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АНАЛИЗ ИЗМЕНЕНИЯ ИНЖЕНЕРНО-ГЕОЛОГИЧЕСКИХ УСЛОВИЙ ТЕРРИТОРИИ ЧАРТАК С ИСПОЛЬЗОВАНИЕМ ГИС И GPS-ТЕХНОЛОГИИ

ANALYSIS OF CHANGE OF ENGINEERING-GEOLOGICAL CONDITIONS OF THE CHARTAK TERRITORY WITH USING GIS AND GPS-TECHNOLOGIES

Макалада Чартак суу сактагычы турган аймактын инженердик-геологиялык шарттарынын өзгөргөндүгүн ГИС жана GPS-технологияларын пайдалануу менен анализдөө иши каралган. Суу сактагычты курууда ошол жердин инженердик-геологиялык шартары изилденген, бул конструкциянын бышыктыгын, узакка тураарын жана курчап турган геологиялык чөйрөнүн геоэкологиялык коопсуздугун камсыз кылат. 2013-жылы жазында ГИС жана GPS-технологияласын пайдаланып изилдөөлөрдүн натыйжасы болжолдонгон эрозия менен иш жүзүндөгү эрозияны салыштырууга мүмкүнчүлүк түздү. Санариптик карталар изилденип жаткан жерлерди космостон ArcGIS комплексин колдонуу менен тартып алынган тасмалардын негизинде түзүлдү.

Ачкыч сөздөр: *сейсмология, геологиялык изилдөөлөр, гидротехникалык курулуштадын бышыктыгын жана коопсуздугун камсыздоо, ГИС, GNSS.*

В статье анализируются изменения инженерно-геологических условий территории водохранилища Чартак с использованием ГИС и GPS-технологий. Были учтены инженерно-геологические условия при выборе площадей для строительства водохранилищ, что обеспечит прочность и долговечность конструкции, а также геоэкологической безопасности окружающей геологической среды. Исследования, проведенные весной 2013 года с применением технологий ГИС и GPS позволило нам сравнить соответствия прогнозируемого определения предельных эрозий с фактическими.

Цифровые карты были построены на основе материалов космических съемок на исследуемой территории с применением комплекса ArcGIS.

Ключевые слова: *сейсмология, геологические изыскания, обеспечение сохранности и безопасности гидротехнических сооружений, ГИС, GNSS.*

This paper analyzes the changes in the engineering-geological conditions of the Chartak reservoir's territory using the GIS and GPS-technologies. Taking into account the engineering and geological conditions while choosing the areas for construction of reservoirs it is possible to provide firmness and durability of the construction, as well as geo-ecological safety of the surrounding geological environment.

The researches conducted in the spring of 2013 with application of engineering and geological route supervisions on the basis of GIS-technologies and GPS allowed us to compare whether the forecasted definition of marginal erosions corresponds with the actual one.

The digital maps were constructed and materials of space surveys on the studied territory with application of a complex of ArcGIS

The engineering-geological conditions in the selection of areas for the construction of reservoirs and their exploitation, as well as designed schematic maps of the seismic microzoning will contribute to the stability of the hydraulic structures and their durability, as well as ensuring the geo-ecological safety of the environment.

Keywords: *seismology, geologic engineering, safety of the hydro-technical structures, GIS, GNSS.*

The stability of the hydro-technical structures mainly depends on a right choice of the location and feature of engineering and seismo-geological conditions of the area for construction and character and intensity of change of these conditions in time during construction and after long operation. It is known that from the moment of carrying out field researches, in the territory chosen for design and construction occur, though insignificant, changes of a natural relief in connection with laying of temporary roads, laying of excavations, etc., and in the course of building the change of conditions become more large-scale [1]. During the period after construction, especially during long operation there is a sharp change in engineering, seismo-geological and the geo-ecological conditions in comparison with the period preceding the construction. It is caused by the fact that hydro-technical structures (HTS) represent a set of engineering constructions which ensures collecting and regulation of water resources for needs of power industry, melioration and other sectors [2,3].

