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The forecast of changes in the natural and technogenic conditions of the built-up territory on the example of the "Northern" district of the city of Kursk

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Abstract. Today, the impact of urbanized territories on the geological and hydrogeological environment is of paramount importance. The studied section of the city of Kursk "Severny" district is intensively built up, therefore, it is characterized by a high degree of technogenic impact.. This article presents the results of engineering and geological surveys on the built-up territory of the Kursk city agglomeration. A hydroisogypsum map was built, the flow filtration rate was calculated, and it's direction was determined. Protective measures were also proposed to prevent flooding of the built-up area. Statistical processing of the primary material was performed, followed by modeling of hydrogeological conditions in the software package ArcGis, Autocad**.**

1. Introduction

The rapid growth of industrial production and development of territories, observed in the XX-XXI centuries, has led to a significant increase in environmental impact. The atmosphere, lithosphere, hydrosphere are subject to anthropogenic influences and changes [1].

At present, technogenic flooding of territories is one of the most acute and urgent problems of modern ecology, which are encountered throughout the world [2-4]. Practically all cities and thousands of small settlements are flooded to one degree or another in Russia alone [5-7].

Engineering protection against flooding of urban areas is increasingly becoming paramount for most cities in Russia [8,9]. If you do not take any measures to eliminate flooding of the city territory, then the possibility of the formation of an emergency geoecological situation, which will require subsequent emergency measures to eliminate the consequences [10]

The construction development of territories and the operation of buildings, structures and other objects located on poorly permeable soils are almost everywhere accompanied by the accumulation of moisture in the thickness of the soil and a rise in the level of groundwater even in those cases when before the development of the territory there were no groundwater [11]. Such a process is called flooding (or technogenic flooding). It arises and develops due to the violation of the existing natural dynamic equilibrium in the water balance of the territory. These violations arise as a result of human activities and in developed areas usually develop in two stages - during construction and operation [12].

Groundwater in the Kursk region is technogenic and has a disturbed regime. In places with poor geological protection of the upper aquifers in floodplains and floodplain terraces of rivers, industrial wastewater penetrating from the surface significantly affect the hydrochemical composition of groundwater, impairing their quality and making it unsuitable for drinking water supply [13]

Thus, as a result of anthropogenic impact on the industrial and residential agglomerations of the city of Kursk, in particular on water resources [14-17] there was a significant violation of the natural regime of groundwater, which leads, on the one hand, to flooding of the territory, as well as to the intensification of engineering and geological processes. The latter leads to a violation of the normal regime of construction, reconstruction and operation of buildings and engineering structures, which entails the development and deepening of environmental, economic and social problems.

This is the studied section of the city of Kursk - the "Northern" district. (Figure 1) To detect flooding in the built-up area, it is necessary to perform modeling of hydrogeological and engineering-geological conditions of the area under study, the direction of the underground flow and the calculation of the filtration rate

Figure 1. Map of the "Northern" district of Kursk.

2. Geomorphological and engineering-geological conditions

Geomorphologically, the site is confined to the slope of the watershed. The relief of the site is broken. The slope of the surface is eastward. Absolute marks on the workings vary from 248.50 to 224.05. The vertical drop is more than 24m.

Consider the geological structure of the studied territory. (Figure 2). Deposits of the Santonian tier are widespread throughout the site and lie eroded on the Turonian-Cognac or Cenomanian deposits. The Santon tier is composed of yellowish and greenish-gray marls and greenish-gray tripoli. Sediments of the tertiary system are distributed mainly on the surface of the watershed. They lie eroded on chalk rocks. Of the tertiary rocks, Neogene-Paleogene deposits predominate, mainly variegated loams and less often clay. Quaternary deposits are represented by mid-upper Quaternary aeolian-deluvial loams and sandy loams of various consistencies and an undivided complex of integumentary formations of problematic genesis. The integumentary formations are represented by loess-like sandy loam (less often loamy) solid and semi-solid consistencies. Loesslike loams have subsidence properties, the thickness of subsidence from 4-7 meters.

