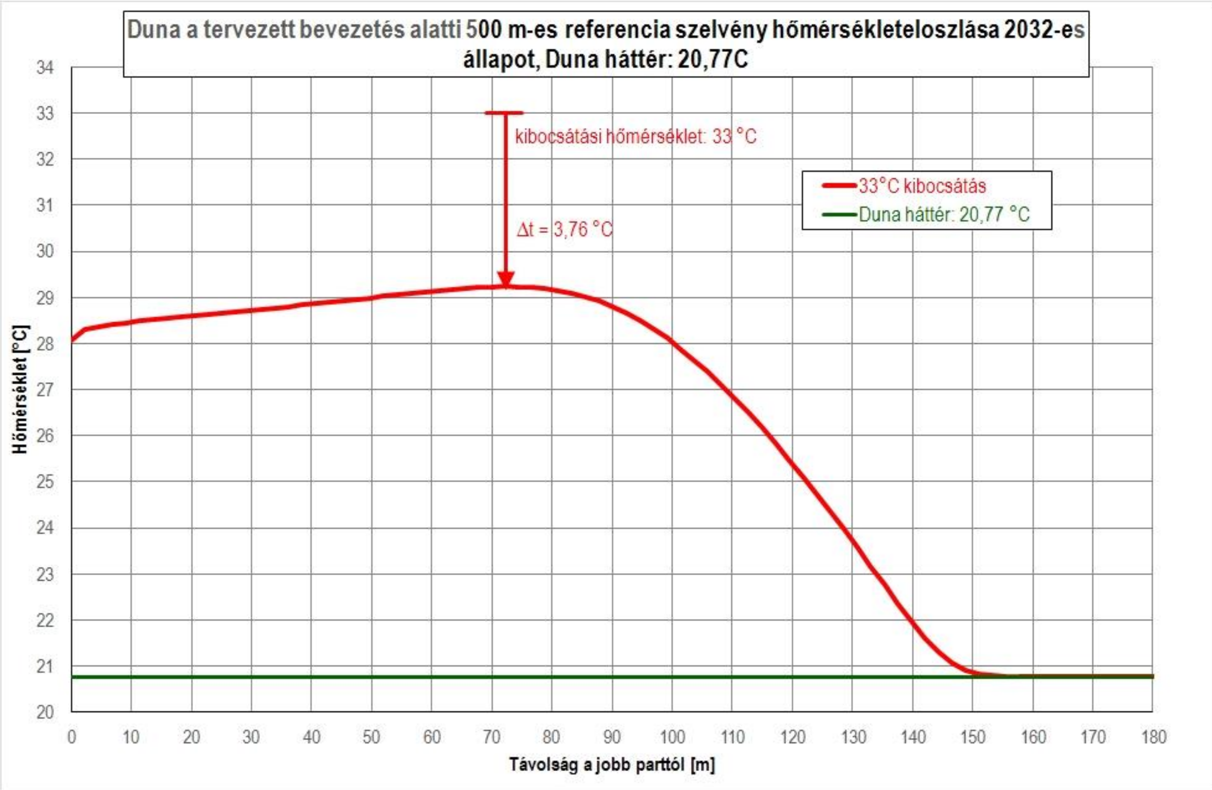


Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

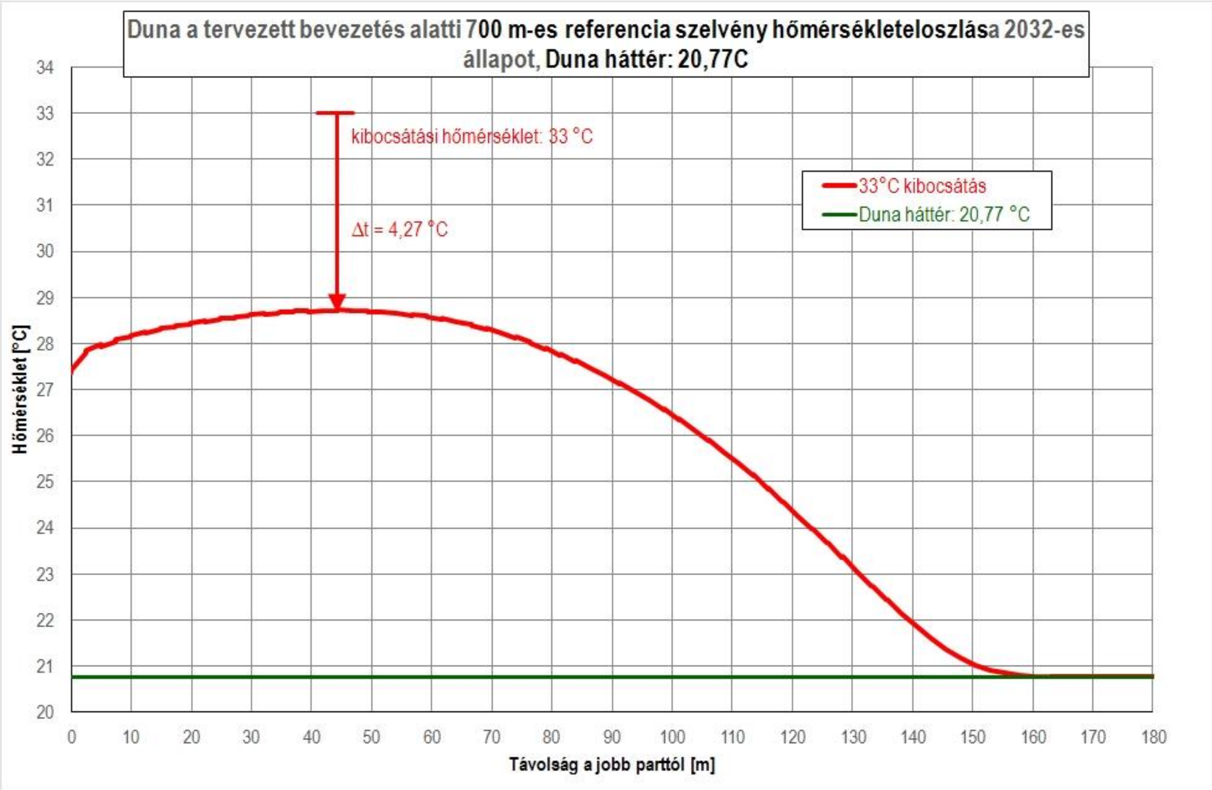
Figure 3-9: Heat plume, in the case of an 8 °C heat gradient – state in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

Figure 3-10 and Figure 3-11 show the distribution pattern of water temperature in both the proposed and in the current reference profiles in the case of a Danube background water temperature of 20.77 °C and 950 m³/s volume rate of flow. Figure 3-12 illustrates the trends in the maximum water temperature values along the longitudinal profile. It can be clearly seen on the figures that the water temperature formed fall short of the 30 °C level stipulated in the Decree as soon as at the proposed reference profile.



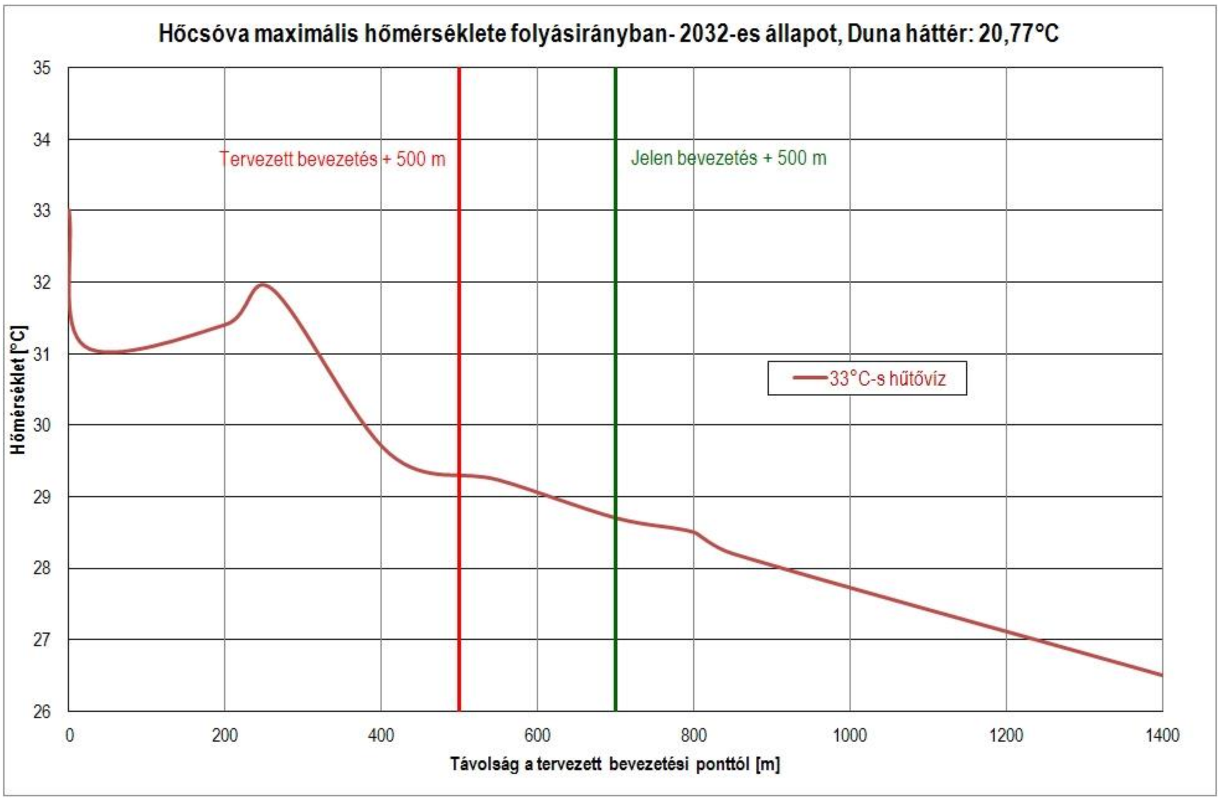
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása – 2032-es állapot, Duna háttér: 20,77 °C – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point – condition in the year 2032, Background temperature of River Danube: 20.77°C;
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
Duna háttér: 20,77 °C - Background temperature of the River Danube: 20.77 °C

Figure 3-10: Expected changes in the water temperature crosswise in the proposed reference profile – probable state of affairs in the year of 2032 ($T_{Danube,max}$=20.77 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 700 m-es referencia szelvény hőmérsékleteloszlása – 2032-es állapot, Duna háttér: 20,77 °C – The temperature distribution of the River Danube at the reference section 700 m downstream of injection point – condition in the year 2032, Background temperature of River Danube: 20.77°C;
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
Duna háttér: 20,77 °C - Background temperature of the River Danube: 20.77 °C

Figure 3-11: Expected changes in the water temperature crosswise in the current reference profile – probable state of affairs in the year of 2032 ($T_{Danube,max}$=20.77 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



