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Contains

Introduction

In frame of the development, construction and operation of the 108 MW Dariali HPP (further the "Project"), the ESIA aimed at conserving aquatic biodiversity, a robust understanding of the baseline conditions of the reach of the Tergi River where the Project is to be implemented is required. To achieve this, the Aquatic Survey and Monitoring Program was developed by the Blue Rivers™ Environmental Consulting experts.

This report presents the results of the implementation of the Program for 2015, aimed first of all at identification of baseline conditions. It consisted of two sub-tasks:

- Ecological monitoring,
- Flow and physical habitat monitoring.

These results will be used for the development of the Adaptive Management Plan, including its redefining for the post-construction monitoring, including fish pass monitoring.

Executive summary

The report presents the results of the implementation of Aquatic Survey and Monitoring Program for 2015. It consisted of two main components: ecological monitoring and flow and physical habitat monitoring. The main goal of the surveys were to establish baseline conditions for Tergi prior Dariali HPP commencement,

The area of the survey was mainly focused on the possibly affected reach (Tergi from downstream the Dariali headworks till the outlet of diversion section). In the same time in order to identify main habitats for the brown trout, the larger area, including upper reaches of Tergi, its main tributaries were studied.

The results showed:

- There is only one fish specie living in Tergi and some of its tributaries – brown trout.

- Brown trout was fixed at Tergi from upper reaches (Trusso gorge) downstream till the Larsi headworks, using it mainly as a migration route, but not for spawning. Out of the tributaries, the suitable for the trout habitats were found in Sno downstream the Juta village and its tributaries and Tibaitskali.

- The main spawning places for the brown trout in upper part of the Tergi basin are the Sno River with its tributaries. There the biggest number of juvenile fish and spawning redds were fixed. Besides, spawning redds were fixed in upper Tergi (upstream Kobi) and Tibaitskali.

- There are big variety of river channel types, in-stream features (substrates, bed elements and flow types) and sediments types at Tergi.

The obtained monitoring data will be further compared with the conditions after the Dariali HPP commencement to define its impact and develop relevant mitigation measures.

1. Aims and tasks of the Program

The aim of the Aquatic Survey and Monitoring Program, developed for 2015 is identification of the baseline conditions, including multi-season, pre-commissioning monitoring of the flow conditions, fish presence (constituting a full fish survey) and habitat mapping at locations upstream and downstream of the Dariali headworks, to develop an initial mitigation strategy.

The tasks of the Program are

1. Identification of the fish species composition and abundance during all fish life cycle (spawning, fattening, migration etc.),
2. Identification of the invertebrates composition,
3. Identification and mapping of fish habitats,
4. Hydromorphological and hydrological assessments of baseline (pre-commissioning) conditions of Tergi and its tributaries,
5. Assessment of multi-season monitoring data on the flow conditions in Tergi,
6. Defining the monitoring stations for the post-commissioning period.

2. Ecological monitoring

Ecological monitoring consists of two components:

- Fish species composition and abundance survey,
- Aquatic invertebrates' composition and abundance survey (mainly as a source of food for fish).

The only fish specie found was **brown trout** *(Salmo trutta m. fario)*. It was studied during the multi-season survey covering key life cycle events: fry emergence, juvenile/adult feeding, migration and spawning periods. The morphometric characteristics of the brown trout needed for development of the recommendations for further post-commissioning monitoring and optimization of the fish pass operation were identified (see chapter 2.2.).

The fish quantity was represented as catch per unitary efforts (CPUE). In order to achieve statistically significant results, statistically significant number of the standardized catches (calculated as **n** using methods of variation statistics) taking into account the state and behaviour of the fish, weather conditions, time of the day and catching efficiency of the devices. To catch adult fish the following devices were used: box traps, casting net, fishing rods, trotlines and seine netting. The juvenile trout was caught using seine/landing nets, drift traps and cone nets.

Aquatic invertebrates' samples were taken and food basis for fish was defined. During the invertebrates samples EU standard methods (EN ISO 5667-3, ISO 7828, EN ISO 8689), developed for mountaineer rivers, method „kick and sweep" (Schmidt–Kloiber, 2006) were used. Homogeneities were identified using the EU scheme „AQEM/STAR". Upstream the Dariali headworks, collection of drifting macroinvertebrates was done 1 day (24 hours with interval) during each season. Identification of the invertebrates was done in the laboratory of Institute of Hydrobiology of National Academy of Sciences of Ukraine.

For assessment of biological quality elements (including aquatic flora, benthic invertebrates and fish fauna as requested by EU Water Framework Directive) the relevant Field protocols were filled out. The results for three seasons generalised are presented in the Annex 1. Separately juvenile amphibians and insects' imago were collected.

2.1 Number of field surveys and monitoring stations

During 2015, ***three ecological field surveys*** were conducted: in spring (26.03-05.04), in summer (26.07-07.08) and autumn (29.10-08.11). Following preliminary monitoring station (further - M) network and possible surveys units (further – SU), identified in the report "Aquatic Survey and Monitoring Programme" (see Table 1 and Figures 1 and 2), the homogeneous sites at Tergi and its tributaries, including their riparian zones, were identified and studied in order to serve as baseline (reference) for post-commission monitoring.

Table 1. List of the survey units and monitoring stations of ecological monitoring

Location	Number
Tergi - near Kobi village	SU 1
Tergi - upstream Sno	SU 2a
Sno - mouth	SU 2b
Tergi - downstream of Sno	SU 2c
Tergi - upstream the Dariali headwork	M 3
Tergi - directly downstream the Dariali headwork	M 5a
Tergi - downstream the Dariali headwork (boulder rapid section)	M 5b
Tergi - downstream the Dariali headwork (braided section)	M 6
Tergi - downstream the Dariali headwork (single thread section)	M 7
Tergi - upstream the Larsi headworks	M 8a
Tergi - downstream the Larsi headworks	M 8b
Sno – upper reaches	SU 9
Bashi	SU 10
Amali – upper reaches	SU 11a
Amali– mouth	SU 11b
Tibaitskali - upper reaches	SU 12a
Tibaitskali – mouth	SU 12b
Chkheri - upper reaches	SU 13
Chkheri river – mouth	M 4
Tergi river – upper reaches	SU 14
Kuro river – mouth	SU 15

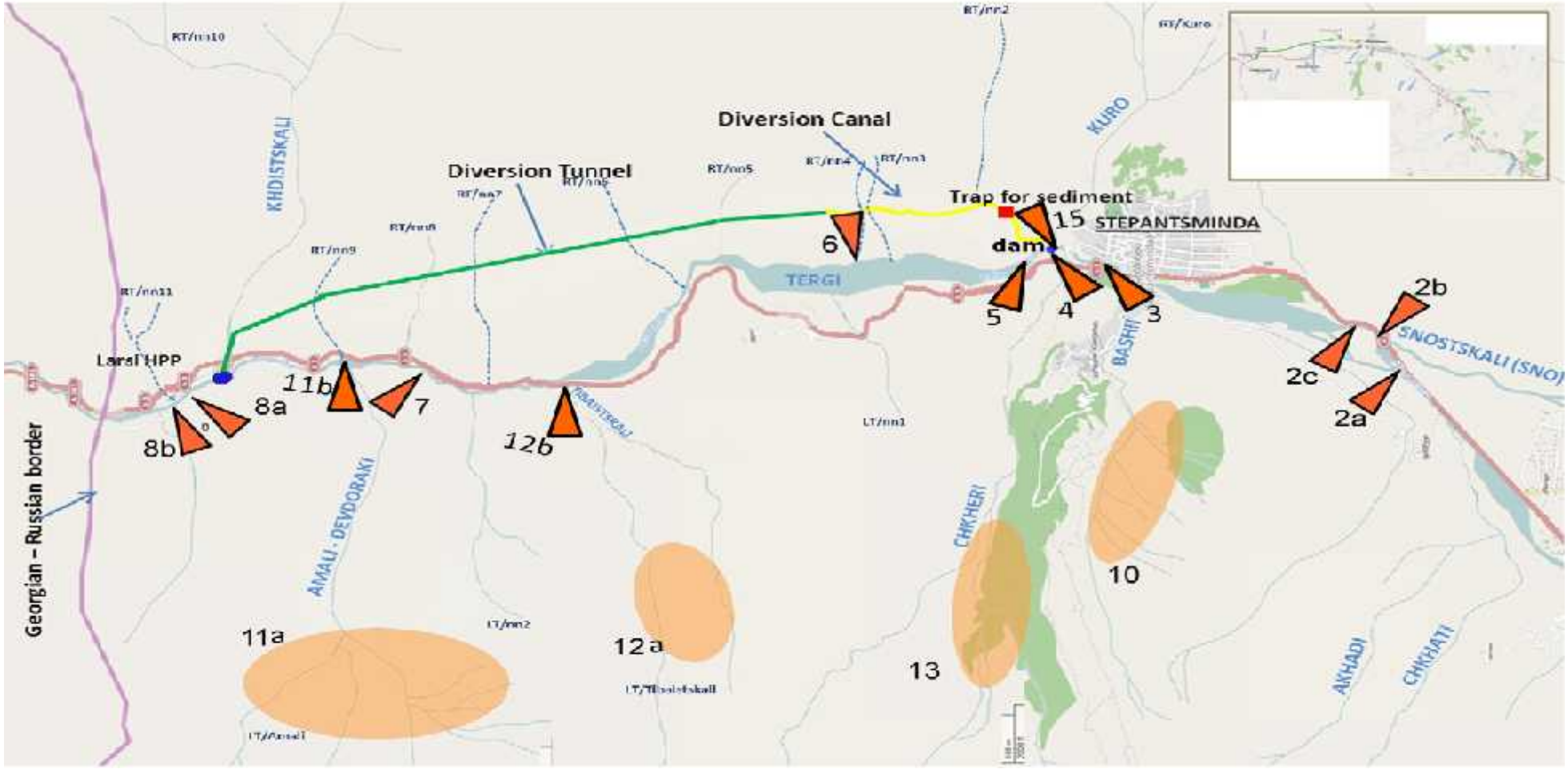


Figure 1. Monitoring station network and survey units (localities) of ecological monitoring (part 1)

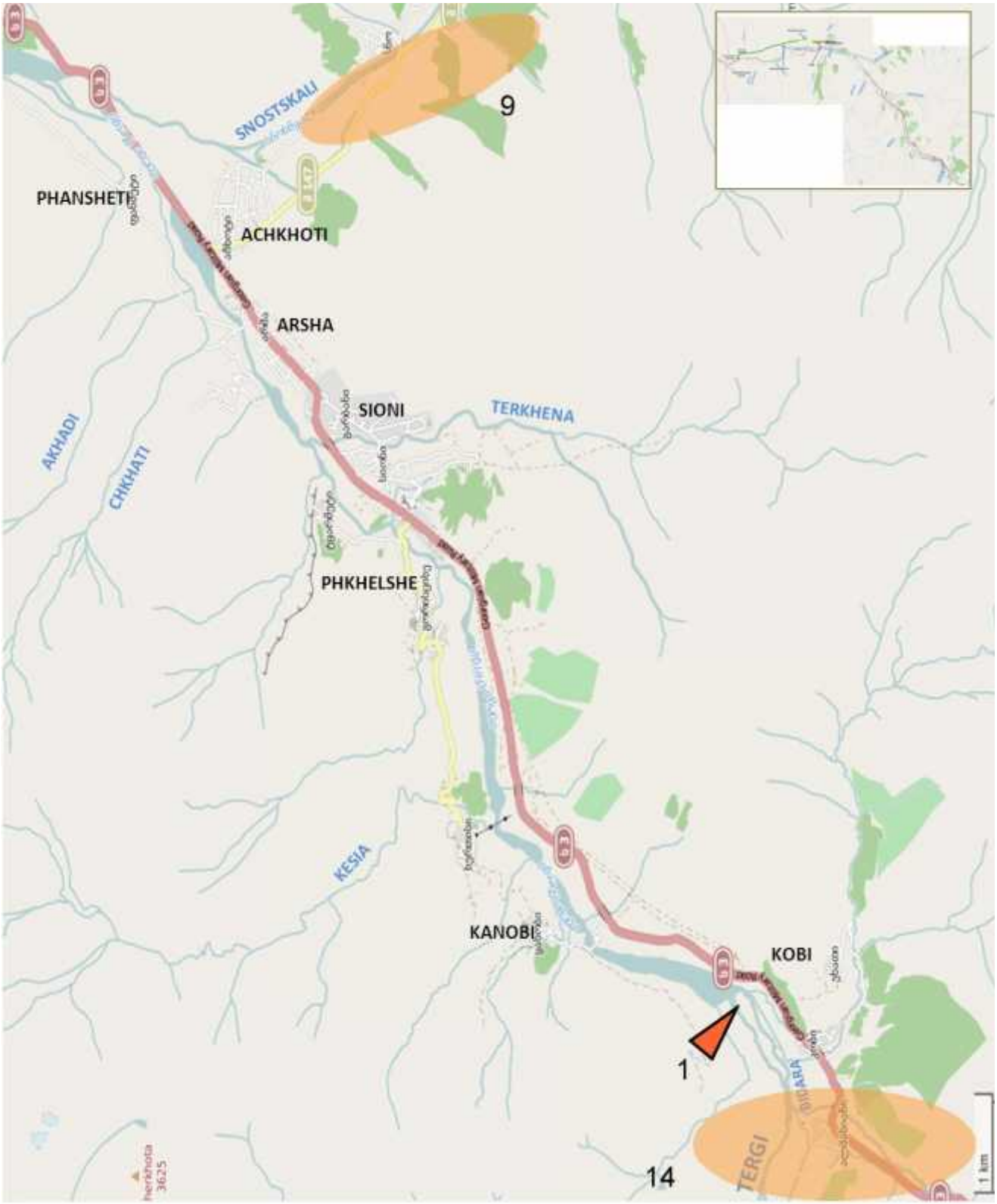


Figure 2. Monitoring station network and survey units (localities) of ecological monitoring (part 2)

During *the first field survey* in March-April, the ecological monitoring was carried out at all monitoring stations and survey units. In total 214 catches by fly fishing rod, 75 catches by ichthyologic sweep net, 2 placements of the fishing baskets and 24 catches by cone net with exposition from 5 min to 24 hours were done. Two samples of adult fish (caught by fly-fishing net) were delivered to Kyiv to laboratory.

During *the second field survey* in July-August, the ecological monitoring was carried out at all monitoring stations and survey units, except Amali (SU 11a and M 11b) and Chkheri (SU 13 and M 4) because of high water velocity and water turbulence. In the same time, in order to check the hypothesis that the most of the trout population is fattening in tributaries and sites of Tergi without significant ice summer flood, the extensive catches were conducted in Trusso gorge (SU 14) and upper Sno (near Juta village, near Artmoskali river and in Artmoskali itself 2 km upstream the Akhaltsikhe village (SU 9)). In total 387 catches of fly fishing rod, 56 catches by ichthyologic sweep net, 18 placements of fishing baskets were done. In total, 65 specimens of adult fish and 82 specimens of juvenile fish were caught.

During *the third field survey* in October – November, the ecological monitoring was carried out at all monitoring stations and survey units, except Amali (SU 11a and M 11b) because of no safe access to the river. In the same time, in order to check the hypothesis that the most of the trout redds are located in the upper tributaries and upper part of Tergi, the extensive catches were conducted in Trusso gorge (SU 14) and upper Sno (near Juta village, near Artmoskali river and in Artmoskali itself (SU 9)). In total 538 catches of fly fishing rod, 75 catches by ichthyologic sweep net, and 2 placements of fishing basket were done. In total, 76 specimens of adult fish and 56 specimens of juvenile fish were caught. Out of that 31 hurt specimen were dissected in order to study contain of their stomachs.

Below the general description of all monitoring points and survey units is provided based on the information collected during all research seasons (See Annex 2 for hydrobiological protocols for more details). For general picture of Tergi and its tributaries, the information is presented from upstream to downstream of Tergi and further by main tributaries.

Tergi

Tergi – upper reaches (SU 14)

Figure 3. Tergi, upper reaches

The river in Trusso gorge had wide braided channel which further conjunction into single threat (see Figure 3). The sediments were represented mainly by boulders, pebble, cobble and gravel. The right bank was flat with wide floodplain; the left bank was steep. The width of some arms varied from 3 to 7-10 m, in the place of their conjunction – up to 50 m; the width of floodplain was up to 200-250 m. The depths varied from 5-10 cm at steps and up to 70-80 cm at pools at braided section; up to 90-100 cm and flow velocity 0,5 - 2 m/s at single threat section.

There were many mineral sources. In the floodplain, many cattle were grazed in summer – autumn period. Vascular plants were represented mainly by riparian meadow forms with some low bushes. There were a few stones overgrown by moss, out of lower plants - 5-7% filamentous alga and some *Hydrurus foetidus*. Significant diversity of macroinvetebrates with domination of the imago and nymphs of secondary water insects was observed. Ichthyofauna was represented by the brown trout of different ages.

Tergi - near Kobi village (SU 1)

Figure 4. Tergi near Kobi village

Survey unit №1 was characterized by the widen floodplain up to 100 m (Figure 4). It had steep left bank and right more flat one along the road; the width of the riverbed is 50-70 m; depths varied between 0,15-1,5 m. Flow velocity was 0,11-1,55 м/с. There was extensive cattle breeding during spring and autumn. The riverbed was formed by boulders, different sizes stones, gravel with some small factions.

The floodplain was mostly overgrown by meadow plants, out of water forms there were only few mosses and filamentous alga at hard substrates; in spring period there were many of

Hydrurus foetidus. The invertebrates' communities had high species diversity and abundance of amphibians and only few *Oligochaeta*, and imago of *Coleoptera*. Ichthyofauna was represented by the brown trout of different ages.

Tergi - upstream the Sno river, Sno river (mouth) and downstream of the Sno river (SU 2a, SU 2b, SU 2c)

Figure 5. Tergi upstream Sno

Survey unit №2 was made of few boulders, different sizes of stones, some gravel with smaller fraction (Figure 5). The unit had flat left bank with widen floodplain up to 50 m and steep right bank along the road with the riverbed width 25-30 m. The depths varied between 20 cm to 1,2 m with flow velocity at thalweg up to 1,5 m/s. Vascular plants were presented by floodplain vegetation with a lot of sea-buckthorn.

Water plants were represented by few mosses overgrowing the stones, out of from lower plants there were *Hydrurus foetidus*. The invertebrates' communities had high species diversity and abundance of amphibians and only few *Oligochaeta*, and imago of *Coleoptera*. Ichthyofauna was represented by the brown trout of different ages.

Tergi - upstream the Dariali headwork (M 3)

Figure 6. Tergi upstream Dariali headworks

M 3 (Figure 6) has flat left bank and steep right bank. For hydrological and hydromorphological description see Chapter 3.2. The riparian vegetation was presented by meadow plants, overgrown by sea-buckthorn. Water plants were represented by few mosses overgrowing the stones, out of from lower plants there were *Hydrurus foetidus*.

The invertebrates' communities had high species diversity and abundance of amphibians and only few *Oligochaeta*, and imago of *Coleoptera*. Ichthyofauna was represented by the brown trout.

Tergi - downstream the Dariali headwork (boulder rapid section) (M 5)

Figure 7. Tergi, downstream the Dariali headwork (boulder rapid section) (M 5b)

The monitoring station is represented mainly by boulders (Figure 7). The station included the two parts: M 5a, directly after the Dariali headworks, where the influence of the construction works is observed, and M 5b after the construction bridge (for hydrological and hydromorphological description see Chapter 3.2). The riparian plants were represented by sea-buckthorn, barberries and dog rose.

Invertebrates' communities are underdeveloped with domination of *Chironomidae,* but there were *Hydrurus foetidus,* actively developing in autumn-spring. It shows instable environmental conditions at this station because of construction. No trout was caught here (because of hard conditions for its catching).

Tergi - downstream the Dariali headwork (braided section) (M 6)

Figure 8. Tergi, downstream the Dariali headwork (braided section)

Downstream Tergi got braided with the width of the floodplain up to 50 m, and sometimes up to 120 m (Figure 8). The width of some arms varied from 5-10 m to 20-25 m in the places of conjunction. The river depths varied between 10-40 cm in riparian zone up to 130 cm at thalweg with turbulent flow with velocity up to 2,15 m/s. Riparian plants are presented by sea-buckthorn, barberries and dog rose. The water plants were represented by few mosses (*Fontinalis sp.)*.

In spring, one can see up to 20%, sometimes 30% of *Hydrurus foetidus* at water's edge. Here the diversity and abundance of invertebrates got increased comparing with M 5, which shows the improvement of ecological conditions. Several brown trouts were caught at this station.

Tergi - downstream the Dariali headwork (single thread section) (M 7)

Figure 9. Tergi, downstream the Dariali headwork (single thread section)

Further downstream the river valley got narrowed and created singly threat section (Figure 9), where the right bank is more flat and left one is more abrupt. The riverbed was formed by stones of the size 2-60 cm. The width of the riverbed was up to 25 m; width of the floodplain was up 45 m, flow velocity varied between 0,5 - 1,98 m/s. Vegetation here is presented only by riparian meadow plants, out of microalgae there are colonies of *Hydrurus foetidus*.

Invertebrates are presented by *Plecoptera, Ephemeroptera, Trichoptera*, dipteran, *Gammaridae* and *Oligochaeta*. Ichthyofauna was represented by the brown trout of different ages.

Tergi - upstream the Larsi headworks (M 8a)

Figure 10. Tergi, upstream Larsi dam

This monitoring station had abrupt riparian line with the riverbed's width 12-18 m and depth's variation from 20 - 30 cm up to 1,5 m (Figure 10). The flow velocity was 0,75 –2,2 m/s. The riverbed was formed mainly from the stones of different sizes. It is worth to mention that right side is modified because of the work of heavy machinery. It is proved by the absence of riparian plants; out of macroalgea there are only a few colonies of *Hydrurus foetidus*.

Communities of invertebrates are characterized by reduction of abundance and species diversity with domination of the forms with short life cycle.

Tergi - downstream Larsi headworks (M 8b)

Figure 11. Tergi – downstream Larsi headworks

The river had abrupt bank line with the width of the riverbed 12 m and depths up to 0,7 m and flow velocity reduction till 0,25–1,2 m/s (Figure 11). The riverbed was formed mainly by stones of different sizes; the riparian vegetation is underdeveloped; out of macroalgea there were only few colonies of *Hydrurus foetidus* and filamentous alga..

Invertebrates' communities were characterized by low abundance and insignificant species diversity with domination of imago of *Chironomidae* and *Oligochaeta* with short life cycle. No trout was caught here

Tergi's tributaries

Rivers with mainly groundwater feeding

Sno River – upper reaches (SU 9)

Figure 12. Sno river – upper reaches

The survey unit start from the Juta village, where the waterfalls of the height up to 1,2-2 m, create natural barriers for upstream trout migration. Further downstream the Sno river flows in the single threat riverbed in narrow gorge with significant inclination and many deepenings favourable for trout and with hard access for human. After the river enters the plateau it has narrow floodplain up to 20 m with quite flat riparian line with significantly meandering riverbed (Figure 12).

The riverbed width varied between 2 and 5 m with small depths 10-60 cm; flow velocity varied between 0,36 up to 1 m/s. The riverbed was mainly made of stones of different sizes, gravel and insignificant number of sand and fallen leaves. Vascular plants were represented only by riparian-meadow plants with some bushes in riparian zone; in the riverbed there were up to

10% of moss. Lower plants were represented some colonies of *Hydrurus foetidus* and filamentous alga. Invertebrates were quite diverse. Ichthyofauna was represented by the brown trout of different ages, in summer a lot of juvenile fish and in autumn spawning migrating trouts.

Sno river - mouth (SU 2b)

Figure 12. Sno river – mouth

The SU had widen floodplain up to 50 m; the right bank was sharply abrupt, the left one was more flat along the road; the width of the riverbed was 12-15 m; the depths varied between 0,10 - 1,2 m, with average flow velocity 0,16-1,25 m/s (Figure 13). The left side of the floodplain was used for cattle breeding in the spring-summer period. The riverbed was made of small boulders, stones of different sizes, gravel with some smaller fractions and silt.

The floodplain was overgrown by riparian-meadow plans and bushes of sea-buckthorn and dog rose; water plants at hard substrates were represented by few mosses; lower plants were presented by *Hydrurus foetidus* and filamentous alga; in lateral tributaries there were *Batrachium* and *Callitriche* as well as *Fontinalis*. Invertebrates' communities had high abundance as well as species diversity of amphibiotic insects and small number of *Oligochaeta*, imago of *Coleoptera.* Ichthyofauna was represented by the brown trout of different ages, in summer a lot of juvenile fish and in autumn spawning migrating trouts.

Bashi River (SU 10)

Figure 13. Bashi river

The SU had mainly narrow floodplain with width up to 15 m; the width of the riverbed was between 0,8 – 7 m (Figure 13). The flow velocity was 0,2-0,8 m/s. The riverbed was formed by stns of different sizes, gravel with smaller fractions. Vascular plants were represented by riparian-meadow vegetation with bushes; there were *Fontinalis sp*. in the riverbed. Macroinvertebrates were not abundant, but had high taxonomic diversity of secondary water insects.

Kuro River (SU 15)

The riverbed was made of mainly small-size stones and pebble with a lot of smaller fractions. The river flew in narrow floodplain with numerous mudflows during high water (Figure 14). There was instable bank zone in the mouth of the river with changing riverbed. The both banks with ripraps were quite steep, sometimes abrupt. The width of the riverbed was not more than 1,5-3 m, with depths varying between 5 - 30 cm and weak flow up to 1,03 m/s.

Figure 14. Kuro river mouth

The given SU had vegetation in the riverbed only, represented by few colonies of filamentous alga. Invertebrates' communities were underdeveloped with domination of amphibiotic insects with shorter life cycle, which showed the instable conditions of the SU because of periodic mudflow. No trout was found here.

Tibaitskali River (SU 12)

The SU had a narrow floodplain up to 10 m with quite steep riparian line with significantly meandering of the riverbed (Figure 15). The riverbed width varied between 2-7 m with insignificant depths 10-40 cm; flow velocity was insignificant from 0,05 up to 0,65 m/s. The riverbed was formed mainly by boulders with some gravel with smaller fraction and fallen leaves. Vascular plants were represented only by riparian-meadow form with significant overgrowing by bushes in the riparian zone.

Figure 15. Tibaitskali river mouth

There was up to 15% of moss in the riverbed. Macroinvetebrates were quite diversity with domination of imago and nymphs of secondary water insects. Ichthyofauna was presented by trout redds and trout of different sizes, which were not caught.

Small rivers with ice water feeding

Chkheri River – upper reaches (SU 13)

Figure 15. Chkheri river – upper reaches

The riverbed was formed mainly by boulders, stones of different sizes, some gravel with smaller fractions (Figure 16). The SU had steep, sometimes abrupt riparian line with narrow floodplain up to 12 m and width of the riverbed 2-7 m. The depths varied between 10 - 40 cm with significant flow velocity up to 1,15 m/s at thalweg. Vascular plants were represented by riparian-meadow plants with some bushes; one could see some mosses in the riverbed.

The lower plants were represented by *Hydrurus foetidus* and filamentous alga in autumn-spring period. This SU had small diversity of macroinvertebrates with dominating of imago and nymphs of secondary water insects with short life cycle. There were destroyed trout redds found in spring.

Chkheri - mouth (M 4)

Figure 17. Chkheri – mouth

The riverbed was made by dominating boulders, stones with some gravel with smaller fraction (Figure 17). The monitoring station had flat left bank with widen floodplain up to 20-25 m and width of the riverbed 5-16 m. The depths varied between 5-50 cm; flow velocity - between 0,05 - 1,2 m/s. Riparian floodplain part mainly was overgrown by riparian-meadow plants and bushes; out of lower plants there are only *Hydrurus foetidus* and filamentous alga at hard substrates.

Invertebrates' communities are underdeveloped in terms of both abundance as well as species composition with domination of the secondary water insects. No trout was caught here, but were fixed visually.

Amali River (SU 11a and M 11b)

Figure 18. Amali river

The riverbed was made of mainly some boulders and stones of different sizes, some gravel with smaller fraction (Figure 18). The site had steep sometimes abrupt banks with width of the floodplain up to 10-12 m, and width of riverbed 2-5 m. The depths varied between 5 - 40 cm with significant flow velocity up to 0,06 - 1,1 м/с at thalweg. Vascular plants were represented by riparian-meadow form with some bushes.

In the riverbed there were *Hydrurus foetidus* and filamentous alga at hard substrates. Invertebrates were not abundance but had high taxonomic diversity of secondary water insects. The trout was not found.

Conclusions:

The brown trout was fixed in **Tergi from upper reaches (Trusso gorge) downstream till the Larsi headworks**. Out of the tributaries the suitable for the trout habitats were found in **Sno** downstream the Juta village and its tributaries and **Tibaitskali.**

2.2 Results of the brown trout monitoring at different life stages

2.2.1 General provisions

Specie description

The only caught fish in Tergi and its tributaries was brown trout *(Salmo trutta m. fario*). According to modern scientific classification, brown trout, living in Tergi is a resident freshwater form of sea trout (*Salmo trutta ciscaucasicus*) (Dorofeeva, 1967).

