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Danger of Engineering-Geological and Geological Processes at Construction of Offshore Facilities (the Coast of Sakhalin Island)

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Danger of Engineering-Geological and Geological Processes at Construction of Offshore Facilities (the Coast of Sakhalin Island)

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Abstract. The article contains the analysis of engineering-geological problems arising at design, placement and operation of fish farms. Dangerous geological processes are considered on the example of the planned fish-breeding enterprise on the bank of Volchanka river, in 200 meters from its mouth in the northwest of Sakhalin Island. The construction project is complicated by the fact that the bank of the construction site is subjected to both river and sea abrasion.

1. Introduction

Dangerous engineering, geological and geological processes, both during construction and during operation, are a real threat to people and structures. The neglect of measures aimed at identifying such processes and the development of measures to minimize the potential impact may lead to unforeseen costs, up to the demolition of the structure.

2. Object of study

In accordance with the resolution of the Government of the Sakhalin Oblast, which provides for the establishment of the basics for the transition to an ecologically and economically progressive way of developing aquatic biological resources through the construction of new salmon hatcheries [1], in the summer of 2017, during engineering and geological studies on the river bank Lupus at 200 meters from the mouth in the north-west of Sakhalin (Figure 1), a number of fundamental factors were obtained, representing a general picture of the dangers of geological and engineering-geological processes. As shown by the data obtained in the survey, the soils on the construction site are monotonous and rather dense, consisting mainly of coarse-grained sand. At first glance, the situation does not require special additional structures, but the problem is that the construction will be located directly on the bank of the river, besides one of the most important structures will be a dam across the river. With additional studies of the territory, it became clear that the monotony of large sand is deceptive, since lenticular forms of silt and peat occur, which can have a negative effect on the stability of structures.



3. The results of the research

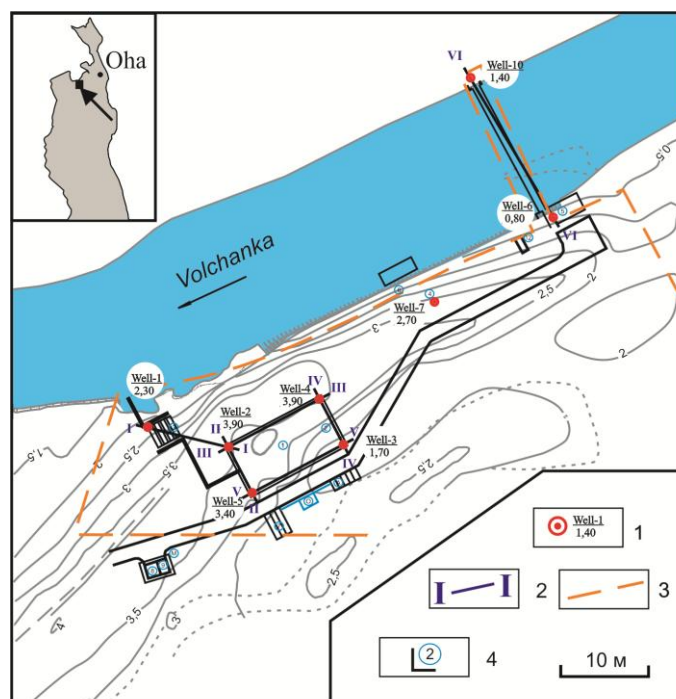


Figure 1. Scheme of location of engineering and geological wells and sections in the study of the construction site of a hatchery: 1 - well (numerator-number, denominator - absolute elevation): 2 - line of engineering-geological section and its number, 3 - construction area, 4 - contours and number of the structure.

When designing the foundation and structures, it is extremely important to take into account the seismicity of the area - this is one of the main tasks in this area. On the territory of Sakhalin there are numerous tectonic disturbances, the north-western system of which consists of numerous faults and shifts of both intralithospheric and intracritical ones. In this case, the greatest concern is the Okhinsko-Piltun seismically active zone, within which, as a result of earthquakes with a magnitude of 7.2 in 1995, the whole city was destroyed [2]. On the territory of construction, the greatest spread and high intensity of manifestation are: marine abrasion, wind and water erosion, avalanching processes and water logging, which determine the overall dynamics of exogenous processes of the geological environment. With strong earthquakes, especially in conditions of considerable moisture of rocks, the activity of these phenomena sharply increases. Based on the processed data, the soil category according to seismic properties, according to SP 14.13330.2014: II category - EWG 1-10. The recommended seismicity of the site is 9 points, the category of the site ground by seismic properties is II [3]. Based on the results of field work, desk and laboratory studies of soils performed in accordance with the requirements of GOST [4, 5], two engineering-geological elements (IGE) were identified in the object in the interaction zone of the foundations of the designed structures. The distribution of soils and isolated IGE is reflected in engineering geological sections (Figure 2). It has been established that with increasing depth of sampling, the density of soils increases and their porosity decreases, which indicates the reliability of soils and allows one to conclude that the phenomenon is eliminated as quicksands. In general, the territory is dominated by alluvial sands (aQ_{IV}) - these sands are coarse grains, less gravelly, medium degree of water saturation, but in the lower parts of the section the soils are saturated with water (Figure 3). The separation of engineering-geological elements in the studied territory was carried out in two stages. In the first stage, according to the data of the visual description of the soils, their genetic and age specificity, and also from the results of a primary analysis of