Design and construction of new HTS is one of the complex challenges of engineering geology and engineering seismology in difference from design of a town-planning complex. HTS differs from constructions of objects industrial and civil engineering by its sizes (length>1km, height>50-100m, volume>50mln.m^3). Therefore, influence of the HTS on the geological environment is very important. The big geometrical size of the HTS, length of seismic waves, not synchronism of waves in the dam basis, on the boards and in the center of a reservoir are the reason of different fluctuations. So, it is an additional threat to stability of the dam and creates a danger to the environment.

While choosing a site for HTS construction along with other factors, those of engineering and geological conditions must be considered first of all. Such components of engineering-geological conditions are: land relief, features of a geological and tectonic structure, geological and lithologic structure of the area, structure, state and physical and mechanical properties of soil developed in the territory of construction, as well as the natural and engineering and geological processes and phenomena taking place on a site. Taking into account the engineering and geological conditions while choosing the areas for construction of reservoirs it is possible to provide firmness and durability of the construction, as well as geo-ecological safety of the surrounding geological environment. Such changes can be also observed on the not large reservoirs such as Chartak (with a design volume of W=50 million m^3, height H=45m). The reservoir is located in a high-seismic zone where can happen 9 points earthquakes. On the Chartak reservoir, we made comparison of engineering and seismo-geological conditions of the area of construction before and after construction for more than 40 years period of operation.

After construction of a reservoir within the studied area there were changes of the physical, mechanical and seismic properties of soil caused by flood, rise in level of underground waters and on the periphery of the reservoir basin there were marginal erosion of the reservoir. The processes of the marginal erosion of the reservoir are very strongly developed in flat territories and territories with a weak inclination and are followed by a set of slope processes and phenomena (abrasion, undermining of slopes, collapse, landslides, etc.) [2,3].

The researches are conducted in the spring of 2013 with application of engineering and geological route supervisions on the basis of GIS-technologies and GPS allowed us to compare whether the forecasted definition of marginal erosions corresponds with the actual one.

While working on a project with a view of more precise analysis of the engineering-geological conditions the IKONOS and QUICKBIRD satellite images were used in the study areas.

For the geo-referenced satellite image of the analyzed used the coordinates of reference points identified by the GPS-receiver. Totally, in the geographic location process of the space photographs, we identified more than 50 reference points in the study area potentially suitable for this work. However, in order to determine more accurately the geographical coordinates we selected more than 20 of them having the most typical direct interpretive features.

As the specific binding criteria of the satellite image we have used the elements of the landscape, very clearly fixed on it: coastlines of the basin, bends and turns the channel, bridges, peaks of heights, etc.

As indicated above, to bind the analyzed space photograph it was used more than 20 reference points whose coordinates are determined by the GPS-receiver.

Transforming and linking the satellite images are made by using ERDAS IMAGINE software complex. The results of satellite images processing with the reference points are shown in Figure 1. The processing allowed to analyze more accurately the geotechnical conditions in the study area.

Along with the complex of geological and geophysical studies it was carried out geotechnical studies and created engineering-geological basis (EGB) which is used to develop maps of seismic microzoning (SMZ).