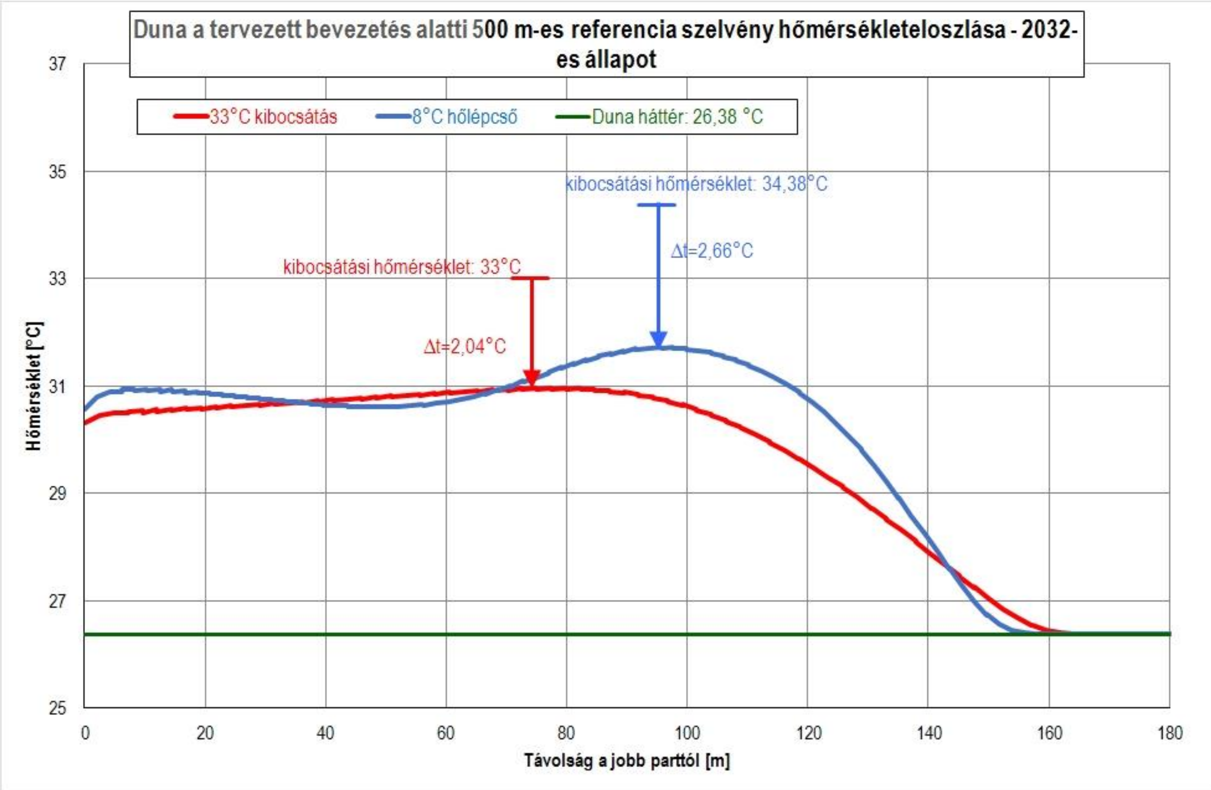
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a tervezett bevezetési ponttól [m] - Distance from the the planned injection point [m],
Dunai hőcsóva maximális hőmérséklete folyásirányban – 2032-es állapot, Dunai háttér: 20,77 °C – The maximum temperature of the heat plume of River Danube downstream – condition in the year 2032, Background temperature of River Danube: 20.77°C;
Tervezett bevetetés + 500 m- Planned injection + 500 m
Jelen bevezetés + 500 m – Present injection + 500 m
33°C-s hűtővíz – 33°C cooling water,

Figure 3-12: Differential temperature downstream – probable state of affairs in the year of 2032 ($T_{Danube,max}$=20.77 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

With the help of Figure 3-15 maximum temperature can be defined at any distance calculated from the point of first discharge. In this case however – just because of the complexity of the three dimensional effects – it might be difficult to decide which portion of the extra temperature concerned can be attributed to the first and to the second outlet, respectively.

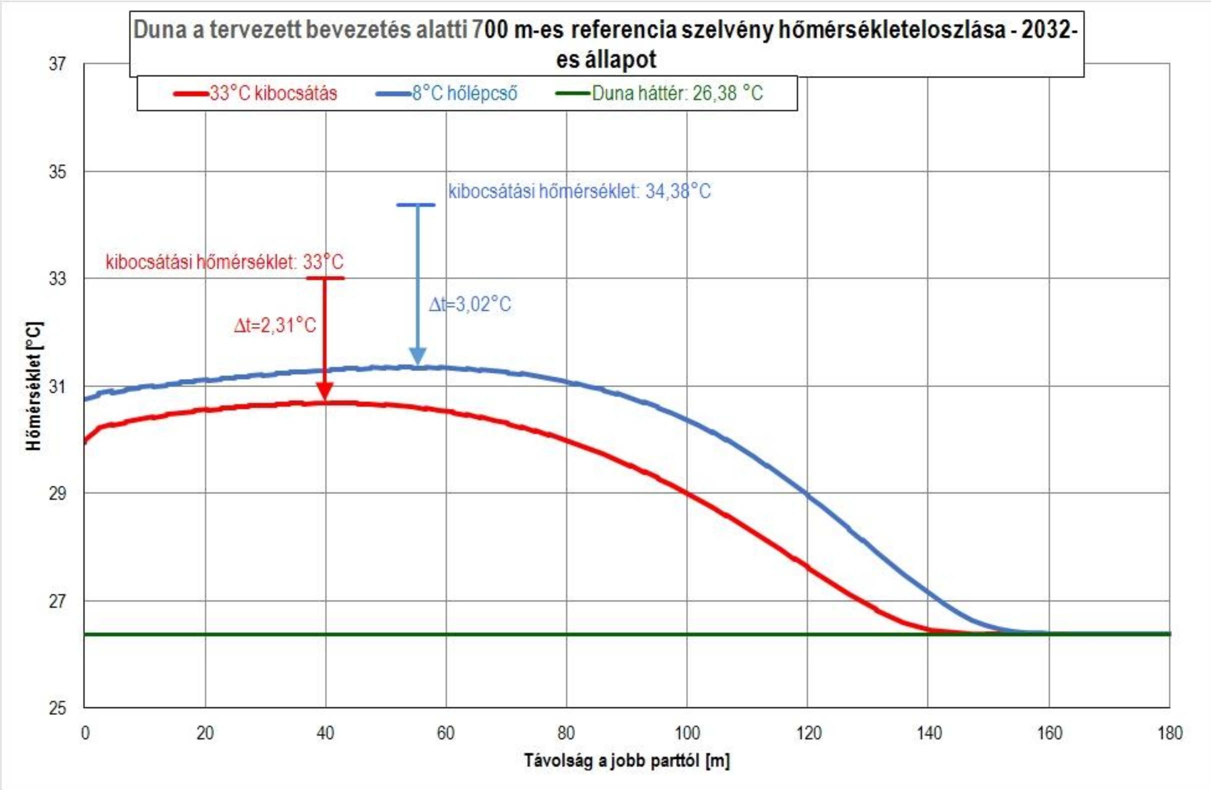
As a result of the 3D blending study the following maximum expected water temperature cross profile is obtained with the design hot water load (100 m³/s + 132 m³/s = 232 m³/s discharge, 8 °C heat gradient and 33 °C discharge temperature) to be introduced into the Danube (at 0 days/year duration, 950 m³/s Danube rate of flow), taking the maximum Danube water temperature expected in the year of 2032 as the basis (26.38 °C) in the following maximum water temperature longitudinal profile and in the current reference profile (+ 500 m) (Figure 3-13 and Figure 3-14). In order allow better interpretability of the data and better comparison with the conditions discussed in the EIS the distribution of the temperature in the proposed reference profile is also provided at 1 500 m³/s Danube rate of flow and 26.38 °C Danube water temperature on Figure 3-16.

Since a 33 °C temperature hot water discharge means a heat gradient of 6.62 °C (33 – 26.38 °C), which does depart more substantially from the discharge with the 8 °C heat gradient, therefore the maximum water temperature distribution values calculated with the model calculations are different to a larger extent. It can be clearly seen from the figures that water temperature in the current and proposed reference profile at a heat gradient of 8 °C and a hot water discharge temperature of 33 °C would exceed the 30 °C limit defined in the Decree. In such cases additional measures must be taken for the period in question in order to avoid violation of the temperature limit.



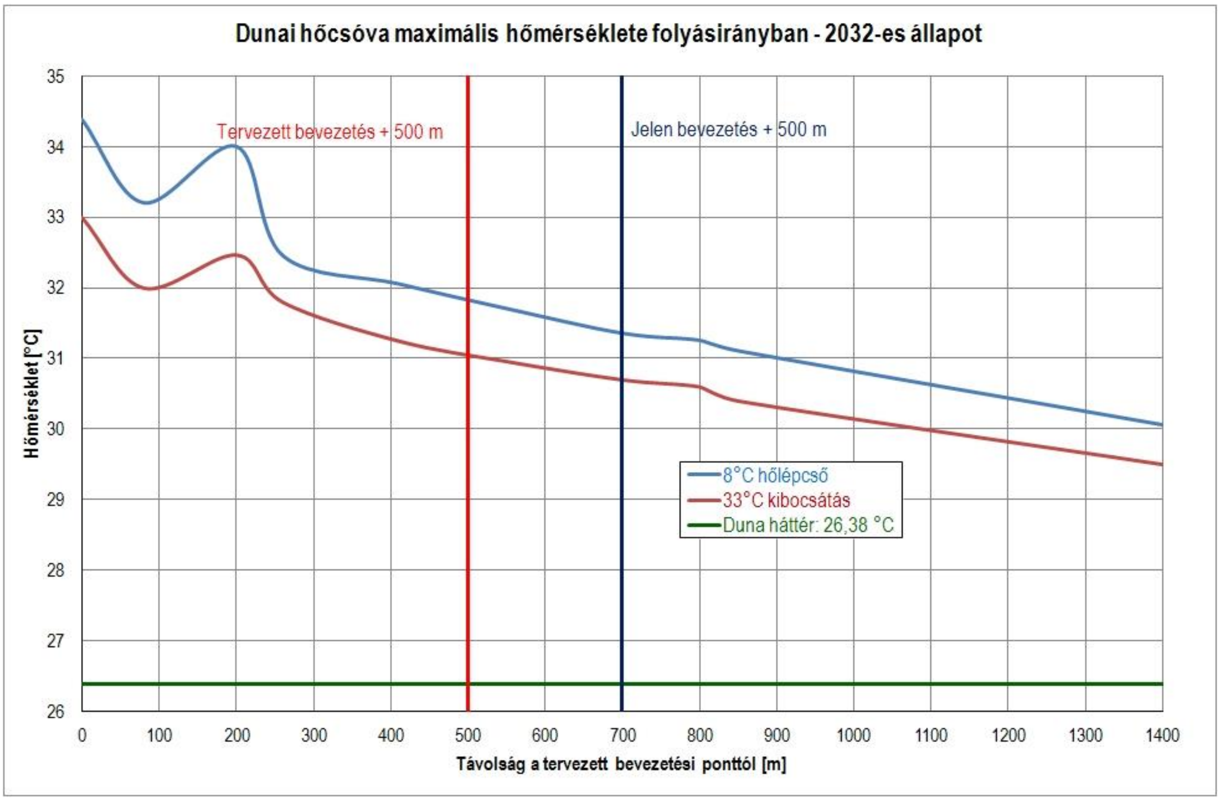
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása – 2032-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point – condition in the year 2032,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient
Duna háttér: 26,38 °C - Background temperature of the River Danube: 26,38 °C
Kibocsátási hőmérséklet: 34,38 °C – Discharge temperature of 34.38 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,

Figure 3-13: Expected changes in the water temperature crosswise in the proposed reference profile –state of affairs in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



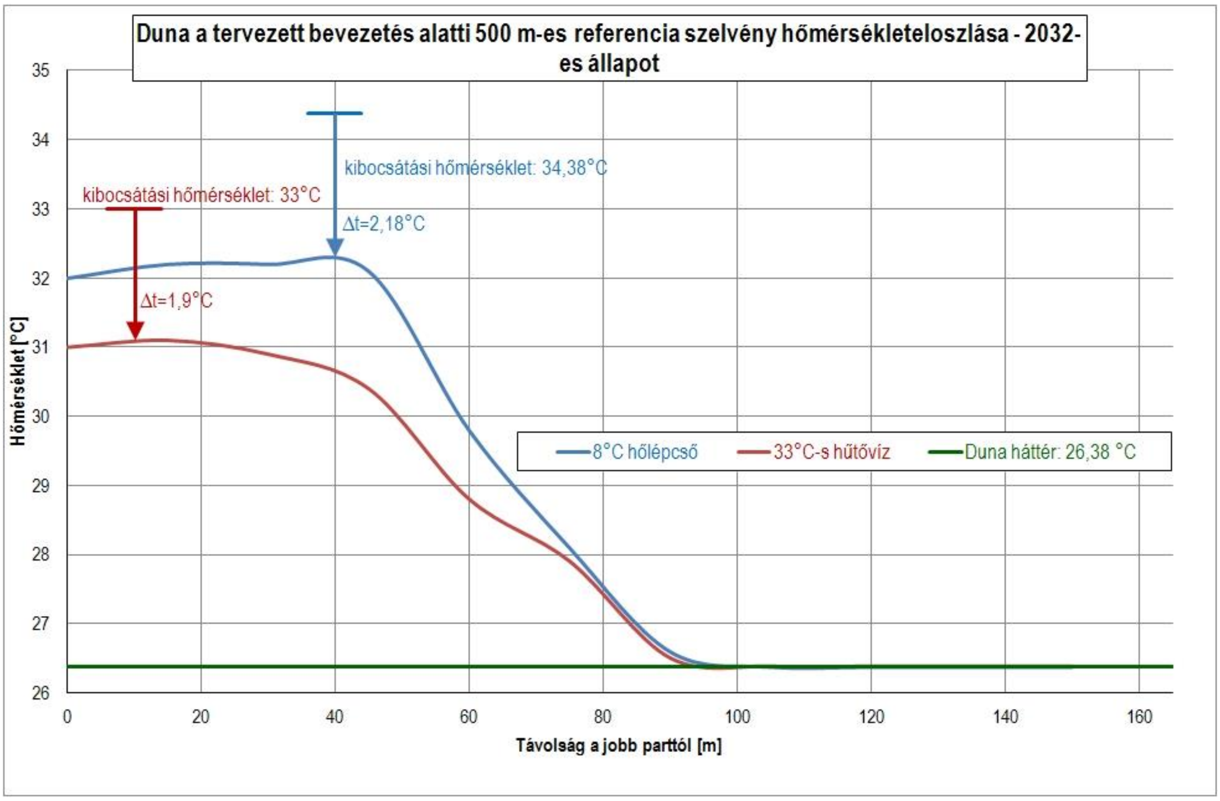
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 700 m-es referencia szelvény hőmérsékleteloszlása – 2032-es állapot,– The temperature distribution of the River Danube at the reference section 700 m downstream of injection point – condition in the year 2032,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8°C heat gradient
Duna háttér: 26,38 °C - Background temperature of River Danube: 26.38°C;
Kibocsátási hőmérséklet: 34,38 °C – Discharge temperature: 34.38 °C
Kibocsátási hőmérséklet: 33 °C – Discharge temperature: 33 °C