laboratory soil analyzes, including materials from previous studies, the stratum, according to the requirements of GOST 20522-2012 [4], was divided into 2 IGE.

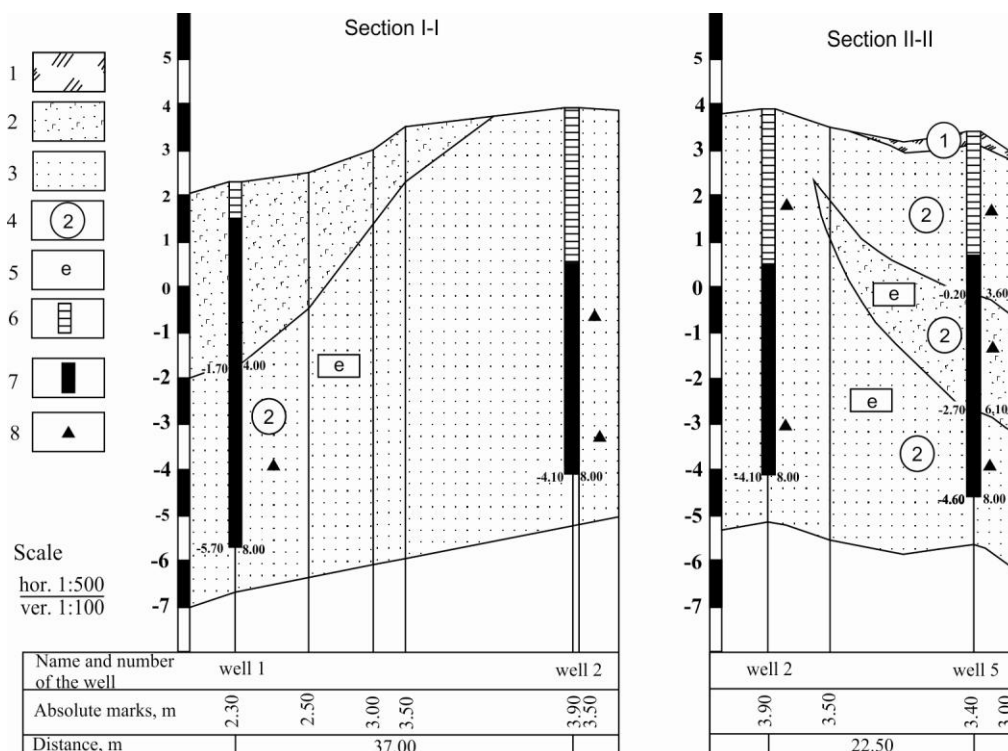


Figure 2. Engineering-geological sections on the projected site: 1 - soil-vegetation layer / slag, 2 - gravel sand, 3 - large sand, 4 - engineering geological unit number, 5 - stratigraphic index, 6 - saturation degree, 7 - consistency (solid), 8 - soils with broken structure (characteristic of the sampling site).

For each isolated IGE, a statistical analysis of the partial values of the main parameters of the physical and physical-mechanical properties of the soils was carried out. The primers of the layer are characterized by the results of laboratory studies of the 21st soil sample of the disturbed structure. According to the statistical processing data, the soil layers are homogeneous in terms of basic physical characteristics, the coefficients of variation 0.01-0.15 satisfy the requirements of GOST 20522 - 2012 [4].