The caught brown trout in 2015 had the following features (Figure 19): the body is oblong, the back is rounded. The number of fin rays are D III - 10, A III – 8; there is adipose fin present. The mouth is big; laws had many sharp teeth. The upper jaw comes beyond the external eye corner. The scales are small, in the side line there are 109 - 118 scales. The body is coloured; the colour changes depending on the water colour and bottom. Normally the back has olive green colour sometimes with bluish pattern, the sides have light colour, sometimes gray-yellow with many dispersed dark brown and red dots. Some red dots are located in order along the side line. The stomach is white. The pair fish rays and anal fin rays are yellow. The caudal (tail) fin is dark blue with reddish pattern, adipose fin is red. The juvenile fish have from silver to dark blue with a number of gray-blue coloured spots of oval form.

Figure 19. Trout caught in autumn

Catches done

During three field surveys, the following catches were done: using casting net - 1139, box traps - 8, fishing rod < 710 ; ichthyologic net - 206, drift traps - 39, cone net - 24, fishing basket - 39 (Table 2).

Table 2: Number of catches and caught fish

Catching device	Spring	Summer	Autumn	Total
Casting net	214	387	538	1139
Box traps	2	4	2	8
Fishing rod	240	280	190	710
Ichthyologic net	75	56	75	206
Drift traps	15	12	12	39
Cone net	24	0	0	24
Fishing basket	0	14	15	39
Trout caught	2/2	65/82	76/56	143/138

It was proved that the most effective catching device in conditions of Tergi is casting net. Using it, 281 trout specimen were caught at 17 monitoring stations and survey units. Out of them, 143 specimens were adult, and 138 juvenile fish.

It was to mention that in spring only 2 trout specimen were caught (the total number of attempts by casting net was 214), while in summer and spring, the number of trout caught was in times more. It is explained by high transparency of water in spring, which allows trout to see the human and escape. In the same time, when water transparency decreases due to floods from melting glaciers in summer and autumn, the number of caught trout increased (in summer 132 and in autumn 147 trout specimen caught).

Quantitative results

The quantity of the caught fish will be represented as catch per unitary effort (CPUE) (Table 3). The table presents only the fish caught within the monitoring stations and survey units; there were some fish caught outside of them.

Table 3. Number of fish caught by casting net in CPUE

#	Locations	Catches			CPUE		
		spring	summer	autumn	spring	summer	autumn
M 3	Tergi upstream the Dariali headwork	17	37	43	0,12	0,7	0,49
M 4	Chkheri river – mouth	21	28	46	0	0	0
M 5a	Tergi, directly downstream the Dariali headwork	19	29	36	0	0,17	0,11
M 5b	Tergi, downstream the Dariali	14	14	15	0	0	0

#	Locations	Catches			CPUE		
		spring	summer	autumn	spring	summer	autumn
	headwork (boulder rapid section)						
M 6	Tergi, downstream the Dariali headwork (braided section)	23	31	36	0	0,13	0,17
M 7	Tergi, downstream the Dariali headwork (single thread section)	16	26	47	0	0,08	0,04
M 8a	Tergi upstream Larsi dam	11	15	19	0	0,13	0
M 8b	Tergi downstream Larsi dam	10	17	26	0	0	0
SU 1	Tergi near Kobi village	11	36	49	0	0,17	0,2
SU 2a	Tergi upstream the Sno river	14	43	43	0	0,28	0,14
SU 2b	Sno river, mouth	23	42	42	0	0,98	1,21
SU 2c	Tergi downstream of the Sno river	13	33	59	0	0,48	0,44
SU 9	Upper reaches of Sno	0	39	41	---	0,56	0,49
SU 10	Bashi river	6	5	4	0	0	0
SU 11a	Amali river – upper reaches	4	0	0	0	---	---
SU 12a	Tibaitskali river - upper reaches	5	3	8	0	0	0
SU 13	Chkheri river - upper reaches	7	0	16	0	---	0
SU 14	Tergi river – upper reaches	0	28	49	---	0,64	0,43

In Amali mouth (SU 11b), Tibaitskali mouth (SU 12b), Kuro mouth (SU 15) the fish was not caught.

Conclusions

The biggest number of fish were caught in mouth of the Sno river (CPUE 0,98 in summer and 1,21 in autumn). In the same time, the share of juvenile fish was the highest comparing with other stations. The second by trout abundance were upper Tergi, upper Sno, Tergi downstream Sno and Tergi upstream Dariali headworks. Comparing different riverbed forms of Tergi at M 5-7, one can mention the braided channel is the richest by trout, the less trout is in single threat channel and in boulder type no trout was caught at all.

Habitat variables important for brown trout

The following habitat variables were studied for the whole life cycle of brown trout (Figure 20):

- Water quality (dissolved oxygen, temperature, pH and average discharge);
- Food supply (dominant substrate type, percent streamside vegetation and percent riffle fines).

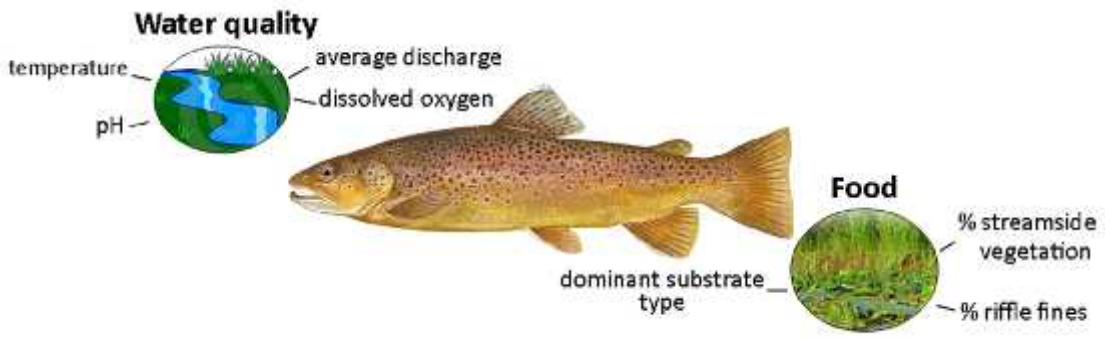


Figure 20. Habitat variables important for brown trout studied

The subcomponent water quality contains four variables: temperature, dissolved oxygen, pH and average discharge. These four variables affect the growth and survival of all brown trout life stages.

The subcomponent food supply contains three variables: dominant substrate type; percent streamside vegetation and percent riffle fines. Predominant substrate type is included because the abundance of aquatic insects, an important food item for brown trout, is correlated with substrate type. Percent streamside vegetation is included because allochthonous materials are an important source of nutrients in cold, unproductive trout streams. Percent fines in riffle-run and spawning areas is included because the presence of excessive fines in riffle-run areas reduces the production of aquatic insects.

2.2.2. Survey of fry emergence and downstream migration

Fry emergence occurs in spring (March-April), approximately 2-3 months after spawning, depending upon water temperatures. At this time, fry emerge from their gravel “redds” and move downstream in search of food.

Survey of fry emergency and downstream migration was done using ichthyologic net and cone nets with mash of 5 mm. The cone nets were installed upstream the Dariali headworks and at the headworks itself, upstream and downstream Larsi headworks as well as at the tributaries Chkheri, Tibaitskali and Sno. Besides, the samples of invertebrates were analysed if any fry entered it. Unfortunately, cone net was not a successful device to catch fry because of unfavourable conditions (snowfall).
However, the sample out of drift trap put at 23^{00}-23^{15} upstream the Dariali headworks contained two trout fry with dissolved yolk sac. Absence of the fries in the samples taken during day light proves the night migration activity of the trout in Tergi.

2.2.3. Juvenile fish rearing and migration survey

After fry emergence and their downgrading from the redds, their fattening migrations start. In order to study the food preferences as well as daily and seasonal fattening migrations, the fish were caught in different times of the day. 33 fish from Tergi and its tributaries were studied in detail. Injured trout specimens were used for it. They were dissected; viscera were fixed by

formalin and sent to Kyiv to the laboratory of the Institute of Hydrobiology of Ukraine, National Academy of Sciences of Ukraine.

Dissection of gastrointestinal tract of the caught juvenile fish showed that the main food component was imago of water insects (see Table 4). Their share was 70 - 95%. In autumn, imagos of Chironomidae were dominant in the food of juvenile fish (present in 98% fish, being the only food component). In summer, half (55,5%) of juvenile fish had small specimen of *Gamaridae* (3-20 specimens in the stomach).

The general analysis of the food preference of the trout of all ages showed that in spring food consisted of up to 45% Gamaridae, and up to 30% of imago and nymphs of water insects (mainly may fly). In summer, food was more diverse. Gamaridae, imago and chrysalis of Chironomidae, imago of water insects were presented in equal shares. The second place was with imago and chrysalis of secondary water insects; their share was up to 15%. Among them, imagoes of mayflies dominate. *Trichoptera,* despite of their relevant abundance in the river, were seen rarer in the fish stomachs and mainly there were large specimen. In autumn, the trout feeds mainly imago of *Chironomidae* with some *Gamaridae.* Imagos of amphibians in trout stomachs were not found.

There were no significant differences in food ranges of the trout at different habitats. Out of studied fish only 3 specimen out of 33 had empty stomach, which proved that there were enough of food available for the fish.

Table 4. Food range in Tergi and its tributaries in different seasons of the year

№	Season (months)	Fish quantity	Trout food composition							
			Gamaridae	Chironomedae	Oligohetae	Other water insects	Air insects	Vertebrates	Empty stomachs	Full stomachs
1	March-April	2	45%	5%	10%	30%	10%	0		2
2	July-August	13	30%	25%	10%	15%	20%	0	1	12
3	October	15	20%	60%	5%	5%	5%	5%	2	13

Conclusion: trout food range depends on the season. In summer, air insects dominate; in cold season, *Gamaridae* and insects imagos, whose development takes place in water, dominate.

In frame of the food range studies, fish tagging was conducted. Fish tagging was done using armed fibre (0,12 mm diameter) and beads of different colours. Medical needle was used as an applicator. Prior tagging, the piece of the fish body near dorsal fin were disinfected by chlorhexidine. The procedure did not take longer than 30-50 seconds from the moment of the fish catch until the moment of its returning back to water, so it was minimally traumatic for the fish. The advantage of this approach is use of beads of different colours, allowing tagging fish in different tributaries by different colours to simply the migration analysis. It is important that this methodology is applicable for the adult fish as well as juvenile ones, because it did not create barriers for swimming even for small size fish.

Figure 21. Fish tagging

Tagging was done in summer and autumn periods. In total 63 trout specimen were tagged in summer, and 56 specimen in autumn at different sites of Tergi and its tributaries (see Table 5). The biggest number of trout was tagged in Sno: 30 specimen in summer and 27 in autumn.

Table 5. Fish tagging in Tergi and its tributaries

№	Location	Summer	Autumn	Colour
M 3	Tergi upstream the Dariali headwork	12	8	Yellow
M 5a	Tergi directly downstream the Dariali headwork	3	2	White
M 6	Tergi, downstream the Dariali headwork (braided section)	2	3	Green
M 7	Tergi, downstream the Dariali headwork (single thread section)	1	1	Red
M 8a	Tergi upstream Larsi dam	1	0	Pink
SU 1	Tergi near Kobi village	5	5	Orange
SU 2a	Tergi upstream the Sno river	6	3	Violet
SU 2b	Sno river, mouth	25	24	Dark blue
SU 2c	Tergi downstream of the Sno river	11	8	Blue
SU 14	Tergi river – upper reaches	10	9	Black
Total:		76	63	

The tagging will give its result for the post-commission monitoring of the trout migration.

2.2.4. Fish fattening and spawning migration survey

In frame of the spawning migrations studies, the study of age and sex structure of the trout was conducted.

Age structure

The generalized age population of Tergi based on all catches in summer and autumn is presented in Table 6.

Table 6. Age structure of the trout population in Tergi and its tributaries

Age	Size, cm	%, summer	%, autumn
This year	2-7	11,6	8,2
1 year	7-12	16,4	11,6
2 years	10-15	32,9	29,5
3 years	13-18	28,8	38,4
4 years	18-22	10,3	12,3

Further there is a table on size-age of trout sub-population in Sno mouth, because it is significantly different from other tributaries and Tergi itself due to dominance of juvenile fish (see Table 7).

Table 7. Age structure of the trout population in Sno mouth

Age	Size, cm	%, summer	%, autumn
This year	2-7	27,6	12,7
1 year	7-12	23,9	23,1
2 years	10-15	25,4	29,9
3 years	13-18	14,2	26,1
4 years	18-22	9,0	8,2

Sex structure

The sex structure of the trout population was studied in limited way, because all caught healthy fish after measurements and tagging was released into the river, and exact sex identification is possible only after dissection. It is worth to mention, that in summer and autumn, the radio of females and males was different. If in summer, the ratio was 2 x 1, than in autumn it was 14/1 (which is threatening for the population ratio). The similar disproportion was observed in Tergi in Kabardino-Balkaria, where males dominate in all spawning age groups. The sex radio during a year was 1:1,8 in favour of males. In the spawning period, there are 2-3 males per each female. Only one of males takes part in fecundation of the eggs, others eat eggs, therefore the female keeps them away.

Too few females show unfavourable state of reproductive potential of the trout population in upper Tergi. This may be caused by the fact, that females migrate longer and downgrade downstream Larsi and further to Russia, where the absence of fish passes does not allow them to return upstream. However at present the Larsi fish pass does not work, so this hypothesis could not be checked.

Spawning redds

In spring (31 March) 5 spawning redds, but without eggs and fries were found in Tibaitskali 700 m upstream the mouth. The width of the riverbed near the spawning redds was 1,5 - 3,5 m;

depth of the thalweg was 15 - 35 cm. The three spawning redds had prolonged shape along the flow and were from 0,3 x 0,8 m to 0,5 x 1,0 m in size in average. There was 10-20 cm from the top of redds to water surface. Their form varied depending on the type of flow, sediments, and available space. In autumn the similar redds were also found in Sno and in Tergi near Kobi (see Table 8, Figure 22).

Figure 22. Spawning redds

Table 8. Spawning redds found and juvenile fish caught

№#	Location	Juvenile fish			Spawning redds	
		Spring	Summer	Autumn	Spring	Autumn
M 3	Tergi upstream the Dariali headwork	0	14	8	0	0
M 5a	Tergi directly downstream Dariali headworks	0	3	2	0	0
M 6	Tergi, downstream the Dariali headwork (braided section)	0	2	3	0	0
M 7	Tergi, downstream the Dariali headwork (single thread section)	0	1	1	0	0
M 8a	Tergi upstream Larsi dam	0	1	0	0	0
SU 1	Tergi near Kobi village	0	5	5	0	4
SU 2a	Tergi upstream the Sno river	0	6	3	0	0
SU 9	Sno – upper reaches	0	0	17	0	12
SU 2b	Sno river, mouth	0	25	0	0	0
SU 2c	Tergi downstream of the Sno river	0	11	8	0	0
SU 12a	Tibaitskali river - upper reaches	0	0	0	5	0
SU 13	Chkheri river - upper reaches	0	0	0	4?	0
SU 14	Tergi river – upper reaches	0	14	9	0	0

Three trout spawning redds were found in melioration channels, crosscutting the Sno river valley near Sno and Artmoskali villages. Many fish enter these channels, where locals catch them using standing nets as well as casting nets, sweep nets and cold weapons, mainly at night.

At these channel one can often see spawning redds, made by trout at the depth more than 1,5 m and flow velocity 0,2 – 0,4 m/s at sand and gravel. The eggs were not extracted from the redds because of deep depth of their laying and U-type channel cross-section.

Conclusions

The main spawning places for the brown trout in upper part of the Tergi basin are the Sno River with its tributaries. There the biggest number of juvenile fish and spawning redds were fixed. Besides, spawning redds were fixed in upper Tergi (upstream Kobi) and Tibaitskali.

2.3 Identification of the specie composition of the invertebrates and their abundance

2.3.1 General provisions

The study of water invertebrates was conducted with the following purposes:

- Obtaining of data about the natural composition and structure of water macroinvetebrates, their quantitative distribution by main habitats.
- Assessment of biological status of Tergi river prior Dariali HPP commencement.
- Calculation of food basis for the trout based on indicators of abundance and biomass of water macroinvertebrates communities.

2.3.2 Invertebrates specie composition and abundance

Collected material showed high species diversity of macroinvertebrates - 109 species (see Annex 1 for more details). There were 18 groups of macroinvertebrates, among which *Insecta* dominating (91,2 % from the total number). *Insecta* includes the following: *Trichoptera* - 33,2%, *Ephemeroptera* - 21,4%, *Plecoptera* – 14,2%, *Diptera,* including imago of *Chironomidae* – 16,8%, *Amphipoda* – 11,2%, others – 3,2% (Figure 23).

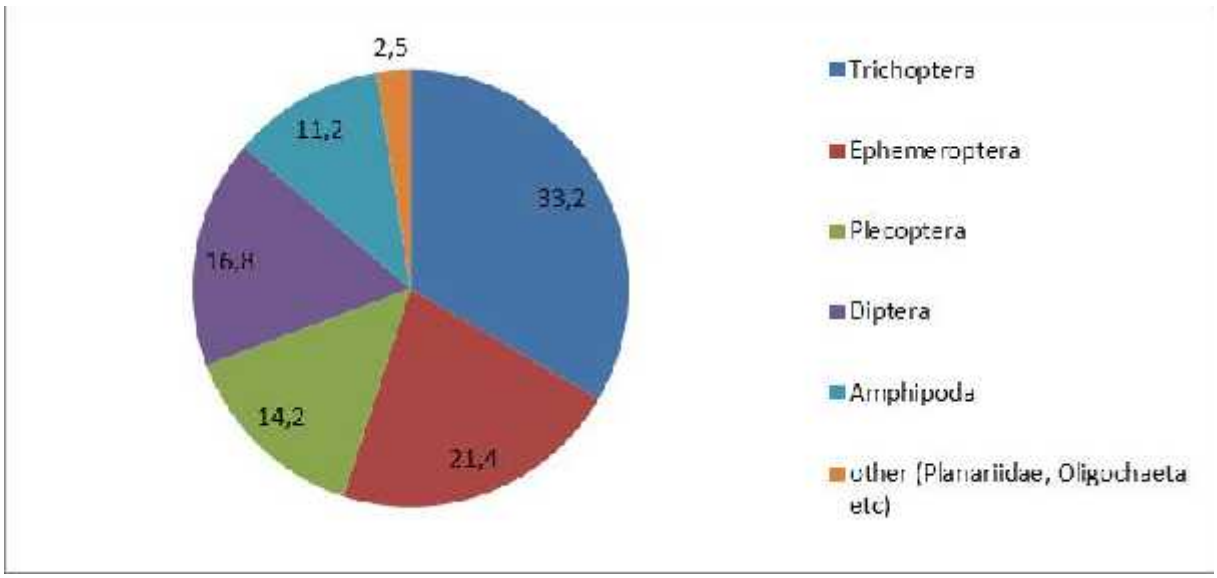


Figure 23. Composition of the insects' macroinvertebrates

The structure of the bottom biotsenosis of rivers of the Tergi basin includes imago of *Diptera* (44 species from 2 families), nymphs of mayflies (15 species from 8 families) and *Ephemeroptera* (15 species from 2 families), and imago of *Trichoptera* (13 species from 6 families).

In the main riverbed of Tergi, the imago of *Trichoptera* were the most numerous and quite diverse. In the tributaries despite the significant dominance by species diversity of the imago of *Trichoptera,* they are less abundant than *Plecoptera* and *Ephemeroptera.*

The following regularities were identified for the main tributaries of Tergi:

- Kuro, Chkheri and Amali had insignificant number of macroinvertebrates (400-750 specimen/m^2), and the dominating species were the species with the short cycle of development. It can be explained by the regular impact of mud flows and large summer flood at Chkheri;
- Bashi and Tibaitskali had more diverse macroinvertebrates with higher abundance (750-1500 specimen/m^2).
- Sno had the highly diverse and abundant water macroinvertebrates. Comparing to previously mentioned tributaries, Sno had more discharge, comparatively smaller flow velocities and higher water temperatures in summer (up to +16 +18 °C). The number of macroinvertebrates was between 950 up to 2500 specimen/m^2.

The following regularities were identified for Tergi itself:

- Upper reaches of Tergi had insignificant number of invertebrates (450-700 specimen/m^2). Upstream Dariali headwork had a stable community of invertebrates (950-2500 specimen/m^2). Downstream Dariali headworks for 2 km long, reduction of diversity and abundance of the invertebrates was observed (450-650 specimen/m^2). Further the number and diversity of invertebrates increased.
- Within the different channels, the number of macroinvertebrates varied: boulders – 950-1250 specimen/m^2 (the highest number was registered outside of the construction zone of the Dariali headworks, namely 2-3 km downstream the headworks); single riverbed – 750 -2000 specimen/m^2; braided channel – 1000-2500 specimen/m^2.
- Downstream Larsi headworks, the number of invertebrates was 450-650 specimen/m^2.

Conclusions

The biggest abundance and diversity of invertebrates was observed in Tergi upstream of Dariali headworks and in braided riverbed at the possibly affected reach of Tergi. Out of tributaries the richest one for macroinvertebrates is Sno.

2.3.3 Identification of food basis for fish

The study of availability of macroinvertebrates for fish was done using drift traps. They were located in Stepantsminda upstream Dariali headworks.

The study of drift as an indicator of production capacities of invertebrates showed that intensity of drift varied significantly during daytime as well as seasons (Figure 24-26).

In spring, maximum of the drift was in the evening. The total number of drifting invertebrates in the cross-section was 1,8 mln. specimens and around 73 kg per day (Figure 24).

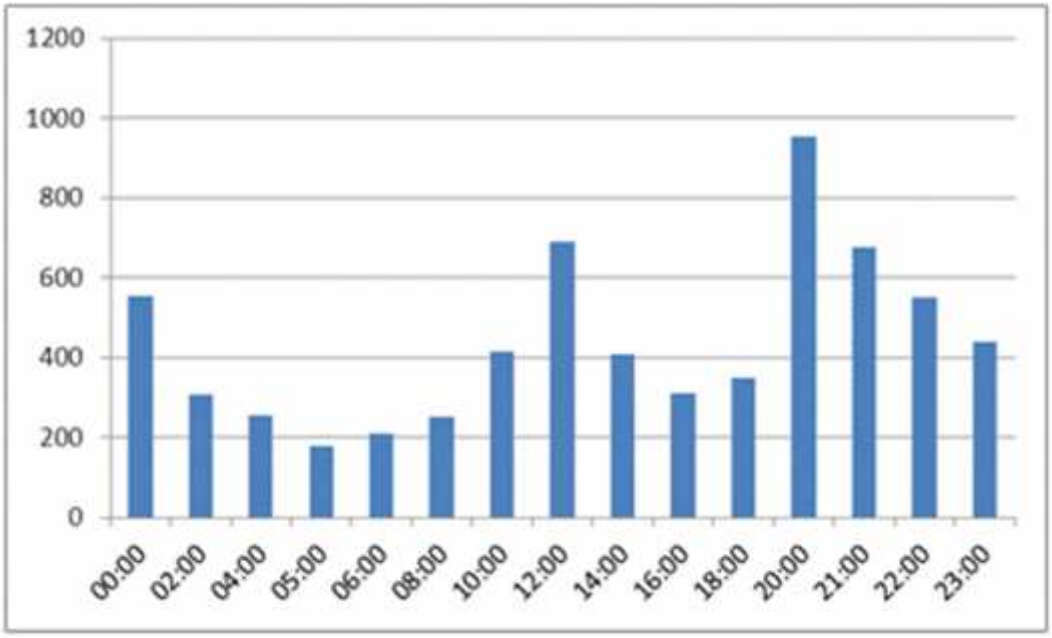


Figure 24. Daily intensity of drifting macroinvertebrates in spring at Tergi

In summer, maximum of the drift was in the evening with reduction in the morning. The total number of drifting invertebrates in the cross-section was 1,7 mln. specimen and around 69 kg per day (Figure 25).

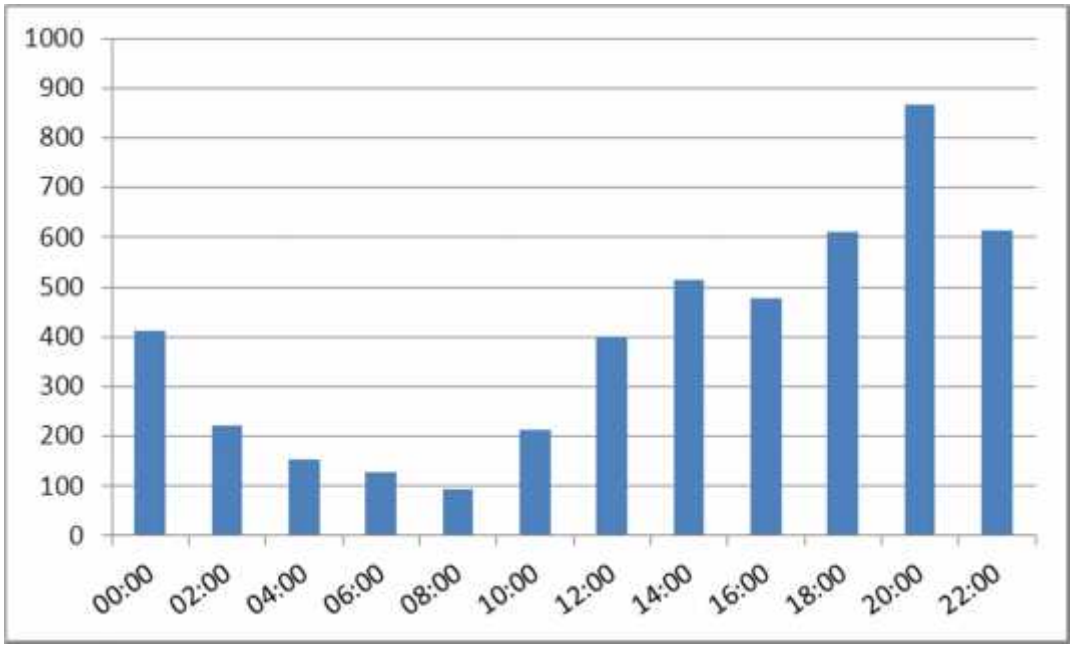


Figure 25. Daily intensity of drifting macroinvertebrates in summer at Tergi

In autumn, maximum of the drift was in the evening and night and minimum in the morning. The total number of drifting invertebrates in the cross-section was 2 mln. specimen and around 83 kg per day (Figure 26).

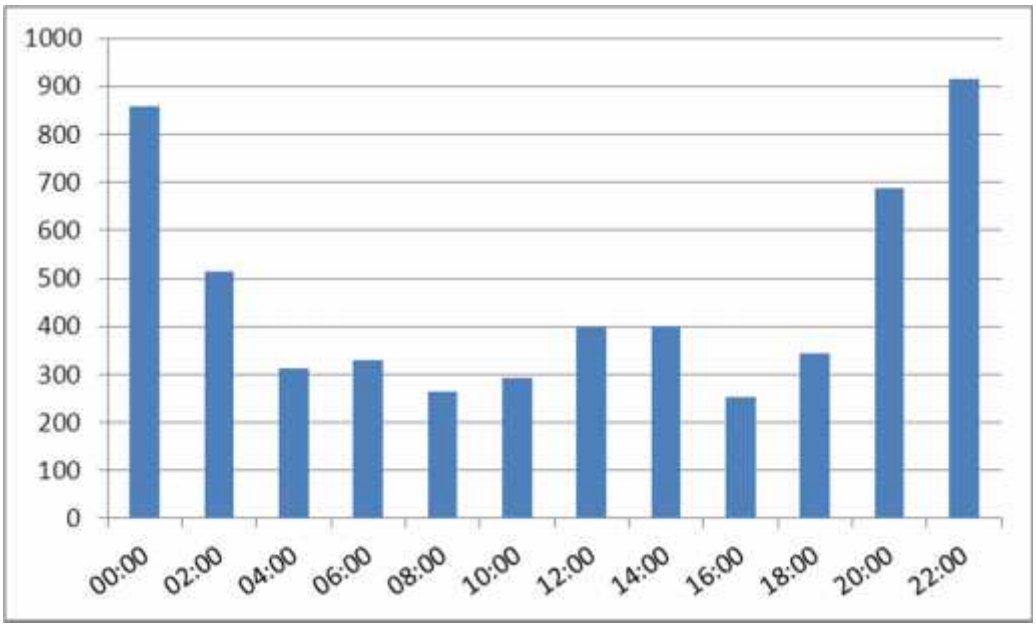


Figure 26. Daily intensity of drifting macroinvertebrates in autumn at Tergi

Conclusions

The study of drifting invertebrates showed good food basis for the trout and in the same time identified the reference values of drift for further comparison with post-commissioning monitoring.

