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MONITORING OF COASTAL DEFORMATIONS IN THE TERRITORY OF THE NATURAL PARK «SIBERIAN RIDGES»

SUMMARY. The paper presents data on the shore deformations of the river Glubokiy Sabun from 2003 to 2011. The study produced the following figures: deformation was registered in 5 shore sections out of 6, with the highest deformation in the fifth section of the second control point — 0.5 m/year. In this regard, the average index for the site was 0.25 m/year. The overall average for 2011 equals 0.07 m/year as compared to 0.3 m/year in 2010. The results indicate a low erosive effect of the channel flow on the coastal slope in 2011.

KEY WORDS. Coastal deformations, river bed, territory of the natural park "Siberian Ridges", morphodynamics, morphometry.

The essence of the channel processes lies in the interaction of the flow and the riverbed in the transportation of the beach drift and as a result, channel deformation, which is a dynamic form of manifestation of channel processes. Each subsequent feature does not exclude the previous one, but supplements it, thus complicating the character of the river bed: interaction of the flow and the bed together with the movement of the sediment, geomorphic conditions of the channel deformation and morphodynamics of the river bed itself. Morphodynamics reflects the unity of the river bed form and the corresponding channel deformations.

Great experience in the study of the river channel deformations in the Tomsk region were gained by the employees of the departments of geography and hydrology of TSU A.A. Zemtsov and D.A. Burakov. Their studies were initiated in the late 1950s and later continued by Yu.I. Kamenskov, V.A. L'gotin, N.S. Evseeva, V.S. Khromykh, and others [1]. The papers discussing a number of studies [2-7] provide information about the types of the rivers, values of the shore erosion, analyze the factors of the channel process, and contain forecasts for the development of the shore area.

The territory of the natural park «Siberian Ridges» is quite actively involved in the modern morpholithogenesis; we observe formation and transformation of the sub-surface geological area including forms of the earth surface. Activity of exogeodynamic processes depends directly on the lithology, topography, climate and hydrological factors.

The behavior of the shore deformations in the river valley of Glubokiy Sabun is defined by its belonging to an elevated area, unclear longitudinal profile of the river in different types of Quaternary sediments. Significant influence on the yearly weather dynamics is exerted by climatic and weather conditions of specific periods.

The average annual air temperature for the park territory is — 4,18°C, while in 2010 the figure was — 5.83°C, which indicates severe climatic conditions. This figure did not exceed the level of 2006, which corresponded to -7°C. The coldest month of the years 2007-2010 was February -25.9°C. The average monthly temperature in January is -23.5°C. The greatest decrease in temperature (the absolute minimum) is -52°C (16 February 2007). The warmest month of the year is July, the average temperature of which is +18,1°C. The absolute maximum temperature is in July +33°C (08 July 2007).

Analyzing the data in Table 1, we arrive at the conclusion of the abnormality of temperature indicators in May and July 2011.

Table 1

Air temperature from 2007 to 2011

Months	Long-time average annual	2007	2008	2009	2010	2011
January	-23,5	-14,5	-24,4	-25,1	-29,9	-24,7
February	-25,9	-29,6	-14,7	-28,8	-30,7	-20,7
March	-11,2	-12,3	-8,3	-12,2	-11,8	-8,0
April	-2,6	1,7	-7,5	-1,7	-2,9	-2,6
May	3,1	2,7	4,8	2,0	2,8	7,5
June	12,2	11,7	11,5	13,3	12,2	19,3
July	18,1	19,9	18,1	19,5	14,9	13,5
August	13,1	12,5	13,5	14,9	11,4	12,2
September	6,5	5,3	8,24	7,8	4,7	-
October	-1,1	-1,3	-0,6	-3,2	0,9	-
November	-13,9	-12,5	-10,9	-19,3	-12,8	-
December	-24,9	-19,4	-19,8	-31,6	-28,8	-
Average annual	-4,18	-2,9	-2,5	-5,4	-5,8	-

The average precipitation for 2003-2010 amounted to 469 mm. Comparative analysis of the data for 2007-2010 showed that a monthly amount of precipitation is unstable and in different years can be significantly different. Maximum monthly precipitation is 100 mm, recorded in August 2010 (Table 2).

Abnormally warm temperature in late May and early June 2011 contributed to a fire in the area of the river Lippyg-Ink-Igol.