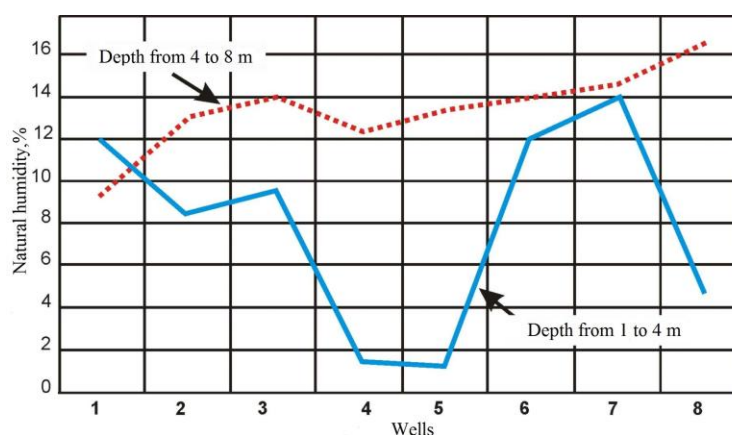


Figure 3. Characteristics of natural soil humidity

From the table there is a noticeable increase in the soil moisture content from 1 well to 8, this should be noted, since it seems that there is a swamping of the territory. The geological structure of the site of exploration is due to its geomorphological conditions and is represented by Quaternary sediments and low-power peat and soil-vegetative layers. A thin soil-vegetative layer (thickness up to 0.3 m) is distributed on the site. The peat lies at a depth of 0.1-0.3 m to a depth of 0.3-1.1 m, capacity is up to 0.8 m. These features make it possible to consider the soils under consideration to be of little use for building various structures on them, that is, a layer of peat during construction it is necessary to remove. According to the conditions of feeding, unloading, deposition and circulation in sedimentary rocks, the following are distinguished: the Quaternary sediment aquifer, the Upper Middle Miocene aquifer complex, and the Upper Cretaceous sediment aquifer complex [6]. The aquifer of the Quaternary sediments is developed everywhere. Its thickness varies from 0.4 to 8 m, increasing in the valleys of rivers and streams to 40-45 m. On the slopes of the hills, deposits are mainly deluvial loams with crushed stone and molten rock, and river alluvium is composed of lenses of sand, gravel with silt and loam. The collectors are lenticular, so the aquifer contains a small amount of groundwater and does not exert any influence on the waterways of the mine workings. The Upper-Middle Miocene aquifer complex plays a major role in the watering of foundation pits and other excavations of soil. Water-bearing rocks are fissured sandstones and siltstones. Two water-bearing zones are distinguished in the complex: the zone of active water exchange, developed to a depth of 100-150 m and the zone of difficult water exchange - below the depth of 150 m. The prevailing role in the feeding of the upper aquifer is played by atmospheric precipitation. The source of nutrition is the water of the upper zone and, in part, the aquifer complex of the Upper Cretaceous deposits. The aquiferous complex of the Upper Cretaceous deposits is represented by sandstones of various degrees of fracturing, conglomerates and, less commonly, siltstones of the Arkovo and Tymovskaya suites. Water conductivity coefficients vary from 1.49 (upper zone) to 0.064 m² / day (lower zone), specific rates from 0.026 to 0.001 l / s [6]. The groundwater in the research area is free-flowing and lies at depths of 1.2-3.2 m (in abs., 2.0-3.8 m). They are confined to sandy sediments. In accordance with the results of groundwater studies (Table 2), it is recommended to use concrete piles in the construction process as more resistant to aggressive environment, as compared to metal structures. A sharp increase in the concentration of sulfates, chlorites and carbon dioxide from the first to the last wells was established (Figure 4). In the same direction, the swamping of the territory also extends. Another process that adversely affects future facilities is water erosion. Erosion processes in the north of Sakhalin are widely developed and are manifested in the form of deep and lateral erosion in the channels of constant watercourses, gully erosion and flat flushing on the slopes of the watersheds. Since the projected object is located both on the left and on the right banks of the river, traces and manifestations of a number of physico-geological phenomena, caused by processes associated with the action of lateral erosion, are fixed in the area of work.

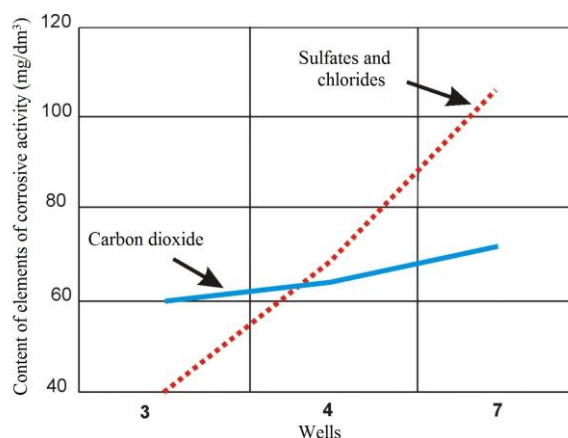


Figure 4. Indices of the corrosivity of groundwater.