2.4 Biological status assessment

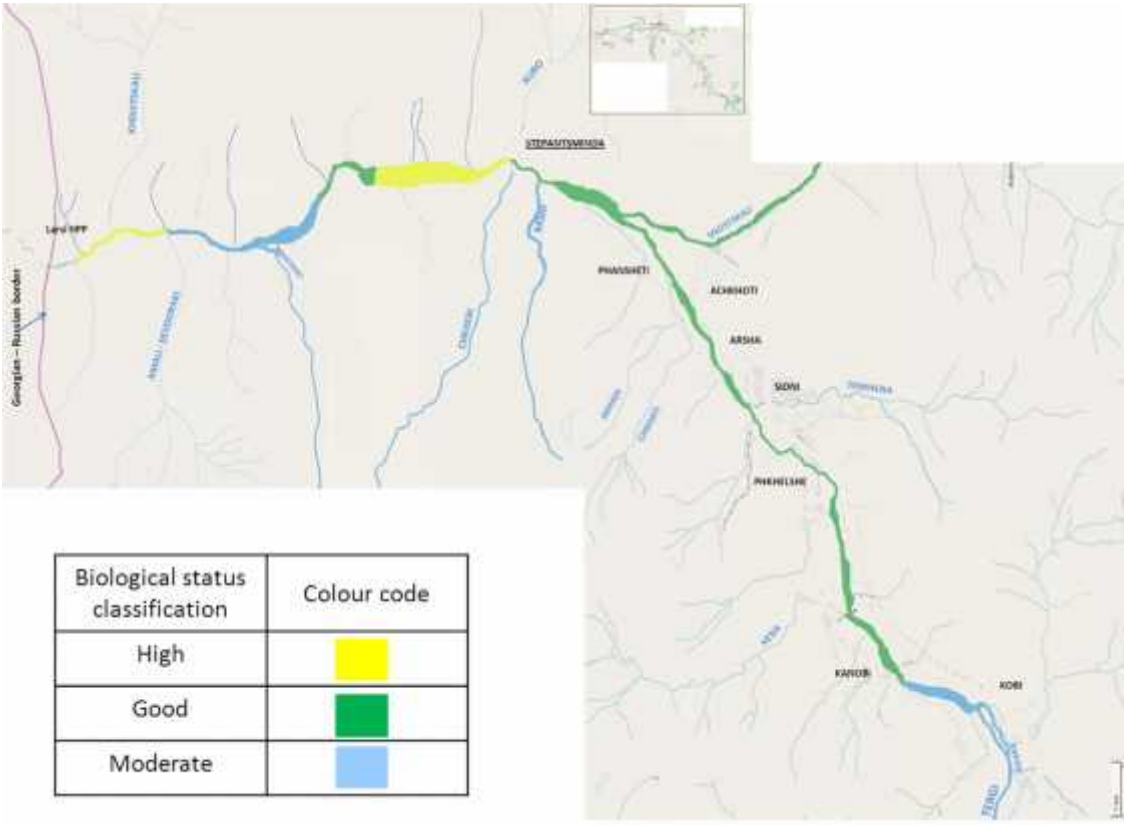
According to the EU Water Framework Directive, the biological quality elements include water plants, invertebrates and fish. Based on biological quality elements, relevant status (from high to bad) is assigned to the water body (part of the river or tributary).

The following results of the biological status assessment were obtained (based on three seasons of the field surveys)

Biological status of Tergi (Figure 27):

- Upper reaches of Tergi down to Kobi village had 1st – high - biological status.
- Tergi from Kobi down to Stepantsminda had 2nd – good - biological status. Reduction of the class was related to the organic pollution coming from the settlements as well as because of the turbulence caused by gravel extraction from the river.
- Tergi downstream the Dariali headworks had 3rd – moderate – biological status because of untreated wastewaters coming from Stepantsminda as well as impact of construction works.
- 2 km downstream the headworks, the biological status improved up to 2nd – good – because of reduction of the pollution load (reduction of the turbulence, number of sediments) and stabilization of the environmental conditions.
- Tergi from 1 km upstream Tibaitskali, the biological status improved again up to 1st – high.

- Downstream Amali mouth the biological status deteriorated again down to 3rd – moderate – because of regular mud and stone flows and machinery works to take away the impacts of mud and stone flows.



Picture 27. Biological status assessment of Tergi

Tergi's tributaries:

- Sno in its upper reaches had the 1st - high – biological status and could be used as reference (no human impact) conditions. Downstream the Akhaltsikhe village, the biological status deteriorated down to the 2nd – good – because of the organic pollution coming from the settlements as we as because of periodic hydrotechnical activities in the riverbed and floodplain.
- Chkheri, Bashi, Chkheri, Tibaitskali during all their courses had 1st – high – biological status and could be used as reference (no human impact) conditions.
- Assessment of Kuro and Amali were not conducted, because these rivers are affected by mudflows and macroinvertebrates' communities there were unstable.

The calculation of quality indexes using software Aquabiobase and Asterix confirm these tendencies. The most suitable indexes for conditions of Caucasus were TBI, BBI, EPT, DSFI Diversity Groups, IBE Aqem, and Diversity (Simpson-Index).

Conclusions

The main impact on biological status was caused by untreated and insufficiently treated wastewaters coming from the settlements as well as periodic turbulence of the river during hydrotechnical construction and gravel extraction.

3. Flow and physical habitat monitoring

3.1. General provisions and monitoring stations

General provisions

Flow and physical habitat monitoring was done following the Hydromorphological Assessment Protocol as stated in the Aquatic Survey and Monitoring Programme. The following the hydromorphological and hydrological parameters, important for biological communities were measured (calculated):

- Form of the valley;
- Catchment area of the monitoring station;
- Channel sinuosity;
- Channel type (boulders, single threat or braided);
- In-stream features (bed elements, bed substrates, variation in width (variability of maximum and minimum width), depth (deviation from the average depth of the flow), ratio of average width of flow to the average depth – $C_{b/h}$, flow types, large woody debris);
- Bank/riparian zone parameters (vegetation, stabilization);
- Floodplain parameters;
- Coefficient of roughness of the riverbed, riparian line and floodplain, which characterises the riverbed resistance for the water flowing;
- Water discharge, velocity (deviation from the average flow velocity).

In the course of the field surveys, some of the parameters mentioned in the Protocol (channel shortening, artificial bed features, and floodplain-flooded area) were considered as non-relevant and not measured.

Monitoring stations

Hydromorphological monitoring network includes 8 stations - 4 on entire Tergi and 4 on tributaries (Figure 28, Table 9):

- At Tergi river at possibly affected by the Dariali HPP reach monitoring stations were located at each of the riverbed channel type (in total 3). The steep boulder rapids, lesser-graded single-thread and low gradient multichannel forms all have different channel sizes, gradients, sediment sizes and general morphology. Changing discharge will have different and complex hydraulic effects according to the type of morphology present at a given location. Thus, the impacts of reduced flow in each type of reach system need to be considered. One of the monitoring stations (at boulders) was selected 200 m downstream the Dariali headworks for further use in the pos-commissioning monitoring for the impact of ecological flow.
- At Tergi at reference conditions (upstream Dariali headworks in Stepantsminda), one monitoring was selected. In post-commissioning monitoring it will show the conditions at Tergi outside of the impact of the Dariali HPP.
- At main tributaries of the first order (Chkheri, Kuro, Tibaitskali, and Amali) 4 monitoring

stations were selected. Chkheri enters Tergi upstream Dariali headworks, others – downstream (see Table 10).

Selection of the monitoring stations was done based on the riverbed type, its representativeness, form (rectilinear), natural character of the riverbed and water regime (absence of impoundments, bank enforcements or other human impacts) and recommendations of biologists.

Table 9. Hydromorphological monitoring stations

№	River	Monitoring station	Elevation, a.s.l.	Coordinates			
				Upper_Left	Upper_Right	Down_Left	Down_Right
1 (M3)	Tergi	upstream the Dariali headworks	1739	42°39'32.96" 44°38'22.79"	42°39'32.82" 44°38'23.60"	42°39'32.57" 44°38'22.70"	42°39'32.52" 44°38'23.56"
2 (M4)	Chkheri	Mouth	1735	42°39'53.78" 44°38'30.54"	42°39'53.90" 44°38'30.66"	42°39'53.59" 44°38'31.05"	42°39'53.68" 44°38'31.09"
3 (SU15)	Kuro	Mouth	1760	42°39'55.37" 44°38'51.43"	42°39'55.29" 44°38'51.11"	42°39'55.86" 44°38'51.18"	42°39'55.84" 44°38'51.02"
4 (M5a)	Tergi	downstream the Dariali headworks (boulder rapid section)	1693	42°40'06.76" 44°38'32.52"	42°40'06.95" 44°38'32.90"	42°40'06.38" 44°38'32.80"	42°40'06.50" 44°38'33.01"
5 (M6)	Tergi	downstream the Dariali headworks (braided section)	1469	42°42'04.60" 44°38'00.16"	42°40'05.07" 44°38'01.01"	42°42'04.66" 44°38'00.56"	42°42'04.92" 44°38'01.49"
6 (SU12b)	Tibaits-kali	Mouth	1436	42°42'35.54" 44°37'35.44"	42°42'35.59" 44°37'35.32"	42°42'35.82" 44°37'35.67"	42°42'35.84" 44°37'35.64"
7 (M7)	Tergi	downstream the Dariali headworks (single thread section)	1413	42°42'53.94" 44°37'31.70"	42°42'54.00" 44°37'33.31"	42°42'53.30" 44°37'31.73"	42°42'53.27" 44°37'32.62"
8 (SU11b)	Amali	mouth	1427	42°43'29.09" 44°37'32.47"	42°43'29.18" 44°37'32.54"	42°43'29.01" 44°37'32.99"	42°43'29.09" 44°37'33.01"

Table 10. Distance of the monitoring stations at the tributaries from the mouth and Dariali headworks

River	Monitoring station	Distance from the mouth, m	Distance from the Dariali headworks, km
Chkheri	mouth	175	0,42 upstream
Kuro	mouth	210	0,26
Tibaitskali	mouth	80	5,82
Amali	mouth	360	7,93

The borders of each monitoring station were fixed using GPS, as well as by colour marks at large boulders or concrete walls (Figure 29). This allows returning into the same monitoring stations during the post-commissioning monitoring.

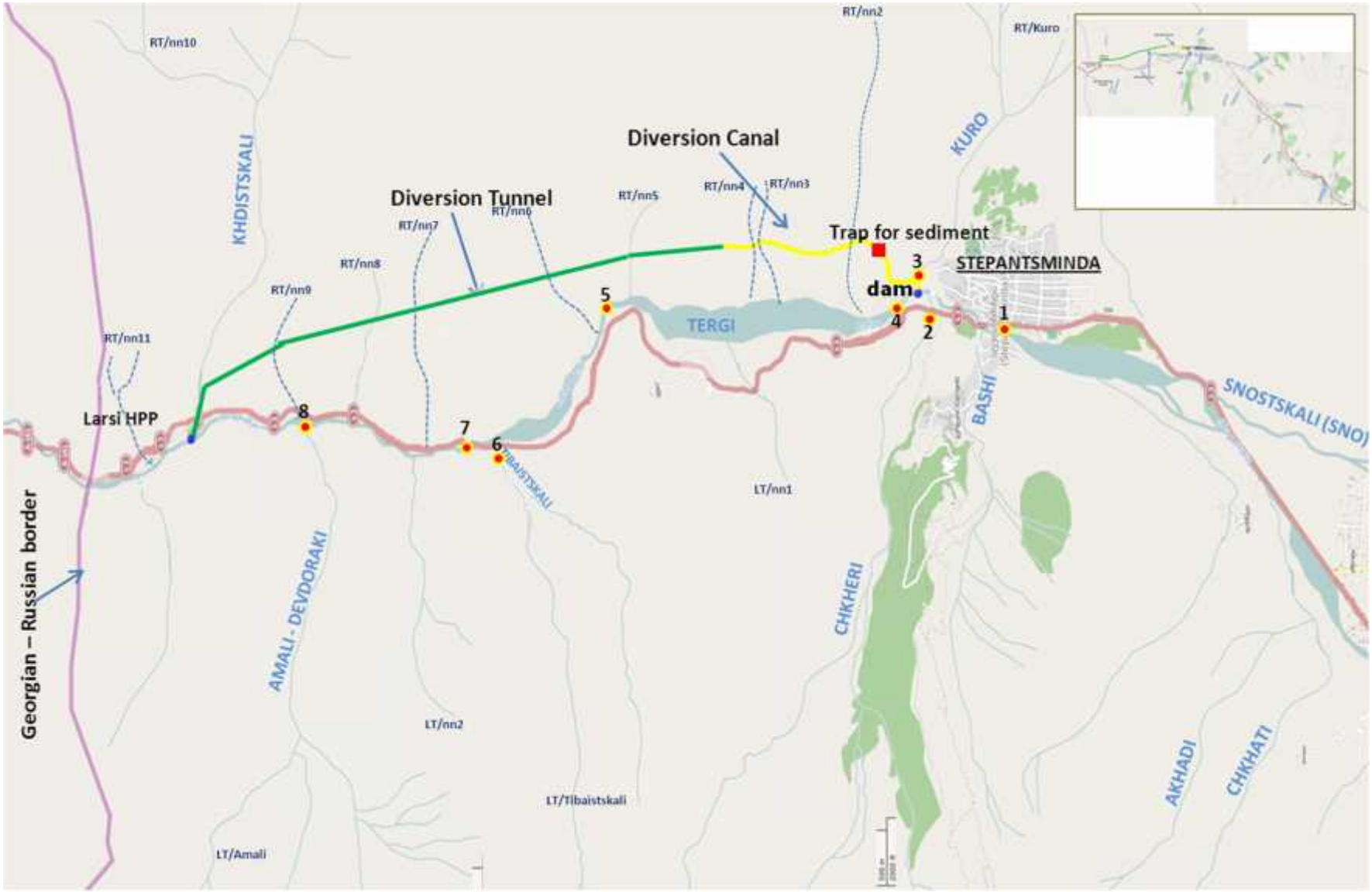


Figure 28. Hydromorphological monitoring station network

Figure 29. Ways of colour marking of the monitoring station

Cross-sections obtained

The length of each monitoring station was 10 m, except Tergi – braided section (M6), because 10-20 m long station does not allow assessing change of hydrological characteristics in braided riverbed. Therefore the length of this monitoring station was 80 m. Also for Kuro mouth (SU 15), the measurements were done for 30 m. It was the first monitoring station where the measurements were done therefore it was a pilot length of the station.

Each monitoring station included a number of riverbed cross-sections. Despite the fact that in the Program it was mentioned 5 cross-sections per the station, their number varied depending on the station. For monitoring stations with the bigger length Tergi – braided section (M6) and Kuro mouth (SU 15), the number of cross-sections was bigger than the proposed: 12 and 7 accordingly. As a result, 49 cross-sections were obtained (Table 11) (See Annex 3 for more details).

Table 11. Cross-sections measured

№	River	Monitoring station	Number of cross-sections	Length of cross-section, m
1	Tergi	upstream the Dariali headworks	5	10
2	Tergi	downstream the Dariali headworks (boulder rapid section)	5	10
3	Tergi	downstream the Dariali headworks (braided section)	12	80
4	Tergi	downstream the Dariali headworks (single thread section)	5	10
5	Chkheri	Mouth	5	10
6	Kuro	Mouth	7	30
7	Tibaitskali	Mouth	5	10
8	Amali	Mouth	5	10

Field surveys

Hydrological and hydromorphological surveys were conducted from 29th of March until 5th of April. During the survey, weather conditions varied significantly. According to the meteostation Stepantsminda, the average monthly temperature in March is +8 °C, and in April +12 °C. During the surveys, the air temperature varied from +6 up to +10 °C, which is much lower than multiannual data for this period.

The survey was affected by snowfall, namely 11-12 mm 30th of March and 3rd of April (in average in March multiannual data shows around 67 mm of precipitation in March and 144 mm in April[1]). Snow cover created barriers for access to the river and proper assessment of the riparian zone.

Average monthly water discharges for Tergi for March and April in 50% of water provision year according to Stepantsminda hydrological station are 8,36 m^3/s and 14,2 m^3/s accordingly. Values of water discharge measured at different monitoring stations at Tergi varied from 7,83 up to 10,4 m^3/s. The discharge measured at former hydrological station in Stepantsminda was 7,83 m^3/s.

One can state, that the discharge in Tergi during field surveys was lower comparing with its average value for multiannual period.

Equipment used

The following equipment was used during hydrological and hydromorphological surveys:

- Universal hydrometric current meter – for flow velocity measurement,
- Large range finder – for distance and riverbed width measurements,
- Gauging rod – for measurements of water levels and flow depths,
- Frame 1 m^2 (metal) - for visual assessment of the percentage composition of sediments,
- GPS 60C Garmin – for coordinates measurements,
- Electronic goniometer – for inclination measurements,
- Electronic compass,
- Thermometer,
- Field computer and FieldMap equipment – for hydromorphological measurements,
- Acoustic Doppler discharge measurement system.

[1] http://www.worldweatheronline.com/kazbegi-weather-averages/dushetis-raioni/GE.aspx

3.2. Results of the hydromorphological and hydrological monitoring by riverbed types

Tergi – general description

Tergi has its source in the Caucasus range, at Zilgakhokhi mountain (3856 m) northern slopes, at 3400 m a. s. l. and flows in Caspian Sea north to Agrakhan peninsula, Russian Federation.
Construction of Dariali headworks is located about 170-1720 m a.s.l. at Tergi, namely, at the confluence of the tributaries of Chkheri and Kuro.

The river length from the source to the Dariali headworks is 49,0 km, general elevation difference is 1677 m; average declination is 34 ‰. The catchment area at the hydrological station in Stepantsminda is 778 km^2; its average elevation is 2820 m a.s.l. The catchment area at Dariali headworks calculated by the Blue Rivers™ experts is 819 km^2, whereas in the project documentation[2] it is 806 km^2. It leads to changes in the minimal ecological flow (Table 12).

Table 12. Found differences in the catchment areas at Dariali headworks

	Catchment area at Dariali headworks	Transitional coeficient	Actual average multiannual water discharge at the hydrological station (for 51 year) m^3/s	Calculated average multiannual water discharge at the hydrological station m^3/s	Calculated minimal ecological flow (10%), m^3/s
Project documentation	806	1,029	24,7	25,4	2,54
Blue Rivers™ calculations	819	1,053	24,7	26,0	2,60

The river gorge is widen and box-shaped. The width of Tergi valley at the possibly affected reach varies between 62 m up to 255 m; the biggest widening of the valley is observed in the middle part of the reach: from 197 m to 255 m (Figure 30). The riverbed meanders moderately and gets branched in wide places. In Stepantsminda city the river is not branched and flows in one deeply embedded riverbed. The average width of the riverbed is 123 m.

[2] Instruction for maintenance of "Dariali HPP". Hydrotechnical strctures – p. 7

Figure 30. Braided riverbed of Tergi

The current depth changes from the source downwards from 0,5 to 1,5 m, its width - from 8-10 m to 15-20 m, and the velocity - from 1 - 1,5 m/s to 1,8 - 2,3 m/s. The riverbed bottom in narrow places is uneven, rocky and made by large boulders / rocks, and in wide places it is sand - gravel.

Results by monitoring stations

Monitoring station #1: Tergi upstream the Dariali headworks (M3)

F*igure 31. Tergi upstream the Dariali headworks*

The monitoring station was located at Tergi within Stepantsminda, downstream Sno - 2,45 km and 1,12 km upstream Dariali headworks (Figure 31). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°39'29.89"N and 44°38'22.39"E. The approximate elevation is 1739 m a.s.l. The river site in both sides for 150 m is requitengular and without tributaries (the closest tributary is located 200 m away downstream of the monitoring station).

The form of the valley is small U-shape. The catchment area in the lower part of the monitoring station is 775 km^2. The length of the river from the source is 48,3 km. Coefficient of sinuosity is 1,095. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 24,7 m^3/s based on the all monitoring data for 51 years (26,9 m^3/s was calculated based on the last 15-years monitoring data for 1976-1991). Measured factual water discharge was 7,83 m^3/s, which corresponded to 85 % of water provision of the average multiannual Q 50% water discharge in Tergi at hydrological station in Stepantsminda. The maximum fixed velocity was 1,27 m/s (one measurement), with deviation from the average flow velocity in 1,6 times (the average flow velocity was 0,79 m/s). Flow types included rippled, broken standing waves, and unbroken standing waves.

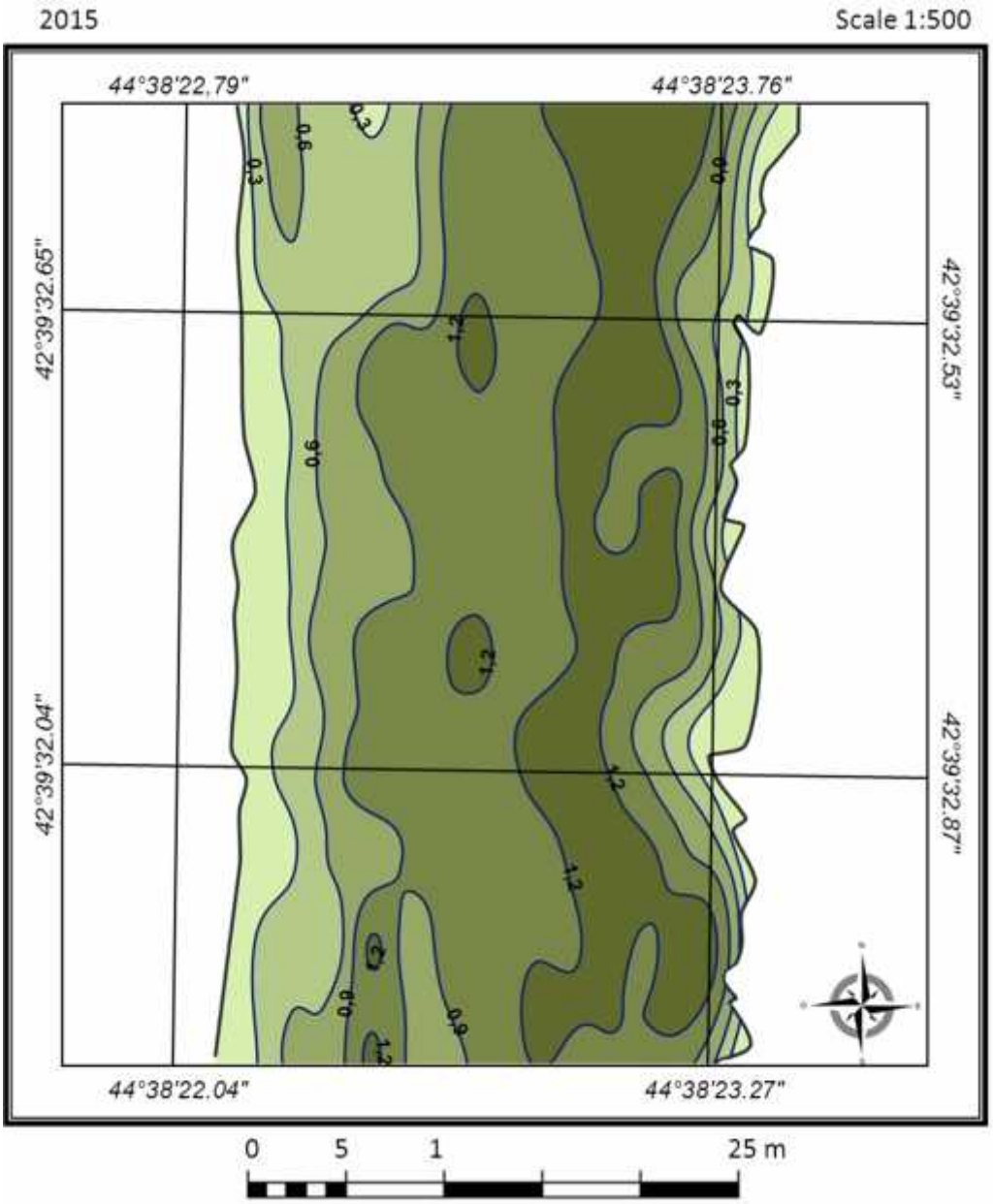


Figure 32. Isotaches of the stream velocity

The fixed riverbed type according to the hydromorphological protocol is classified as a single threat type (Figure 32). The riverbed cross-section was even without significant steps. Bed elements included bars, and riffles.

There were no bank enforcements fixed. The width of the river varied from 12,3 to 13,9 m in low water period and from 20 to 30 m during high water period. The river was classified as a river of average size (width from 10 to 30 m). Variability of maximum and minimum width of the riverbed in the low water period was low = 1,13 (low variability is in the range of 1,11 - 1,25). The fixed maximum depth was 0,96 m, with deviation from the average depth of the flow in 2,59 times (the average depth is 0,37 m) (Figure 33). The variability of the depths according to the obtained data was classified between insignificant to average. Ratio of average width of flow to the average depth was $C_{b/h}$=35. Flow thalweg (midcourse) passed by the central part of the flow and had depth 0,7 - 0,96 m.

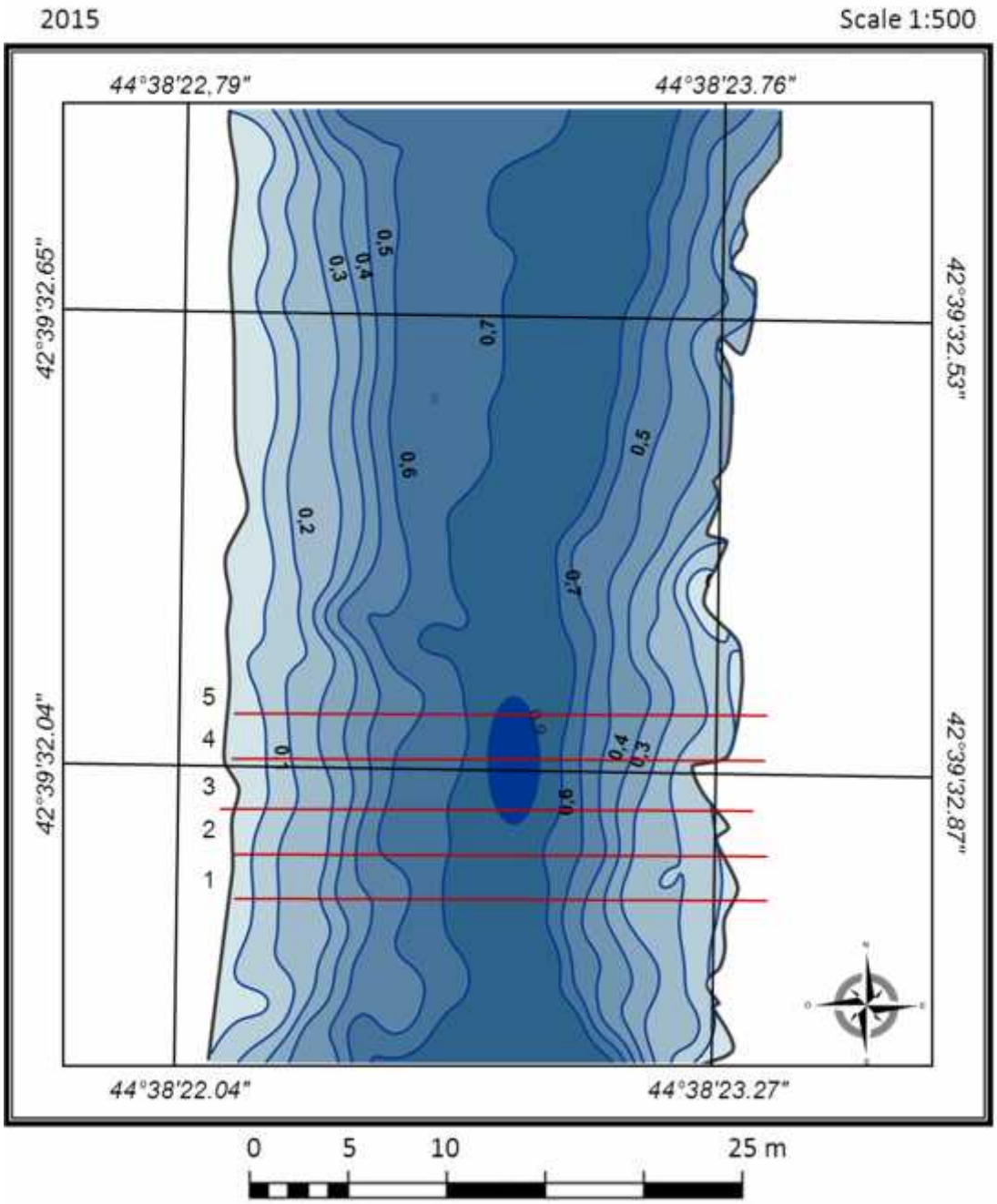


Figure 33. Isobaths (depths)

The left bank was quite flat with significant amount of sediments in the floodplain in the upper part of the monitoring station; right bank was inlaid, steep. Only second overfoodplain terrace was weakly visible with the width up to 5 m; it was covered by grass with insignificant number bushes and some trees and large boulders. The riparian line of the right bank was made mainly out of boulders; left bank was covered by pebble and small and large boulders (up to 0,4 m). The riverbed was covered by pebble and gravel, with insignificant number (1-3%) of boulders of middle size (up to 0,5) (Figure 34).