Table 2

Precipitation in mm from 2007 to 2011

Months	Long-time average annual	2007	2008	2009	2010	2011
January	17,1	40,7	9	16	3	17,7
February	22,4	18,6	36	15	20	30,4
March	32,6	25,5	58	18	29	24,0
April	19,3	17,2	29	19	12	45,0
May	35,0	44,0	32	13	51	29
June	61,6	82,8	66	38	50	71

The end of Table 2

July	46,6	8,2	46	34	55	90
August	73,2	83	54	50	100	79,2
September	56,6	61	24,95	89	83	-
October	48,5	46	72	39	37	-
November	38,8	19	79	38	38	-
December	24,2	28	40	9	20	-
Annual precipitation	480	474	546	378	498	-

Analyzing the water levels we come to the conclusion that the overall picture was shifted to the top of the year due to the early and quickly thaw which began in early April 2011. Low water level in the river during the period May-June was the result of the abnormally warm steady weather at the given period.

The study of the intensity of the deep shore transformation of the river Glubokiy Sabun was conducted in the summer periods from 2002 to 2011. During the field work we obtained results for six key areas shown in Tables 3 and 4 (Fig. 1)

Table 3

Results of the carried-out work on intensity of the shore transformation of the river Glubokiy Sabun, 2003-2011

Research time	Results received in the course of work
1	2
2003	On the local site the maximum stream bank erosion within the third key area was 1.2 m/year; with an average value on the site of 0,4 m/year. In the second key area the average value was 0.12 m/year. Overall average a year was 0.26 m/year
2004	On the local site the maximum stream bank erosion within the third key area was 0.35 m/year; with an average value on the site of 0.11 m/year. On the second site the average value was 0.13 m/year. Overall yearly average for the two sites in question was 0.12 m/year
2005	The maximum erosion is registered on the fifth site, 2.55 m/year. Data in all control points of this site showed intensive erosion of the terrace above the flood-plain at the beginning of the river bend. The average value of erosion in control points was 2.13 m/year. The third and fourth bottomland areas were characterized by low erosive activity. An exception is control point number four on the fourth site where the indicator of erosive activity was 2.15 m for 2 years. The overall average for the studied sites in 2005 was 0.4 m/year
2006	The maximum erosion is recorded on the fifth site, control point 2,0.75 m/year. The average value of erosion on all control points of the first site over the four years was 0.35 m/year. The average values of the shift of the coastal slope in 2006 for all sites are as follows: the second sire — 0.08 m/year; the third site — 0.06 m/year; the fourth site — 0.02 m/year; the fifth site — 0.56 m/year; the sixth site — 0.08 m/year; the overall average value for all sites is equal to 0.21 m/year

The end of Table 3

2007	Erosion is recorded only on the fifth and sixth sites with a maximum value on the fourth control point — 7 m for two years, which is 3.5 m/year. In this regard the average value for the site is 1.03 m/year. The overall average value for 2007 is equal to 0.18 m/year. We can speak of a low erosive impact of the stream flow on the coastal slope of the river Glubokiy Sabun
2008	Erosion was equal to 0.61 m/year on all sites, with the maximum indicator on the fifth site of the third control point — 2 m/year. In this regard the average value for the site is 1.3 m/year. In this case it is possible to claim a high erosive impact of the stream flow on the coastal slope of the river Glubokiy Sabun in 2008
2009	Erosion was recorded only on two sites — on the fifth and the sixth — with the maximum value on the fifth site of the second control point — 0.8 m/year. In this regard the average value for the site is 1.3 m/year which means reduced erosive activity in 2009. The overall average for 2009 is equal to 0.13 m/year in comparison with 0.61 m/year in 2008. The received results testify to low erosive impact of the stream flow on the coastal slope in 2009
2010	Retreat of the shore during field routes was registered on 5 key sites, however the figures were not high, and they ranged from 0.1 to 0.9 m/year. The overall average for 2010 is equal to 0.27 m/year without the key site «The mouth of the river Zhuravlinaya», and taking it into account it is 0.3 m/year
2011	For the nine years of summer studies the lowest values of deformation of the coastal line is 0.07 m/year, in this regard the overall long-term value decreased to 0.25 m/year

Nowadays areas with transitional conditions of the channel deformations (prevalence of adapted beds) and areas of bending of small rivers have been developed on the territory of the natural park.

In terms of morphodynamics wide floodplain types of channels prevail, where the bends are free, segmented flat (with longitudinal displacement), segmented steep with widespread omego-type bends (with longitudinal-lateral displacement).

Table 4

The key sites intended for studying of the intensity of coastal deformations of the river Glubokiy Sabun

1. Mouth of the river Zhuravlinaya					
Setting up time	Control point I	Control point II	Control point III	—	—
09.07.2002	10/11,8	13,2/15,7	20/20	—	—
2003, 2004, 2005	no measurements due to remoteness of the site from the places of the main stationing				
02.07.2006	9,9(**0,1**)*	11,3(**1,9**)	17,8(**2,2**)	—	—
06.08.2007	9,9	11,3	17,8	—	—
05.09.2008	9,6(**0,3**)	8,0(**3,3**)	15,0(**2,8**)	—	—

Table 4 cont.