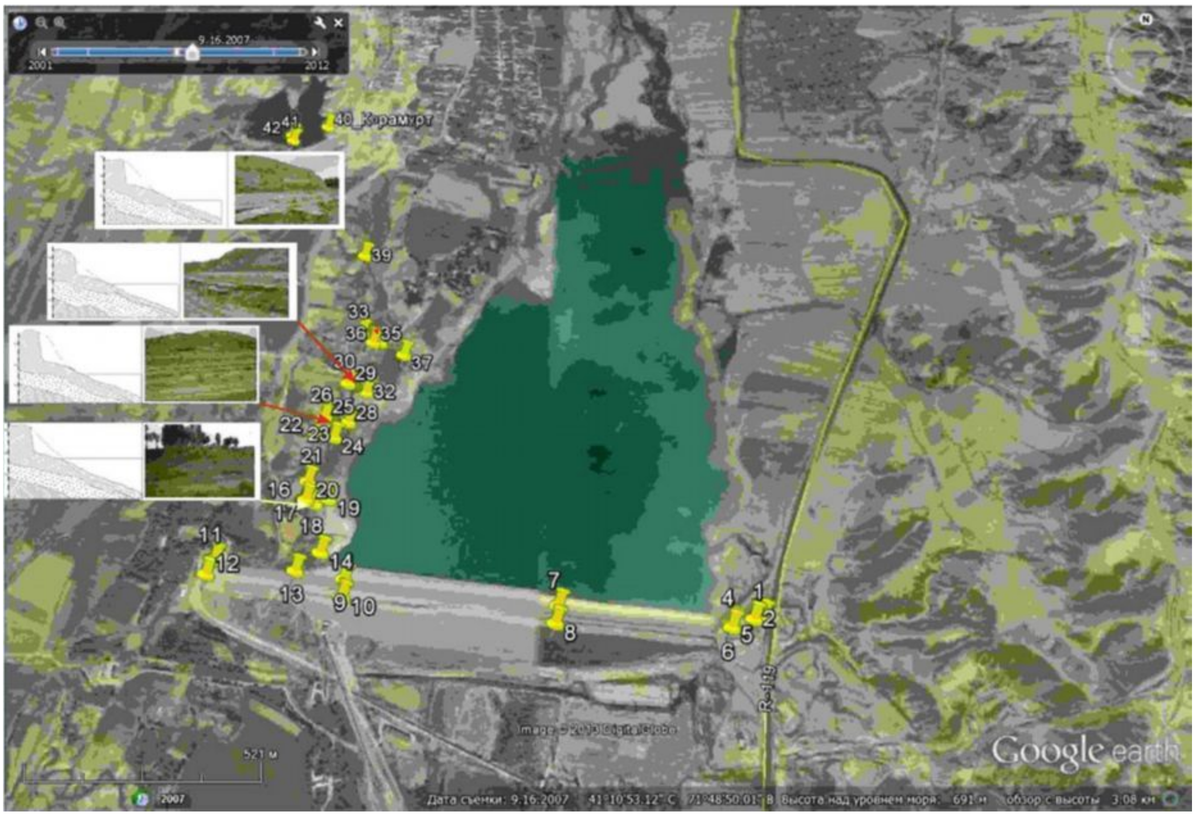

Figure 1. Satellite image of the Chartak reservoir and points of the route geotechnical observations using GPS (May 2013). 1-1÷42 - points of observation; 2-A - schematic geological section indicating element of the shores processing; 3-D - photo of location; 4- ▼ WLR - water level in reservoir.

With the increasing shortage of water resources in the region, a rational and safe operation of existing hydrological structures, both large and small, represents a particular relevance. In connection with the need in water resources for land irrigation of the Republic of Uzbekistan by the flood and storm flow control of the mountain rivers, along with the construction of large reservoirs it is designed and constructed the small ones, as Chartak reservoir (volume of 50 million m^3, dam height of 45m) and Chadak reservoir (volume 80 million m^3, dam height of 130m) in the Namangan region, located in the seismically active zones where are expected the earthquakes of 8-9 points. On the Tupolang reservoir it is realized the works to build a dam of 10m height. Increasing the height of the dam will increase the water reserves in the reservoir, and thus it will serve for addressing the issues in the region associated with irrigation. In the future, the height of the dam can be further increased.

In this regard, it should be noted a great importance of the correct assessment of the seismic hazard for the hydraulic structures and ensuring its hydro-stability. It is necessary to solve a number of problems connected with study of the seismic conditions of the construction areas in Uzbekistan.

The main task of the field observation was to assess the nature and extent of changes in these conditions and to develop on the basis of the obtained results and analysis of the studies previously conducted by various authors to construct digital maps of the engineering-geological conditions and to develop on its basis the digital maps of the seismic microzoning for the researched areas. These differences are detected well after the reconnaissance engineering-geological studies on the objects using the GNSS systems and drawing up of the relevant digital maps. Below are stated the results of these studies.

The digital maps were constructed and materials of space surveys on the studied territory with application of a complex of ArcGIS [4] (Figure 2) software products were applied. The shorelines of the reservoir are generally put by sandy and loamy soil and they are easily exposed to erosions. The supervisions show that the left shoreline is lesser subject to erosions than it was assumed, and the right shoreline, on the contrary, more than forecasted. The height of breaks on the right shoreline makes 1,5÷3м, and on the left shoreline it is very small, from 0,5 to 1,5m.