Substrate types	% of sediments
Boulder (256 mm–2048 mm)	22
Cobble (64 mm – 256 mm)	28
Pebble (17 mm – 64 mm)	14
Gravel (2 mm – 17 mm)	26
Sand (0.06 mm – 2 mm)	10

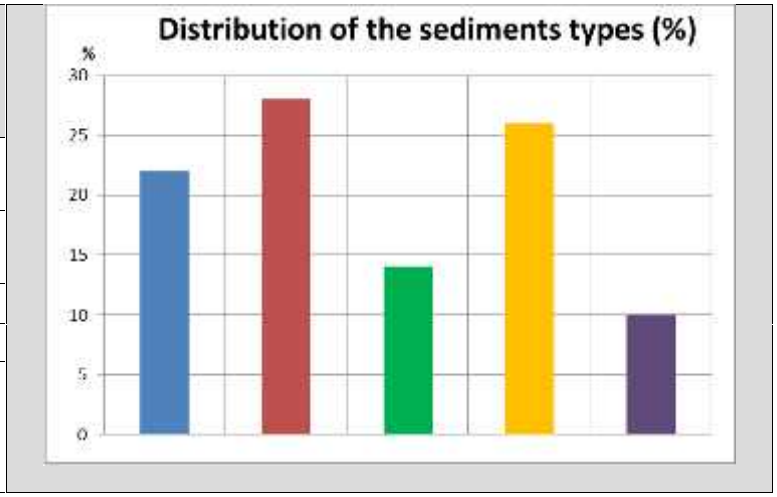


Figure 34. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,26; coefficient of roughness of the riparian line and floodplain was 0,31 and 0,36 correspondingly.

Monitoring station #2: Tergi downstream the Dariali headworks (boulder rapid section) (M 5b)

Figure 35. Tergi, downstream the Dariali headwork (boulder rapid section) (M 5b)

Monitoring station was located at Tergi downstream Dariali headworks (Figure 33). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°40'06.50"N and 44°38'33.01"E. The approximate elevation is 1693 m a.s.l. The river site in both sides for 150 m is requitengular and without tributaries.

The form of the valley is small U-shape. The catchments area in the lower part of the monitoring station is 825,2 m^2. The length of the river from the source is 49,7 km. Coefficient of sinuosity is 1,15. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 26,0 m^3/s. Measured factual water discharge was 8,89 m^3/s, which corresponded to 62% of water provision of of the average multiannual Q 50% water discharge in Tergi at hydrological station in Stepantsminda. The maximum fixed velocity was 1,45 m/s, with deviation from the average flow velocity in 2 times (the average flow velocity was 0,67 m/s). Flow types included chute, chaotic, broken standing waves, and unbroken standing waves.

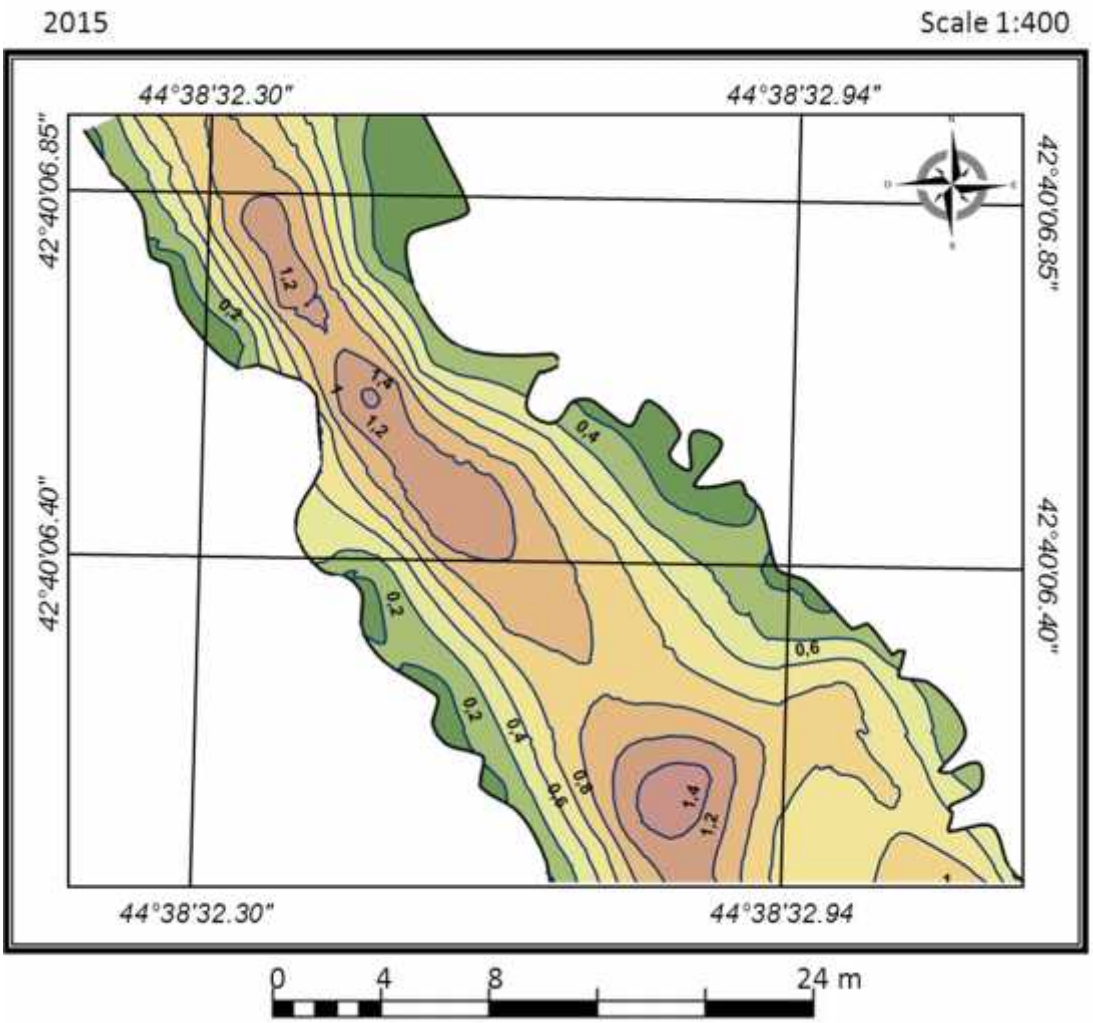


Figure 36. Isotaches of the stream velocity. Boulders channel type

The fixed riverbed type according to the hydromorphological protocol is classified as boulder (Figure 35). The riverbed cross-section was even without significant steps; it belonged to natural one. Bed elements included rapids and rocks.

There were no bank enforcements fixed. The width of the river varied from 5,55 to 13,6 m in low water period and from 20 to 30 m during high water period. The river was classified as a river of average size (width from 10 to 30 m). Variability of maximum and minimum width of the riverbed in the low water period was 2,5. The fixed maximum depth was 1,25 m, with deviation from the average depth of the flow in 1,8 times (the average depth is 0,69 m) (Figure 36). The variability of the depths according to the obtained data was classified as significant. Ratio of average width of flow to the average depth was $C_{b/h}$=15. Flow thalweg passed by the left part of the flow and had depth 1 – 1,2 m.

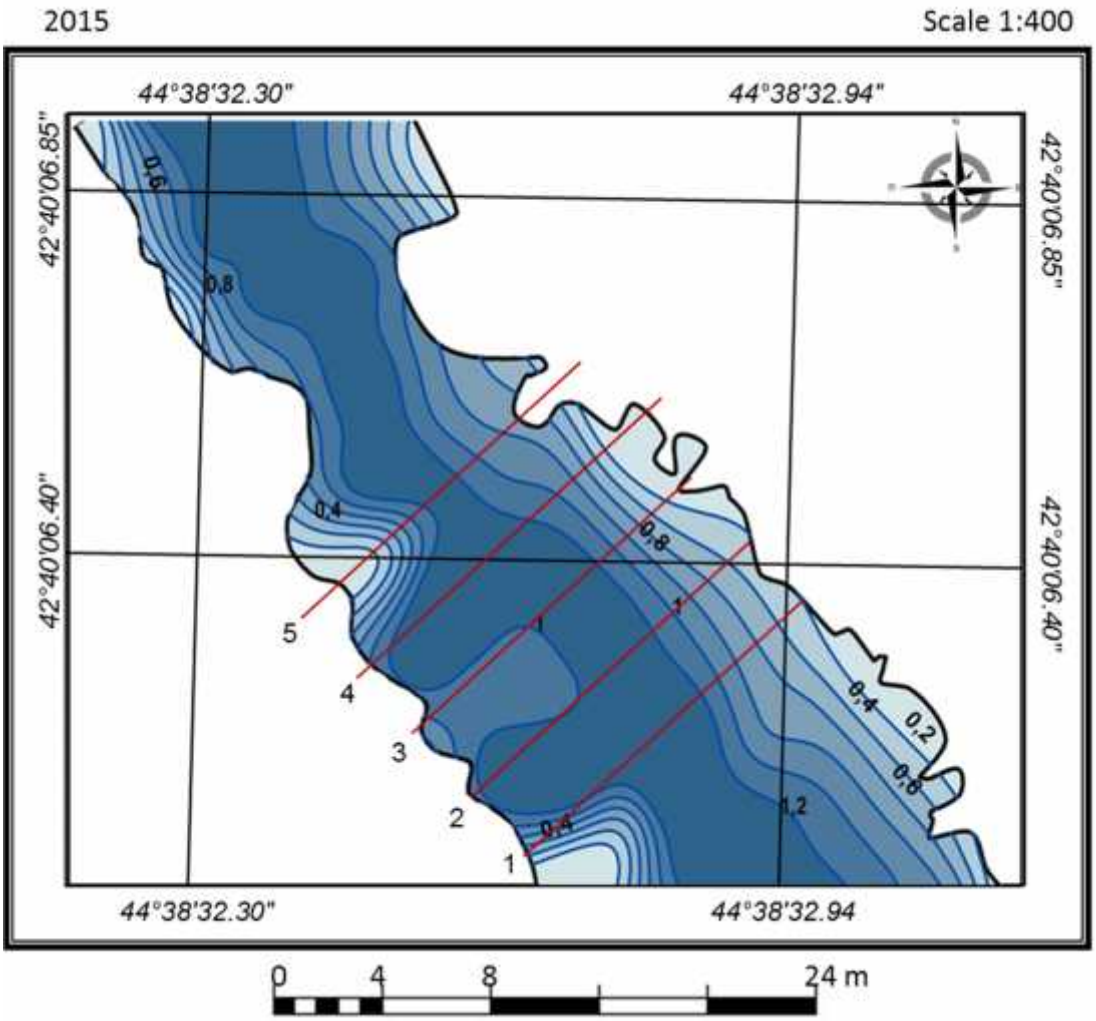


Figure 37. Isobaths (depths). Boulders channel type.

The left bank was steep with significant amount of sediments in the floodplain along the whole monitoring station; right bank was more flat, also covered by stones and large boulders. The riparian lines of the both banks were made out of boulders up to 2 m and gravel. The riverbed is evenly covered by pebble, gravel and sand, with some bedrock up to 3 m in diameter (Figure 38).

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	51
Cobble (64 mm – 256 mm)	22
Pebble (17 mm – 64 mm)	12
Gravel (2 mm – 17 mm)	8
Sand (0.06 mm – 2 mm)	7

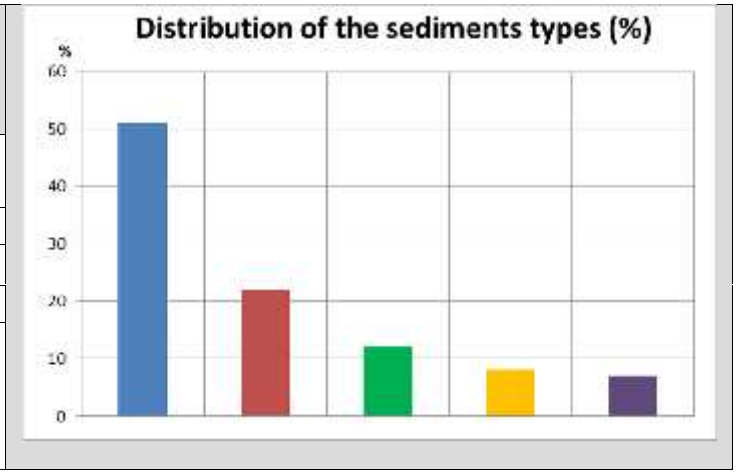


Figure 38. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,36; coefficient of roughness of the riparian line and floodplain was 0,32 and 0,40 correspondingly.

Monitoring station #3: Tergi downstream the Dariali headworks (braided section) (M 6)

Figure 39. Tergi, downstream the Dariali headwork (braided section) (M 5b)

Monitoring station was located at Tergi downstream Dariali headworks (4,35 km), upstream of confluence with Tibaitskali (1,34 km) (Figure 39). The length of the monitoring station is 80 m with the following coordinates in lower part: 42°42'04.60"N and 44°38'00.56"E. The approximate elevation is 1469 m a.s.l. The river site in both sides for 300 m is requitengular and without tributaries (the closest tributary is left tributary Tibaitskali).

The form of the valley is small U-shape. The catchments area in the lower part of the monitoring station is 842,1 m^2. The length of the river from the source is 54,1 km. Coefficient of sinuosity is insignificant 1,14. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 26,8 m^3/s. Measured factual water discharge was 9,77 m^3/s, which corresponded to 42 % of water provision of the average multiannual Q 50% water discharge in Tergi at hydrological station in Stepantsminda. The maximum fixed velocity was 2 m/s, with deviation from the average flow velocity in 2,2 times (the average flow velocity was 0,91 m/s). Flow types included chaotic, broken standing waves, and unbroken standing waves.

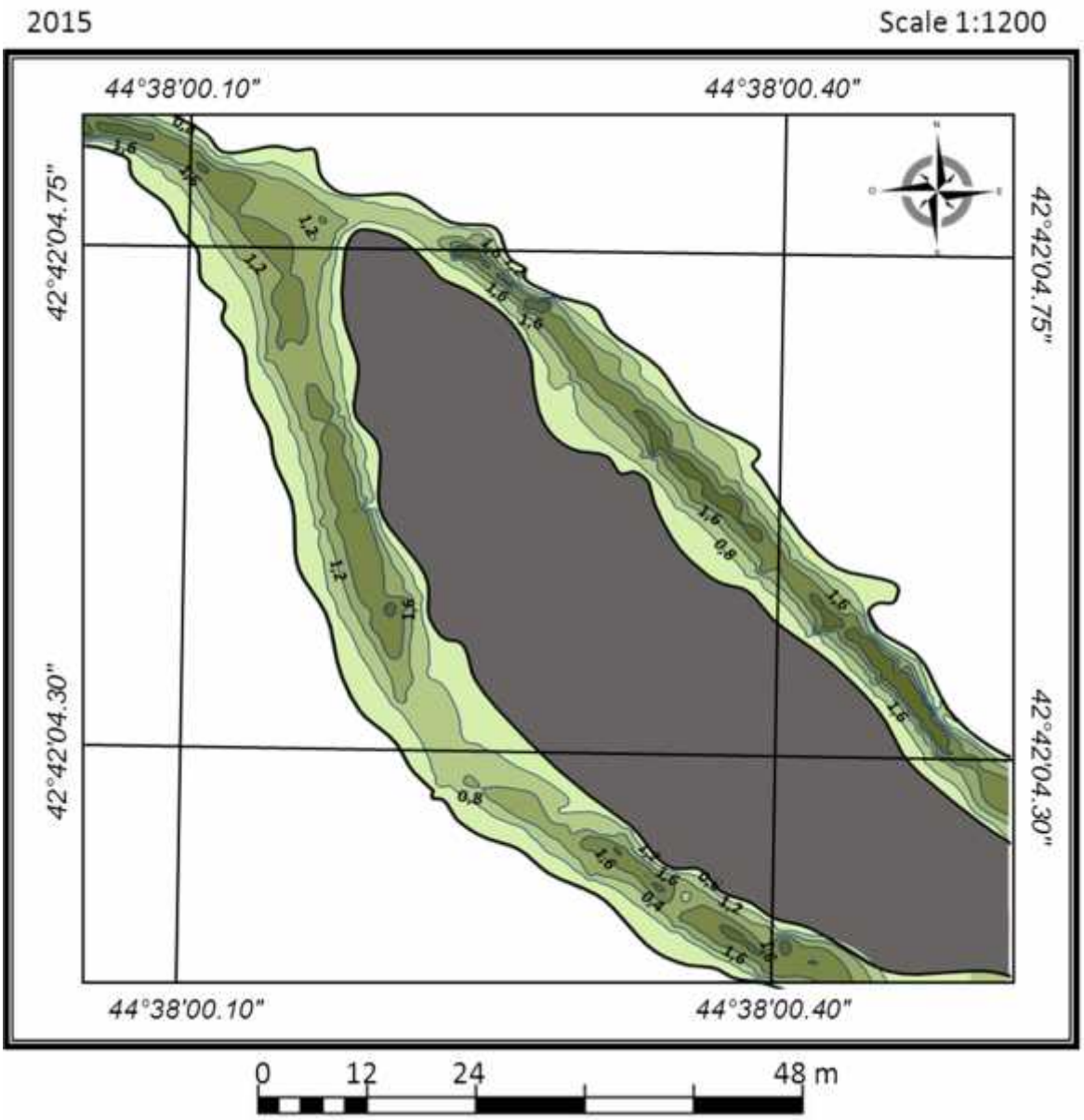


Figure 40. Stream velocity. Braided channel type

The fixed riverbed type according to the hydromorphological protocol is classified as a braided type (Figure 39). The riverbed cross-sections were made for each arm separately. The cross-sections of both arms were even without significant steps, belonging to natural type. Bed elements included island, riffles, and pools.

There were no bank enforcements fixed. The width of the right arm varied from 8,9 to 13,9 m and the width of the left arm varied from 8,2 to 11,8 m. The fixed maximum depth was 1 m, with deviation from the average depth of the flow in 2 times (the average depth is 0,47 m) (Figure 41). The variability of the depths according to the obtained data was classified between insignificant to average. Ratio of average width of flow to the average depth was $C_{b/h}$=21. Flow thalweg for both arms was not explicit; there were some local deepenings in the riverbeds due to increased depths.

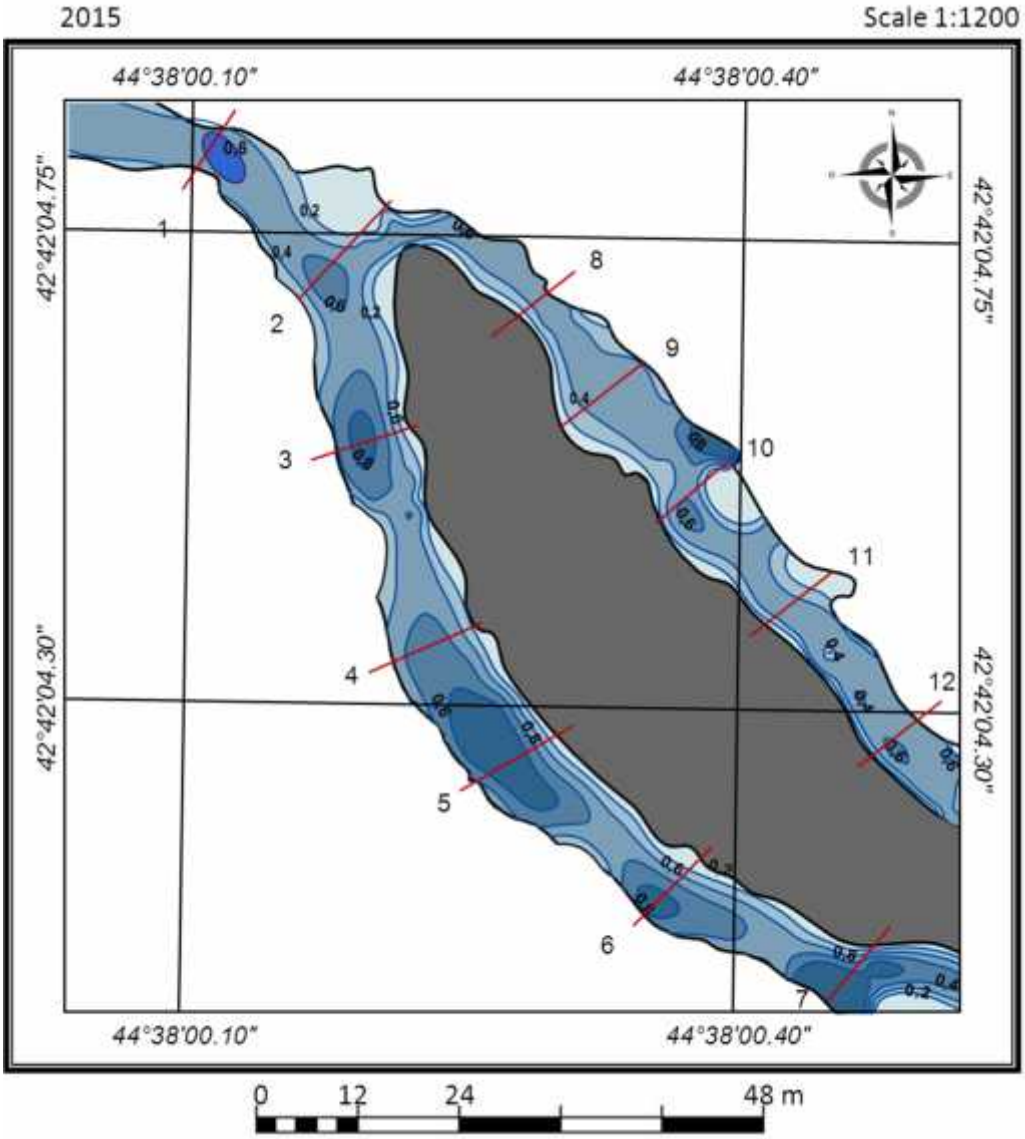


Figure 41. Isobaths (depths). Braided channel type

The left bank was flat; right bank was inlaid, steep; both banks were covered by grass and bushes and boulders were observed only near the water. The riparian line of the right bank was made mainly out of boulders of middle size; left bank was covered by pebble. The riverbed was evenly covered by pebble (56%) and gravel, with 20% of boulders (Figure 42).

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	21
Cobble (64 mm – 256 mm)	56
Pebble (17 mm – 64 mm)	10
Gravel (2 mm – 17 mm)	7
Sand (0.06 mm – 2 mm)	6

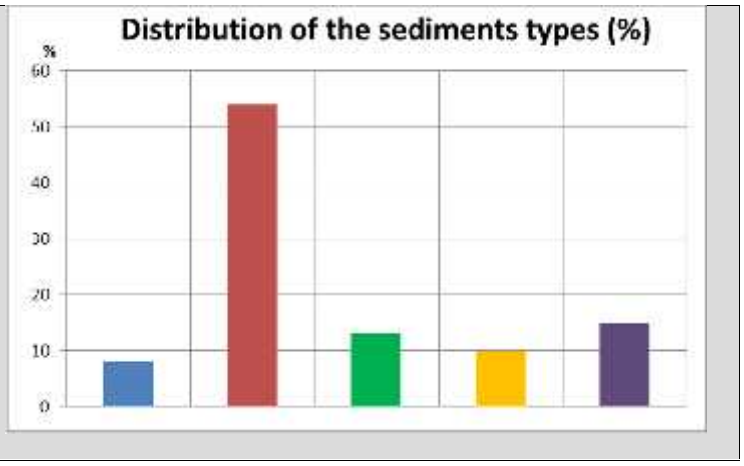


Figure 42. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,29; coefficient of roughness of the riparian line and floodplain was 0,31 and 0,37 correspondingly.

Monitoring station #4: Tergi downstream the Dariali headworks (single thread section) (M7)

Figure 43. Tergi downstream the Dariali headworks (single thread section) (M7)

The monitoring station was located at Tergi downstream Dariali headworks (6,2 km), downstream the confluence with Tibaitskali (0,51 km) (Figure 43). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°42'53.94"N and 44°37'32.62"E. The approximate elevation is 1413 m a.s.l. The river site in upper part for 300 m was requitengular and without tributaries and in lower part, the right turn was at the distance of 100 m (the closest tributary is Tibaitskali).

The form of the valley is small U-shape. The catchment area in the lower part of the monitoring station is 854,6 km^2. The length of the river from the source is 54,8 km. Coefficient of sinuosity is 1,08. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 27,2 m^3/s. Measured factual water discharge was 10,4 m^3/s, which corresponded to 26 % of water provision of the average multiannual Q 50% water discharge in Tergi at hydrological station in Stepantsminda. The maximum fixed velocity was 1,83 m/s, with deviation from the average flow velocity in 3,3 times (the average flow velocity was 0,55 m/s). Flow types included chute, chaotic, broken standing waves, and unbroken standing waves.

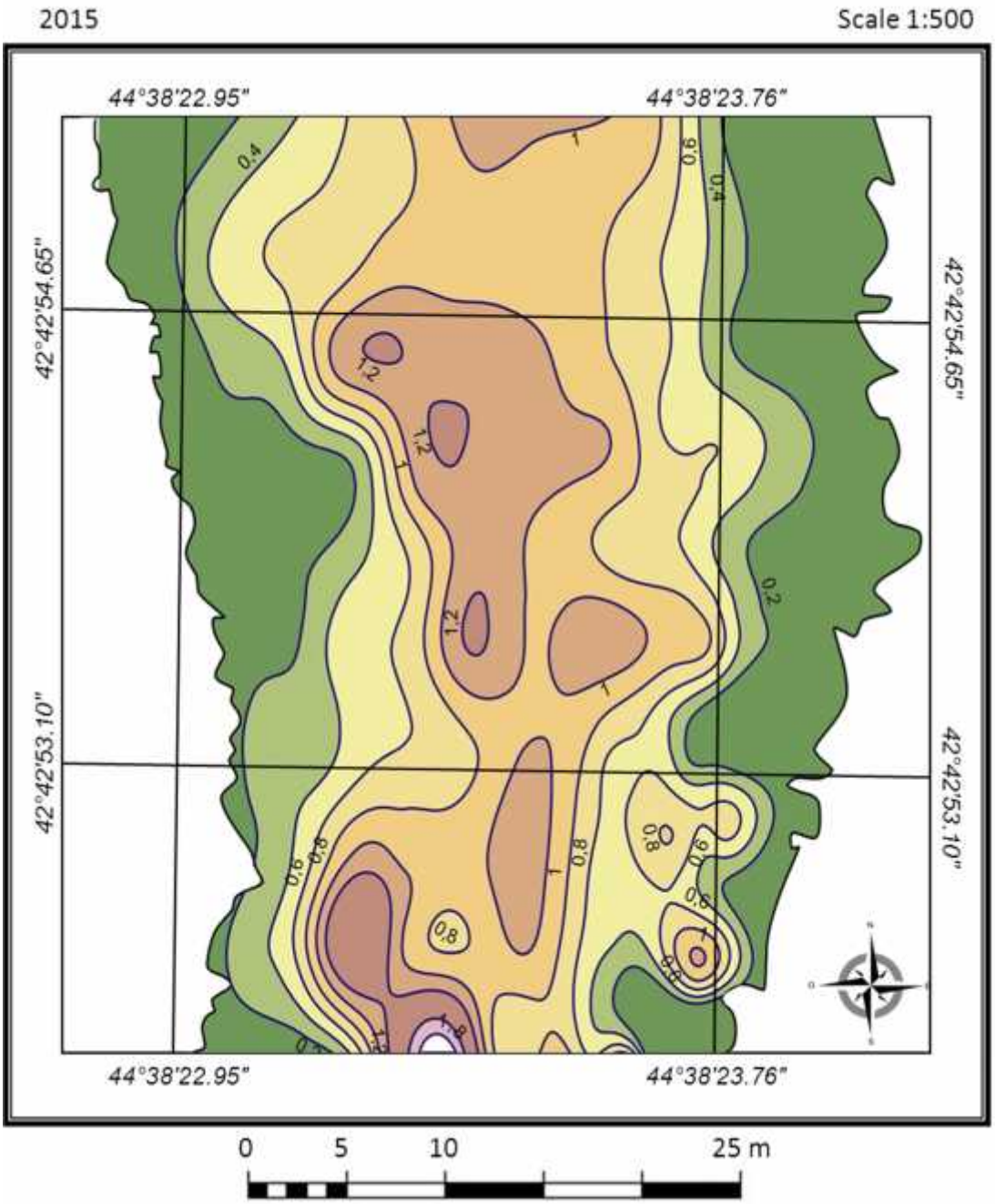


Figure 44. Isotaches of the stream velocity. Single channel type

The fixed riverbed type according to the hydromorphological protocol was classified as single threat (Figure 44). The riverbed cross-sections were even without significant steps; they belonged to natural one. Bed elements included rapids, riffles and pools.

There were no bank enforcements fixed. The width of the river varied from 14 to 21 m. Variability of maximum and minimum width of the riverbed was 1,5. The fixed maximum depth was 1,1 m, with deviation from the average depth of the flow in 1,5 times (the average depth is 0,75 m) (Figure 45). The variability of the depths according to the obtained data was classified as from insignificant to average. Ratio of average width of flow to the average depth was $C_{b/h}$=24. Flow thalweg passed closer to the right bank; there were local deepenings fixed.

