Assessment of the Impact on Natural Resources Associated with Oil and Gas Production in the Lena-Tunguska Oil and Gas Province

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Abstract. Oil has become an integral part of our world, if we look around and think about it, we will see familiar objects made thanks to this wonderful natural hydrocarbon. Now everyone is used to criticizing oil and everything connected with it, but let us look at it in a new way. Oil and natural gas are familiarly associated with fuel, but this is only a small part of what they are capable of: glue, plastic, polymeric materials, fabrics, varnishes, cosmetic and medical materials. Indeed, it has become an indispensable material. Let us consider the environmental impact associated with the extraction of this wonderful and irreplaceable material. Nevertheless, oil and gas production inflicts enormous damage on the ecological situation in the regions of oil and gas provinces. To extract “black gold” one has to go a long way that sometimes lasts for decades, the process of field exploration and development is very cost intensive. New technologies in exploration help enterprises reduce costs, but still these stages remain expensive. Enterprises try to minimize their costs and expenses at all stages. In this paper, we will consider the consumption of water resources and the total loss of aquatic biological resources of four fields in the Lena-Tunguska oil and gas province: the Yarakta, Iktekh, Markovo and Dulisma fields. The assessment was carried out at the stage of the construction and development of the fields.

1. Introduction

The ichthyofauna of the Irkutsk Region includes 57 species. The region’s fund of fishery waters includes Lake Baikal, reservoirs and their tributaries, the Angara, Chuna, Biryusa, Katanga, Lower Tunguska rivers and their tributaries, and lakes in the basins of these rivers.

River waters of the region are used for the development of recreational fishing. The fish capacity of rivers is usually lower than that of lakes, but they are invaluable as reproduction sites for many commercial fish. The Irkutsk Region accounts for 40% of the total length of the Lena river, most of the Angara river and half of the L. Tunguska river, where the majority of valuable fish species live and reproduce: taimen, lenok, whitefish, grayling, etc.

Commercial fishing in the region is carried out on Lake Baikal, at the Bratsk and Ust-Ilimsk reservoirs. The total allowable catch of omul on Baikal is determined within 650 tons, at the Bratsk reservoir - 8 tons of omul, 80 tons of bream, at the Ust-Ilimsk reservoir - 8 tons of bream.

There are not so many cases of fish kill registered as a result of oil spills, but plankton suffers extremely often. This leads to fishery damage - spilled oil causes changes in internal organs of fish,
they lose the ability to reproduce, plankton that fish feeds on is killed in most cases. There are cases when fish are caught with the smell of diesel fuel.

The Dulisma field is located between the rivers of Nepa and Lower Tunguska. The hydrographic network in the area is well developed and is represented by tributaries of the Lower Tunguska river - the Dulisma, the Surinda, and the Poimyga. Floodplains and river valleys are very swamped. In the field area, the swamped sites are passable. Lakes (loop lakes and cryogenic lakes) are widespread. The source of water in the Dulisma field is represented by 2 artesian wells being designed (1 operating and 1 reserve) located in the territory of a rotation village. The yield of the operating well is 16 m$^3$/day. During the construction period, water is used for household and drinking water supply, fire protection needs, as well as pipeline hydrotesting. The volume of water consumption for household and drinking needs during construction amounts to 5.1 l/sec. The volume of water for hydrotesting: oil gathering networks - 2079.6 m$^3$; gas gathering networks - 968.5 m$^3$; high-pressure conduits - 1853.7 m$^3$.

At the Yarakta field, the impact on water bodies characterizes its balance of water consumption and disposal. To assess this impact, we reviewed the design documentation on water consumption and disposal during the construction of production gas wells at the typical cluster site No. 219 of the Yarakta OGCF. Total fresh water consumption when drilling the typical cluster site No. 219 for 5 horizontal directional wells: 10,143 m$^3$ + 550 m$^3$ = 10,693 m$^3$.

Water consumption at the Markovo field: Preparatory work for drilling: 6.0*43 = 258 m$^3$; water while oil mud drilling: 1,208 m$^3$; casing - 194 m$^3$; placing of cement plugs and a shot pit - 51 m$^3$; steam production by a boiler plant - 10 m$^3$* (626 m$^3$); total process fresh water for the first horizontal directional well - 2,525 m$^3$. Total process fresh water for each next horizontal directional well on the site - 2,009 m$^3$. The facilities being designed for the Markovo field are located along the upper reaches of the Lena river, in the area of Verkhnemarkovo. The river valley is deep-cut, terraced. The hydrographic network in the operation area is well developed and is represented by the Lena river and its many tributaries, such as the Small Tira, the Big Tira and others. In the area of the wells being designed, the Podgoleshny stream flows into the Lena river from the left bank, downstream - the Shabashny stream. The total water consumption for the well construction cycle is 4,279.84 m$^3$, including 2172.56 m$^3$ used for industrial water supply with process water, 1736.28 m$^3$ used for industrial water supply with drinking water, 305.17 m$^3$ used for household and drinking water supply.