Figure 3-14: Differential temperature crosswise in the current reference profile – state of affairs in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a tervezett bevezetési ponttól [m] - Distance from the the planned injection point [m],
Dunai hőcsóva maximális hőmérséklete folyásirányban – 2032-es állapot, – The maximum temperature of the heat plume of River Danube downstream – condition in the year 2032,
Tervezett bevetetés + 500 m- Planned injection + 500 m,
Jelen bevezetés + 500 m – Present injection + 500 m,
8 °C hőlépcső – 8 °C heat gradient,
33°C kibocsátás – 33°C discharge,
Dunai háttér: 26,38 °C - Background temperature of River Danube: 26.38°C;

Figure 3-15: Differential temperature downstream – state of affairs in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása – 2032-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point – condition in the year 2032,
Kibocsátási hőmérséklet: 34,38 °C – Discharge temperature of 34.38 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient
Duna háttér: 26,38 °C - Background temperature of the River Danube: 26,38 °C

Figure 3-16: Differential temperature crosswise in the proposed reference profile – design state in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 1 500 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

It should be noted that the figures presented above illustrate the maximum water temperature calculated in a three dimensional water space using the 3D hydrodynamic and transport model, which exceeds the depth integrated 2D water temperature levels. The maximum water temperature values can be found in the near surface range of the Danube water space up to a distance of approximately ~2-3 km downstream from the discharge point, while after ~2-3 km the hot water in the Danube is practically completely mixed across depth, therefore the 2D transport model can be expediently used to model mixing of the hot water.

Based on the results it can be concluded that the 30 °C limit temperature can not be maintained on all days of the year due to the large heat volumes of the discharged water and the increased background temperature levels during the joint heat loads from Paks Nuclear Power Plant and Paks II.

Control actions are required when the temperature limit values are expected to be exceeded, such as when Danube water temperature exceeds 24.66 °C at a heat gradient of 8 °C (expected duration for the sake of safety is calculated below the 2800 m³/s Danube water rate of flow: 8.68 days/year, and in the range of below 950 m³/s Danube water rate of flow 1.53 days/year), and 25.42 °C at a hot water discharge load of 33 °C (expected duration for the sake of safety is calculated below the 2800 m³/s Danube water rate of flow: 5,23 days/year, and in the range of below 950 m³/s Danube water rate of flow 0.95 days/year).

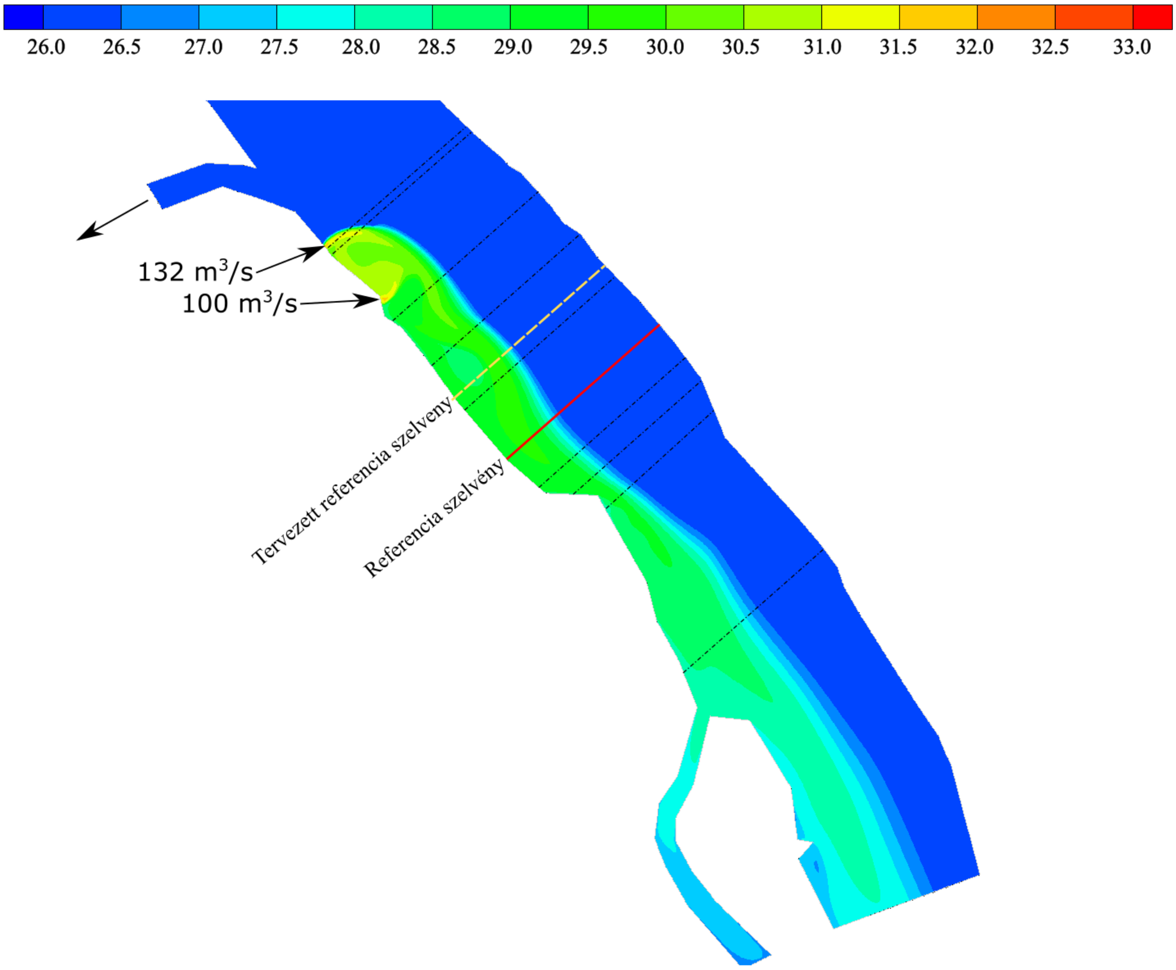
Possibilities to avoid the violation of the temperature limit:

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

3.1.2.1 Determination of the permitted discharge temperature - 2032

Section 1 of order No P2D/601/2014 of the Baranya County Government Office issued on 15 May 2015 contains the following: "Please demonstrate that the temperature of the receiver water body at any point on the 500 metres section downstream of the discharge point does not exceed the level of 30 ºC during the joint operation of the existing nuclear power plant and the nuclear power plant proposed by the User of the Environment for implementation and during the stand alone operation of the nuclear power plant proposed by the User of the Environment for implementation, as required by item b) 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 (hereinafter referred to as: Discharge Decree)."

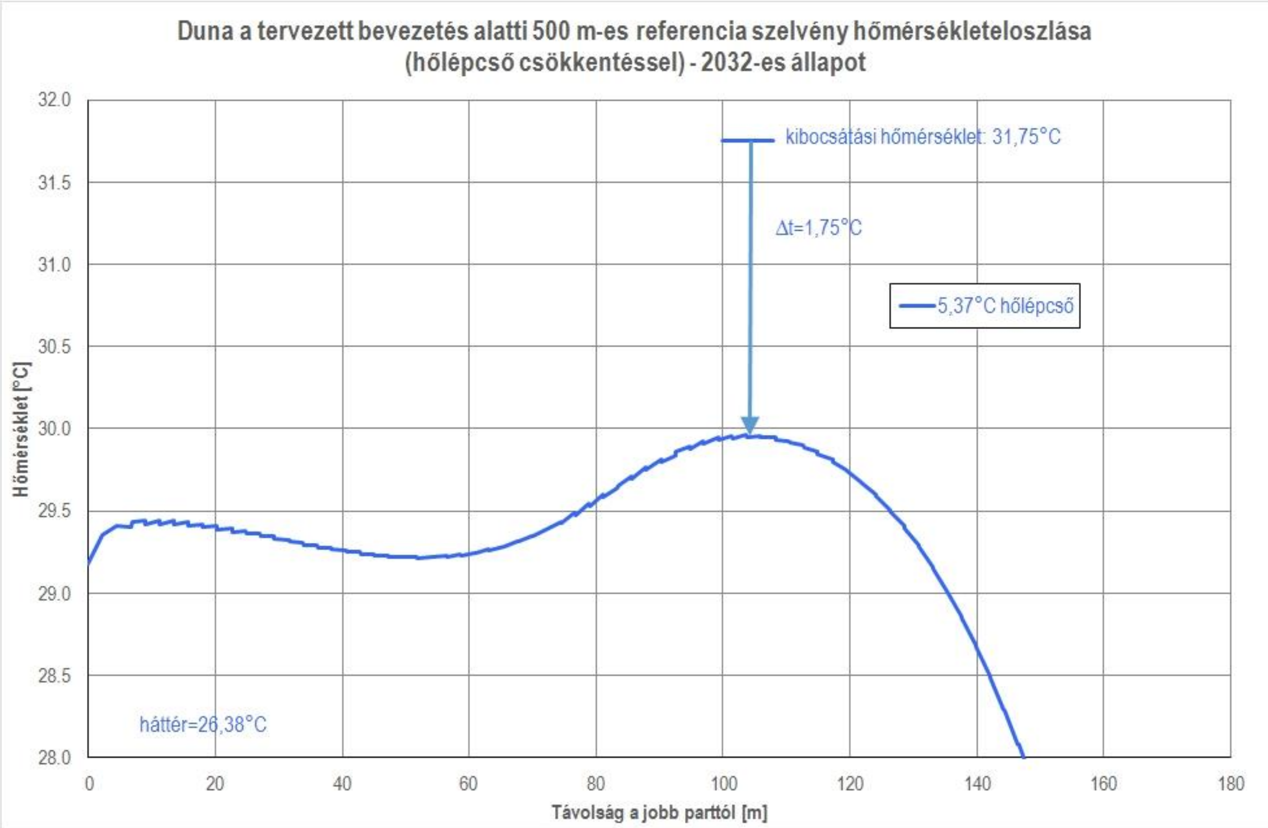
In the 3D mixing study the maximum permitted discharge temperature has been determined taking into account the design hot water discharge rate (100 m^3/s + 132 m^3/s = 232 m^3/s) to be introduced into the Danube at 950 m^3/s Danube volume rate of flow with a view to the maximum Danube water temperature expected for the year of 2032 (26.38 °C). Using the modelling results this value corresponded to a heat gradient of 5.37 °C. The heat plume associated with the 5.37 °C heat gradient is illustrated on Figure 3-17. Water temperature distribution expected in the proposed reference profile is shown on Figure 3-18.



Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-17: Heat plume, in case of a reduced heat gradient – state of affairs in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása (hőlépcső csökkentéssel) – 2032-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point (with heat gradient reduction) – condition in the year 2032,
Kibocsátási hőmérséklet: 31,75 °C – Discharge temperature of 31.75 °C,
5,37 °C hőlépcső – 5,37°C heat gradient,

Figure 3-18: Differential temperature crosswise in the proposed reference profile in the event of a reduction in the heat gradient – state of affairs in the year of 2032 ($T_{Danube,max}$=26.38 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

3.1.2.2 Duration and persistence of the 30 °C temperature limit violation expected in the current and proposed reference profiles

The trends in maximum Danube water temperature levels calculated for the current reference profile in the design states and the duration, persistence of the 30 °C limit violation calculated on the basis of the climate model are summarised in the table below (Table 3-1). In the event of the background Danube water temperature taken as the baseline (26.38°C) the duration of the volume rate of flow below 950 m³/s on the Danube is 0.00 days/year (see in Chapter 11.7.4 of the EIS entitled “Current and expected future trends in the water temperature of the Danube”), but for the sake of safety the higher persistence levels associated with the 2800 m³/s rate of flow were taken into account. Durations in the proposed reference profile are presented in Table 3-2.