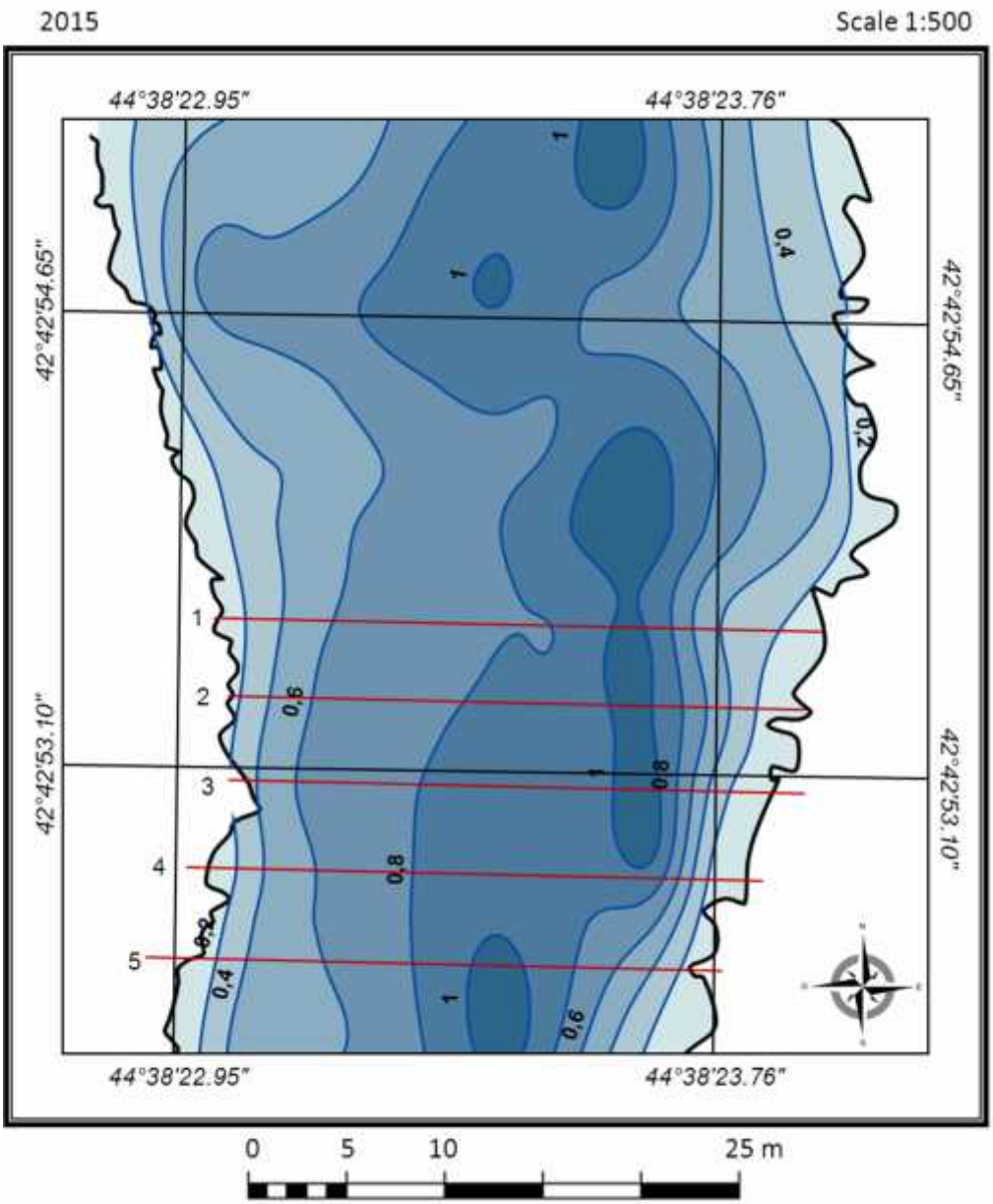


Figure 45. Isobaths (depths). Single channel type

The left bank was flat; the right bank was inlaid; the both banks were covered by tall herbs / shrubs; there were bedrocks near the water. The riverbed was evenly covered by pebble (31%), gravel and boulders (18%) (Figure 46).

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	18
Cobble (64 mm – 256 mm)	31
Pebble (17 mm – 64 mm)	15
Gravel (2 mm – 17 mm)	27
Sand (0.06 mm – 2 mm)	9

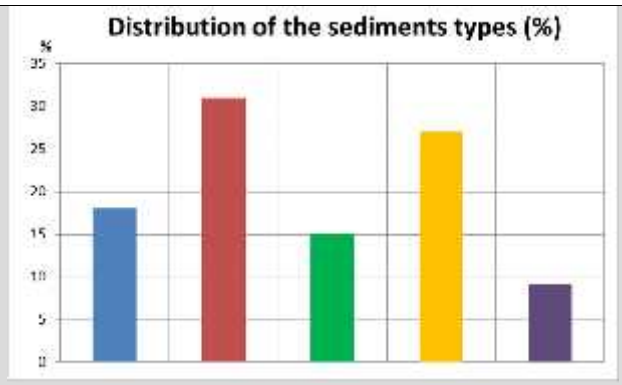


Figure 46. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,31; coefficient of roughness of the riparian line and floodplain was 0,33 and 0,39 correspondingly. No man-caused influence at the monitoring station was fixed.

Monitoring station #5: Chkheri (M4)

Figure 47. Chkheri

The monitoring station was located at Chkheri 0,42 km upstream Dariali headworks (Figure 47). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°39'53.68"N and 44°38'31.09"E. The approximate elevation is 1735 m a.s.l. The river site in both sides for 100 m is requitengular and without tributaries.

The form of the valley is U-shape. The catchment area in the lower part of the monitoring station is 33,6 km^2. The length of the river from the source is 14,6 km. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 0,47 m^3/s. The maximum fixed velocity was 0,8 m/s, with deviation from the average flow velocity in 3 times (the average flow velocity was 0,26 m/s). Flow types included chaotic, broken standing waves, and unbroken standing waves.

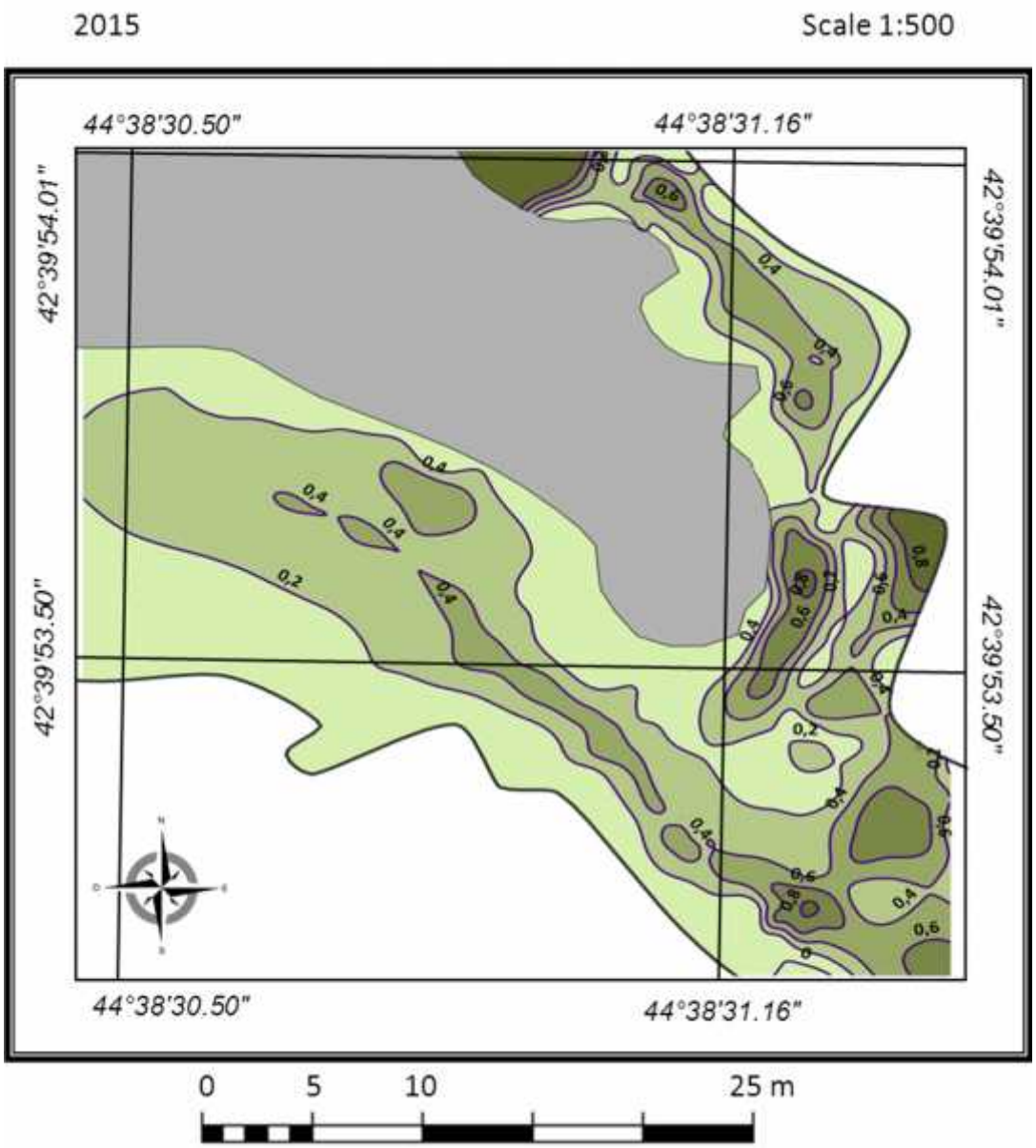


Figure 48. Isotaches of the stream velocity

The riverbed cross-sections were even without significant steps, belonging to natural type. In the middle of the riverbed, there was embankment from pebble, therefore the cross-sections were done considering it. Bed elements included island, step/pool, and riffles.

There were no bank enforcements fixed. The width of the river varied from 4,5 to 12,2 m. Variability of maximum and minimum width of the riverbed in the low water period was 2,7. The fixed maximum depth was 0,65 m, with deviation from the average depth of the flow in 3 times (the average depth is 0,21 m) (Figure 49). The variability of the depths according to the obtained data was classified between insignificant to average. Ratio of average width of flow to the average depth was $C_{b/h}$=48. Flow thalweg passed by the right part of the flow and there were local deepenings.

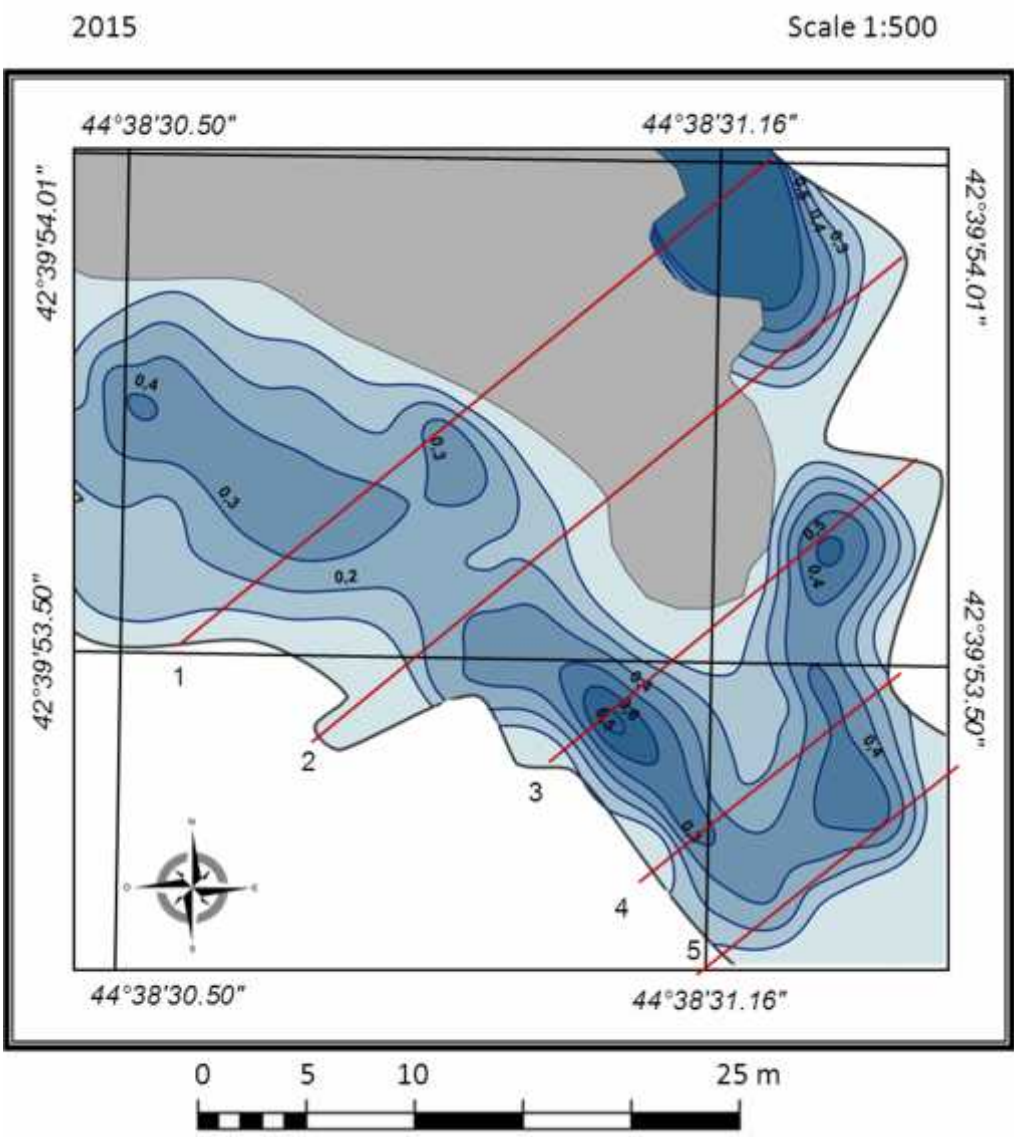


Figure 49. Isobaths (depths)

The both banks were inlaid; the right bank was higher than the left bank. The banks were covered by tall herbs / shrubs, and single trees. Banks were made of boulders and large pebble. The riverbed was covered by boulders (36%) and pebble (24%) (Figure 50).

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	36
Cobble (64 mm – 256 mm)	24
Pebble (17 mm – 64 mm)	17
Gravel (2 mm – 17 mm)	15
Sand (0.06 mm – 2 mm)	8

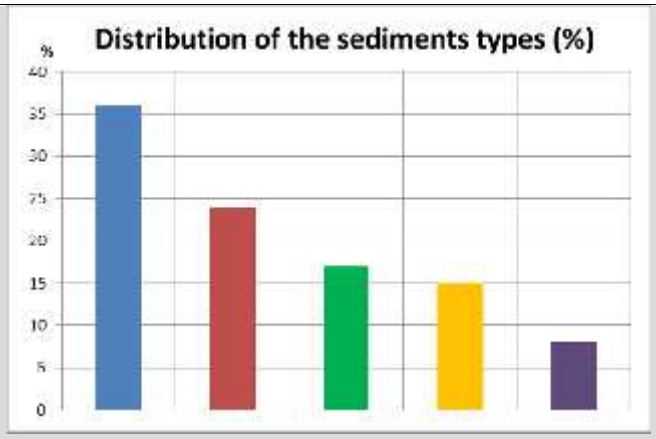


Figure 50. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,35; coefficient of roughness of the riparian line and floodplain was 0,34 and 0,39 correspondingly. No man-caused impact on morphometric features and hydrological regime was fixed.

Monitoring station #6: Kuro (SU 15)

Figure 51. Kuro

The monitoring station was located at Kuro, distance from Dariali headworks is 0,26 km (Figure 51). The length of the monitoring station is 30 m with the following coordinates in lower part: 42°39'55.84"N and 44°38'51.02"E. The approximate elevation is 1760 m a.s.l. The river site in upper part for 50 m was requitengular and without tributaries.

The form of the valley is U-shape. The catchment area in the lower part of the monitoring station is 8,8 km^2. The length of the river from the source is 5,08 km. The riverbed straightening or artificial bottom sediments were not fixed at this station.

The calculated average multiannual discharge for this monitoring station was 0,085 m^3/s. The maximum fixed velocity was 1,03 m/s, with deviation from the average flow velocity in 1,6 times (the average flow velocity was 0,62 m/s). Flow types included broken standing waves, and unbroken standing waves.

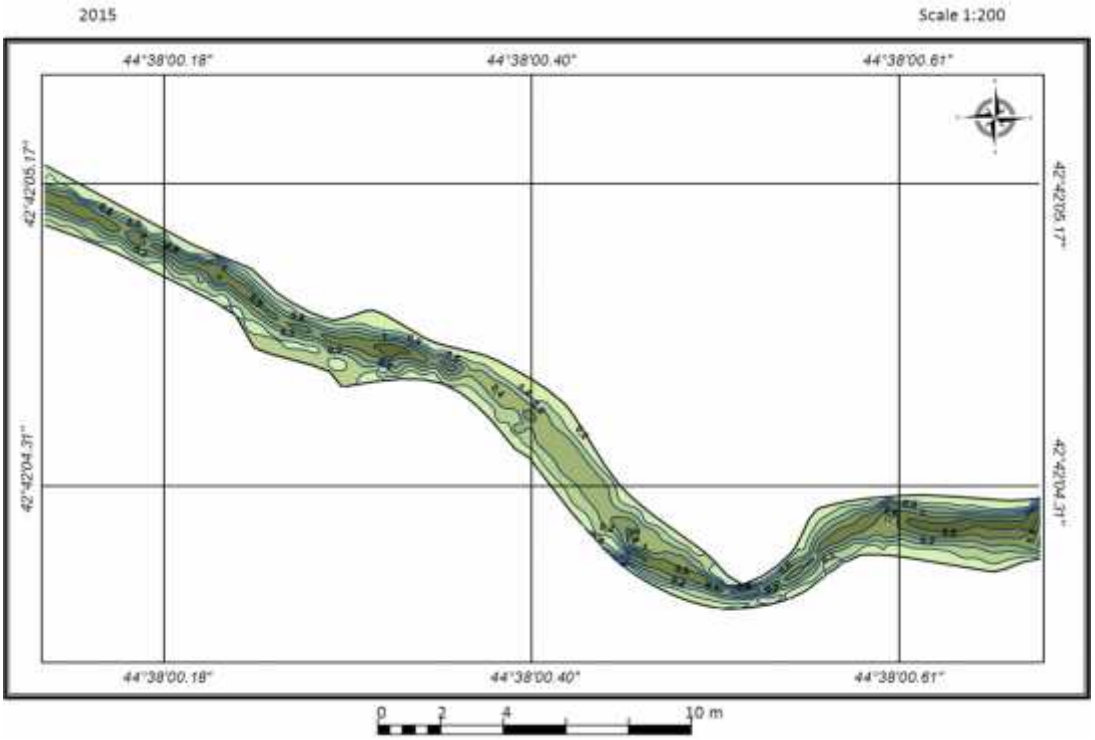


Figure 52. Isotaches of the stream velocity

The riverbed cross-sections were even without significant steps; they belonged to natural one. Bed elements included rapids and riffles.

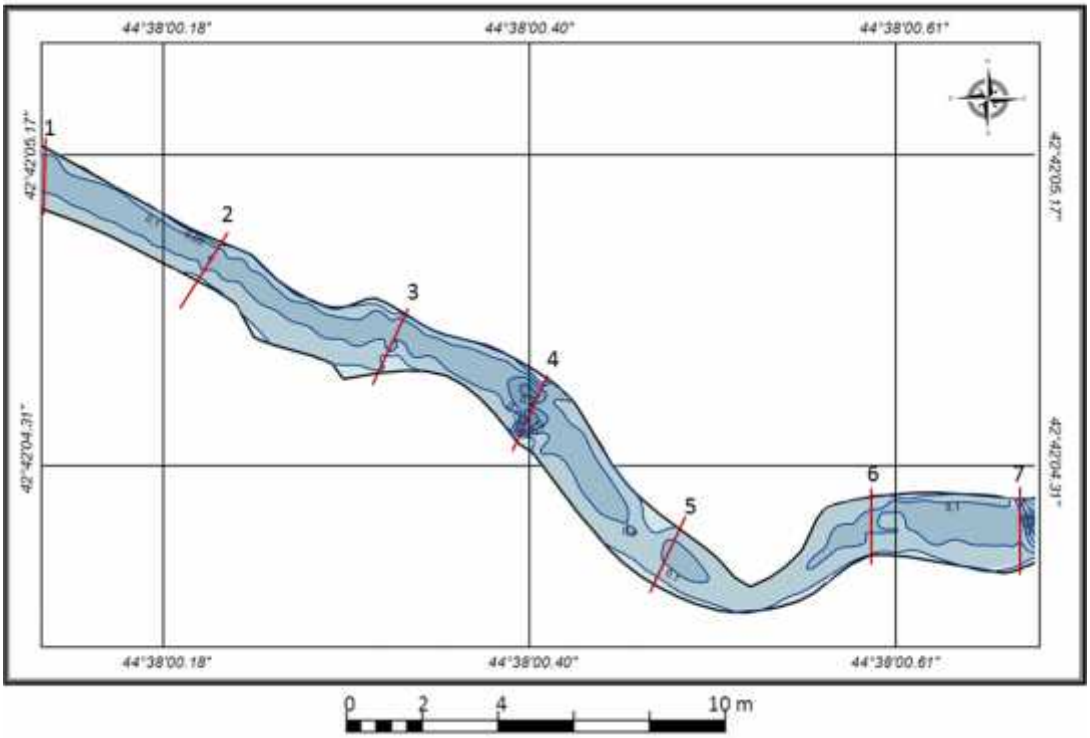


Figure 53. Isobaths (depths)

There were no bank enforcements fixed. The width of the river varied from 0,7 to 8,1 m. Variability of maximum and minimum width of the riverbed was 2,6. The fixed maximum depth was 0,16 m, with deviation from the average depth of the flow in 2 times (the average depth is 0,08 m) (Figure

53). The variability of the depths according to the obtained data was classified as from insignificant to average. Ratio of average width of flow to the average depth was $C_{b/h}$=16. Flow thalweg was not explicit.

The both banks were inlaid; the left bank was higher than the right bank; banks were not covered by vegetation. The banks were made of cobble, pebble and gravel. The riverbed was covered mainly by pebble (45%), and gravel (23%) (Figure 54).

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	15
Cobble (64 mm – 256 mm)	13
Pebble (17 mm – 64 mm)	45
Gravel (2 mm – 17 mm)	23
Sand (0.06 mm – 2 mm)	4

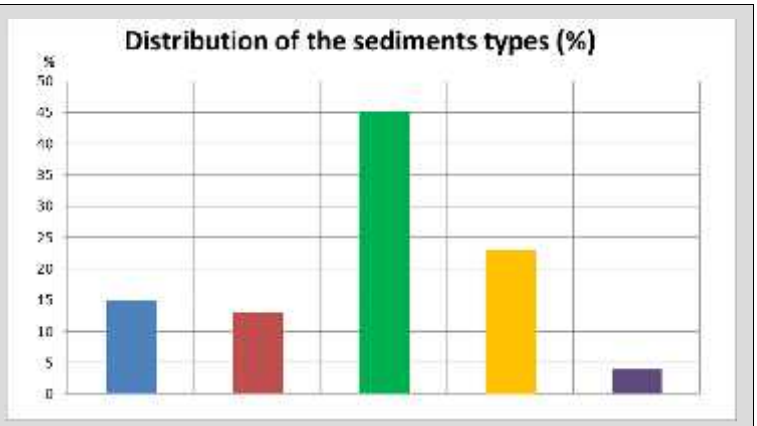


Figure 54. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,29; coefficient of roughness of the riparian line and floodplain was 0,36 and 0,38 correspondingly. No man-caused influence at the monitoring station was fixed.

Monitoring station #7: Tibaitskali (SU 12 b)

Figure 55. Tibaitskali

The monitoring station was located at Tibaitskali (Figure 55). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°42'35.84"N and 44°37'35.64"E. The approximate elevation is 1436 m a.s.l. The river site in both sides for 75 m is requitengular and without tributaries.

The form of the valley is wide U-shape. The catchment area in the lower part of the monitoring station is 10,6 km^2. The length of the river from the source is 7,5 km.

The calculated average multiannual discharge for this monitoring station was 0,14 m^3/s. The maximum fixed velocity was 0,48 m/s, with deviation from the average flow velocity in 1,3 times (the average flow velocity was 0,37 m/s). Flow types included broken standing waves, and unbroken standing waves.

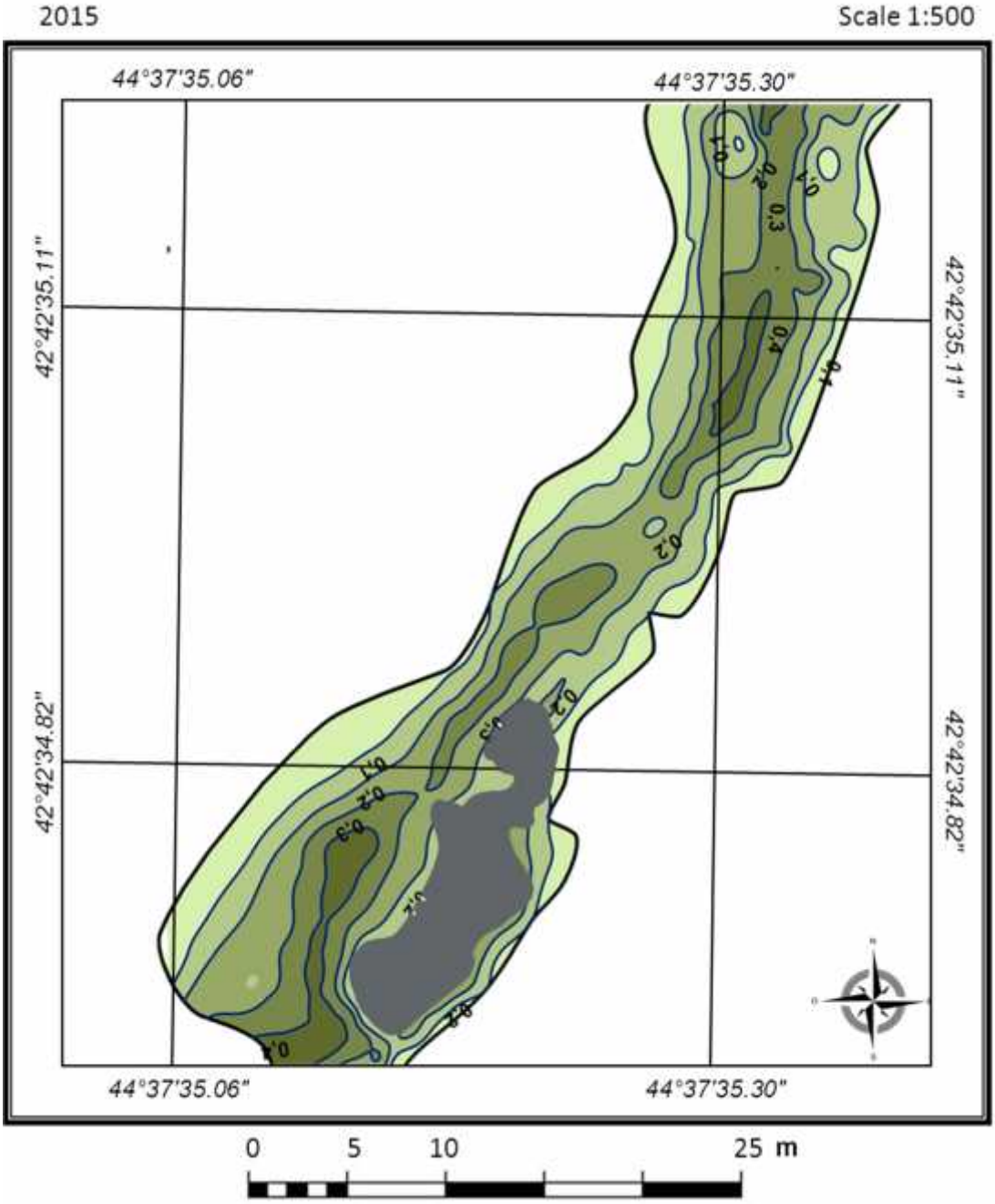


Figure 56. Isotaches of the stream velocity

The riverbed cross-section was even without significant steps, belonging to natural type. Bed elements included island, and riffles.

There were artificial bank enforcements of the right bank fixed. The width of the river varied from 2,5 to 3,7 m. Variability of maximum and minimum width of the riverbed was 1,48. The fixed maximum depth was 0,26 m, with deviation from the average depth of the flow in 2,36 times (the average depth is 0,11 m) (Figure 57). Ratio of average width of flow to the average depth was $C_{b/h}$=30. Flow thalweg passed closer to the right part of the flow.