The regular evolution of the shoreline of the Volchanka River is characterized by special or even spectacular erosion episodes. Flushing of the banks, retreat of the coast by several tens of meters indicates geomorphological instability of the terrain. Vortex boards are actively eroded. Migration of the shoreline can be carried out at a speed of 5 to 15 m / year. An example is the exceptional erosion that occurred in 2014 within the port of Moskalvo, 20 km north of the study site, where there was a sharp decrease in the coastline from 6 to 10 meters during storm surges. According to E.Kato, Yu.V. Lyubitsky and others [7], the maximum surge wave was recorded on October 15-19, 1977, when the measurements from the port of Moskalvo deviated from the mean level of 272 cm, which led to serious violations of the coastal infrastructure and some structures. It should be feared that the erosion will increase due to an increase in the average ocean level associated with climate change. The area of the test site is exposed to extreme weather phenomena: abundant rain, drought, heat, cyclones and storms that exacerbate instability and riverside banks of the river. The observed silting of the estuary occurs at the same time as the shores are destroyed, and the outlet of the river is blocked by sand forming the river bar.

Table 1. Physical and mechanical properties of soils.

№ well	Depth of sampling	Density, g/cm ³				Angle of slope in dry / saturated	Porosity coefficient σ	Natural humidity, %	Classification group in accordance with GOST 25100-11
		Particles of the soil	Density of the soil	Dry soil	Friable / dense				
1	2.0-3.0	2.63	-	-	1.57/1.87	27/19	0.67/0.41	12.0	Sand gravel
1	5.0-6.0	2.65	-	-	1.70/1.89	29/20	0.56/0.40	9.5	Sand large
2	3.4-3.7	2.65	-	-	1.74/1.92	27/19	0.52/0.38	8.7	Sand large
2	7.4-7.7	2.65	1.45	1.28	1.74/1.91	28/20	0.52/0.39	13.1	Sand large
3	1.2-1.5	2.63	1.87	1.70	1.57/1.86	27/19	0.67/0.41	9.7	Sand gravel
3	6.2-6.5	2.66	1.94	1.70	1.73/1.88	26/18	0.54/0.41	14.1	Sand large
4	0.7-1.0	2.64	1.52	1.49	1.69/1.86	27/19	0.56/0.42	1.5	Sand large
4	4.2-5.0	2.65	1.71	1.53	1.70/1.91	26/18	0.56/0.39	12.4	Sand large
5	2.5-2.8	2.66	1.56	1.54	1.72/1.89	25/19	0.55/0.41	1.2	Sand large
5	4.5-4.8	2.63	1.82	1.60	1.57/1.86	25/18	0.67/0.41	13.8	Sand gravel
5	7.4-7.7	2.66	1.67	1.48	1.72/1.90	26/18	0.55/0.40	13.4	Sand large
6	1.8-3.0	2.65	1.59	1.42	1.61/1.88	24/20	0.64/0.41	11.9	Sand gravel
6	6.0-6.5	2.65	1.85	1.62	1.62/1.88	23/19	0.64/0.41	13.9	Sand large
7	3.1-3.4	2.65	1.67	1.47	1.62/1.87	24/17	0.64/0.42	13.9	Sand large
7	6.0-6.3	2.66	1.60	1.39	1.74/1.91	24/21	0.53/0.39	14.7	Sand large
8	1.1-1.4	2.64	1.16	1.10	1.66/1.88	23/22	0.59/0.40	5.01	Sand gravel
8	6.6-6.9	2.63	1.79	1.53	1.64/1.86	23/20	0.60/0.41	16.6	Sand large

Table 2. Corrosion aggressiveness of groundwater.

Well	pH	Total concentration of sulfates and chlorides, mg/dm ³	Bicarbonate alkalinity, mg-equiv/dm ³	Content of aggressive carbon dioxide, mg/dm ³	Degree of aggressive impact on metal and concrete structures (By: SP 28.13330.2012, B.3, X 3, updated version of SNiP 2.03.11-85)	
					Metal	Concrete
3	6.52	41.0	4.20	58.9	Medium aggressive	Slightly aggressive
4	6.45	68.0	6.10	64.2	Medium aggressive	Slightly aggressive
7	6.72	106.0	4.10	72.2	Medium aggressive	Slightly aggressive

The erosion of the sides of the valley of the river is dangerous and it can be higher than the calculated level, as well as a sharp increase in the speed of the water flow, saturation of the flow with ground and wood material (karchi) in the breakage of rubble can lead to an increase in the eroding capacity of the stream, this all can affect the destruction of the river's sides and , in a consequence. to the destruction of the building.