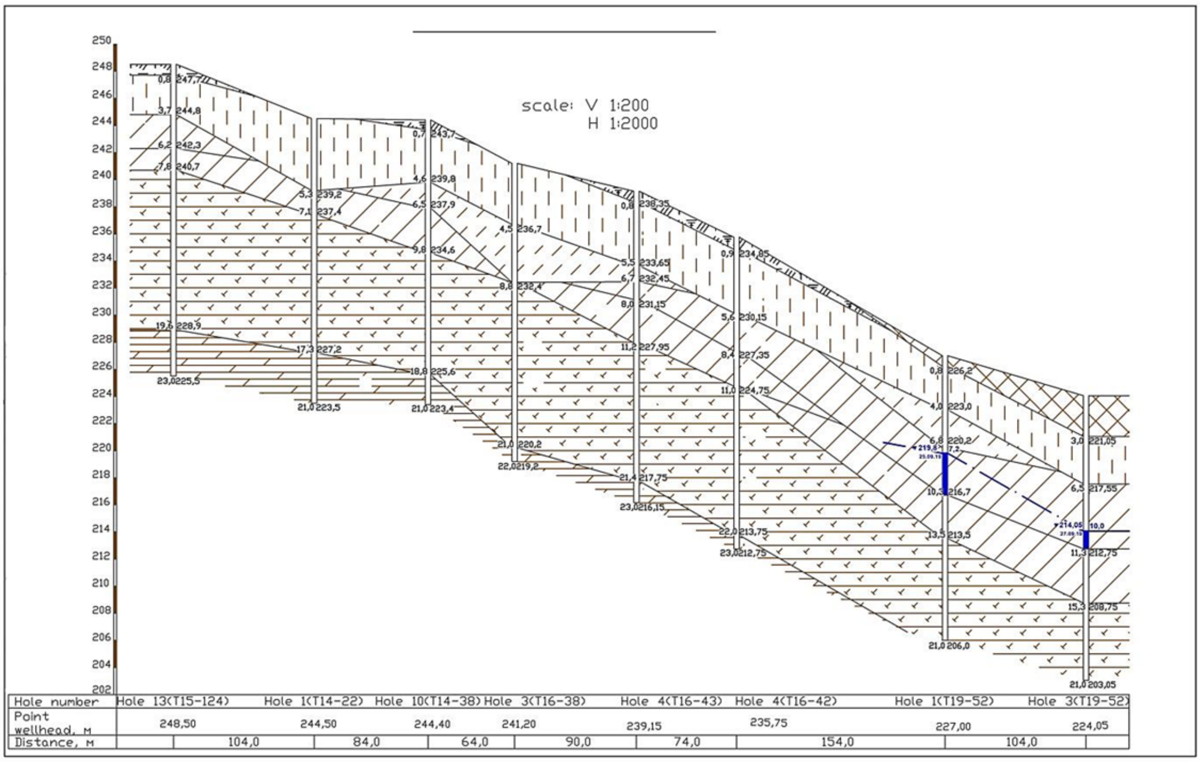

Figure 2. Geological structure of the "Northern" district.

