Specifics of creating database of hydraulic structures of Chelyabinsk region and analyzing their condition

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Abstract. This article describes the stages of creating a database (DB) of 346 hydraulic structures (HS) of the Chelyabinsk Region, and its specifics. Based on the reports by NIEP, LLC, on the performed inventory check of the Chelyabinsk Region HS as of 2008-2016, an HS DB in the All Maps of Russia geoinformation system (GIS) was created by the authors. Also, the analysis of the location and condition of the hydraulic structures on the region’s territory was performed by the authors. The DB analysis revealed that ponds and water reservoirs are located irregularly, and many of those are in critical condition. Based on the results of the performed SWOT analysis, an alternative HS development strategy is suggested by the authors.

1. Introduction

The Chelyabinsk Region is among the most developed industrial regions of Russia. Over 150 enterprises of the Chelyabinsk Region deal with production and processing of natural raw materials. The most developed sectors are wet industries: metallurgy, mechanical engineering, agriculture, fuel and energy complex.

The uneven distribution of water resources across the region’s territory, low water level in rivers, development of industry and agriculture, and the problem with the quality of water used for water supply of the cities determine a necessity of supervision and elaboration of measures for maintaining the hydraulic structures of water reservoirs and ponds in operable condition, and for ensuring their efficiency. Controlling the condition of the mentioned facilities and their monitoring are being performed by various services and structures, which often lack interaction and information exchange. As an efficient mechanism of information support for the activity on controlling the condition water facilities and studying them, such a form of organizing heterogeneous information as a uniform database may be used.

The team of authors’ goal was to create a database of the Chelyabinsk Region HS based on the analysis of data from inspection of their condition and on data systematization. To achieve this goal, the following tasks were solved:

- collection, studying and systematization of data on the hydraulic structures of the Chelyabinsk Region;
- classification of the Chelyabinsk Region hydraulic structures based on their systematization;
• SWOT analysis of the condition of the Chelyabinsk Region hydraulic structures, and revealing the prospects of their further operation;
• analysis of the system of HS monitoring, and coming up with the recommendations on its improvement;
• analysis of the HS location across the region’s territory, and revealing the patterns of their distribution; and
• creation of a complex database on the Chelyabinsk Region HS.

As a source of information for forming of the database, the materials of inspection of the HS technical condition held by NIEP LLC in 2001-2003 were used, as well as [1], as well as the results of works on the inventory check of the HS located on the territory of the Chelyabinsk Region performed in 2008-2016 [2].

The analysis of the condition of the Chelyabinsk Region hydraulic structures was based on the creation of a map of the HS location across the region’s territory, using All Maps of Russia GIS technology. The analysis of the location of the hydraulic structures across the region’s territory (total of 346 HS) revealed that the ponds and water reservoirs are located in all districts of the Chelyabinsk Region, though there are distributed extremely unevenly.

Irregular geographical location of water reservoirs is mainly explained by the following factors:
• Differences in the territory’s needs in control of runoff for various purposes;
• Unequal degree of agricultural development and urbanization of the landscape;
• Presence of wet industries;
• Peculiarities of river runoff regime.

According to GOST 27.002-89 [3], the Chelyabinsk Region HS were divided into three classes as per their technical condition: operable; non-operable; critical. The analysis of the materials and the map created by us revealed that out of 346 hydraulic structures of the Chelyabinsk Region 45 are federal-owned, 89 are municipal property, 133 are private property, and 141 are unclaimed.

In the process of analyzing the technical condition of the HS, the structure of their danger was revealed (Figure 1).

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2. Methods
To analyze the HS condition, various methods were used: statistical, cartographical, geoinformational, SWOT analysis.

To determine the ratio among the components of SWOT (opportunities, threats, strengths and weaknesses) of the state of the HS the overall assessment of each of four SWOT parameters was calculated and compiled a generalized matrix (table the Greatest impact on the activities of the HS have its weaknesses - 26 points. "Opportunities" are represented by a total of 7.1 points. Threats are the result of weaknesses and have 12.3 points) (Table 1).
Table 1. A matrix summarizing the SWOT analysis of the HS

|                  | Threat Points (7,1) | Opportunities Points (12,3) |
|------------------|---------------------|-----------------------------|
| Strength Points  | 92,3                | 159,9                       |
| Weakness Points  | 184,6               | 319,8                       |

Multiplying the factors presented in the SWOT matrix gives us an opportunity to obtain the corresponding values in the matrix fields ("Weakness and opportunities", "Weakness and threats", "Strength and opportunities", "Strength and threats"). The largest value determines the main strategic goal, the direction of the HS in Chelyabinsk region development which is the choice of an alternative strategy for the HS development or its combination. The results of calculations showed that the largest value was determined in "Weakness and threats" cell (319.8 points). Therefore the efforts of the HS management in Chelyabinsk region should be directed to minimize weaknesses and the use of opportunities associated with environmental factors.

Thus, for the purpose of managing the state of the HS, it is necessary to implement programs to address the weaknesses of the HS. They can be achieved through a combined strategy. The choice of strategy is made from basic or alternative strategies for the development of the HS [4-8].

3. Results

Thus SWOT-analysis showed that one of the reasons of a large number of HS in the limiting state are the conditions of construction. The service life of most HS is more than 40 years. It is known that all the hydraulic structures that have been in operation for more than 25 years, regardless of their technical condition, should be periodically subjected to complex research by specialized organizations estimating their strength, stability and operational reliability [4,5].

SWOT analysis performed by the authors revealed the general situation of the HS in Chelyabinsk Region condition, and based on that, strategies of further HS development were suggested (removing Weak aspects by means of Strong points), as well as the alternative strategies using.

1. As a result of research, we conclude that it is necessary to take measures directed to check the technical condition of hydraulic structures in order to provide safety. Hydraulic structures of Chelyabinsk region have significant deterioration, the technologic equipment is often outdated. The lack of funding does not allows to keep them in good technical condition, to carry out regular preventive and major repairs. The absence of all the hydraulic structures safety declaring obligation makes impossible the technical conditions of structures constant monitoring and measures to maintain them in safe conditions developing. All of these reasons increase the risks of emergency cases in the sphere of water resources use in Chelyabinsk region recently [9-15]. This situation determines the relevance of the program to improve the monitoring of hydraulic structures of the Chelyabinsk region (Figure 2).

2. The monitoring of the HS technical condition based on DB is being performed for the purposes of: timely revealing and predicting of the development of negative processes; assessing the efficiency of the assumed measures; ensuring the HS safety; and ensuring efficient management and control [16-21].

3. Enhancing the HS safety will allow to improve the amenities for the people residing on the territory in the context of possible occurrences of emergencies during the flood period, and to prevent economical and social losses related to possible floods and underfloodings.
The complex database on HS that we created comprises four types of databases: attributive, relative, cartographic, and actual, and is structured as follows:

- Consolidated working sheet HS of the Chelyabinsk Region;
- 40 working sheets corresponding to the region’s municipalities;
- Consolidated Table on the Municipality HS; and
- Information on certain HS.

4. Findings
The information on each particular HS contains the following data: geographical location; ownership; year of commissioning; designation; class of permanence; composition of the hydroengineering complex; photographs; and classification as per technical condition.

5. Conclusion
Thus, the DB that we created has two types of application:
1. Practical: ensuring informational interaction and joint activity of services and structures controlling the condition of HS and guaranteeing their efficient operation; and
2. Methodical: using in the educational process to train on creating DB in MS Excel.

An Act of Implementation is available for the created database.

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