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Investigation of the effect of backwater on the propagation of thermal pollution during operation of a thermal power plant

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For operation of large thermal power plants, reservoirs-receivers are the most common type of cooler. Depending on the capacity of the power plants and the size of the water bodies used as reservoirs-receivers, the organization of the cooling system may be direct-flow or reverse. The main task of the effective operation of the cooling system is to ensure the stability of its functioning under conditions of significant variability of both hydrological and meteorological parameters. For the solution of this problem, the development of technological operation schemes based on computational experiments is of fundamental importance. It is also important to take into account the effect of thermal pollution on changes in the ice-thermal regime, hydrobiological processes in the area of the influence of the discharge of heated water. At the same time, it is important to take into account both technological and environmental criteria when assessing the parameters of temperature fields created during the discharge of heated water, depending on the complex of technological and hydrometeorological parameters.

In the present paper, we considered the scenarios of the impact of the Perm Power Plant on the Kama reservoir using a direct-flow cooling system, which are of the great interest from an environmental and technological points of view. Three-dimensional numerical simulation was carried out for different operating modes of the Kama reservoir. Since significant vertical temperature heterogeneity is observed in reservoirs-receivers, in order to achieve sufficient correctness, calculations should be conducted in the general case using 3D models. However, the implementation of such calculations for large water bodies in the conditions of the extremely limited current monitoring network encounters very significant difficulties due to the limited computing resources. In this regard, a combined calculation scheme is proposed and is being implemented, including models in 1D, 2D, 3D formulations. 1D model was built for the entire reservoir, 2D model for 30 km-length section adjacent to the Perm Power Plant, and for 10 km-length section that includes the supply and discharge channels of the Perm Power Plant, 3D model was created.

The calculations have shown that under conditions of strong wind in a direction opposite to the direction of the river flow, large-scale three-dimensional vortex is formed within several hours, the horizontal size of which is equal to the distance between the junctions of the supply and discharge channels with the reservoir, and the vertical size is equal to the depth of the river. The presence of backwater from the Kama hydroelectric station leads to the active movement of warm water in the surface layer against the river flow. In this case, in a few hours, warm water reaches the water intake point of the cooling channel, which is extremely undesirable from a technological point of view. Significant temperature heterogeneity also arises in depth, with the temperature gradient being greatest near the bottom of the river.

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