Limit violation range to be handled by control action	**Design state (2014.)**		**Design state (2032.)**	
	8 [°C] heat gradient	**33 [°C] hot water discharge**	**8 [°C] heat gradient**	**33 [°C] hot water discharge**
Maximum expected background water temperature of the Danube [°C]	25.61 [°C]		26.38 [°C]	
Maximum calculated water temperature of the Danube [°C]	26,11 [°C]	26,36 [°C]	25,02 [°C]	25,69 [°C]
Calculated period of limit violation, duration [days]	0.1 [days/year]	0.1 [days/year]	7 [days/year]	4 [days/year]

Table 3-1: Duration and persistence of the limit violation in the current reference profile (2032.) – Paks Nuclear Power Plant + Paks II

Limit violation range to be handled by control action	**Design state (2014.)**		**Design state (2032.)**	
	8 [°C] heat gradient	**33 [°C] hot water discharge**	**8 [°C] heat gradient**	**33 [°C] hot water discharge**
Maximum expected background water temperature of the Danube [°C]	25.61 [°C]		26.38 [°C]	
Maximum calculated water temperature of the Danube [°C]	25,31 [°C]	25.61 [°C]	24,66 [°C]	25,42 [°C]
Calculated period of limit violation, duration [days]	0.7 [days/year]	0.4 [days/year]	9 [days/year]	5 [days/year]

Table 3-2: Duration and persistence of the limit violation in the proposed profile (2032.) – Paks Nuclear Power Plant + Paks II

Duration levels calculated in the EIS for the profile in a distance of 500 m from the current discharge point at 1500 m³/s rate of flow of the Danube are not changed in the proposed reference profile situated 200 m upstream since they were figures rounded substantially upwards. Since due to the overestimation the maximum duration levels estimated in the EIS are more unfavourable than those presented above, it is recommended that the original duration levels of the EIS should be taken into account for the purposes of the design.

Possibilities to avoid the violation of the temperature limit:

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

3.1.3 CHARACTERISATION OF THE DESIGN STATE IN 2085 (PAKS II IN STAND ALONE OPERATION)

In the case Paks II is operated, 132 m³/s cooling water is led into the Danube at the new discharge site. Even though the heat load is less than in the 2032 scenario, yet the 30 °C temperature limit can only be maintained downstream of the cross dam – below a volume rate of flow of 950 m³/s on the Danube and with an expected duration of not more than 0.1 days/year -, as a result of the increasing background temperature which is the consequence of the global climate change, since in this case the permitted extra temperature of the heat plume in the proposed reference profile is merely 30 - 28.64 = 1.36 °C.

Any limit violation can be expected when the Danube water temperature exceeds 25.97 °C at a heat gradient of 8 °C (expected duration: for the sake of safety below the 2800 m³/s Danube water volume rate of flow range: 12 days/year, while below the Danube water volume rate of flow range below 950 m³/s it is 3 days/year), and 27.59 °C in the case of a 33 °C temperature heat load (expected duration: for the sake of safety below the 2800 m³/s Danube water volume rate of flow range: 4 days/year, while below the Danube water volume rate of flow range below 950 m³/s it is 3.5 days/year). Such cases need control actions (for instance, shut down of a unit, maintenance of units, reduction of loading, post cooling).

3.1.3.1 Duration and persistence of the 30 °C temperature limit violation expected in the current and proposed reference profiles

The trends in maximum Danube water temperature levels calculated for the current reference profile in the design states and the duration, persistence of the 30 °C limit violation calculated on the basis of the pessimistic (DMI-B2 PRODUCE) climate model are summarised in the table below (Table 3-3). In the event of the background Danube water temperature taken as the baseline (28.64°C) the duration of the limit violations in the volume rate of flow below 950 m³/s on the Danube is 0.00 days/year (see in Chapter 11.7.4 of the EIS entitled "Current and expected future trends in the water temperature of the Danube"), but for the sake of safety the higher persistence levels associated with the 2800 m³/s rate of flow were taken into account.

Durations in the proposed reference profile are presented in Table 3-4.

Limit violation range to be handled by control action	Design state (2014.)		Design state (2085.)	
	8 [°C] heat gradient	33 [°C] hot water discharge	8 [°C] heat gradient	33 [°C] hot water discharge
Maximum expected background water temperature of the Danube [°C]	25.61 [°C]		28.64 [°C]	
Maximum calculated water temperature of the Danube [°C]	26,11 [°C]	26,36 [°C]	26,25 [°C]	27,76 [°C]
Calculated period of limit violation, duration [days]	0.2 [nap]	0.1 [days/year]	10 [days/year]	3,5 [days/year]

Table 3-3: Duration and persistence of the limit violation in the current profile (2085) – Paks II in stand alone operation

Limit violation range to be handled by control action	Design state (2014.)		Design state (2085.)	
	8 [°C] heat gradient	33 [°C] hot water discharge	8 [°C] heat gradient	33 [°C] hot water discharge
Maximum expected background water temperature of the Danube [°C]	25.61 [°C]		28.64 [°C]	
Maximum calculated water temperature of the Danube [°C]	25.31 [°C]	25.61 [°C]	25.97 [°C]	27.59 [°C]
Calculated period of limit violation, duration [days]	0.7 [nap]	0.4 [days/year]	12 [days/year]	4 [days/year]

Table 3-4: Duration and persistence of the limit violation in the proposed profile (2085) – Paks II in stand alone operation

Duration levels calculated in the EIS for the profile in a distance of 500 m from the current discharge point at 1500 m³/s rate of flow of the Danube are not changed in the proposed reference profile situated 200 m upstream since they were figures rounded substantially upwards. Since due to the overestimation the maximum duration levels estimated in the EIS are more unfavourable than those presented above, it is recommended that the original duration levels of the EIS should be taken into account for the purposes of the design.

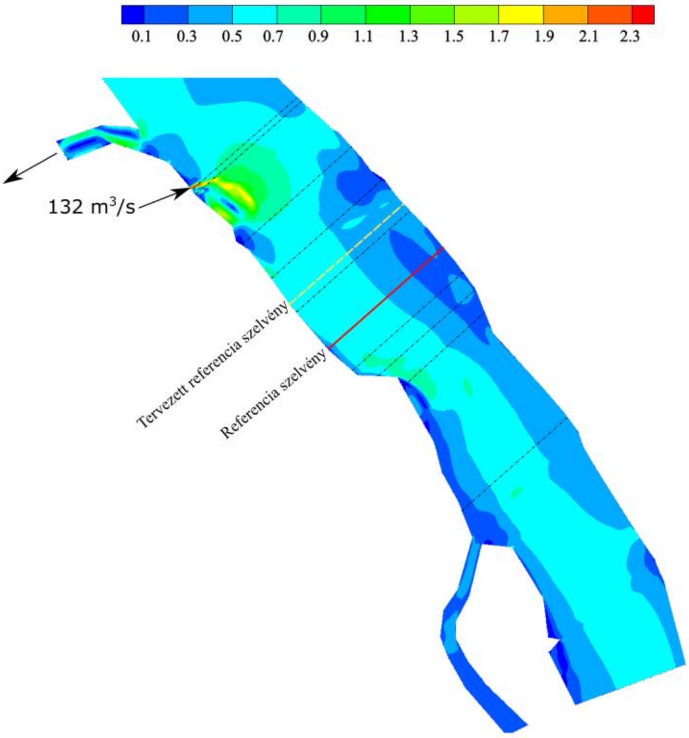
Possibilities to avoid the violation of the temperature limit:

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

3.1.3.2 Findings of the 3D hydrodynamic and heat transport model calculations

The expected duration of Danube water volume rate of flow below 950 m³/s in 2085 for Danube water temperatures above 28.64 °C is 0.0 days/year.

Near surface velocity distribution calculated with the 3D hydrodynamic model for a maximum 132 m³/s proposed cooling water extraction volume and at the same time hot water discharge in times of 950 m³/s Danube water volume rate of flow is illustrated on Figure 3-19 below.



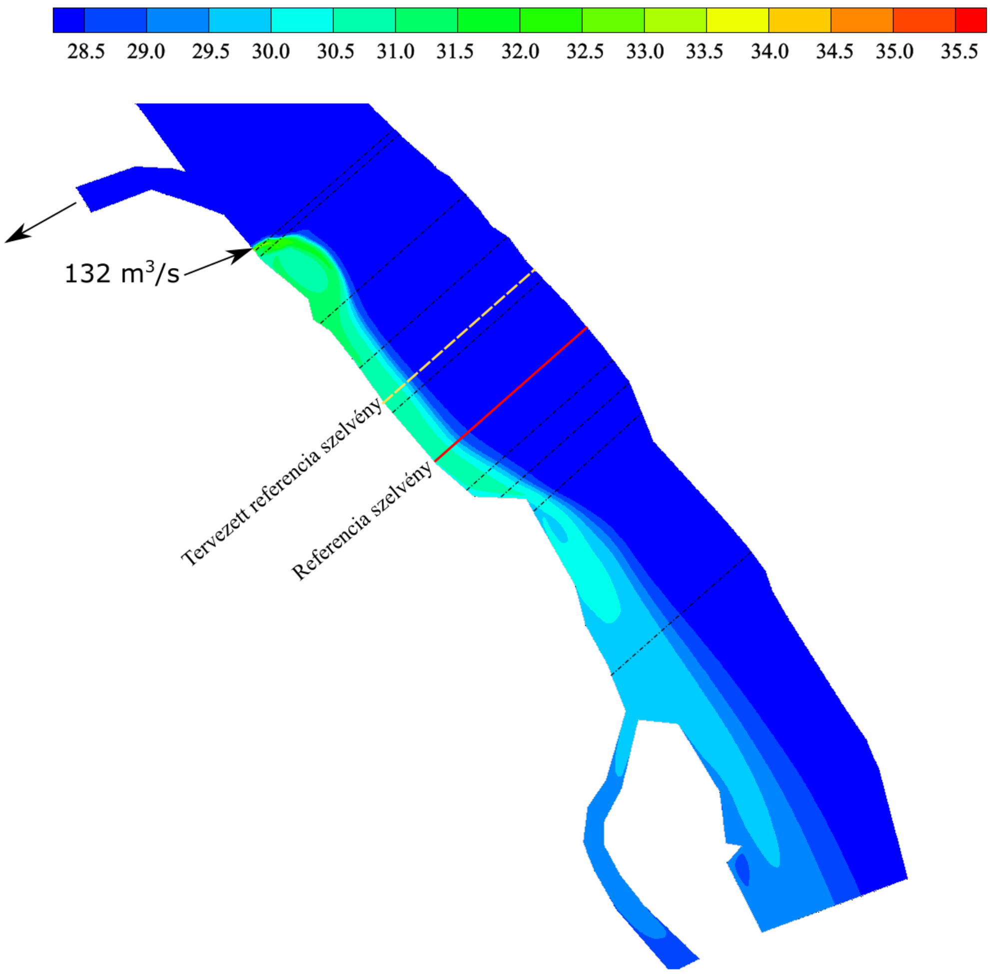
Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-19: Near surface velocity distribution – state of affairs in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow 950 m³/s) – Paks II in stand alone operation

Maximum near surface velocity distribution calculated with the 3D hydrodynamic model for a maximum 132 m³/s proposed cooling water extraction volume and at the same time hot water discharge at a temperature of 33 ºC (2085) in times of 950 m³/s Danube water volume rate of flow is illustrated on Figure 3-20 below. The plume for the 8°C heat gradient is shown on Figure 3-21.