3. Hydrogeological conditions

The construction of the "Northern" district of the city of Kursk began in 2011. Earlier in this area was an apple orchard. The first surveys were carried out for the construction of a thermal power station in 2011. Groundwater at the time of exploration to the investigated depth of 21m were not met. Next was a phased development of residential buildings. Groundwater of the type «top water» was first encountered in 2016, when surveys were conducted for building a house in microdistrict №3, having an absolute groundwater level of 224.3 m. Subsequently, groundwater was met for the survey of several residential buildings, a sports complex, as well as for the reconstruction of the thermal power station in 2019, which suggests that after the start of construction and operation of buildings and structures in the area due to leaks from water-bearing communications, conditions of surface runoff, deforestation of a garden located earlier in this territory, and other reasons, an anthropogenic aquifer of the “top water” type was formed. These waters are confined to sandy loam plastic and loamy clay loam. Solid, heavy loam, as well as Neogene-Paleogene variegated loams and clays, which are distributed mainly on the slope of the watershed, are an upholstery. Non-pressure waters, calcium bicarbonate. Their nutrition is carried out due to precipitation and leaks from water-bearing communications. After analyzing all the data of surveys and the level of groundwater in this territory, a map of hydroisogypsum was compiled (Figure 3) to determine the direction of movement of the underground stream, determine its slope, as well as the maximum and minimum filtration rates.

The construction was performed using the interpolation method, which is a method for calculating an intermediate value based on several already known values. The ArcInfo GIS provides several methods of interpolation for our case was chosen as a variation on the name Spline, since this method is best for generating gently varying surfaces.The cross-section between the hydroisogips is 1 meter. The map scale is 1:2000