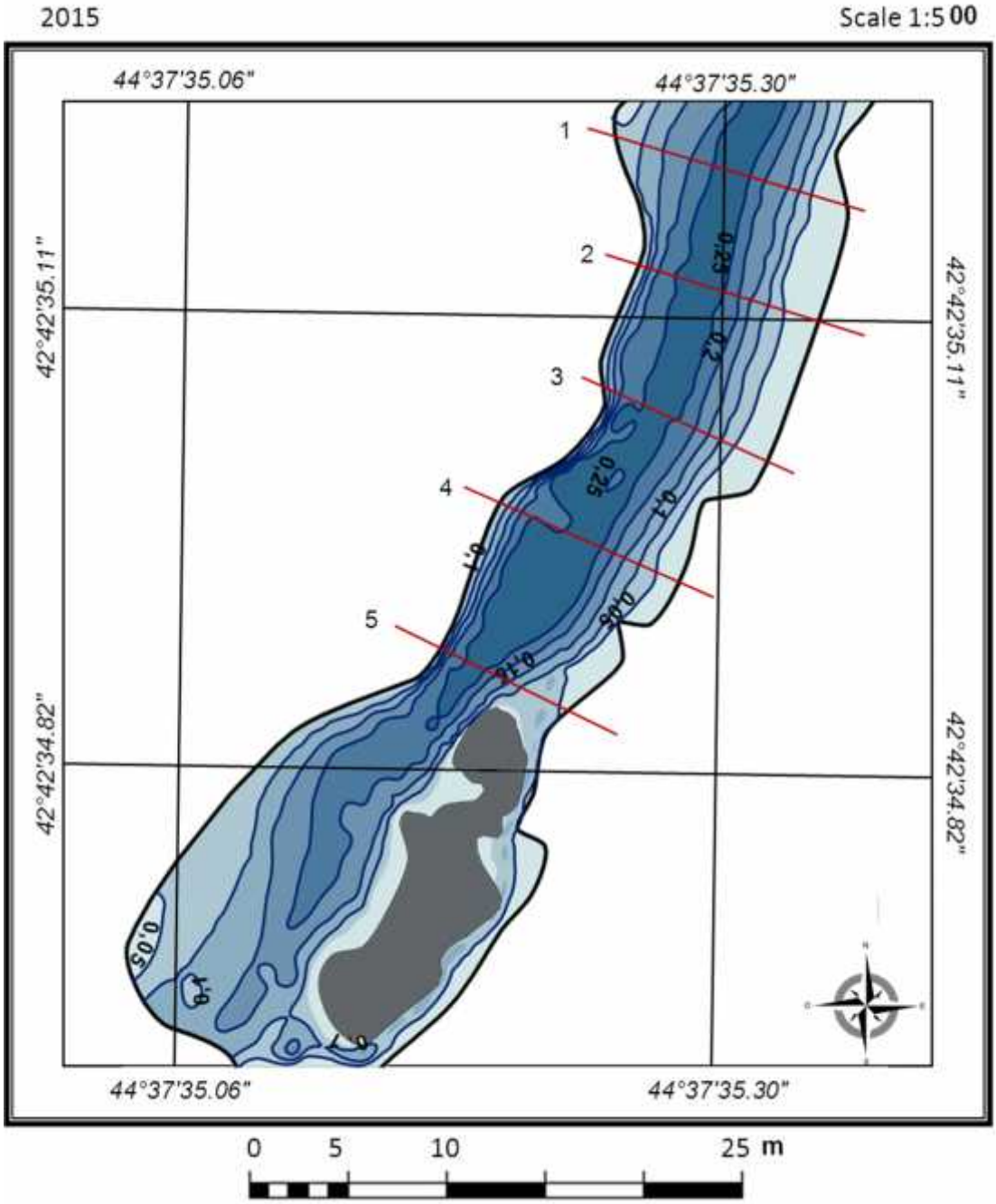


Figure 57. Isobaths (depths)

The left bank was steeper; the right bank was flat and reinforced by concrete wall. The bank line of both banks was made mainly from pebble. The terrace was covered by tall herbs / shrubs, and grass; there were some bedrock. The riverbed was covered by cobble, pebble, and gravel (Figure 57).

Sediments types	% of sediments
Boulder(256 mm–2048 mm)	5
Cobble (64 mm – 256 mm)	48
Pebble (17 mm – 64 mm)	10
Gravel (2 mm – 17 mm)	24
Sand (0.06 mm – 2 mm)	13

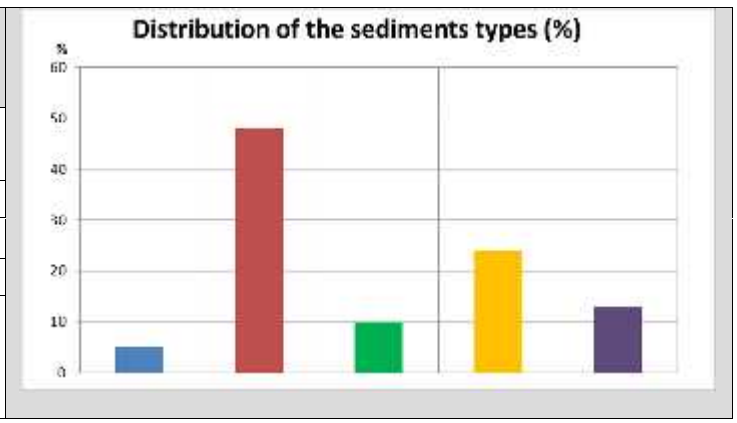


Figure 58. Distribution of the sediments

Coefficient of roughness of the riverbed was 0,33; coefficient of roughness of the riparian line and floodplain was 0,33 and 0,39 correspondingly. No man-caused impact on morphometric features and hydrological regime was fixed.

Monitoring station #8: Amali (SU 11b)

Figure 59. Amali

The monitoring station was located at Amali (Figure 59). The length of the monitoring station is 10 m with the following coordinates in lower part: 42°43'29.09"N and 44°37'33.01"E. The approximate elevation is 1427 m a.s.l. The river site in both sides for 100 m is requitengular and without tributaries.

The form of the valley is wide U-shape. The catchment area in the lower part of the monitoring station is 45,7 km^2. The length of the river from the source is 11,7 km.

The calculated average multiannual discharge for this monitoring station was 0,48 m^3/s. The maximum fixed velocity was 1,04 m/s, with deviation from the average flow velocity in 2 times (the average flow velocity was 0,51 m/s). Flow types included broken standing waves, and unbroken standing waves.

The riverbed cross-section was even without significant steps, belonging to natural type. Bed elements included riffles and rocks.

The width of the river varied from 3,2 to 3,8 m. Variability of maximum and minimum width of the riverbed was 1,18. The fixed maximum depth was 0,35 m, with deviation from the average depth of the flow in 1,8 times (the average depth is 0,19 m). Ratio of average width of flow to the average depth was $C_{b/h}$=18. Flow thalweg passed closer to the right part of the flow.

The left bank was flatter; the right bank was steep. The bank line of both banks was made mainly from cobble and pebble with some large boulders. The terrace was covered by tall herbs / shrubs, and grass; there were some bedrock. The riverbed was covered by cobble, pebble, and gravel (Figure 61). Upstream the monitoring station there is a natural migration barrier in form of water fall.

No hydromorphological mapping of velocities and depths was doe because of the disturbance of the natural regime of the flow because of ascent of the part of glacier Devdoraki on 17th May 2014, which got transformed into the mudflow, which blocked part of the military Georgian motor way and Tergi riverbed (Figure 60).

Figure 60. Mud flow at Amali (2014)[3]

Later Amali riverbed was cleaned from the stones and mudstone. There glacier ascent can reoccur, which will cause repeated impact on the Amali riverbed.

Substrate types	% of sediments
Boulder (256 mm – 2048 mm)	8
Cobble (64 mm – 256 mm)	54
Pebble (17 mm – 64 mm)	13
Gravel (2 mm – 17 mm)	10
Sand (0.06 mm – 2 mm)	15

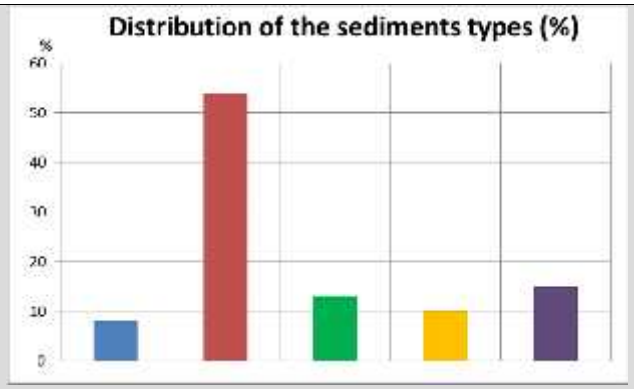


Figure 61. Distribution of the sediments

[3] http://www.ossetia.ru/news/accidents/mchs_voenno_gruzinskaya_doroga_budet_zakryta_eshch.html

Coefficient of roughness of the riverbed was 0,34; coefficient of roughness of the riparian line and floodplain was 0,35 and 0,38 correspondingly. Man-caused impact on morphometric features and hydrological regime was fixed in the form of cleaning of the riverbed from detrital rocks, brought from upstream during the catastrophic floods.

Conclusions

The following results were obtained:

- Hydromorphological monitoring network includes 8 stations - 4 on entire Tergi and 4 on tributaries.
- There were variability of riverbed width, flow depths and flow velocities fixed. The average value measured for Tergi varied from 13,3 m (single riverbed) to 9,88 m (braided riverbed). The maximum depth of the flow was fixed at braided riverbed 1,25 m. The average value of the flow depth varied from 0,40 to 0,71 m. The maximum flow velocity was 2 m/s (at boulders riverbed). The average velocity varied from 0,55 to 0,91 m/s.
- Based on the hydromorphological measurements, maps of isobaths (depths) and isotaches (velocity) were produced, visualizing variation of the depths and widths of the riverbed within the monitoring station.
- Sediments sampling was conducted to assess sediments composition for each monitoring station. Analysis of the sediments was conducted following the fixed gradations for each substrate type and presented in the relevant tables.
- For all stations the roughness coefficient of the riverbed varied within 0,26 – 0,36, bank line 0,31 – 0,36 and floodplain 0,36 – 0,40.

The results of monitoring show the baseline conditions of the flow and physical habitat, which will be used as a starting point (reference) for the post-commissioning monitoring

3.3. Input of tributaries

There are 15 tributaries, which join with the Tergi River between the headworks and the outlet of the tailrace tunnel. The Kuro, Tibaitskali and Amali rivers are the most significant tributaries in this section (Table 13). One of them (Kuro) is right and two (Tibaitskali, Amali) – left (Figure 62). Also monitoring was done at Chkheri, which enters the river upstream Dariali headworks from the left side.

Table 13. Discharge input of the tributaries at the possibly affected reach

№	Tributary	Distance from Dariali headworks, km	Catchment area, km^2	Input of tributaries comparing to total discharge of Tergi in %
1	Kuro_Right	0,05	8,8	1,1
2	Tibaitskali _Left	5,74	10,6	1,4
3	Amali_Left	7,57	45,7	5,9

Each tributary contributes to the Tergi discharge. The input of lateral tributaries to total discharge of Tergi can be calculated using transitional coefficient (ratio) of catchment area to its discharge. The total catchment areas of all tributaries is 130,4 km^2 (based on maps and Google maps): out of them the catchment of the three main tributaries was 65,2 km^2, others – small or temporary watercourses. The received transitional coefficient is 0,168.

The total discharge of the tributaries between the dam headworks and the outlet of the tailrace tunnel was about 18,3% of the discharge of Tergi itself. Out of them the total discharge of only three main tributaries is 8,4%.

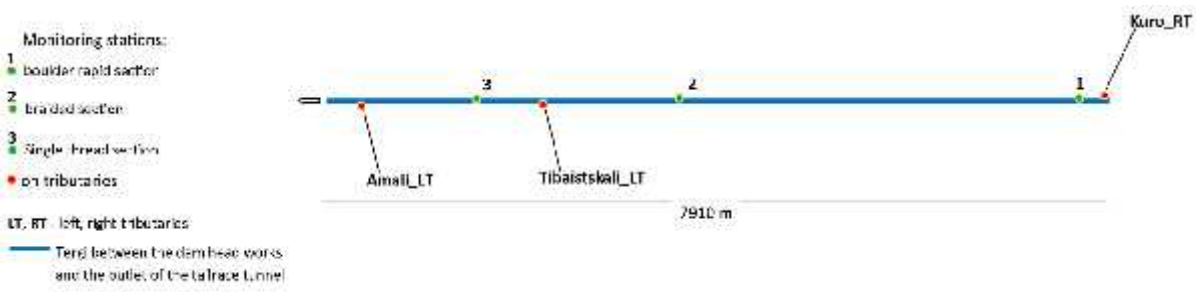


Figure 62. Scheme of the tributaries and locations of monitoring stations

Conclusion
Under environmental flow lateral tributaries will play a role of natural mitigation measure.

3.4 Extend and location of the river channel (and tributaries) that is subject to freezing

Ice cover creates additional resistance to the flow, causes change of the inclination of water surface and increase of water level in winter, not related to the increase of discharge. The mass ice sludge causes rapid fluctuations of water levels; in times of ice drift, large masses of ice can destroy hydrotechnical constructions.

During the field surveys (March – April 2015), no ice phenomena were fixed at the possibly affected reach, even though the temperatures were lower than multiannual for this period. Based on the data obtained on temperature regime, depth and flow velocity, the probability of the ice phenomena were calculated (Table 14).

Table 14. Calculated probability of ice phenomena

River	Stations	possibility of occurrence, %				
		complete ice coverage	incomplete ice coverage	land fast ice	underwater ice	sludge
Tergi	Stepantsminda	≤3	5-50	30-70	≤ 20	≥20
Tergi	Between Stepantsminda and the HPP	≤3	5-50	30-70	≤ 20	≥20
Tergi	Boulders channel type	≤1	1-10	20-40	≤ 25	≥20
Tergi	Braided channel type	≤3	10-60	40-80	≤ 30	≥20
Tergi	Single channel type	≤2	5-50	30-70	≤ 25	≥20
Kuro	Mouth	≤25	30-80	50-90	≤ 35	≥20
Chkheri	Mouth	≤15	20-70	50-80	≤ 25	≥20
Tibaitskali	Mouth	≤25	30-80	50-90	≤ 35	≥20
Amali	Mouth	≤15	20-70	50-80	≤ 25	≥20
Small and temporary water courses		≥50	50-90	80-100	≤ 45	≥20

Conclusion

Ice phenomena can appear at tributaries and temporary watercourses, which can be fully frozen. For Tergi, the post probable is land fast ice (up to 70%). It is impossible to have complete ice coverage in the given depths and flow velocities.

Project "Development and Implementation of Aquatic Biodiversity Action Plan for Dariali HPP"

Blue Rivers ™

Environmental Consulting

Draft Report

Results of 1st year of Survey and Monitoring Plan implementation

ANNEXES

Kyiv

December 2015

Document verification

Job title		Development and Implementation of Aquatic Biodiversity Action Plan for Dariali HPP
Document title		Results of 1st year of Survey and Monitoring Plan implementation
Revision	**Date**	**Authors**
Draft 1	30.12.2015	Dr. Sergey Afanasyev, Dr. Valentin Dolynsky, Mr. Oleg Golub, Dr. Oleksii Iarochevitch, Dr. Olena Lietytska, Mr. Vasyl Manivchuk, Ms. Olena Marushevska. Ms. Kateryna Mudra
Draft 2	20.01.2016	Dr. Sergey Afanasyev, Dr. Valentin Dolynsky, Mr. Oleg Golub, Dr. Oleksii Iarochevitch, Dr. Olena Lietytska, Mr. Vasyl Manivchuk, Ms. Olena Marushevska. Ms. Kateryna Mudra

Contains

Annex 1. List of the macroinvertebrates' species

Species	Identification
PARAZOA	
• Demospongia	+
TURBELLARIA	
• Dugesia gonocephala (Duges)	+
NEMATODA	
• Nematoda sp.	+
NEMATOMORPHA	
• Gordius sp.	+
OLIGOCHAETA	
• Dero sp.	+
• Nais communis	+
• Nais elingvis	+
• Tubifex tubifex (O.F. Muller)	+
HIRUDINEA	
• Piscicola sp.	?
CRUSTACEA	
• Ostracoda sp.	+
• Cyclopoida sp.	+
• Gammarus pulex	+
ARANEIDA	
• Araneida sp.	+
• Hydrachneida sp.	+
COLLEMBOLA	
• Podura aquatica	+
ODONATA	
• Odonata sp.	?
NEUROPTERA	
• Osmylus sp.	+
EPHEMEROPTERA	
• Ametropus fragilis (Albarda)	+
• Baetis rhodani (Pictet, 1843)	+
• B. buceratus (Taton, 1870)	+
• B.(Baetis) gemelus (Eaton, 1870)	?
• B.(B.) ilex (Jakob et Zimm.,1978)	+
• B.(Nigrobaetis) muticus (L., 1758)	+
• B (N.) digitatus (Bengtsson, 1912)	+
• B.(N.) niger (L., 1761)	+

Species	Identification
• Baetis baksan (Soldas, 1977)	+
• Baetis sp.	+
• Epeorus caucasicus (Tsh., 1938)	+
• Ecdyonurus (E.) venosus (Fabr., 1775)	+
• Rhithrogena caucasica (Braasch, 1979)	+
• Heptagenia sulfurea (Muller)	+
• Heptagenia flava (Rostock, 1878)	+
PLECOPTERA	
• Bracbvptera transcaucasica (Zhiltz., 1956)	+
• Perla caucasica (Guer.)	+
• P. pallida (Guer, 1838)	+
• Perlodides microcephala (Pict, 1833)	+
• Isoperla caucasica (Balin, 1950)	+
• Capnia nigra (Pict, 1833)	+
• Taeniopteryx caucasica (Zhiltz.)	+
• Amphinemura trialetica (Zhiltz, 1957)	+
• A. mirabihs (Mart, 1928)	+
• Protonemura ailticola	+
• P. bacurianica (Zhiltz, 1957)	+
• P. capitata (Mart, 1928)	+
• Nemoura cincrea (Retz., 1783)	+
• Leuctra fusca (L., 1758)	+
• L. hippopus (Kemp, 1899)	+
HETEROPTERA	
• Hemiptera sp.	+
COLLEOPTERA	
• Lacophilus sp.	+
• Dytiscidae sp.	+
• Agabus areticus	+
• Hydrochus elongatus	+
TRICHOPTERA	
• Glossosoma capitatum (Mart, 1913)	+
• G. unguiculatum (Mart, 1925)	+
• Sericostoma grusiensis	+
• Rhyacophila nubila (Zett, 1840)	+
• Rh. forcipulata (Mart., 1926)	+
• Rh. cupressorum (Mart, 1913)	+
• Potamophylax latipennis (Curt, 1834)	+

Species	Identification
• Diplecrona felex	+
• Chaetopteryx abchasica (Mart., 1916)	+
• Hydropsyche angustipennis	+
• H. instabilis (Curt., 1834)	+
• H. contubernalis (McL.)	+
• Halesus digitatus (Schrank, 1781)	+
CHIRONOMIDAE	
• Coryneura skutellata	+
• C. lobata	+
• Diamesa insignipes (Kieffer)	+
• Diamesa longipes	+
• Diamesa baiadensis	+
• Syndiamesa branickii	+
• Pseudodiamesa branickii	+
• Parorthocladius nudipennis	+
• Parametriocnemus boreoalpinus	+
• Eukiefferiella alpestris	+
• E. devonica	+
• E. longicalcar	+
• E. lobifera	+
• Heleniella ornaticollis	+
• Orthocladius rivicola (Kieffer)	+
• O. rivulorum	+
• O. bicinctus	+
• O. obumbratus	+
• Synorthocladius semivirens	+
• Crycotopus algarum	+
• C. trianulatus	+
• Chironomus sp.	+
• Endochironomus stackelbergi (Goetghebuer)	+
• Tanytarsus verralli	+
DIPTERA	
• Diptera sp.	+
• Atherix ibis (F.)	+
• Dixa sp.	+
• Brachycerus sp.	+
• Blephariceridae sp.	+
• Hemerodromia sp.	+

Species	Identification
• Dicranota sp.	+
• Dicranota bimaculata (Schummel)	+
• Erioptera lutea	+
• Wiedemannia zettertealti	+
• W. lamellata	+
• Prinocera turcica	+
• Psychodidae sp.	+
• Pericoma falax	+
• Orimarga attenuata	+
• Odontonia sp.	+
• Scleroprocta sp. Limmonidae	+
• Simulium caucasicum	+
• S. ornatum	+
• Wilchelmia pseudequina	+

Remark:
Taxons whose identification is not clear are marked with

Annex 2. Field protocols for biological assessment

Name of the water body	Monitoring station 1
Tergi upstream the Dariali headworks 	Neighbourhood settlement Stepantsminda <u>Coordinates:</u> N – 42^{0}39'32,9" E – 44^{0}38'22,7" H – 1740 m
Date 2015-04-01; 08-09; 10-30	**Weather: +5 to +27**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left bank – precipitous, steep places, right bank – settlements along the steep*
Width of the water body	*on the water's edge 12-15 m,* *width of the dry riverbed – 22 m*
Depth	*Near the bank 10-20 cm, deepening – to 110 cm*
Flow velocity (m/ s)	*0,7-1,62*
The predominant type of substrate	*boulders 2%, stones 88%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*Household waste, runoff of untreated water*
Temperature C°	*the average daily +3 to 19,2*
Color	*cannot be determined*
Transparency of Secchi depth	*to 30-70 cm, in summer not more than 20 cm*
pH	*7,7*
O_2%	*140*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 3, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation, to 3% Fantinalis*
Macroalgae	*fouling of stones less than to 15-20* ***%*** *Hudrurus in spring, overgrowth of filamentous algae up to 5 %*
Macroinvertebrates	*stoneflies -* ***3 species****, mayflies -* ***4 species****, caddis flies -* ***5 species****, chironomids, oligochaetes, dipterans, midges, gammarids, nematodes , mites , larvae of midges*
Amphibia	*Rana macrocnemiss*
Ichthyofauna	*Brown trout (Salmo trutta)*

ASSESSMENT BLOCK

Plecoptera 3+			
Ephemeroptera **(*Baetis* excluded) 4+**	Trichoptera **(*Ecnomus* excluded) 5+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**7**	**6-7**	**7**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
							Salmo trutta	**6**	**4**				**0,4**
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity – *oligosaprobic- oligomezotrofic.*

Name of the water body	Monitoring station 2
Tergi downstream the Dariali headworks (boulder section) 	Downstream the dam of Dariali HPP Coordinates: N – 42^{0}40'06,7" E – 44^{0}38'32,5" H – 1693 m
Date 2015-03-29; 04; 11-01	**Weather: sunny +4 – + 26**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*change on the right side of the construction site both banks are very steep , sometimes precipitous*
Width of the water body	*on the water's edge 15 m, width of the dry riverbed – 25 m*
Depth	*Near the bank 10-50 cm, deepening - to 140 cm*
Flow velocity (m/ s)	*0,15-2,53*
The predominant type of substrate	*boulders 55%, stones 35%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*household waste*
Temperature C°	*the average daily of 14,4*
Color	*cannot be determined*
Transparency of Secchi depth	*to 0,5 m (slight turbidity of water)*
pH	*7,75*
O_2%	*135-140*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 7, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation, Fantinalis - sometimes*
Macroalgae	*fouling of stones less than to 10% Hudrurus in spring fouling filamentous algae sometimes*
Macroinvertebrates	*stoneflies - **3 species**, mayflies **- 4 species**, caddis flies - **4 species,** chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibian	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 3+			
Ephemeroptera **(*Baetis* excluded) 4+**	Trichoptera **(*Ecnomus* excluded) 4+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**6-7**	**5-6**	**6-7**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of the trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 3
Tergi downstream the Dariali headworks (braided section) 	Upstream the confluence with Tibaitskali <u>Coordinates:</u> N – 42^{0}42'04,6" E – 44^{0}38'00,1" H – 1469 m
Date 2015-03-28; 08-03; 11-02	**Weather: +3- +28**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left bank - precipitous, right bank – fletter, steep*
Width of the water body	*on the water's individual sleeves of 5-10 m in the confluence of the edge 20-25 m, width of the dry riverbed - 40-50 m, in some places up to 120 m*
Depth	*Near the bank 10-45 cm, deepening - to 130 cm*
Flow velocity (m/ s)	*0,15-2,13*
The predominant type of substrate	*boulders 10%, stones 75%, gravel 10%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of + 3 – 16,2*
Colour	*cannot be determined*
Transparency of Secchi depth	*to 0,3-0,6 m*
pH	*7,8*
O_2%	*150-160*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 6, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation, to 2% Fantinalis*
Macroalgae	*fouling of stones less than to 10-15**%** Hudrurus in spring fouling filamentous algae sometimes*
Macroinvertebrates	*stoneflies - 5* ***species****, mayflies* ***- 6 species****, caddis flies -* ***5 species,*** *chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibia	*no*
Ichthyofauna	*Brown trout (Salmo trutta)*

ASSESSMENT BLOCK

Plecoptera 5+			
Ephemeroptera **(*Baetis* excluded) 6+**	Trichoptera **(*Ecnomus* excluded) 5+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**9**	**7-8**	**9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
							Salmo trutta	**6**	**4**				**0,4**
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic and oligomezotrofic.*

Name of the water body	Monitoring station 4
Tergi downstream the Dariali headwork (single thread section) 	Downstream the confluence with Tibaitskali <u>Coordinates:</u> N – 42^{0}42'52,9" E – 44^{0}31'34,5" H – 1413 m
Date 2015-03-28; 08-07; 11-01	**Weather: +3-+26**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left bank – craggy, right bank – flatter*
Width of the water body	*on the water's edge 15-30 m,* *width of the dry riverbed – 40-50 m*
Depth	*Near the bank 20-30 cm, deepening - to 140 cm*
Flow velocity (m/ s)	*0,51-1,98*
The predominant type of substrate	*boulders 5-10%, stones 75-85%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of +5 – +13,8 in summer*
Color	*cannot be determined*
Transparency of Secchi depth	*to 0,6m (slight turbidity of water), in flooding of up to 30 cm*
pH	*7,8*
O_2%	*140-155*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 5, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation, Fantinalis sometimes*
Macroalgae	*fouling of stones less than to 15-20% Hudrurus in spring fouling of filamentous algae - sometimes*
Macroinvertebrates	*stoneflies - **4 species**, mayflies **- 4 species**, caddis flies - **3 species,** chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibia	*no*
Ichthyofauna	*Brown trout (Salmo trutta)*

ASSESSMENT BLOCK

Plecoptera 4+			
Ephemeroptera **(*Baetis* excluded) 4+**	Trichoptera **(*Ecnomus* excluded) 3+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**8-9**	**6-7**	**8-9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
							Salmo trutta	**6**	**4**				**0,4**
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 5
Tergi upstream the Larsi headworks 	downstream the confluence with Amali river Coordinates: N – 42^{0}44'15,4" E – 44^{0}37'38,1" H – 1290 m
Date 2015-03-27; 08-01; 11-02	**Weather: +3 – +25**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*Significant changes in the coastline, banks - steep*
Width of the water body	*on the water's edge 12-18 m,* *width of the dry riverbed – 20 m*
Depth	*Near the bank 20-60 cm, deepening - to 140-150 cm*
Flow velocity (m/ s)	*0,75-2,2*
The predominant type of substrate	*boulders 15%, stones 70%, gravel 10%, mud sediments 5%*
Water use	*no*
Visible pollution	*Some communal waste*
Temperature C°	*the average daily of +3,4 – +15,6*
Color	*cannot be determined*
Transparency of Secchi depth	*to 0,2-0,5 m (slight turbidity of water)*
pH	*7,8*
O_2%	*130-140*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 8, ichthyological catches*
Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*no*
Macroalgae	*fouling of stones less than to Hudrurus* *overgrowth of filamentous algae sometimes*

Macroinvertebrates	*stoneflies - 1* ***species****, mayflies* ***- 2 species****, caddis flies -* ***3 species,*** *chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibia	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 1+			
Ephemeroptera **(*Baetis* excluded) 2+**	Trichoptera **(*Ecnomus* excluded) 3+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**7**	**5-6**	**6-7**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of the trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 6
Tergi downstream the Larsi headworks 	downstream the confluence with Amali river <u>Coordinates:</u> N – 42^{0}44'15,4" E – 44^{0}37'38,1" H – 1280 m
Date 2015-03-27; 08-01; 11-02	**Weather: +3 – +25**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*Significant changes in riparian zone, left bank - steep , on the right side along the road has construction works*
Width of the water body	*on the water's edge 3-7 m, width of the dry riverbed – 30 m*
Depth	*Near the bank 10-30 cm, deepening - to 70-90 cm*
Flow velocity (m/ s)	*0,75-2,2*
The predominant type of substrate	*boulders 10%, stones 75%, gravel 15%, mud sediments 5%*
Water use	*no*
Visible pollution	*Some communal waste*
Temperature C°	*the average daily of +3,4 – +16,2*
Color	*cannot be determined*
Transparency of Secchi depth	*to 0,2-0,5 m (slight turbidity of water)*
pH	*7,8*
O_2%	*130-140*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 8, ichthyological catches*
Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*no*
Macroalgae	*fouling of stones less than to Hydrurus overgrowth of filamentous algae sometimes*