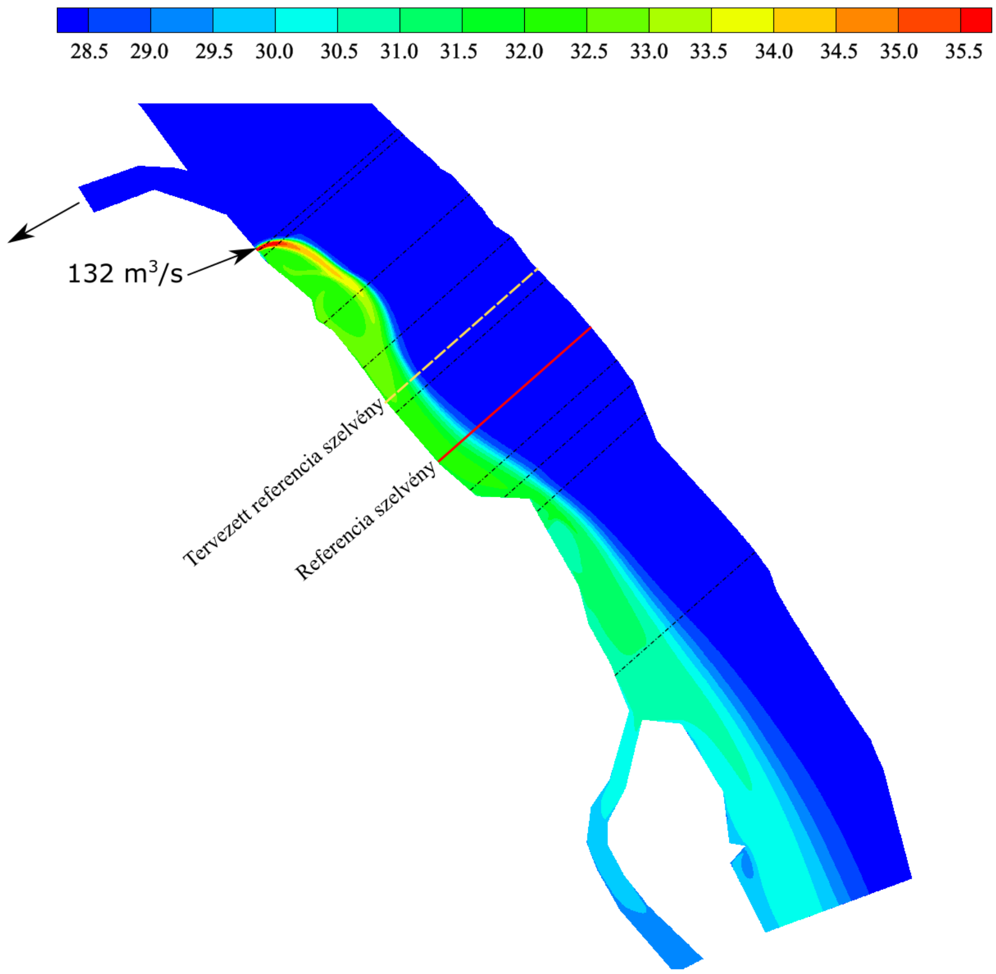
.



Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-20:Heat plume, in the event of 33°C hot water discharge – state of affairs in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube vízhozam= 950 m³/s) – Paks II in stand alone operation



Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

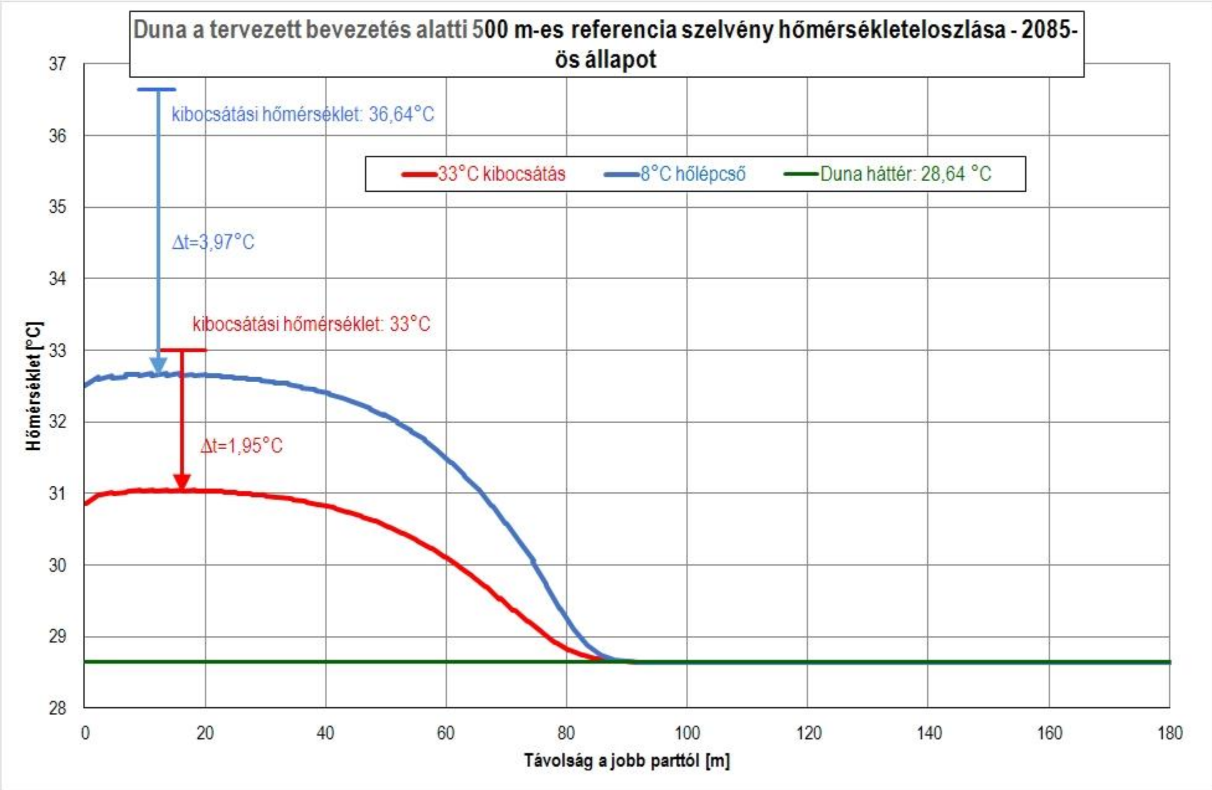
Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-21: Heat plume for the 8°C heat gradient – state of affairs in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow = 950 m³/s) – Paks II in stand alone operation

In the 3D mixing study the following maximum permitted water temperature has been determined in the longitudinal profile (Figure 3-24) and the cross profiles (Figure 3-22 and Figure 3-23) taking into account the design hot water loads (132 m³/s, 8 °C heat gradient and 33 °C hot water discharge) to be introduced into the Danube at 950 m³/s Danube volume rate of flow with a view to the maximum Danube water temperature expected for the year of 2085 (28.84 °C).

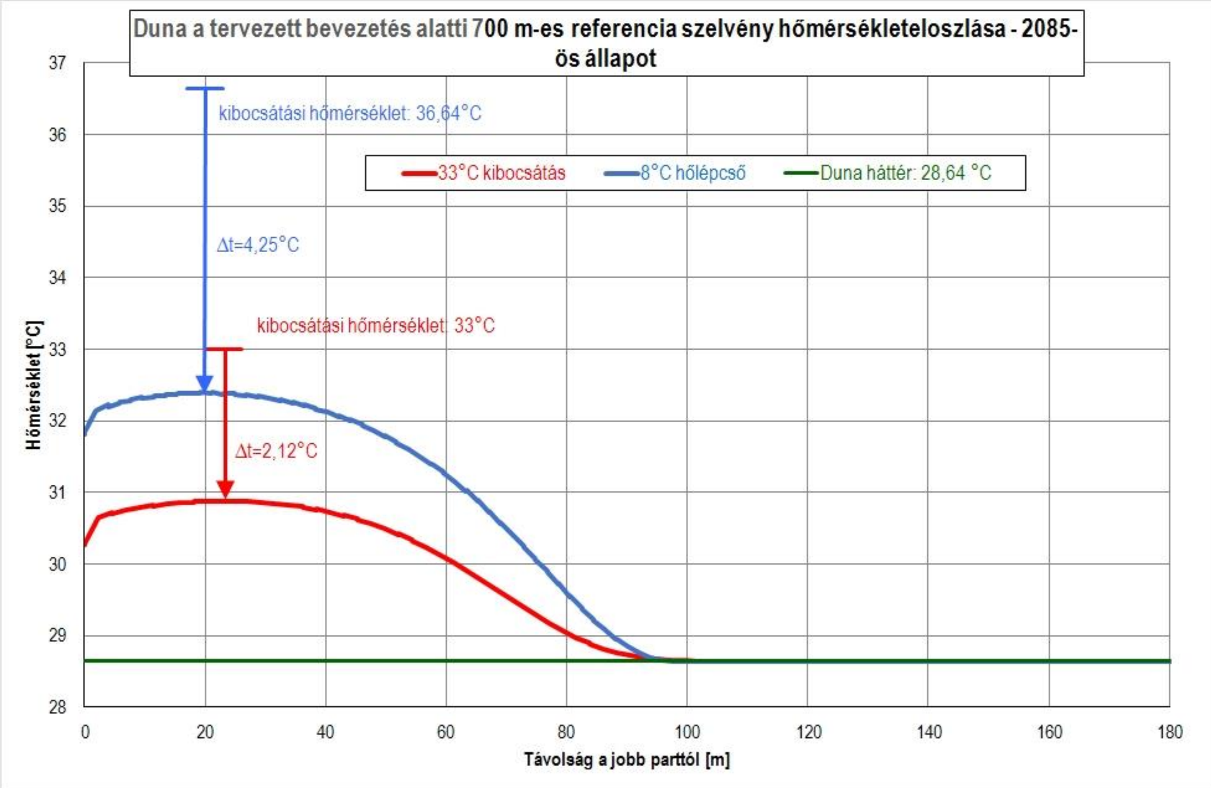
Since a 33 °C temperature hot water discharge means a heat gradient of 4.36 °C (33 – 28.64 °C), which does depart more substantially from the discharge with the 8 °C heat gradient, therefore the maximum water temperature distribution values calculated with the model calculations are different to a larger extent.

In order allow better interpretability of the data and better comparison with the conditions discussed in the EIS the distribution of the temperature in the proposed reference profile is also provided at 1 500 m³/s Danube rate of flow and 26.38 °C Danube water temperature on Figure 3-25.



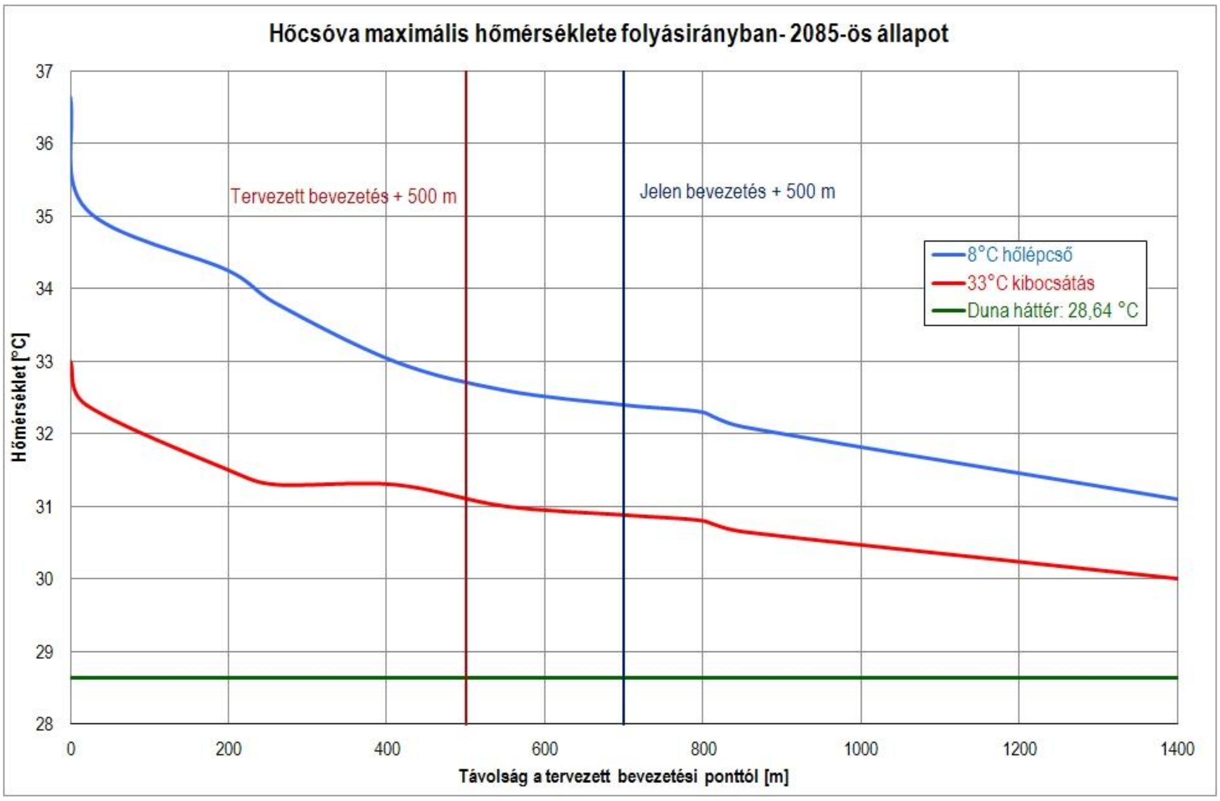
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása – 2085-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point – condition in the year 2085,
Kibocsátási hőmérséklet: 36,64 °C – Discharge temperature of 36.64 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient,
Duna háttér: 28,64 °C - Background temperature of the River Danube: 28.64 °C