29.07.10	9,2(**0,4**)	7,5(**0,5**)	14,8(**0,2**)	—	—
13.07.11	9,2	7,5	14,58 (**0,22**)	—	—
2. «Pervaya gorka»					
	Control point I	Control point II	Control point III	Control point IV	Control point V
12.07.02	—	—	—	12,35/9,25	13,7/15
13.11.03	—	—	—	12,2(**0,15**)	13,6(**0,1**)
01.03.05	—	—	—	12,2	13,35(**0,25**)
25.08.05	12,4	10,8	9,9	12(**0,2**)	13,2(**0,15**)
06.07.06	12,4	10,7(**0,1**)	9,8(**0,1**)	11,8(**0,2**)	13,2
07.08.07	12,4	10,7	9,8	11,8	13,2
08.09.08	12,4	10,7	9,8	11,8	12,0(**1,2**)
07.09.09	12,4	10,7	9,8	11,6(**0,2**)	12,0
01.08.10	12,4	10,7	9,8	11,6	12,0
15.08.11	12,4	10,7	9,8	11,6	10,8
3. Base «Glubokiy Sabun»					
	Control point I	Control point II	Control point III	Control point IV	Base Control point
14.07.2002	11	8,3	13,5	9,3	—
13.11.03	9,8(**1,2**)	8,3	13,1(**0,4**)	9,3	—
01.03.05	9,8	8,3	12,75(**0,35**)	9,2(**0,1**)	—
27.08.05	9,8	7,9(**0,4**)	12,75	9,2	12,4
08.07.06	9,8	7,9	12,75	8,9(**0,3**)	12,4
08.08.07	9,8	7,9	12,75	8,9	12,4
08.09.08	9,6(**0,2**)	7,85(**0,05**)	12,75	8,9	12,4
07.09.09	9,6	7,85	12,75	8,9	12,4
03.08.10	9,6	7,65(**0,2**)	12,75	8,9	12,4
16.08.11	9,6	7,57 (**0,08**)	12,75	8,9	12,4
4. The first bend before base "Brusovaya"					
	Control point I	Control point II	Control point III	Control point IV	Base Control point
10.07.03	8,3/9,5	6,4/5,35	7,3/9,4	8,55/8,15	10,7/7,85
01.09.05	7,85(**0,45**)	5,9(**0,5**)	7,3	6,4(**2,15**)	9,8(**0,9**)
10.07.06	7,85	5,9	7,3	6,4	9,7(**0,1**)
10.08.07	7,40	5,9	7,3	6,4	9,7
11.09.08	6,30(**1,1**)	5,8(**0,1**)	7,0(**0,3**)	6,2(**0,2**)	9,7
05.09.09	6,30	5,8	7,0	6,2	9,6(**0,1**)
06.08.10	5,4(**0,9**)	5,8	7,0	6,2	9,6
20.08.11	5,33(**0,07**)	5,65(**0,15**)	7,0	6,2	9,6
5. Base "Brusovaya"					
	Control point I	Control point II	Control point III	Control point IV	—
11.07.03	10	10	10	—	—
02.09.05	7,45(**2,55**)	8,55(**1,45**)	7,6(**2,4**)	9,4	—

The end of Table 4

10.07.06	6,8(**0,65**)	7,8(**0,75**)	7,3(**0,3**)	—	—
10.08.07	6,8	7,5(**0,2**)	6,9(**0,4**)	2,4(**7,0**)	—
11.09.08	5,2(**1,6**)	6,3(**1,2**)	4,9(**2,0**)	2,0(**0,4**)	—
05.09.09	4,7(**0,5**)	5,5 (**0,8**)	4,5(**0,4**)	2,0	—
06.08.10	4,5(**0,2**)	5,4(**0,1**)	4,3(**0,2**)	2,0	
20.08.11	4,3(**0,2**)	4,9(**0,5**)	4,0(**0,3**)	2,0	
6. The bend lower than Base "Brusovaya"					
	Control point I	Control point II	Control point III	Control point IV	—
12.07.03	9,7/9,3	9,15/12,7	4,5/11,5	9,2/15,5	—
3.09.05	9,3(**0,4**)	8,2(**0,95**)	4(**0,5**)	8,6(**0,6**)	—
10.07.06	9,2(**0,1**)	8,0(**0,2**)	4,0	8,6	—
11.08.07	9,1(**0,1**)	7,9(**0,1**)	4,0	8,6	—
12.09.08	9,1	7,3(**0,6**)	4,0	8,0(**0,6**)	—
05.09.09	9,0 (**0,1**)	6,8 (**0,5**)	3,9 (**0,1**)	7,8 (**0,2**)	—
07.08.10	8,9 (**0,1**)	6,8	3,7(**0,2**)	7,8	
21.08.11	8,8 (**0,1**)	6,7(**0,1**)	3,6 (**0,1**)	7,8	

Note: in brackets are values of the shore retreat, m/year.