It should also be noted that the placement of building soils in flooded areas of the floodplain and in places of natural discharge of groundwater will entail a multiple increase in the turbidity of river waters in spawning rivers - both in floods and in low water. To prevent bottom erosion, it is recommended to build retaining walls, banquetts, prizmzhnyayuschih walls, located at an angle to the direction of the river and deflect it from the shore, as well as protective dams and buns that regulate the direction of the river.

In the process of lateral erosion, the erosion and accumulative activity of the river occurs: sandy soils form an elongated valley, the river, through erosion, deepens its valley, expresses a certain longitudinal profile, striving to achieve maximum depth. Thus, washing one of the banks. For buildings and structures located in river valleys, washing the banks and deepening the bottom of the river is a significant danger. This leads to the collapse of the coast, the reduction of construction sites, the emergence of landslides, landslides and other undesirable phenomena. The rate of erosion of shores, composed of loose rocks, can be significant. For example, p. Kuban near blurs the loess shore at a speed of up to 20 m per year [8].

With landslide phenomena we have to face everywhere on the plains along the banks of rivers, lakes, reservoirs, and on the slopes in the mountainous terrain. Landslide processes arise mainly because of the discrepancy between the steepness of the slope and the composition of the constituent rocks, when the tangential stresses become greater than the shear resistance. As a result, part of the landslide massif is separated and slides along the slope along the slip surface. The configuration of the slip surface is determined by the conditions of bedding of lithologically different rocks, the degree of their weathering and moistening, the presence of tectonic disturbances and a number of other factors. Landslides are a threat to all engineering structures without exception, and they are classified as dangerous geological processes [9].

At the site of the dam construction, the stream approaches the shore at an angle, causing some compression of the stream and erosion of the left bank, exactly where the structures will be located. As a result of the blurring of one of the banks, a circular rotation is formed. Having stumbled on a sharply washed shore, the water flow turns back, moving against the current, but all the water to return back does not have time and stumbles upon a newly arriving water stream. As a consequence, it begins to spin at a speed that largely depends on the speed of the main current. Rotating in a fairly limited space, the water makes a circular motion and gets to the outer edge of the waterworm, creating a depression in the center. That gives even greater probability of washing and collapse of the shore.

The north of Sakhalin Island is almost completely covered with a sedimentary cover of sand, and this contributes to wind erosion. Intensive transfer of sands is characterized by openness of the territory and oppression of vegetation. The speed of the dunes, about 2 meters per year. Friable Quaternary sediments that form a coastline near Baikal Bay can be eroded at a speed of 20 m per year or more. This suggests that during the operation of the structures, the movement of sand masses can adversely affect the bearing capacity of the foundation, since there will be additional pressure on the ground, which is not taken into account in the design. To combat this process, shields can be used to protect against sand deposits.

The results of studies carried out in the area of the site of work may be influenced and flooded due to rising water levels, the difficulty of filtering it and the formation of a stagnant regime when the water level rises, or during periods of high water, or excessive or prolonged precipitation. Increased intensity of underground water exchange in the warm season on the territory of Sakhalin contributes to the value of atmospheric precipitation (up to 1000 mm and more) [10].

In some areas of work, where peat deposits are formed and relative marks tend to zero, during flooding flooding and erosion of structures are possible. And also groundwater will contribute to this,

since in places their established level is less than two meters. To eliminate this phenomenon, it is necessary to develop measures to intercept surface and groundwater and to divert it outside the site using open and closed drains. Another process, rather little described in the literary sources, is the wave-surfacing activity of the river, which reacts to the tidal processes of the sea. The construction will be located 200 meters from the mouth, which speaks of the connection of the wave surf action of the sea with the collapse of the sides of the river bank. On the coast, the tides are semidiurnal with a strong daily inequality. The height of the tide can exceed 1.5 m. In general, the height of the tide ranges from 0.40 m to 1.3 m during the spring tides. This indicates that the river will accordingly ascend, washing away a significant part of the coast. The fight against this phenomenon is mostly pointless on the river, since during the storms the waves can be on the river up to 1.5 meters. Apparently, it is necessary to plan the construction of buns at the mouth of the river.

4. Conclusion

Thus, the danger of engineering-geological and geological processes can not be underestimated. Identify them at the design level, otherwise the consequences for the hatchery can be catastrophic.

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