

## **Ice Jams And Their Hydrological Implications**

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This report is devoted to the problems connected with ice jams, which are widely distributed on the rivers of average and high breadths of northern hemisphere. Ice jams are formed in the spring during the period of ice cover destruction. They represent the multi-layered congestions of floes in a river vein, which cause the constraint of river-channel and the rise of water level. Ice jams are formed in places where the process of ice cover destruction is late on the reasons of increased ice thickness and increased ice cover strength, and also owing to jamming a river channel by the ice fields near the specific river network forms (numerous islands, channels, spits and etc.). However ice jams are not necessarily formed annually in the same places. They can change the location of formation. However, even ice jams, which are observed always in the same place of the river, are formed not every year.

In this report it is shown, that the ice jams are complex and dangerous natural phenomenon. It is marked, that the hydrological role of ice jams is inconsistent. On the one hand these hydrological phenomena cause flooding which cause significant damage to economy of regions, and sometimes they result in human victims too. On the other hand, ice jams, which are formed on the rivers, which flow from the south to the north, lead to more early ice cover destruction, than it would be possible to expect on meteorological conditions. The most catastrophic "ice jam" flooding, which was observed on the rivers of Russia for the last ten years are considered. The reasons of most destructive ice jams are shown too. By example of catastrophic flooding in the river Lena basin, which was observed in 2001, the mechanism of the most dangerous ice jams formation is considered. It is shown, that for the powerful ice jams formation the simultaneous performance of following conditions are need:

- High soil humidity during the autumn period,
- The large thickness of ice,
- High intensity of snow melting,
- Superfluous liquid precipitation during the destruction of snow cover,
- Sharp contrasts of air temperature in the area of ice jam formation and in the top part of the river basin.

The data on spatial distribution of ice jams on the rivers of Russia are considered. By example of the river Lena the repeatability of ice jams formation and repeatability of flooding caused by them are considered too. It is shown that the probability of ice jams formation is higher in the years with high runoff.

In the report it is marked, that the regime of ice jams formation is very complex, as their formation occurs in the conditions of unsteady water regime, the degree of river channel corking by ice changes in the time and on the space, the slope of water surface is distributed non-uniformly on the length of the river. However, despite of the large complexity of the ice phenomena classification, usually allocate two types of processes of ice jams formation:

- formation of ice jams by a tightening of ice floes under an edge of ice (the "dive jams");

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- formation of ice jam congestions at destruction of an ice cover during the process of hummocking and compression of ice floes (“jams of hummocking”).

In the first case the ice jams formation is determined by the energy of the stream, which is necessary and sufficient to the tightening of ice floes under an edge of ice and their moving under the ice cover up to the place with the lowered speeds of current. In the second case the ice jams are formed as a result of collision of ice floes with various kinetic energy. Process of formation of ice jams of the second type depends on speed of a wind and its direction.

Ice jams also classified on morphological attributes of the river section. According this classification there are three types of jams:

- Ice jams at the edge of ice cover;
- Ice jams in the mouth section of the rivers running into the seas and lakes;
- Ice jams in the zones of sharp change of the bottom in the reservoirs of river type.

The basic methods of researches of ice jams, including the method of natural modelling are considered. The experts of the State Hydrological institute (Saint Petersburg) successfully applied this method for the studying of the mechanism of ice jams formation in the river Lena near the Lensk town.

In the report some methods of the calculation of basic characteristics of ice jams most used in practical hydrology, such as the ice jam thickness, the slope of water surface, the transport force of river stream, the maximum ice jam water level are considered. It is theoretically shown, that the formation of the most powerful ice jams is characteristic for river sections, where behind a long rectilinear section ( $L > 12B$ , where  $L$  - length of a site,  $B$  - width of the river) the abrupt turn ( $90 - 115^\circ$ ) of river channel follows.

In the report the most widespread in operative practice methods of ice jam forecasting are considered. The existing opportunities of the long-term (with the lead-term more than one month) and short-term forecasting of the possibility of ice jams formation and the size of maximal «ice jam water levels» are shown.

In the conclusion the basic methods of struggle with the ice jams, and also the actions spent with the purpose of mitigation of «ice jam» flooding consequences are considered.