Figure 3-22: Expected changes in the water temperature crosswise in the proposed reference profile –state of affairs in the year of 2085 ($T_{Danube,max}$ =28.64 °C, Danube rate of flow = 950 m³/s) – Paks II in stand alone operation



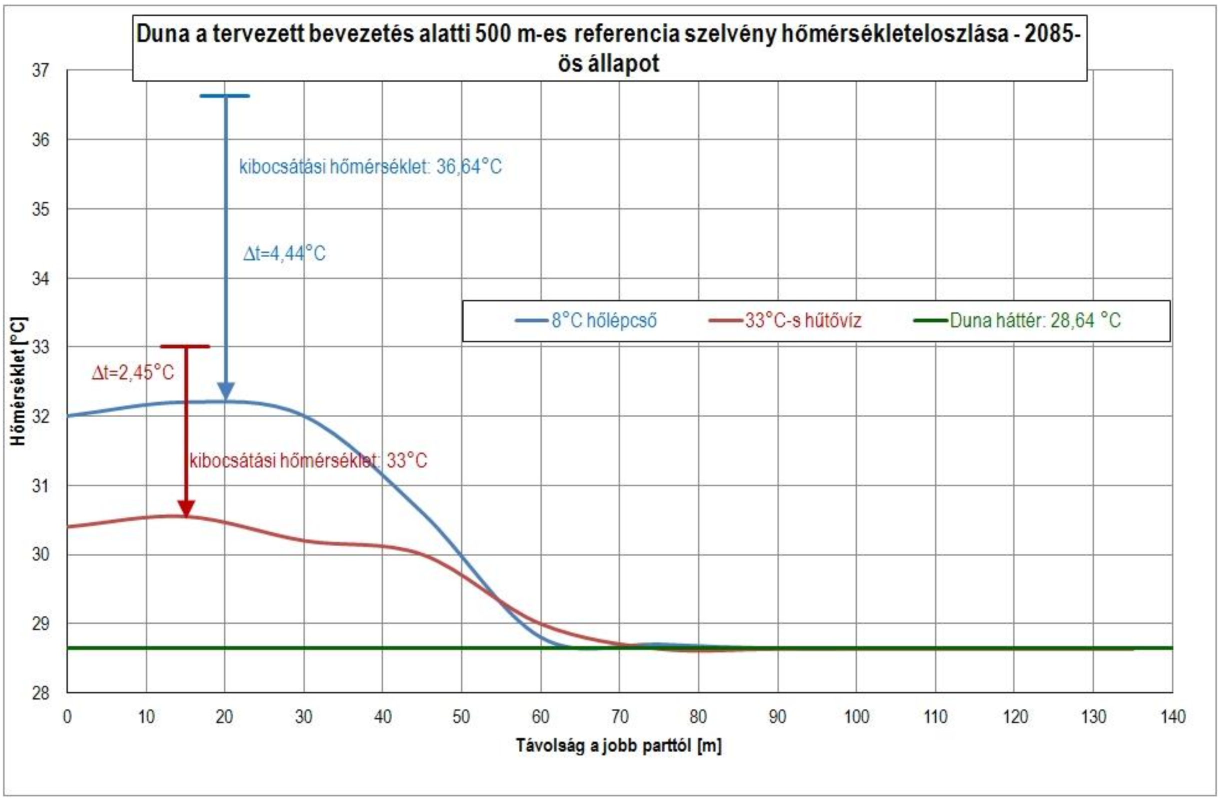
Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 700 m-es referencia szelvény hőmérsékleteloszlása – 2085-es állapot – The temperature distribution of the River Danube at the reference section 700 m downstream of injection point – condition in the year 2085,
Kibocsátási hőmérséklet: 36,64 °C – Discharge temperature of 36.64 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient
Duna háttér: 28,64 °C - Background temperature of the River Danube: 28,64 °C

Figure 3-23: Differential temperature crosswise in the current reference profile – design state in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow = 950 m³/s) – Paks II in stand alone operation



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a tervezett bevezetési ponttól [m] - Distance from the the planned injection point [m],
Hőcsóva maximális hőmérséklete folyásirányban – 2085-es állapot, – The maximum temperature of the heat plume downstream – condition in the year 2085,
Tervezett bevetetés + 500 m- Planned injection + 500 m,
Jelen bevezetés + 500 m – Present injection + 500 m,
8 °C hőlépcső – 8 °C heat gradient,
33°C kibocsátás – 33°C discharge,
Dunai háttér: 28,648 °C - Background temperature of River Danube: 28.64°C;

Figure 3-24: Differential temperature downstream – design state in the year of 2085 ($T_{Danube,max}$ =28.64 °C, Danube rate of flow = 950 m³/s) – Paks II in stand alone operation

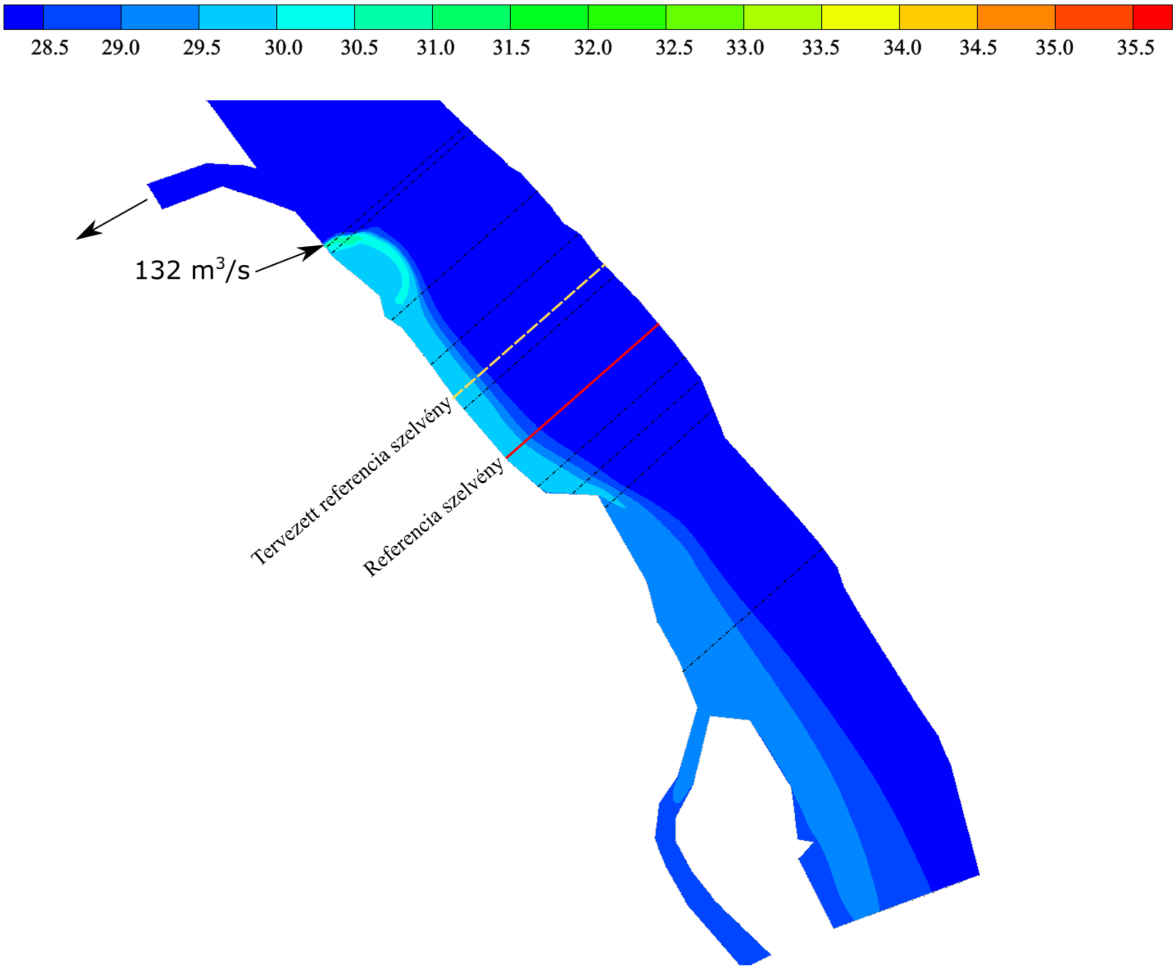


Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása – 2085-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point – condition in the year 2085,
Kibocsátási hőmérséklet: 36,64 °C – Discharge temperature of 36.64 °C,
Kibocsátási hőmérséklet: 33 °C – Discharge temperature of 33 °C,
33°C kibocsátás – 33°C discharge,
8 °C hőlépcső – 8 °C heat gradient,
Duna háttér: 28,64 °C - Background temperature of the River Danube: 28.64 °C

Figure 3-25: Differential temperature crosswise in the proposed reference profile – design state in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow = 1 500 m³/s) – Paks II in stand alone operation

3.1.3.1 Determination of the maximum permitted temperature level - 2085

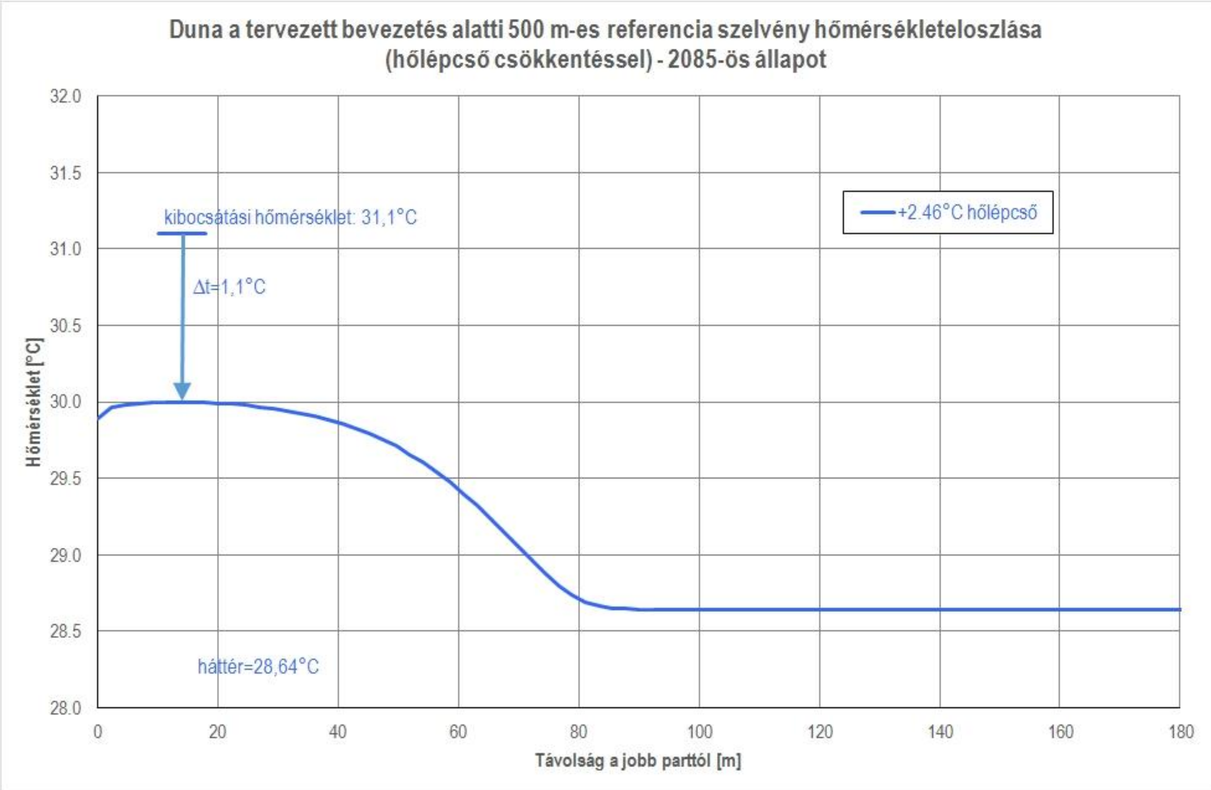
In the 3D mixing study the maximum permitted discharge temperature has been determined taking into account the design hot water discharge rate (100 m³/s + 132 m³/s = 232 m³/s) to be introduced into the Danube at 950 m³/s Danube volume rate of flow with a view to the maximum Danube water temperature expected for the year of 2085 (28.64 °C). Using the modelling results this value corresponded to a heat gradient of 2.46 °C. The heat plume associated with the 2.46 °C heat gradient is illustrated on Figure 3-26. Water temperature distribution expected in the proposed reference profile is shown on Figure 3-27, while the longitudinal profile of the water temperature can be seen on Figure 3-28.