Macroinvertebrates	*stoneflies - 1* ***species****, mayflies* ***- 3 species****, caddis flies -* ***4 species,*** *chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibia	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 1+			
Ephemeroptera **(*Baetis* excluded) 3+**		Trichoptera **(*Ecnomus* excluded) 4+**	Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**7**	**5-6**	**6-7**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 7
Sno mouth 	Mouth, merging with the left lateral inflow Coordinates: N – 42^{0}38'13,3" E – 44^{0}37'56,1" H – 1750 m
Date 2015-03-28; 07-29; 10-31	**Weather: +3 to +26**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left bank - steep , right bank – precipitous*
Width of the water body	*on the water's edge 12-15 m,* *width of the dry riverbed – 50 m*
Depth	*Near the bank 10-60 cm, deepening - to 120 cm*
Flow velocity (m/ s)	*0,16-0,88*
The predominant type of substrate	*stones 85%, gravel 10%, mud sediments 5%*
Water use	*grazing cattle*
Visible pollution	*household garbage, manure*
Temperature C°	*the average daily + 5 in spring and autumn, + 17,2 in summer*
Color	*cannot be determined*
Transparency of Secchi depth	*0,3 - 0,9 m*
pH	*7,9*
O_2%	*162*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 26, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*floodplain vegetation, to 10% Fantinalis*
Macroalgae	*fouling of stones less than to 5-7% Hudrurus, up to 5-% filamentous algae*
Macroinvertebrates	*stoneflies - **4 species**, mayflies - **6 species**, caddis flies - **5 species**, chironomids, oligochaetes, dipterans, midges, gammarids, leeches, nematodes , mites , lice larvae*
Amphibia	*Rana macrocnemis*
Ichthyofauna	*Brown trout (Salmo trutta)*

ASSESSMENT BLOCK

Plecoptera 4+			
Ephemeroptera **(*Baetis* excluded) 6+**	Trichoptera **(*Ecnomus* excluded) 5+**		Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**8**	**7**	**8**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
							Salmo trutta	**6**	**4**				**0,4**
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic and oligomezotrofic.*

Name of the water body	Monitoring station 8
Bashi mouth 	Coordinates: N – 42^{0}39'37,7" E – 44^{0}38'13,4" H – 1754 m
Date 2015-08-10	**Weather: +26**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left bank - precipitous, right bank - flat*
Width of the water body	*on the water's edge 0,8-75 m,* *width of the dry riverbed – 15 m*
Depth	*Near the bank 10-20 cm, deepening - to 70 cm*
Flow velocity (m/ s)	*0,2-0,8*
The predominant type of substrate	*boulders 5%, stones 85%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of +13,0*
Colour	*cannot be determined*
Transparency of Secchi depth	*to 0,7 m (slight turbidity of water)*
pH	*7,75*
O_2%	*165*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 10, ichthyological catches*
Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian meadow vegetation, to 15% Fantinalis*
Macroalgae	*fouling of stones less than to 5% of Hydrurus*
Macroinvertebrates	*stoneflies - 4* ***species****, mayflies* ***- 4 species****, caddis flies -* ***5 species,*** *chironomids, oligochaetes, dipterans, midges,*

	gammarids
Amphibia	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 4+			
Ephemeroptera **(*Baetis* excluded) 4+**		Trichoptera **(*Ecnomus* excluded) 5+**	Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**9-10**	**7-8**	**9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 9
Chkheri mouth 	Upstream the bridge Coordinates: N – 42^{0}39'53,7" E – 44^{0}38'30,5" H – 1735 m
Date 2015-04-30; 08-07, 10-30	**Weather: +3 +28**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *left – bank steep , right bank – precipitous*
Width of the water body	*on the water's edge 5- 16 m,* *width of the dry riverbed – 20-25 m*
Depth	*Near the bank 5-20 cm, deepening - to 50-80 cm*
Flow velocity (m/ s)	*0,05-1,2*
The predominant type of substrate	*boulders 35%, stones 55%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of +3 in spring – autumn, +14,6 in summer*
Color	*cannot be determined*
Transparency of Secchi depth	*Up to 0,4, in summer due to glacier melting - 0*
pH	*7,7*
O_2%	*167*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 4, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation meadow vegetation, Fantinalis sometimes*
Macroalgae	*fouling of stones less than to 2% Hudrurus overgrowth of filamentous algae - sometimes*
Macroinvertebrates	*stoneflies - 4* ***species****, mayflies -* ***6 species****, caddis flies -* ***6 species,*** *chironomids, oligochaetes, dipterans, midges, gammarids, the larvae of beetles , water bugs, small crustaceans , centipedes*
Amphibia	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 4+			
Ephemeroptera (***Baetis*** **excluded) 6+**		Trichoptera (***Ecnomus*** **excluded) 6+**	Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**9**	**7-8**	**9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 10
Kuro mouth 	Coordinates: N – 42^{0}40'40,4" E – 43^{0}18'26,2" H – 1760 m
Date 2015-03-30; 07-29 ; 10-30	**Weather: + 2 – +24,3**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *precipitous, sometime steep with scree*
Width of the water body	*on the water's edge 1,0-3,0 m,* *width of the dry riverbed – 5-7 m*
Depth	*Near the bank 5 cm, deepening– to 25-30 cm*
Flow velocity (m/ s)	*0,36-1,03*
The predominant type of substrate	*stones 60%, gravel 30%, mud sediments 10%*
Water use	*grazing, watering*
Visible pollution	*Household waste is insignificant , manure*
Temperature C°	*the average daily of +2 - +16,1*
Color	*cannot be determined*
Transparency of Secchi depth	*to 30 cm*
pH	*7,8*
O_2%	*120-140*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 15*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*no*
Macroalgae	*fouling of filamentous algae of stones less than to 1-**2%***
Macroinvertebrates	*stoneflies – 1 **species**, mayflies **- 4 species**, caddis flies – **2 species,** chironomids, oligochaetes, dipterans, midges, gammarids*
Amphibia	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 1+			
Ephemeroptera **(*Baetis* excluded) 4+**		Trichoptera **(*Ecnomus* excluded) 2+**	Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera, planaria			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**7-9**	**7**	**9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 11
Tibaitskali mouth 	Coorinates: N – 42^{0}42'35,5" E – 44^{0}37'35,4" H – 1436 m
Date 2015-04-01; 08-07; 11--02	**Weather: + 4 – +23,2**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *right bank - steep, left bank - rocky , steep*
Width of the water body	*on the water's edge 2,0-6,5 m,* *width of the dry riverbed – 7-10 m*
Depth	*Near the bank 10 cm, deepening - to 40 cm*
Flow velocity (m/ s)	*0,05-0,65*
The predominant type of substrate	*boulders 60%, stones 30%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of + 2,1 – +15,5*
Color	*cannot be determined*
Transparency of Secchi depth	*to 40 cm*
pH	*7,75*
O_2%	*150-162*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 12, ichthyological catches*

Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian meadow vegetation, to 15% Fantinalis shrubs*
Macroalgae	*fouling of Hydrurus of stones less than to 5%, filamentous algae to 10%*
Macroinvertebrates	*stoneflies – 5* ***species****, mayflies* ***- 6 species****, caddis flies -* ***6 species,*** *chironomids, oligochaetes, dipterans, midges, gammarids, planaria*
Amphibia	*no*
Ichthyofauna	*Brown trout (Salmo trutta)*

ASSESSMENT BLOCK

Plecoptera 5+			
Ephemeroptera **(*Baetis* excluded) 6+**	Trichoptera **(*Ecnomus* excluded) 6+**		Gammaridae +
Odonata +	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera, planaria			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**9-10**	**7-8**	**9**
geobotanical indicators			

INDICATOR SPECIES

Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
							Salmo trutta	**6**	**4**				**0,4**
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

Category of trophicity - *oligosaprobic.*

Name of the water body	Monitoring station 12
Amali mouth 	Coordinates: N – 42^{0}43'29,9" E – 44^{0}37'32,4" H – 1427 m
Date 2015-04-01	**Weather: +5,4**

DESCRIPTION BLOCK

Landscape and biotopic description:	
Geology	*siliceous*
Altitude category	*high type*
Type of water body	*a mountain river*
Structure of the bank	*in natural outlines* *precipitous in the canyon*
Width of the water body	*on the water's edge 2-5 m,* *width of the dry riverbed – 7-10 m*
Depth	*Near the bank 5 cm, deepening - to 40 cm*
Flow velocity (m/ s)	*0,06-1,18*
The predominant type of substrate	*boulders 20%, stones 70%, gravel 5%, mud sediments 5%*
Water use	*no*
Visible pollution	*no*
Temperature C°	*the average daily of +2,3*
Color	*cannot be determined*
Transparency of Secchi depth	*to 40 cm*
pH	*7,8*
O_2%	*150-160*
Additional Information	*samples were taken of bottom fauna (washout from stones + kick & sweep) № 11, ichthyological catches*
Biotsenotic description	
Survey method	*manual collection*
Macrophytes	*riparian floodplain vegetation, to 5% Fantinalis*
Macroalgae	*fouling of Hydrurus of stones less than to 5%*
Macroinvertebrates	*stoneflies -* ***3 species****, mayflies -* ***4 species****, caddis flies -* ***4species,*** *chironomids, oligochaetes, dipterans, midges,*

	gammarids
Amphibian	*no*
Ichthyofauna	*no*

ASSESSMENT BLOCK

Plecoptera 3+			
Ephemeroptera **(*Baetis* excluded) 4+**		Trichoptera **(*Ecnomus* excluded) 4+**	Gammaridae +
Odonata –	Bivalvia (*Sphaeridae* excluded) –	Gastropoda –	Bryozoa –
Spongia –	Asellus –	Hirudinea –	Sphaeridae –
Chironomidae +		Tubificidae +	
Other: larvae of midges, diptera			

Biotic indices	Periphyton	Benthos	General
Trent Biotic Index	**9**	**7-8**	**9**
geobotanical indicators			

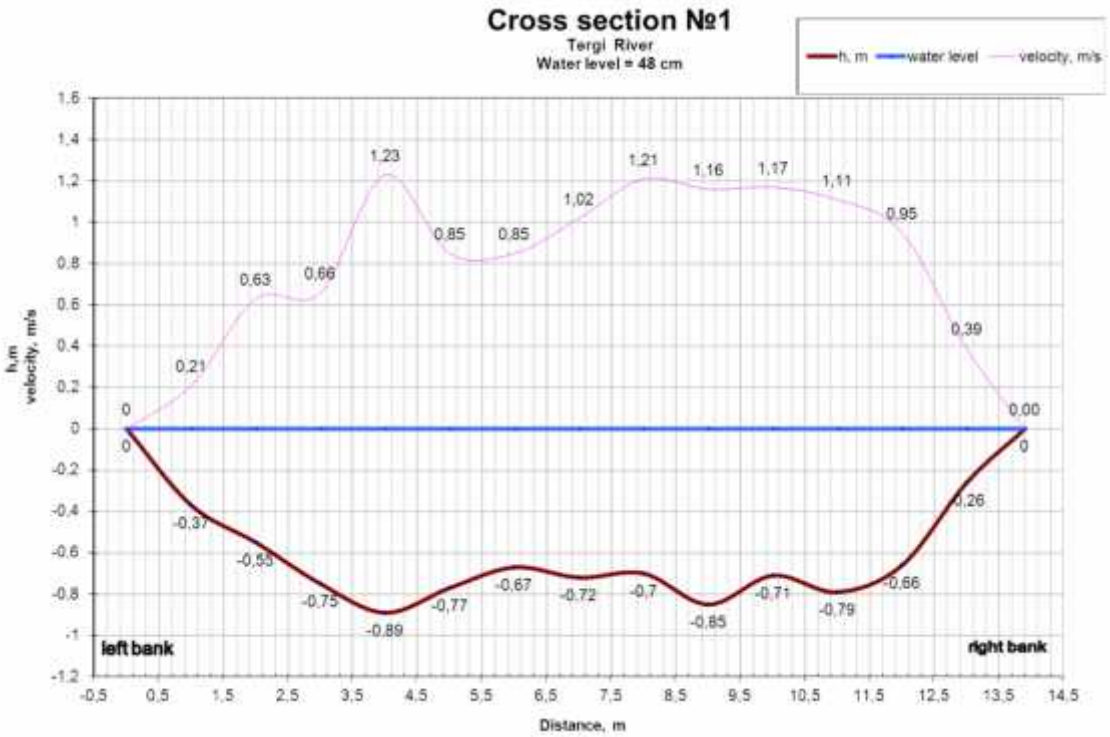
INDICATOR SPECIES

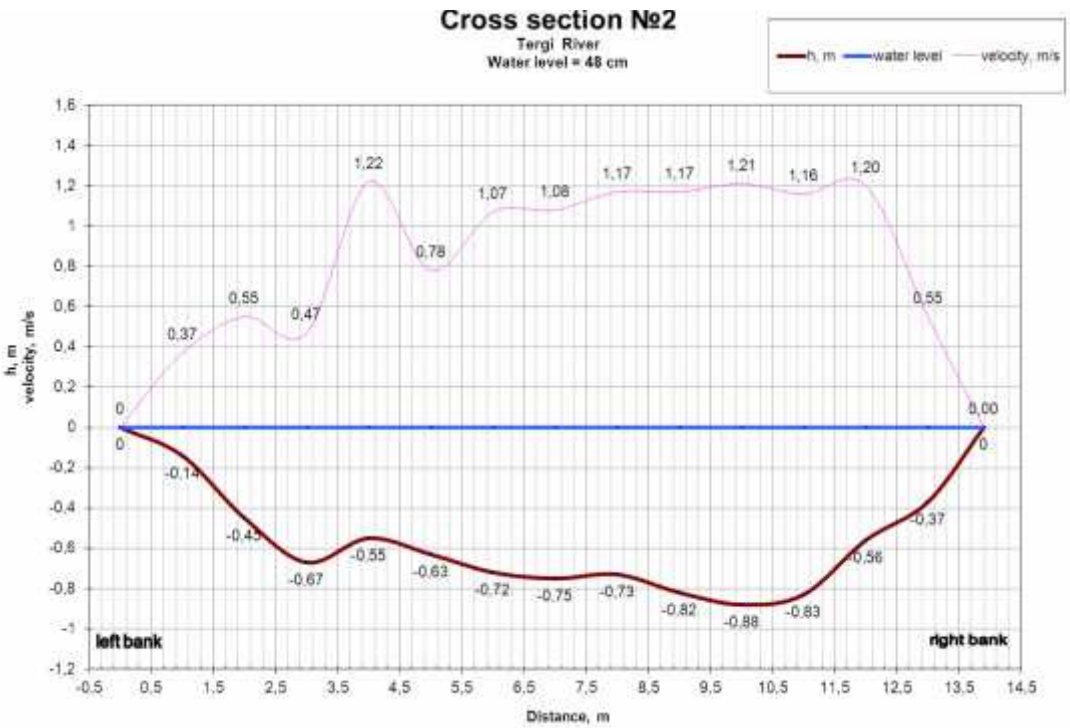
Benthic fauna							Fish						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***
Higher aquatic vegetation							Other indicators						
Saprobity area	**X**	**o**	**α**	**β**	**p**	***S***	Saprobity area	**x**	**O**	**α**	**β**	**p**	***S***

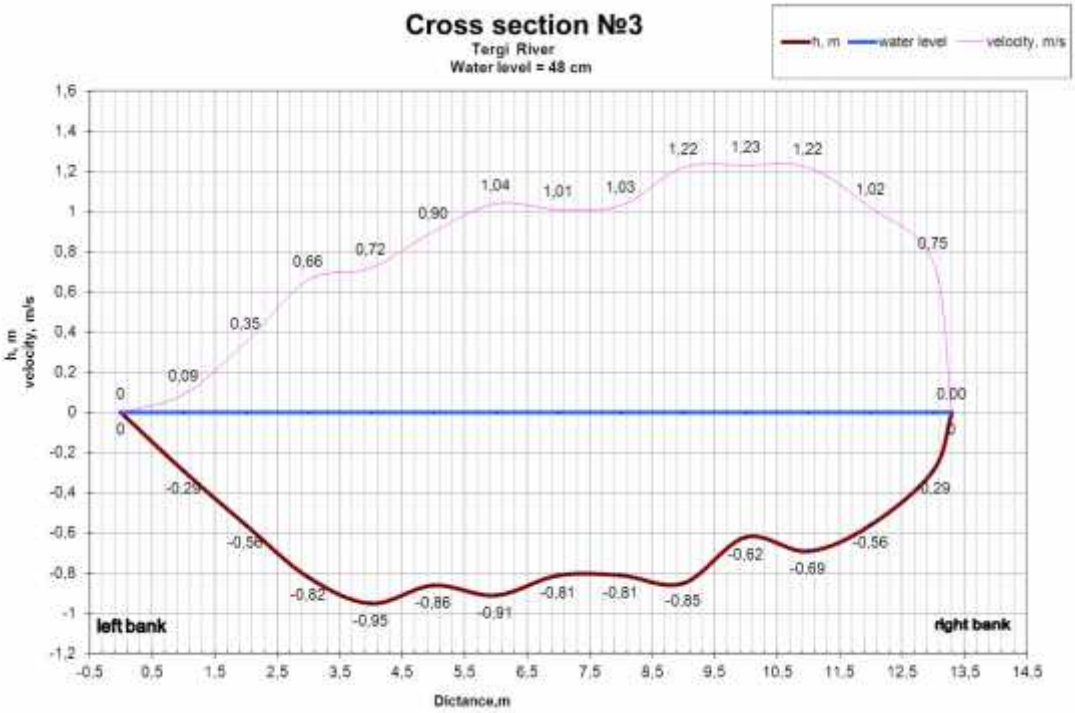
Category of trophicity - *oligosaprobic.*

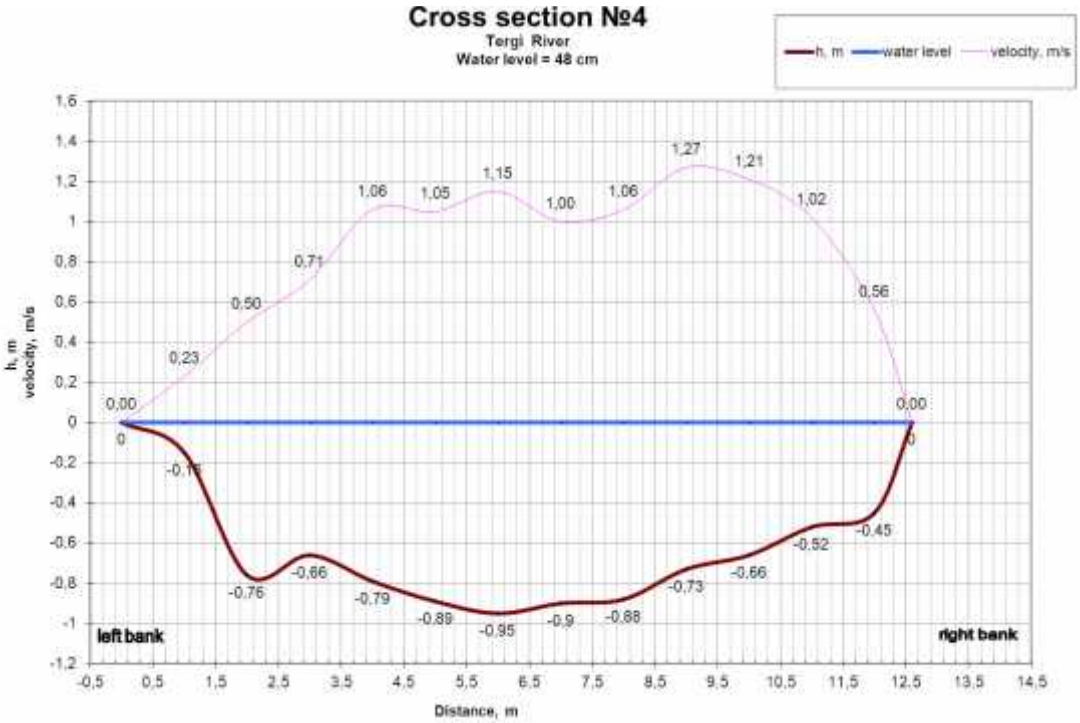
Annex 3. Hydrological cross sections for monitoring stations

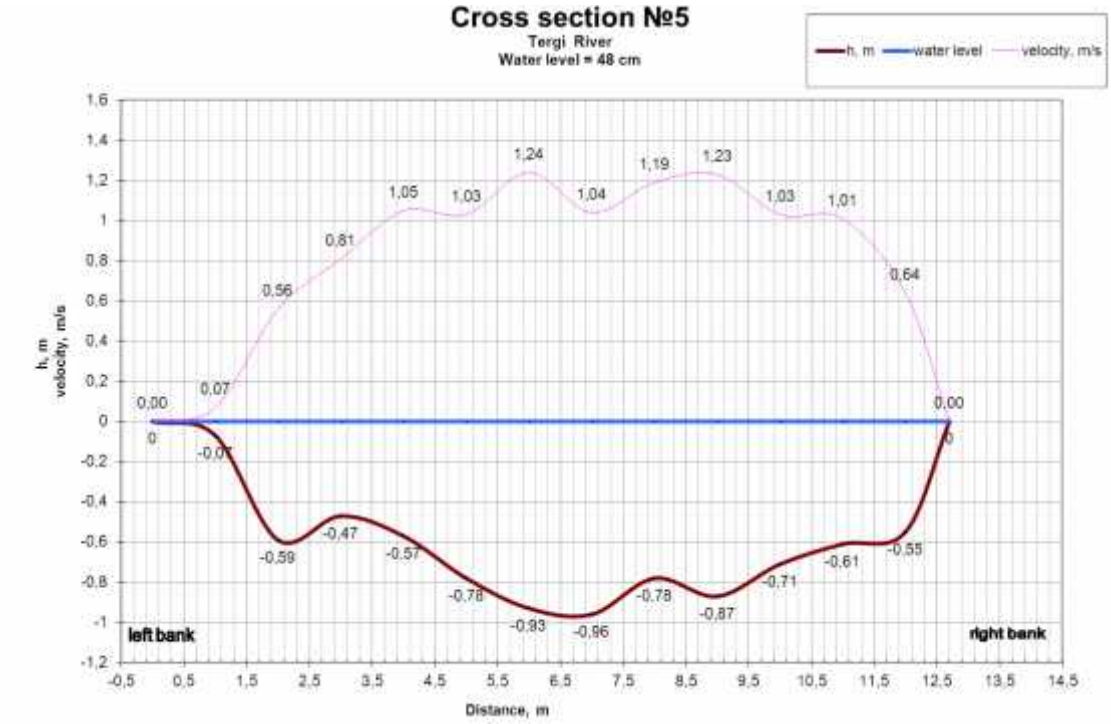
Monitoring station 1 – **Tergi upstream the Dariali headworks**



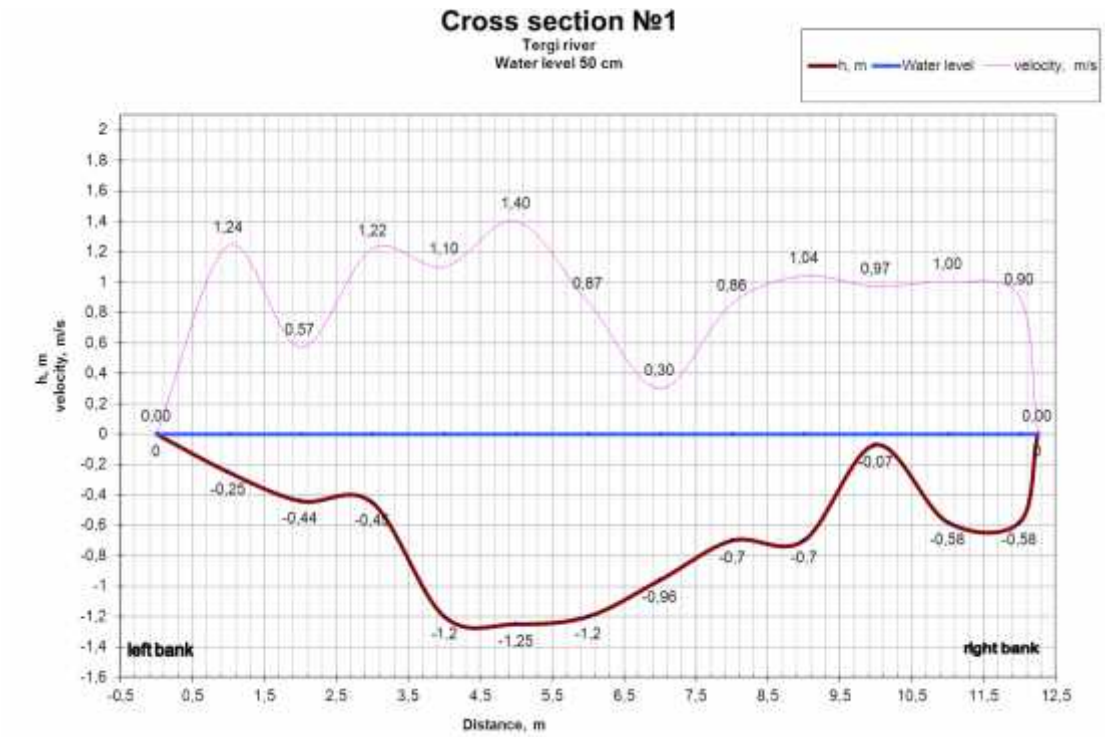


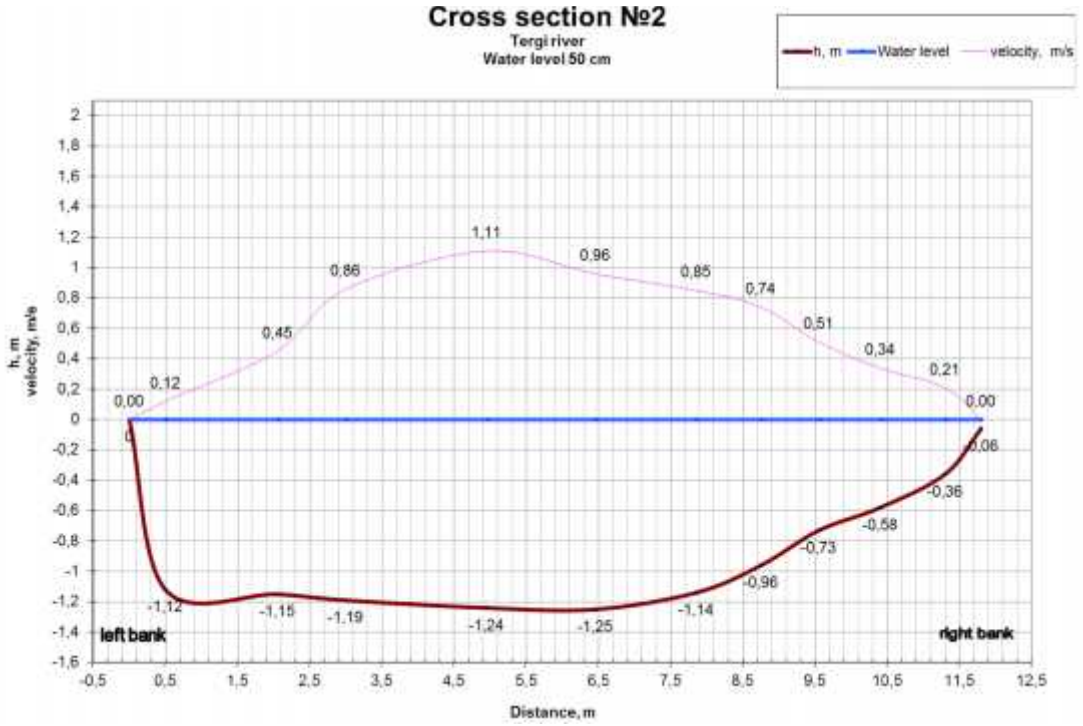

Cross section №3
Tergi River
Water level = 48 cm
h, m
water level
velocity, m/s
h, m
velocity, m/s
Dictance,m
left bank
right bank

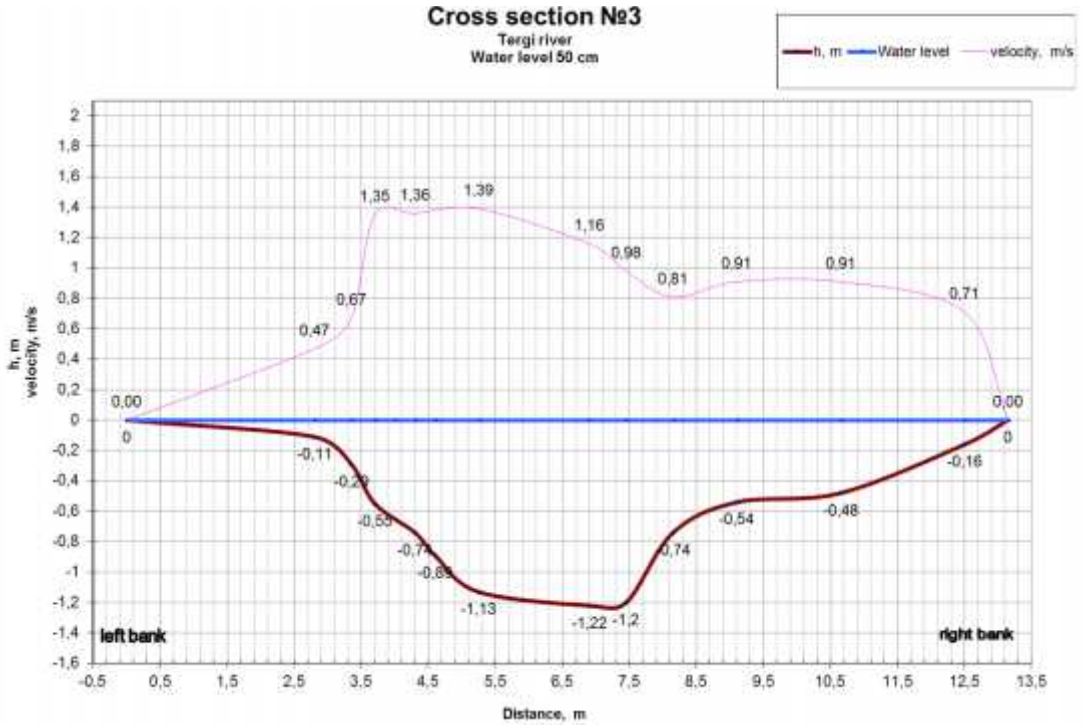

Cross section №4
Tergi River
Water level = 48 cm
h, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