The average value for the coastal line transformation for 9 years was changing as follows: 2003 — 0.26 m/year; 2004 — 0.12 m/year; 2005 — 0.40 m/year; 2006 — 0.21 m/year; 2007 — 0.18 m/year; 2008 — 0.61 m/year; 2009 — 0.13 m/year; 2010 — 0.3 m/year (with the key area of «Mouth of the River Zhuravlinaya»); 2011 — 0.07 m/year. The overall average for 9 years of observations is 0.28 m/year (Fig. 1).

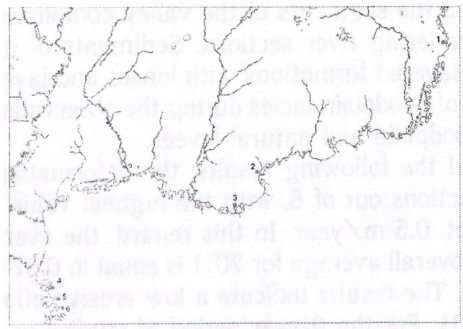

Fig. 1. Key areas of the coastal deformations of the River Glubokiy Sabun (1 — the mouth of the river Zhuravlinaya, 2 — «Pervaya gorka», 3 — base «Glubokiy Sabun», 4 — the first bend before the base «Brusovaya», 5 — base «Brusovaya», 6 — the bend after the base «Brusovaya»)

The results indicate low erosive effect of the channel flow on the coastal slopes of the river Glubokiy Sabun in 2009 and 2011.

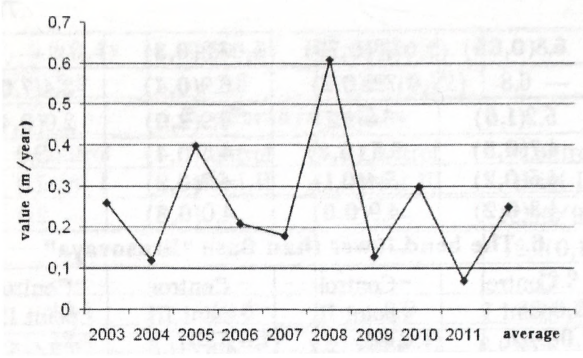

Fig. 2. Average annual value of the coastal deformations of the River Glubokiy Sabun

The nature, intensity and speed of the erosion damage largely depend on the composition and the current state of the rock, which is defined both by the degree of its lithification and the phase composition of water in it. Coasts composed of melt sand and sandy loam are most rapidly destroyed. Coasts, formed by various dispersion loams, erode to a lesser extent. Holocene loamy formations are eroded more rapidly than the upper clayey rocks of the same origin. coasts composed of the middle Quaternary moraine loams within the valley of Glubokiy Sabun, especially in the areas where the lower part of the slope is lined with coarse material, are eroded even at a lower rate. Turfs have a relatively high resistance to erosion.

Accumulative fluvial activity of exogenous type of the transformation depends on the depth and lateral erosion as well as the duration of flooding during spring and summer. In all the river valleys of the studied area we observe an active accumulation of riverbed, flood plain and old river bed facies of alluvium. The first of them is formed by all the segments of the valley complexes, but the most active of formation is in meandering river sections. Sediments of oxbow lakes are finely dispersed, horizontally layered formations with lenses and layers of peat and alluvial detritus. Accumulation of floodplain facies during the observation period was recorded within the low-level floodplain and natural levees.

The study produced the following results: the deformation of the coastal slope is recorded on the 5 sections out of 6, with the highest value in the fifth section of the second control point, 0.5 m/year. In this regard, the average for the site value was 0.25 m/year. The overall average for 2011 is equal to 0.07 m/year, as compared to 0.3 m/year in 2010. The results indicate a low erosive effect of channel flow on the coastal slope in 2011. For the 9-year period of studies in 2011 we received the lowest deformation of coastal line, 0.07 m/year, in connection with this the overall long-term average went down to 0.25 m/year. Such figures in 2011 are related to the abnormally low level of water in May and June, which was due to the temperature readings of the season.

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