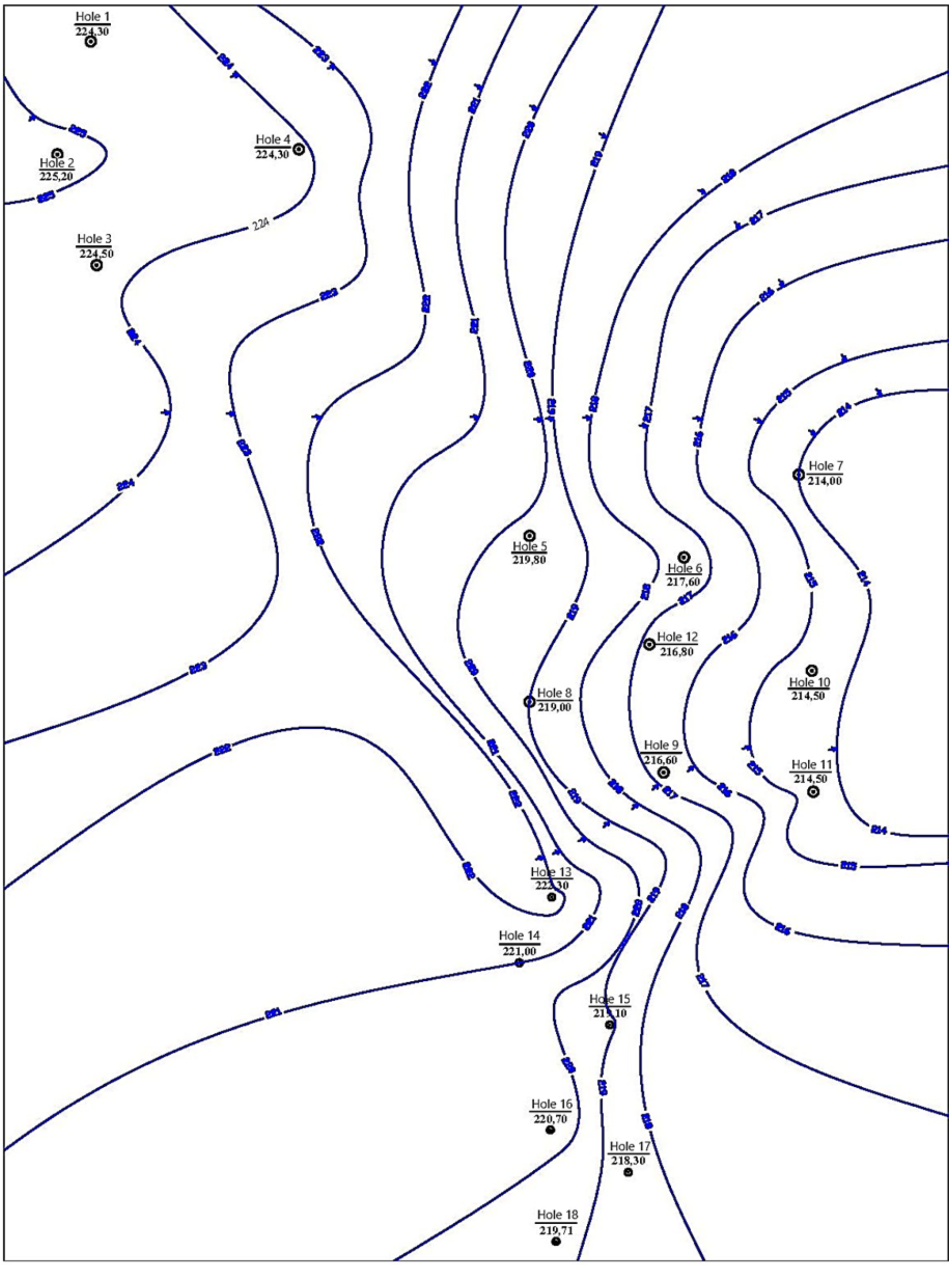

Figure 3. Map of hydroisogypsum of groundwater in the "Northern" district of the city of Kursk.

The map shows that the distribution of groundwater is radial in nature, the direction of flow is eastward towards the slope.

Calculation of the maximum and minimum slope of the soil flow:

$$j = \frac{\Delta h}{l}, \quad (1)$$

where Δh-difference in absolute marks between hydroisogypses, l-filtration path length in meters

$$j_{\max} = \frac{222 - 217}{50} = 0,1 \quad (2)$$

$$j_{\min} = \frac{224 - 222}{110} = 0,02 \quad (3)$$

Calculation of flow filtration rate:

$$V = k \times j, \quad (4)$$

where V- filtration rate, k- filtration coefficient, i- ground slope

$$V_{\max} = k \times j_{\max} = 0,23 \times 0,1 = 0,023 m/day \quad (5)$$

$$V_{\min} = k \times j_{\min} = 0,23 \times 0,02 = 0,005 m/day \quad (6)$$

4. Conclusion

After analyzing and comparing all the data of surveys and constructions, we can conclude that in the future in the studied area, an increase in the groundwater level is possible and, as a result, flooding of the built-up territory. Also, with an increase in the level of "high water", groundwater can infiltrate into mid-upper Quaternary formations, represented by loesslike sandy loams having subsidence properties, which in turn can lead to dangerous engineering and geological processes. Due to the lack of an observational regime network, it is impossible to make an accurate forecast of the maximum groundwater level. Therefore, it is necessary to develop a number of protective measures to prevent the further development of the technogenic aquifer, as well as the development of flooding and dangerous engineering and geological processes. In this area it is recommended:

1) to conduct proper organization and acceleration of runoff of surface waters; Artificially increasing the planning marks of the territory;

2) protective waterproofing device for buried structures, structures and underground utilities;

3) the construction of preventive wall, reservoir and associated drainages;

4) thorough implementation of works on the construction of water-carrying communications and their correct operation in order to prevent permanent and emergency leaks;

5) placement of parks and green spaces throughout the district

In order to monitor dangerous geological processes in the city of Kursk, it is proposed to deploy a special geodetic network on one of the slopes where multi-storey construction is planned. Near each of the points, observation wells should be equipped for monitoring ground water (level measurement, thermometry, hydrogeochemical indicators). Conducting observations on slopes should ensure the solution of the following main tasks: studying the mechanism and dynamics of the landslide process and ensuring the safety of design, construction, reconstruction and operation of real estate objects.

In this regard, the results of monitoring in conjunction with geodesic, geotechnical and hydrogeological studies will serve as the basis for the development of necessary protective measures in the study area and will allow to develop a methodological basis for transferring them to other complex areas of Kursk and other settlements with similar natural and man-made conditions.

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