On the area of interest of the Chartak reservoir are mainly developed the sedimentary deposits which are divided into half-rock, rudaceous and coherent by its geotechnical properties.

The half-rock soils: the stone loess exposed at the bottom of the steep ravines, slopes and cliffs, often in the adyr (dissected) areas on the sides of the Chartak river valley. They occur everywhere under the quaternary deposits, age N2 - Q1.

In the dam alignment of the Chartak reservoir the stone loess is opened under the modern sediments at a depth of 10-20 m. The explored width exceeds 100 m.

By its granulometric texture the stone loess are represented by light, medium and heavy silty loams. At the same time there are considerable variations in the content of sand and clay fraction.

Figure 2 shows a schematic engineering-geological map of the Chartak reservoir developed in the ArcGIS environment based on the field observation in 2013. Figure 3 contains the explication of the map.

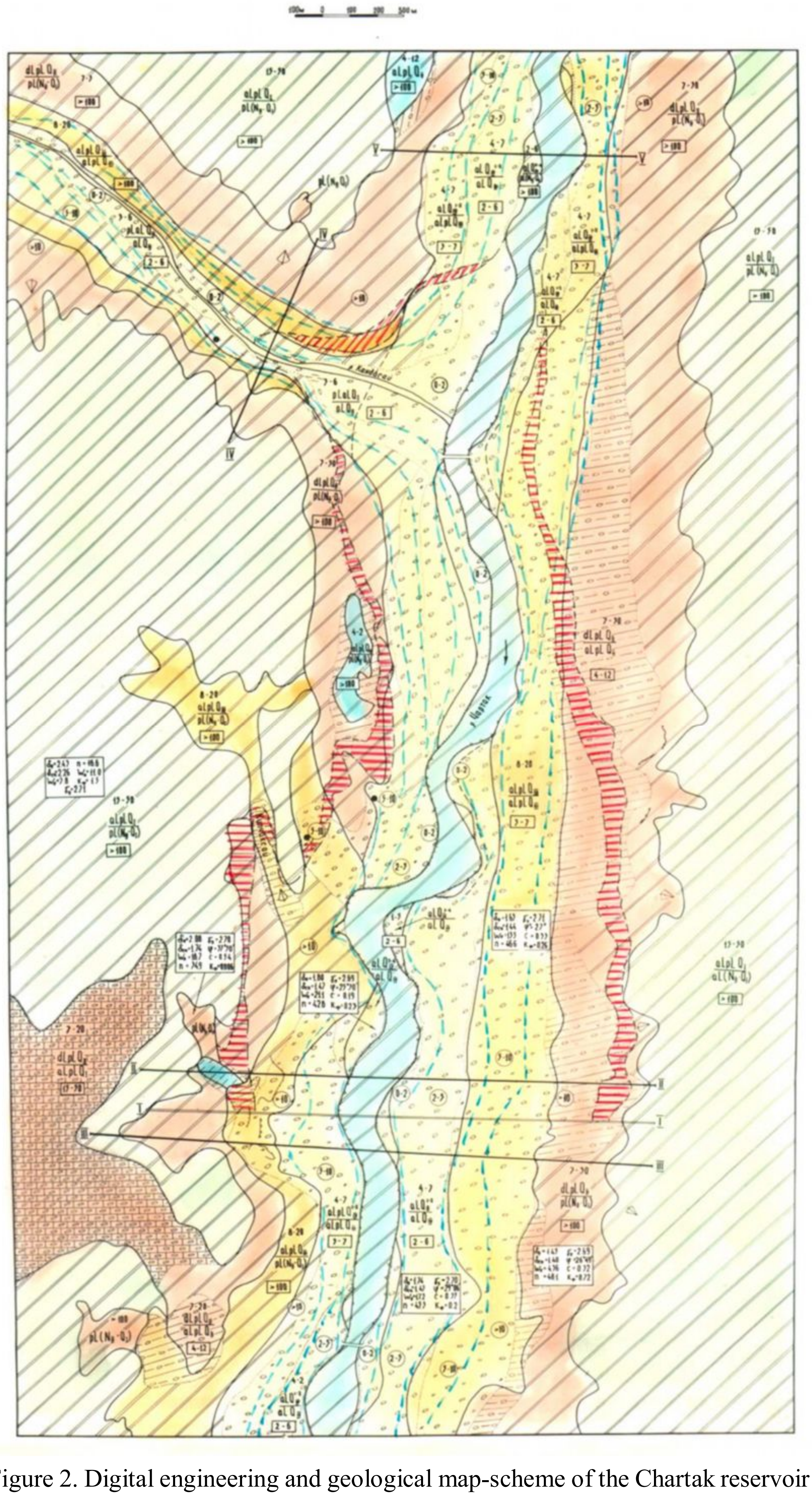

Figure 2. Digital engineering and geological map-scheme of the Chartak reservoir area

Group of soils	Geological and genetic complexes of rocks		Hydro-geological characteristics	Index and width (м)
half-rock		Stone loess	Ground waters occur at a depth of <100 m. Low-aggressive	$pl(N_{II}-Q_I)$ >100
rudaceous		Conglomerate	Mostly waterless	$alplQ_I$ 15-50
coherent		Loessial sandy loam	The groundwater level lies at a depth of 12-20 m and more. Low-aggressive	$dlplQ_{II}$ 7-30
rudaceous		Boulder-pebble deposits with sandy-loamy filler	Ground waters occur at a depth of 14-20 m and more. Low-aggressive	$alplQ_{II}$ 4-12
coherent		Loessial loam	Ground waters occur at a depth of 10-15 m and more. Low-aggressive	$alplQ_{III}$ 8-20
rudaceous		Boulder-pebble deposits with sandy-loamy filler	Ground waters occur at a depth of 8-19 m and more. Low-aggressive	$alplQ_{III}$ 3-7
coherent		Loessial loam	Ground waters occur at a depth of 5-10 m. Low-aggressive	alQ_I^{1-2} 4-7
coherent		Loessial sandy loam	Ground waters occur at a depth of 2-5 m. Non aggressive	alQ_I^{3-4} 1-5