Notes: Unit of measurement on the colour code is in °C (Celsius centigrade)

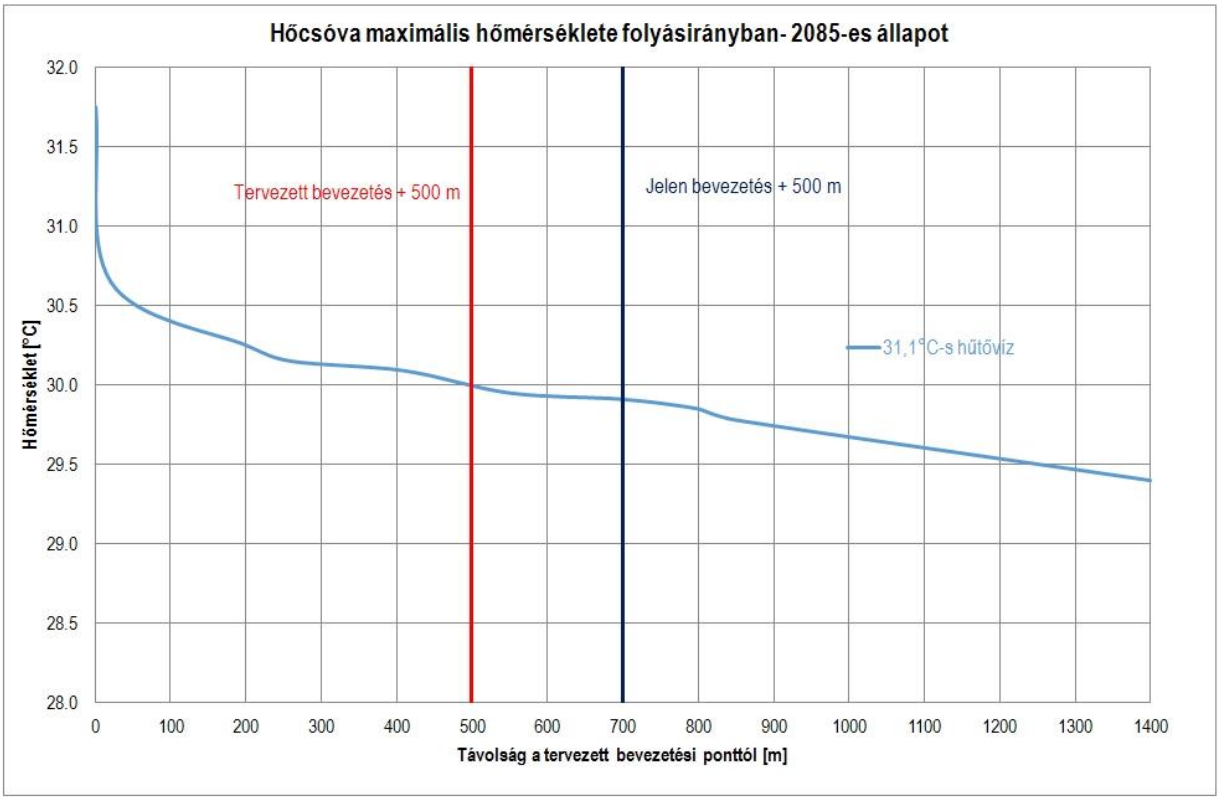
Legend: Tervezett referencia szelvény - Proposed reference profile,
Referencia szelvény - Reference profile

Figure 3-26: Heat plume in the event of a drop in the heat gradient – state of affairs in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube vízhozam= 950 m³/s) – Paks II in stand alone operation



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a jobb parttól [m] - Distance from the right bank [m],
Duna a tervezett bevezetés alatti 500 m-es referencia szelvény hőmérsékleteloszlása (hőlépcső csökkentéssel) – 2085-es állapot – The temperature distribution of the River Danube at the reference section 500 m downstream of injection point (with heat gradient reduction) – condition in the year 2085,
Kibocsátási hőmérséklet: 31,1 °C – Discharge temperature of 31.1 °C,
+ 2,46 °C hőlépcső – +2.41 °C heat gradient,
Háttér =28,64 °C – Background=28.64 °C

Figure 3-27: Differential temperature crosswise in the proposed reference profile (heat gradient reduction) – design state in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II



Legend: Hőmérséklet [°C] – Temperature [°C]
Távolság a tervezett bevezetési ponttól [m] - Distance from the the planned injection point [m],
Hőcsóva maximális hőmérséklete folyásirányban – 2085-es állapot – The maximum temperature of the heat plume downstream – condition in the year 2085,
Tervezett bevezetés + 500 m- Planned injection + 500 m,
Jelen bevezetés + 500 m – Present injection + 500 m,
31,1 °C hűtővíz – 31.1 °C cooling water

Figure 3-28: Differential temperature in the proposed reference profile downstream in the case of heat gradient reduction – state of affairs in the year of 2085 ($T_{Danube,max}$=28.64 °C, Danube rate of flow = 950 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

3.1.4 Determination of the impact area concerned with a Danube water temperature exceeding 30 °C at 950 m³/s volume rate of flow of the Danube

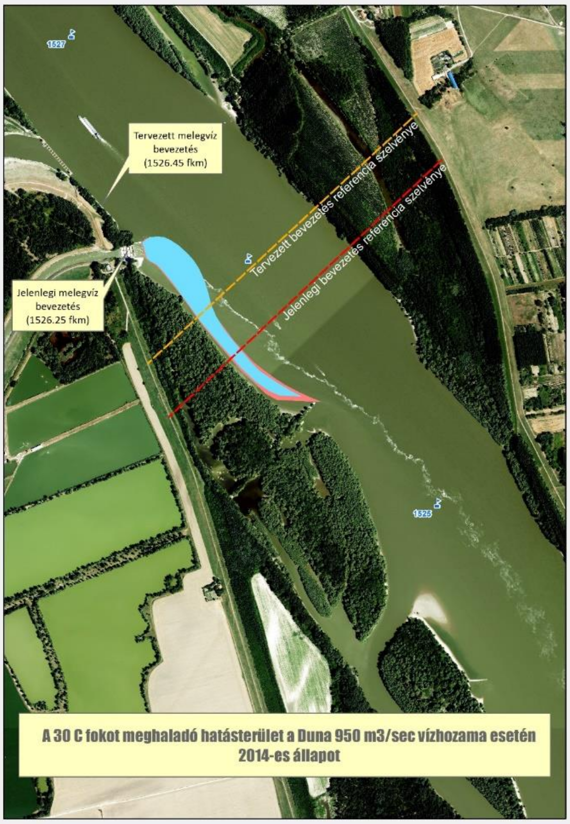
The impact areas of the heat plume calculated for the design states in the years of 2014, 2032 and 2085, respectively, and the Danube water space affected by a water temperature of 30 °C are presented in the following figures (Figure 3-29, Figure 3-30 and Figure 3-31).

On the basis of the pessimistic (DMI-B2 PRODUCE) climate model in the event of the background Danube water temperatures (2014: 25.61 °C; 2032: 26.38 °C and 2085: 28.64 °C) taken for the design years (2014, 2032 and 2085), the average duration of limit violation in the volume rate of flow below 950 m³/s on the Danube is 1.00 days/year.

3.1.4.1 Definition of the impact area for the design state in 2014 in the case of a volume rate of flow below 950 m³/s on the Danube

- Danube background temperature (T_{Danube}) 25.61 °C
  On the basis of the pessimistic (DMI-B2 PRODUCE) climate model and the mathematical statistical analysis <u>the duration of temperature limit violation in the volume rate of flow below 950 m³/s on the Danube is 0.04 days/year in 2014</u>,
- the discharge volume of the cooling water (q) 100 m³/s, which is let into the Danube at the current inlet point,
- the temperature of the warmed up cooling water is:
  (Case 1) $T_{hot\ water}$=33°C and
  (Case 2) discharge with an 8°C heat gradient ($T_{hot\ water}$ = T_{Danube}+8°C = 33,61°C).

The area of the water body characterised with a water temperature exceeding 30 °C in the Danube water temperature distribution calculated with an expected duration of 0.04 for the year of 2014 is illustrated on Figure 3-29 for the cases of design loads with an 8 °C heat gradient and a 33 °C discharge, as well as a 100 m³/s hot water yield.



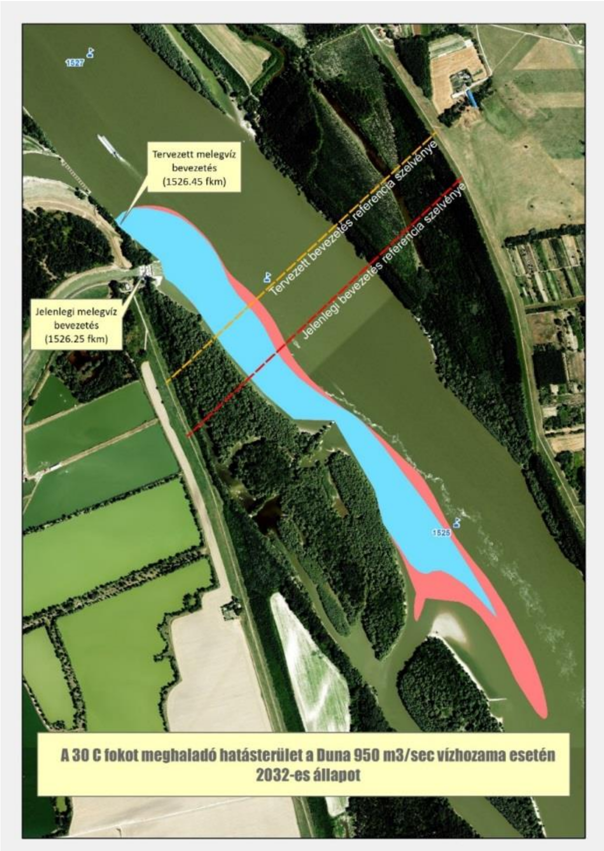
Legend: Tervezett melegvíz bevezetés (1625,45 fkm) – Planned point of warm water injection (at 1526.45 km)
Jelenlegi melegvíz bevezetés (1625,25 fkm) – Present point of warm water injection (at 1526.25 km)
Tervezett bevezetés referencia szelvénye - Reference profile of the proposed injection,
Jelenlegi bevezetés referencia szelvénye - Reference profile of the present injection
A 30 °C meghaladó hatásterület a Duna 950 m³/sec vízhozama esetén – 2014-es állapot – Impact area of the heat plume with a water temperature exceeding 30 °C at a flow rate of 950 m3/sec on the River Danube – condition in the year 2014

Figure 3-29: Calculated impact area of the heat plume with a water temperature exceeding 30 °C (blue: hot water discharge 33 °C, red: heat gradient 8 °C) – design state in the year of 2014 ($T_{Danube,max}$=25.61 °C, Q_{Danube}= 950 m³/s, hot water yield: 100 m³/s) – Paks Nuclear Power Plant stand alone operation

3.1.4.2 Definition of the impact area for the design state in 2032 in the case of a volume rate of flow below 950 m³/s on the Danube

- T_{Danube}=26.38 °C
  On the basis of the pessimistic (DMI-B2 PRODUCE) climate model and the mathematical statistical analysis <u>the duration of temperature limit violation in the volume rate of flow below 950 m³/s on the Danube is 0.45 days/year in 2032 approaching from below</u>,
- due to the simultaneous operation of both Paks Nuclear Power Plant and Paks II $q_{current}$ =100 m³/s flows into the Danube at the current discharge point and $q_{2032.}$=132 m³/s at the new discharge point proposed at the upstream section of the current inlet point (200 metres upstream),
- the temperature of the warmed up cooling water is:
  (Case 1) $T_{hot\ water}$=33 °C and
  (Case 2) $T_{hot\ water}$=34.38 °C (8 °C heat gradient).