The Iktekh oil and gas field: the volume of water disposal during the construction of wells is 3,715.46 m$^3$, including the disposal of domestic wastewater to the storage unit - 271.87 m$^3$, production wastewater - 3,443.59 m$^3$. Irretrievable losses (water consumed for waterproofing, preparation of drilling mud, stock for the preparation of drilling mud, casing cementing, well testing in the production string, feeding the boiler room and cooling diesel engines, etc.) during the construction of wells will amount to 2,989.83 m$^3$.

2. Study objects and methods

The calculations are made based on the Method for Calculating the Amount of Damage Caused to Aquatic Biological Resources, Order of the Federal Agency for Fishery dated November 25, 2011 No. 1166.

We carried out the calculation of damage caused to the fishing industry.

The amount of damage to aquatic biological resources is determined by the total value of its constituent components calculated for each type of aquatic biological resources, and is expressed by the formula:

$$N = N^1 + N^2$$  \hspace{1cm} (1)

where $N$ is the amount of damage to aquatic biological resources caused by violation of the law, rubles;

$N^1$ is the amount of damage from the loss of aquatic biological resources (with the exception of forage organisms), rubles;

$N^2$ is the amount of damage from the lost growth gain of aquatic biological resources as a result of the loss of forage organisms (plankton, benthos), rubles;
The calculation of the damage from the loss of fish, aquatic invertebrates, and other aquatic animals (with the exception of aquatic mammals and plants) is performed according to the formula:

\[ N_1 = \sum Z \cdot P_e \]  

(2)

where \( Z \) is the cost of products manufactured from one kilogram of raw materials for individual types of fish, aquatic invertebrates, and other aquatic animals (except for aquatic mammals and plants), rubles;

\( P_e \) is the total weight of lost biological resources for individual types of fish, aquatic invertebrates, and other aquatic animals (except for aquatic mammals and plants), kg.

\[ N^2 = \sum (P_0 \cdot Z) \]  

(3)

where \( \sum \) is the sum of the results of calculations for individual types of aquatic biological resources;

\( P_0 \) is the total weight of the lost growth gain of aquatic biological resources, kg;

\( Z \) is the cost of products obtained from 1 kg of raw aquatic biological resources, or the penalties approved in the prescribed manner, rubles.

Whereby the total weight of the lost growth gain of aquatic biological resources (\( P_0 \)) is determined by the formula:

\[ P_0 = \sum \frac{a_n}{k_2} \]  

(4)

where \( \sum \) is the sum of the results of calculations for individual types of aquatic biological resources;

\( k_2 \) is the feed ratio (the amount of feed (kg) needed to gain 1 kg of aquatic biological resources);

\( a_n \) is the index of the lost forage organisms (kg) determined by the formula:

\[ a_n = \sum (n - n_1) \cdot W \cdot 10^{-3} \]  

(5)

where \( \sum \) is the sum of the results of calculations for individual systematic groups of forage organisms (with registered losses);

\( n \) is the biomass of forage organisms before negative impact, g/m\(^3\);

\( n_1 \) is the biomass of forage organisms after negative impact, g/m\(^3\);

\( W \) is the volume of water in the water body (or in its part), where there was a loss (death) of planktonic forage organisms, m\(^3\).

10\(^{-3}\) is a multiplier for converting grams to kilograms.

3. Results and discussion
In assessing the impact of the studied enterprises on the environment, we evaluated the total water consumption of the enterprises for the field development, the volume of biomass and the nearest natural water flow for possible water intake. The results are presented in Table 1.

| Parameters                                      | Dulisma field | Yarakta field | Markovo field | Iktekh field |
|-------------------------------------------------|---------------|---------------|---------------|--------------|
| Nearest water supply sources                    | the Dulisma river | the Yarakta river | the Lena river | the Iktekh river |
| Water consumption, m\(^3\)                      | 4901.8        | 10,693        | 6871          | 4279.84      |
| Biomass of forage organisms, g/m\(^3\)          | 1             | 1             | 1             | 1            |
| Specific fish capacity for a unit of water mass, kg/thnd | 0.15        | 0.15        | 0.15         | 0.15         |
| Total loss of aquatic biological resources, kg  | 7.84          | 17.11         | 10.99         | 6.84         |
| Loss of aquatic biological resources, kg        | 0.735         | 1.6           | 1.03          | 0.641        |
| Total loss of aquatic biological resources, kg  | 8.575         | 18.71         | 12.03         | 7.48         |
Figure 1. Results of assessing the total losses of aquatic biological resources from water intake in the development of oil and gas fields.

The calculated loss of aquatic biological resources from the deterioration of the feeding conditions due to the loss of forage organisms of zooplankton from water intake for the four fields amounted to 43.69 kg from the total loss of aquatic biological resources of the Baikal region.

4. Conclusion
The study allowed us to reveal significant losses of aquatic biological resources. These losses are typical only during the construction of wells, and are local in nature. Damage from the loss of bioplankton as a product is not only dangerous for biodiversity, but it also affects feeding of fish, as well as the conditions for self-purification of water resources. In aggregate, all this causes a local decrease in the fish capacity of watercourses. During the work, the damage caused to aquatic biological resources is relatively noticeable. If the losses were permanent, the depletion of aquatic biological resources would be catastrophic.

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