rudaceous		Boulder-pebble deposits with sandy-loamy filler	Ground waters occur at a depth of 0-2 m. Non aggressive	alQ_{IV} 2-6

Figure 3. Legend to the conceptual engineering and geological map-scheme of the Chartak reservoir developed in the ArcGIS environment according to materials of the field observation held in 2013

The Chartak reservoir. It has a kind of geological and lithological structure, geotechnical and hydrogeological conditions. We can expect an earthquake of 9 points intensity in this area.

After the analysis of the geotechnical parameters of the soils, the original score was assigned to the middle ground loess sandy-loamy deposits III of the floodplain terraces of the Chartak river of 20m width or more, laying on the pebbles and stone loess. The level of the groundwater is below 6m.

Regarding the engineering-geological conditions it was estimated the seismic intensity increment.

The areas, where seismic intensity is taken below the initial to 1 point, take the outbreak surface of the stone loess and conglomerate with a thin cover of fine soil (up to 1.0m).

The surface territories of the I, II, III, IV terraces stacked by the rudaceous proluvial-alluvial deposits coated of the coherent - sandy loam, clay loam and alluvial rudaceous sediments with low (<6 m) level of subsoil waters, are assigned to the sites where the original point remains without change.

The central part of the Kandak valley – tributary of the Chartak river – is composed of sandy-loamy deposits with a high content of humus formation, close occurrence of the groundwater levels (<6 m) and represents the worst ground conditions.

The detailed instrumental researches for the purpose of determining and calculating the increment of the earthquakes intensity of the specific ground points supplement and clarify the values I. The figures 4 and 5 show a schematic digital map of the seismic microzoning of the Chartak reservoir area developed in 2014 according to the ArcGIS environment.