The area of the water body characterised with a water temperature exceeding 30 °C in the Danube water temperature distribution calculated with an expected duration of 0.45 for the year of 2032 is illustrated on Figure 3-30 for the cases of design loads with an 8 °C heat gradient and a 33 °C discharge, as well as a 232 m³/s hot water yield.



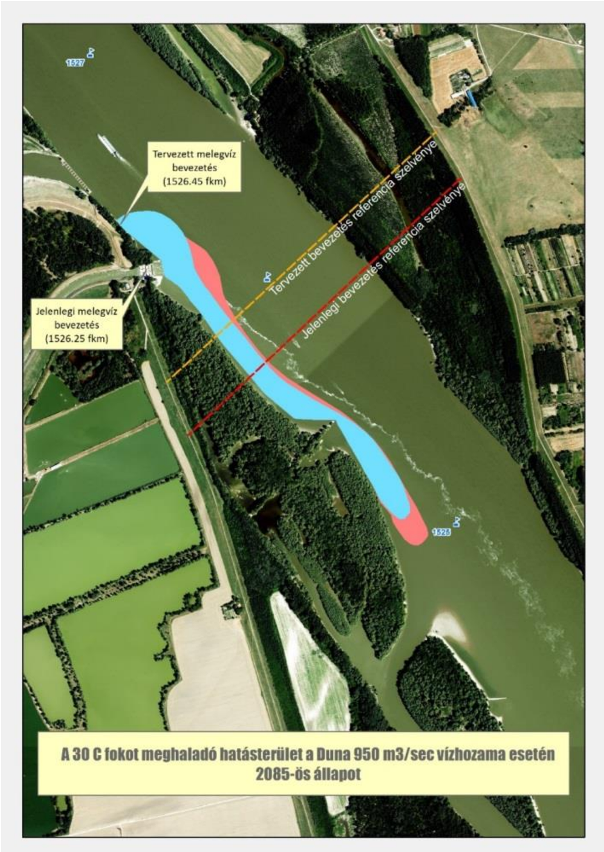
Legend: Tervezett melegvíz bevezetés (1625,45 fkm) – Planned point of warm water injection (at 1526.45 km)
Jelenlegi melegvíz bevezetés (1625,25 fkm) – Present point of warm water injection (at 1526.25 km)
Tervezett bevezetés referencia szelvénye - Reference profile of the proposed injection,
Jelenlegi bevezetés referencia szelvénye - Reference profile of the present injection,
A 30 °C meghaladó hatásterület a Duna 950 m³/sec vízhozama esetén – 2032-es állapot – Impact area of the heat plume with a water temperature exceeding 30 °C at a flow rate of 950 m3/sec on the River Danube – condition in the year 2032

Figure 3-30: Calculated impact area of the heat plume with a water temperature exceeding 30 °C (blue: hot water discharge 33 °C, red: heat gradient 8 °C) – design state in the year of 2032 ($T_{Danube,}$max=26.38 °C, Q_{Danube}= 950 m³/s, hot water yield: 100 ³/s + 132 m³/s) – Joint operation of Paks Nuclear Power Plant + Paks II

3.1.4.3 Definition of the impact area for the design state in 2085 in the case of a volume rate of flow below 950 m³/s on the Danube

- T_{Danube}=28.64°C
  On the basis of the pessimistic (DMI-B2 PRODUCE) climate model and the mathematical statistical analysis the duration of temperature limit violation in the volume rate of flow below 950 m³/s on the Danube is 0.36 days/year in 2085, approaching from below,
- the discharge volume of the cooling water is $q_{2085.}$=132 m³/s, which is let into the Danube at the inlet point designed for the upstream section of the current discharge point,
- the temperature of the warmed up cooling water is:
  (Case 1) $T_{hot\ water}$=33°C, or
  (Case 2) $T_{hot\ water}$=36,64°C (8°C heat gradient).

The area of the water body characterised with a water temperature exceeding 30 °C in the Danube water temperature distribution calculated with an expected duration of 0.36 for the year of 2085 is illustrated on Figure 3-31 for the cases of design loads with an 8 °C heat gradient and a 33 °C discharge, as well as a 132 m³/s hot water yield.



Legend: Tervezett melegvíz bevezetés (1625,45 fkm) – Planned point of warm water injection (at 1526.45 km)
Jelenlegi melegvíz bevezetés (1625,25 fkm) – Present point of warm water injection (at 1526.25 km)
Tervezett bevezetés referencia szelvénye - Reference profile of the proposed injection,
Jelenlegi bevezetés referencia szelvénye - Reference profile of the present injection
A 30 °C meghaladó hatásterület a Duna 950 m³/sec vízhozama esetén – 2085-es állapot – Impact area of the heat plume with a water temperature exceeding 30 °C at a flow rate of 950 m³/sec on the River Danube – condition in the year 2085

Figure 3-31: Calculated impact area of the heat plume with a water temperature exceeding 30 °C (blue: hot water discharge 33 °C, red: heat gradient 8 °C) – design state in the year of 2085 ($T_{Danube,max}$=28.64 °C, Q_{Danube}= 950 m³/s, hot water hozam: 132 m³/s) – Paks II in stand alone operation

3.1.5 Demarcation of the wildlife conservation impact area (background water temperature + 2,5 °C) (for a Danube rate of flow of 950 m³/s)

During joint operation the discharge of the warmed up cooling water represents the most important environmental impact on the ecological status of the Danube, which at the same time the detectable impact considered to be the most significant in its entirety during the implementation and operation of Paks II from the perspective of the living communities.

The wildlife impact area was also defined on the basis of the model calculations described above – for the current state of affairs and the design situations in 2032 and 2085 –, which is shown on Figure 3-32. The impact area for wildlife conservation associated with the 950 m³/s Danube volume rate of flow is similar to the impact area defined in the EIS for the 1500 m³/s rate of flow with the difference that the area is somewhat elongated downstream. This however does not result in the joint impact area affecting the jurisdiction of any other municipality. Widening of the area in crosswise profile direction is so small which can be neglected.

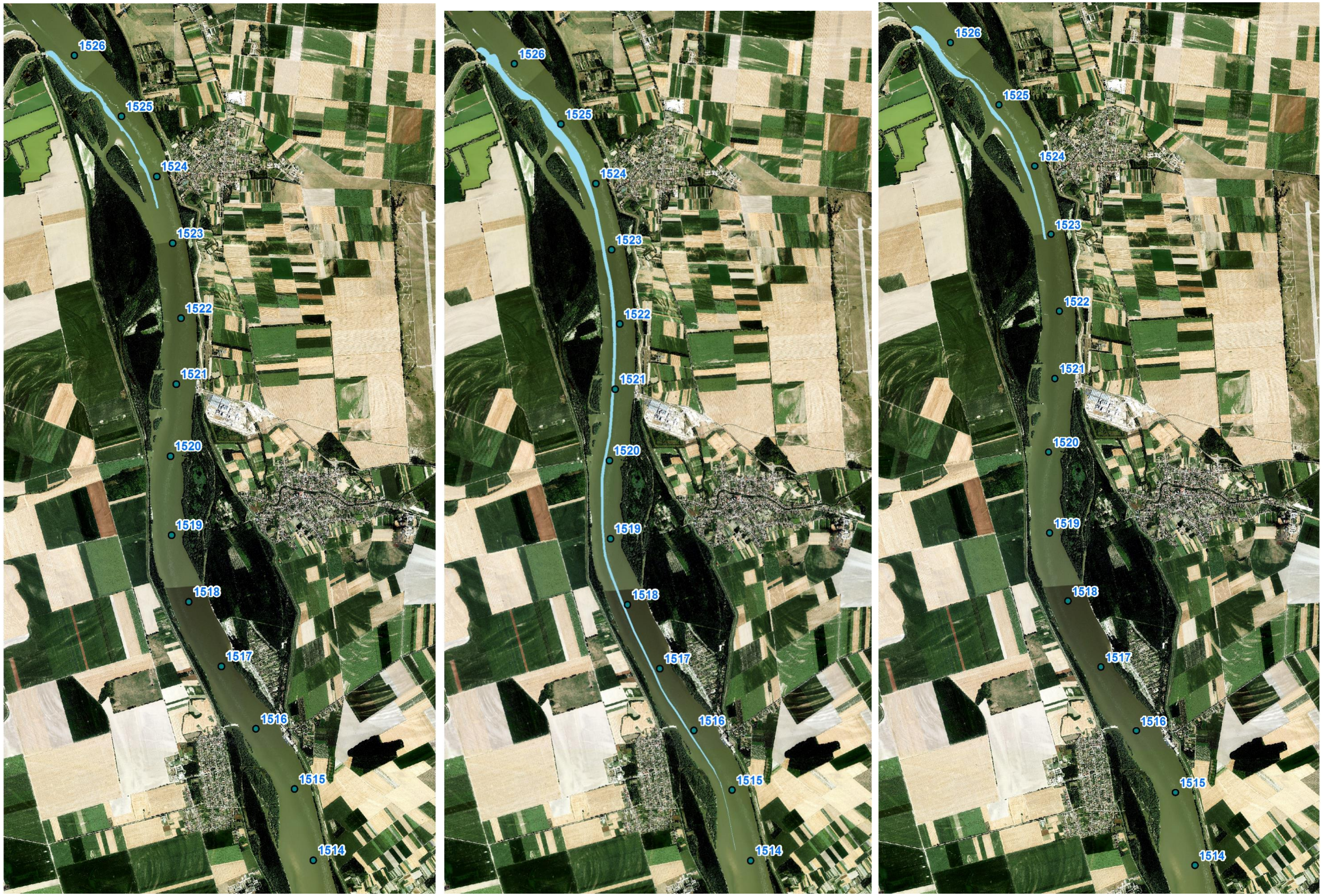


Figure 3-32: Wildlife conservation impact areas (background water temperature + 2.5°C) (left to right) states in the year 2014, 2032 and 2085

4 New energy dissipation device to improve mixing

With reference to section 6 in the order of the South Transdanubian Environmental and Nature Conservation Inspectorate with the reference No 558-37/2015 to submit missing information and the statement made on 24 March 2015 Chapter 6.11.5 of the EIS will be amended as follows.

The new energy dissipation device improving the mixing of water dimensioned to accommodate the hot water volumes discharged from the new nuclear power plant units will be situated at the end of the northern mouth of the hot water canal on the Danube bank. The new energy dissipation structure is designed to minimise the impact of hot water discharge on the established Danube bed, to avoid adverse effects on the navigability of the Danube and to promote blending of the hot water discharged as soon as possible, at the same time preventing the development of a heat plug choking the entire Danube profile.

The potential energy between the design water level of the hot water canal is (approximately 95 above Baltic sea level) and the Danube water level at any time is processed by the new structure transforming such energy in a way which does not exert any substantial impact on the bed, yet provides an initial velocity of 2.2 m/s to the hot water on the outlet side of the structure. Using this momentum hot water can get to the wide profile of the Danube and mixes better than it does in the neighbourhood of the existing energy dissipation device. As a result it is cooled down by approximately 1 °C 50 m downstream of the discharge point (design state from the year 2032, at 132 m^3/s discharge rate and 8°C cooling water heat gradient), and at 500 m downstream cooling rate reaches 4-4.5°C (design state from the year of 2085, at a discharge rate of 132 m^3/s and 8 °C cooling water warming up heat gradient).

The energy dissipation device is a stand alone facility surrounded by fencing, not requiring continuous presence of an operator. Security is provided by a physical barrier and a signalling system.

The new energy dissipation device improving mixing has a connection canal, chute pulse reduction walls and downstream baffler. It is a structure of nearly the same width as the hot water canal, it is approximately 50-60 metres wide, with a length downstream on the hot water canal of approximately 35-45 m, ranging up to approximately 100-120 m in conjunction with the connecting canal and chute.

Dimensions (W x L x H):	*60 x 45 x 25 m*
Wall structure:	*reinforced concrete*
Flooring structure:	*reinforced concrete*
Foundations:	*foundation slab supported by reinforced concrete poles*
Estimated depth of foundations:	*between 20 and 25 m*
Other requirements:	*dimensioning for noise and vibration control*