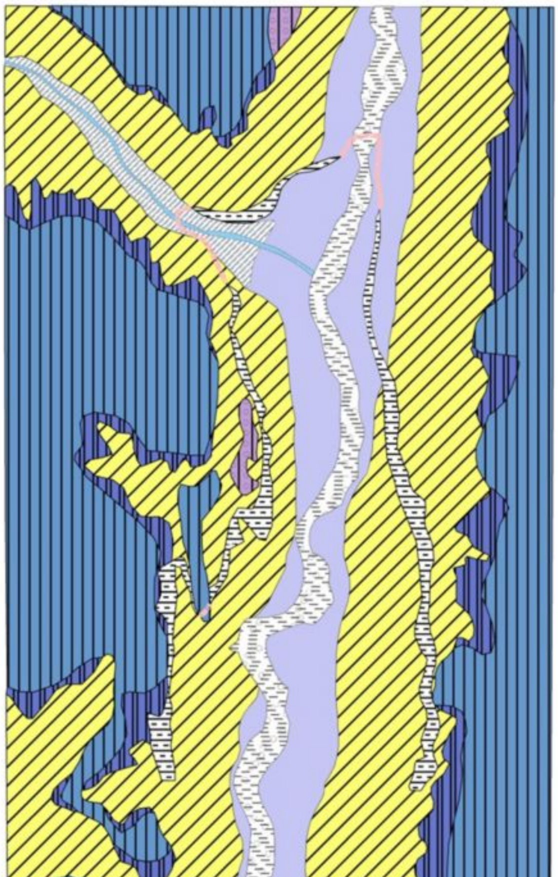

Figure 4. Digital schematic map of the seismic microzoning of the of the Chartak reservoir area developed in 2014 according to the ArcGIS environment

Group of soils	Areas of possible changes in the intensity of earthquakes					
	Reduction of the initial to “-1” point (8)		Retention of the initial point (9)		Increase of the initial to “+1” point (10)	
	more	less	more	less		
	favourable		favourable			
half-rock	conglamerate, stone loess with sloping relief	with dissected				
rudaceous		Boulder-gravel-sandy loamy filler, dry		Flooded gravel		
coherent			Sandy loam and clay loam on the stone loess, conglamerate and dry boulder-gravel	flooded gravel	sandy loam and clay loam with level of the groundwater at a depth <4m	After construction

Figure 5. Legend to the seismic microzoning of the of the Chartak reservoir area

Except these processes around the reservoir basin, it is observed a rise in level of ground waters up to a mark less 4 m in loessial soils, flood of soil lower than a dam and weak infiltration of regenerated waters. In the result of long operation of the reservoirs (more 30 years) there were marginal erosions and water inflow with high concentration of muddy materials, during leads it occurred accumulation of materials in a reservoir basin in large quantity, and the "dead-storage capacity" allocated for these cases was filled.

Besides, from the right inflow of the Chartak river, along the bed of the Karamurtsay, at water transfer (from the Karamurtsky reservoir) during leads there are erosional and suffusional processes which in turn increase drifts in the reservoir basin. It leads to reduction of net volume and to various difficulties during normal operation of the reservoir. For the purpose of increasing the net volume of the reservoir it is provided a project for accumulation of the dam height to 10m, appropriately it leads to increasing a volume and area of the reservoir basin. After raising of the dam it repeats almost the same processes which happened during construction of the reservoir and its filling of water, but in other scale. Studying of engineering and geological conditions of the area allowed us previously to allocate zones of possible marginal erosions of the reservoir after rising of water to a new mark.

On the basis of the conducted researches, it is possible to draw the following conclusions:

- period after construction and long operation of reservoirs leads to the changes of the engineering and geological conditions of the territory; these changes are generally connected with change of the water column height and volume of the reservoir: rise in level of ground waters, flooding of the area, marginal erosions of the reservoir, mud accumulation in the reservoir basin;

- comparison of the actual marginal erosions surface of the reservoir with the forecasted ones, shows us that they are in general close;

- after raising of the dam to 10m, the process of marginal erosions of the reservoir is repeated and proceeds more intensively, in comparison with the present;

- use of GPS and GIS technology allows to make quickly the necessary map and forecast maps of processes and phenomena, as well as to make monitoring of dangerous processes and phenomena in the territory of the reservoir.

All the developed cartographic materials are obtained on the basis of GIS and GNSS- technologies.

The engineering-geological conditions in the selection of areas for the construction of reservoirs and their exploitation, as well as designed schematic maps of the seismic microzoning will contribute to the stability of the hydraulic structures and their durability, as well as ensuring the geo-ecological safety of the environment.

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