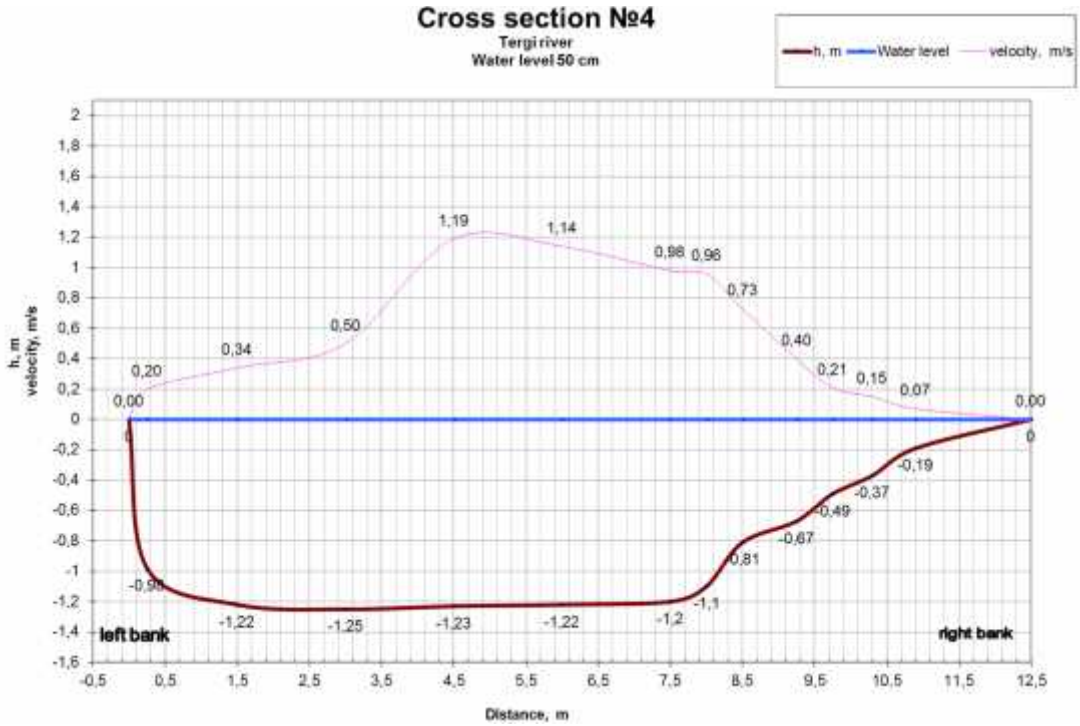


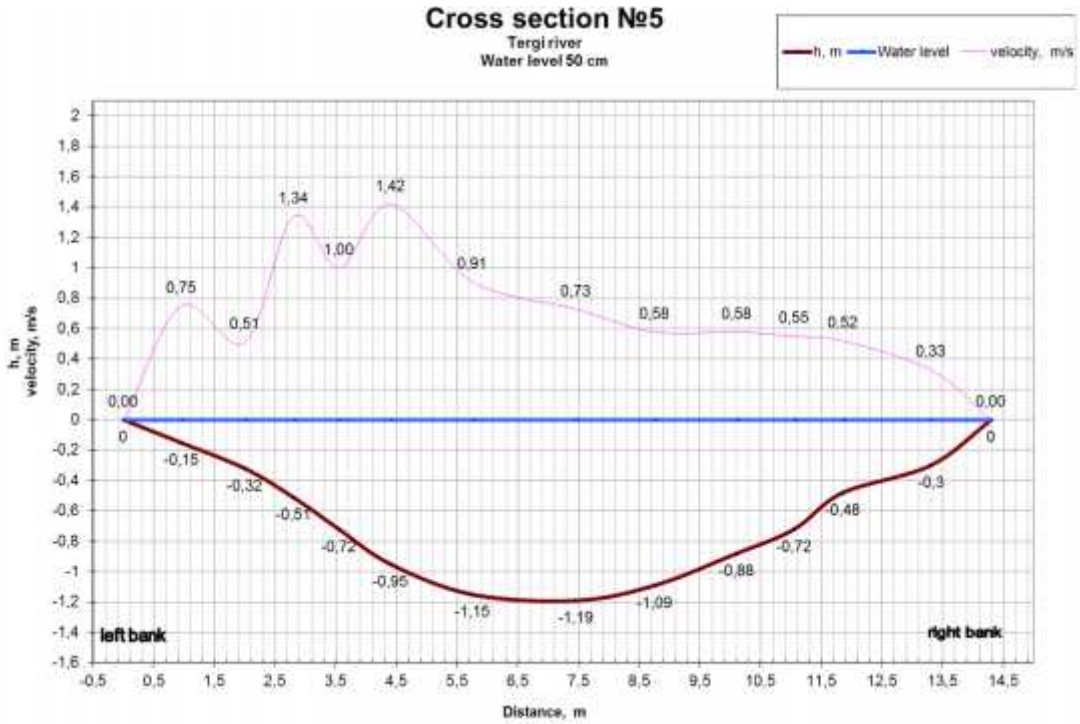
Monitoring station 2 - **Tergi downstream the Dariali headworks (boulder section)**



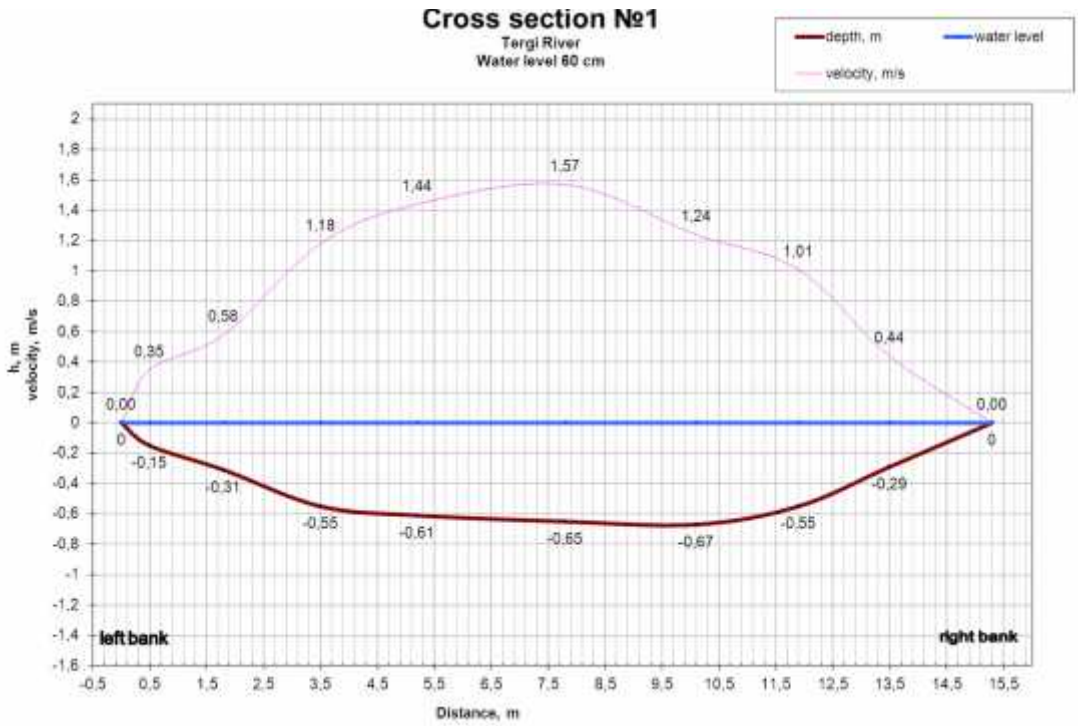

Cross section №2
Tergi river
Water level 50 cm
h, m
Water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

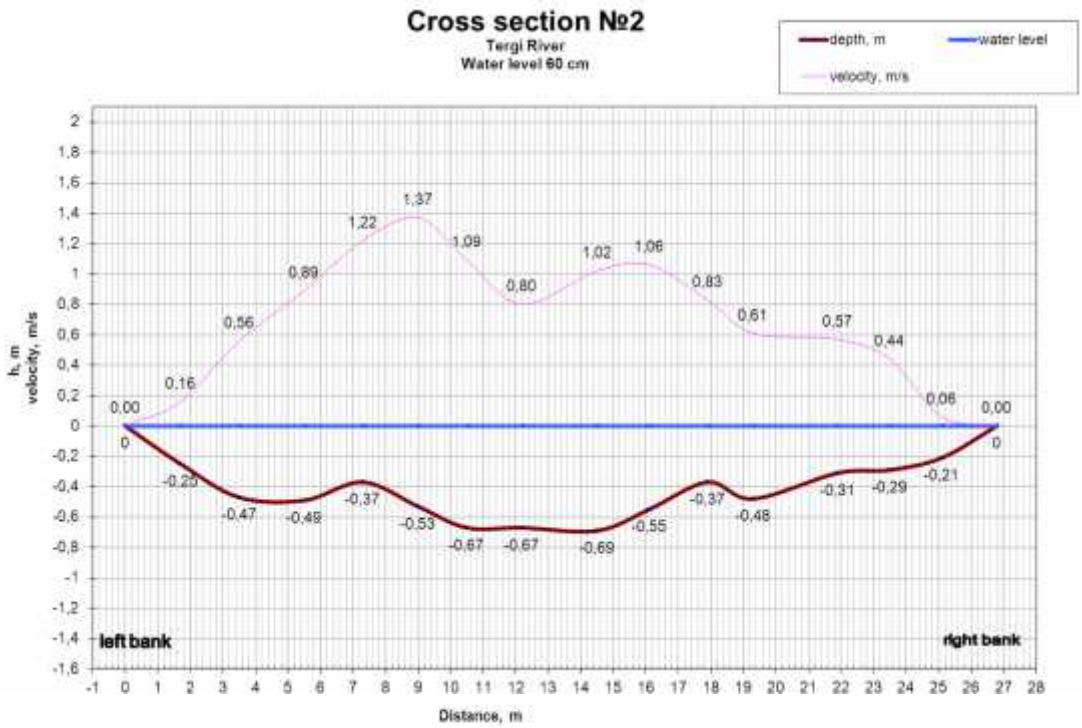

Cross section №3
Tergi river
Water level 50 cm
h, m
Water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

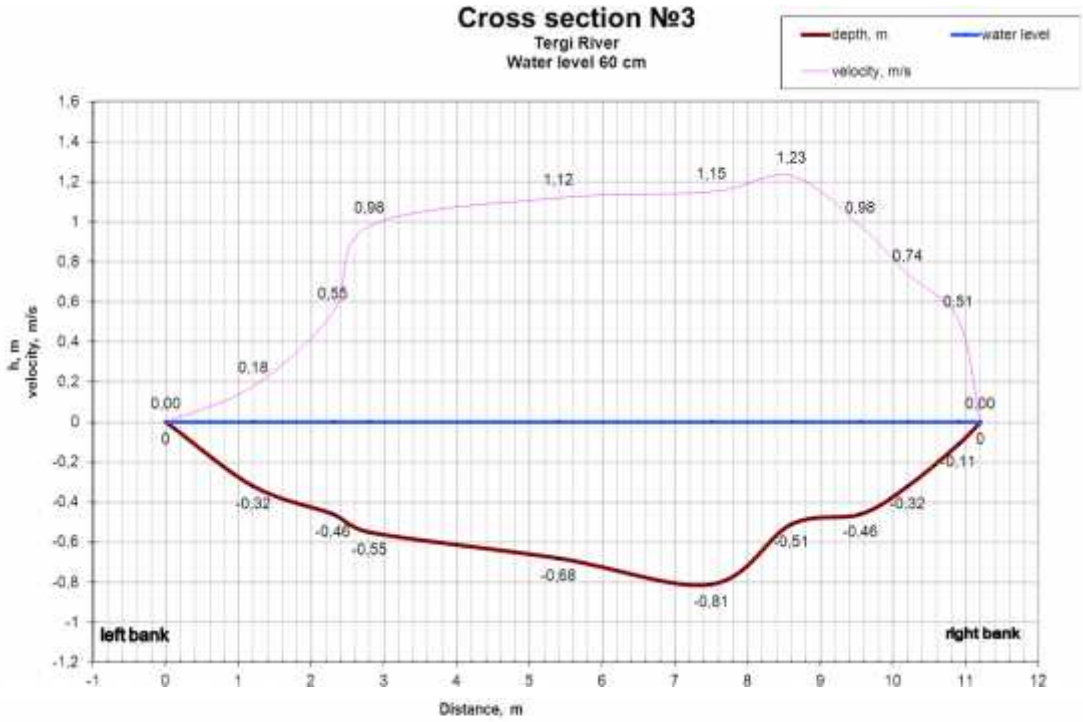

Cross section №4
Tergi river
Water level 50 cm
h, m
Water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

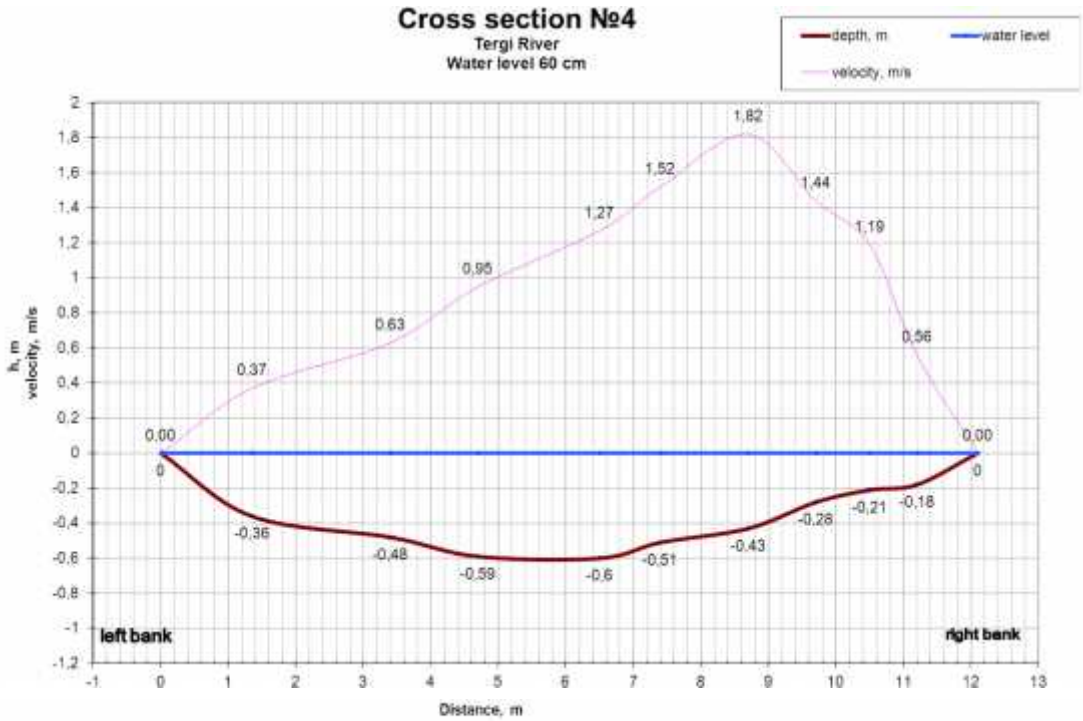

Cross section №5
Tergi river
Water level 50 cm
h, m
Water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

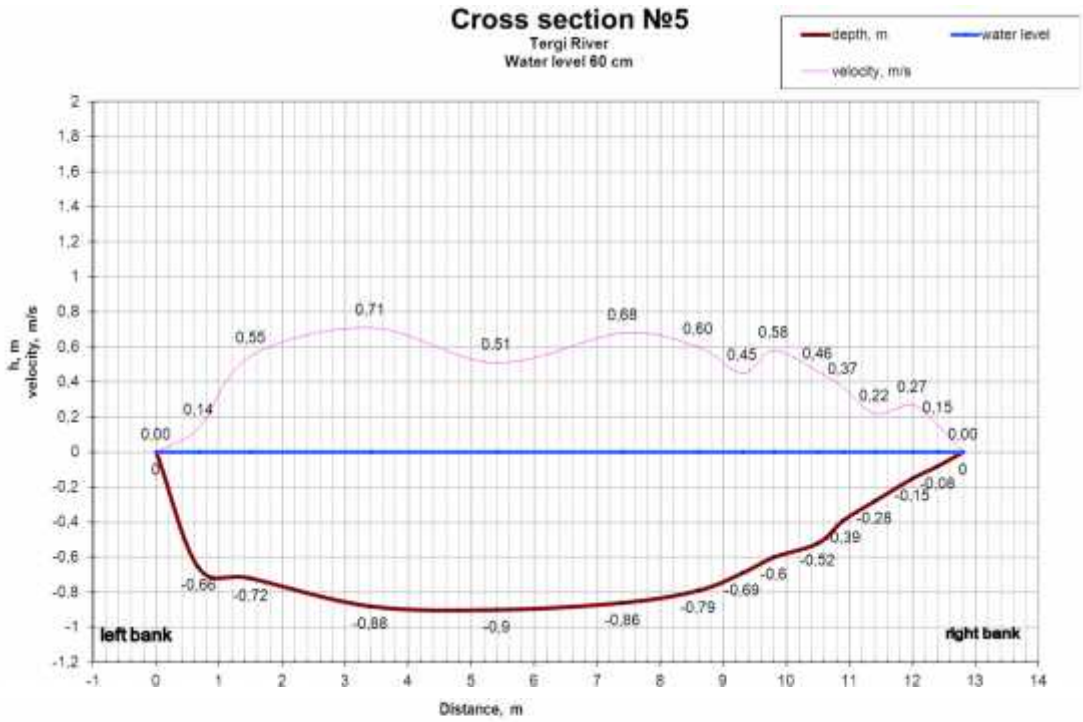
Monitoring station 3 – **Tergi downstream the Dariali headworks (braided section)**

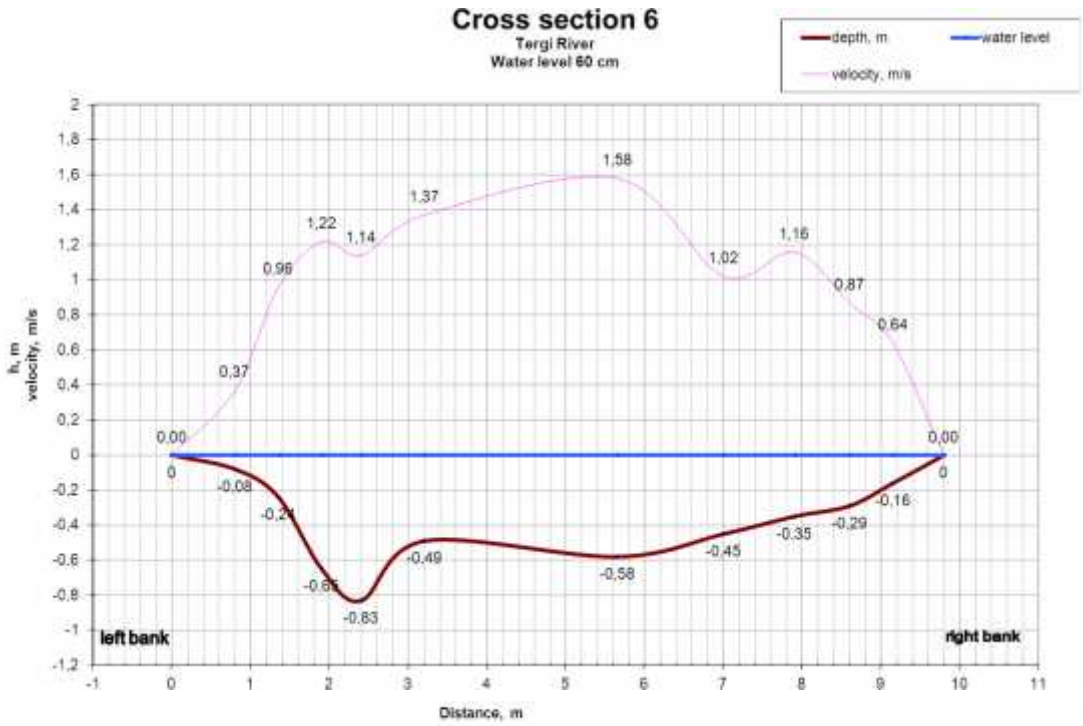


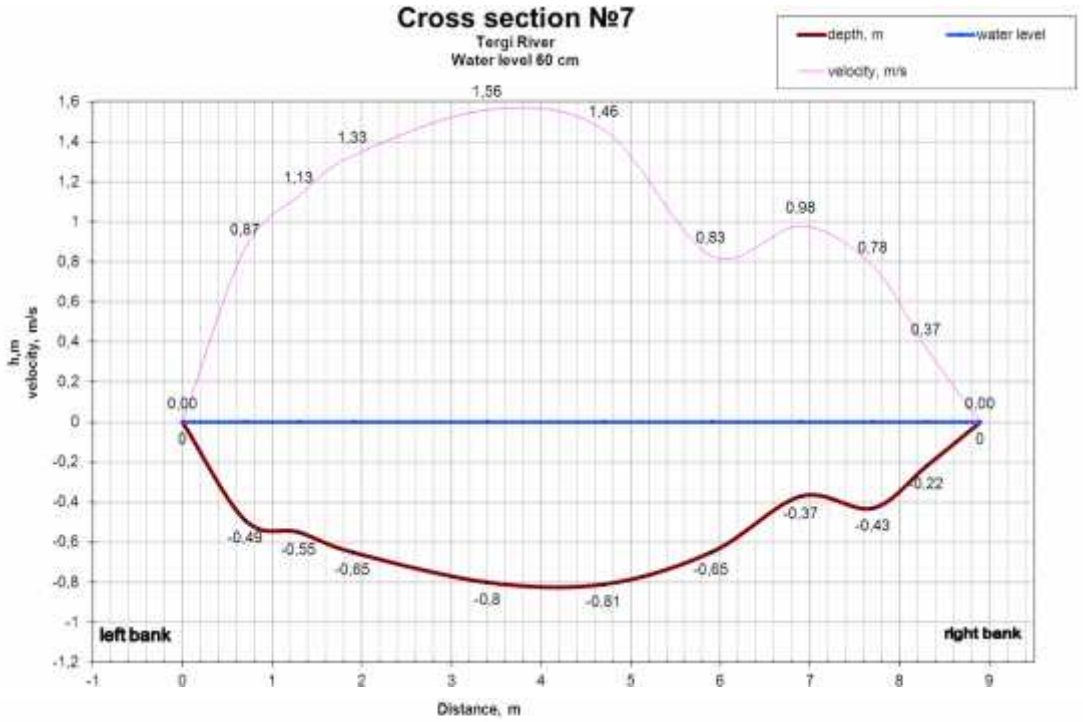


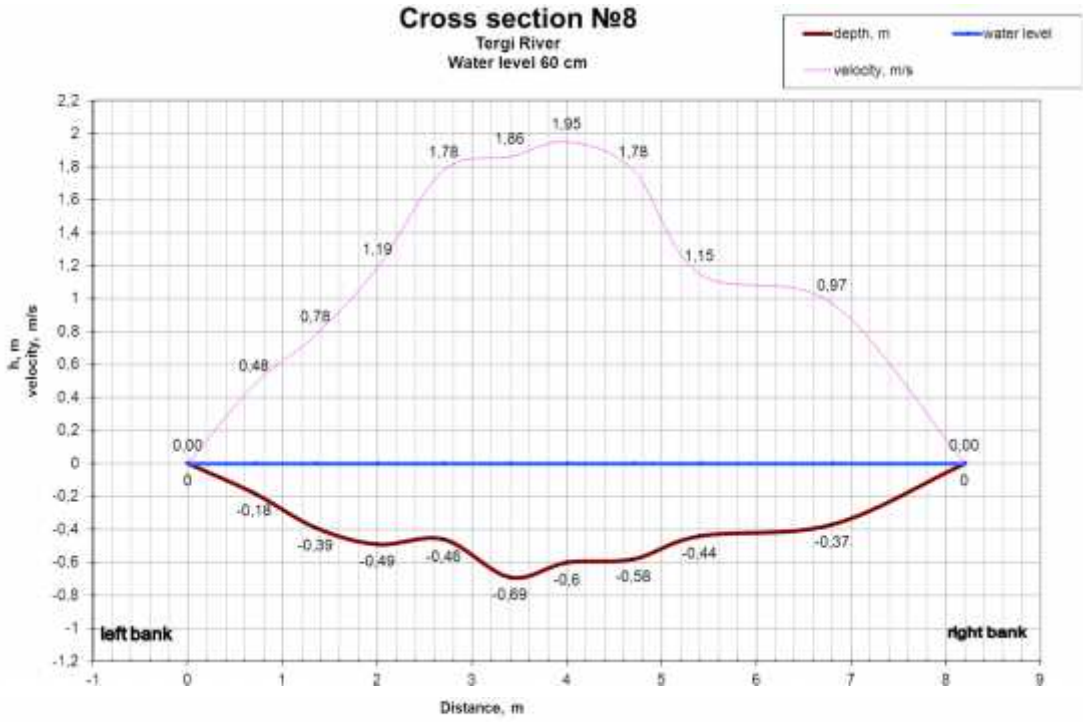

Cross section №3
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,18
0,55
0,98
1,12
1,15
1,23
0,98
0,74
0,51
0,00
0
-0,32
-0,46
-0,55
-0,68
-0,81
-0,51
-0,46
-0,32
0,11
0

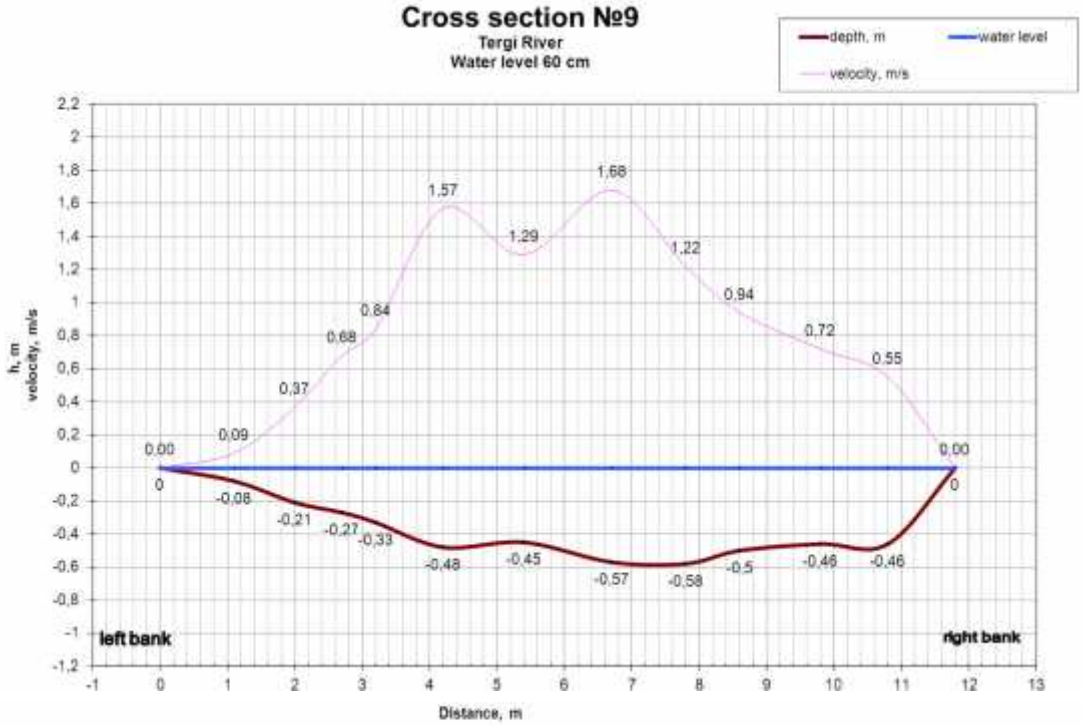

Cross section №4
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,37
0,63
0,95
1,27
1,52
1,82
1,44
1,19
0,56
0,00
0
-0,36
-0,48
-0,59
-0,6
-0,51
-0,43
-0,28
-0,21
-0,18
0

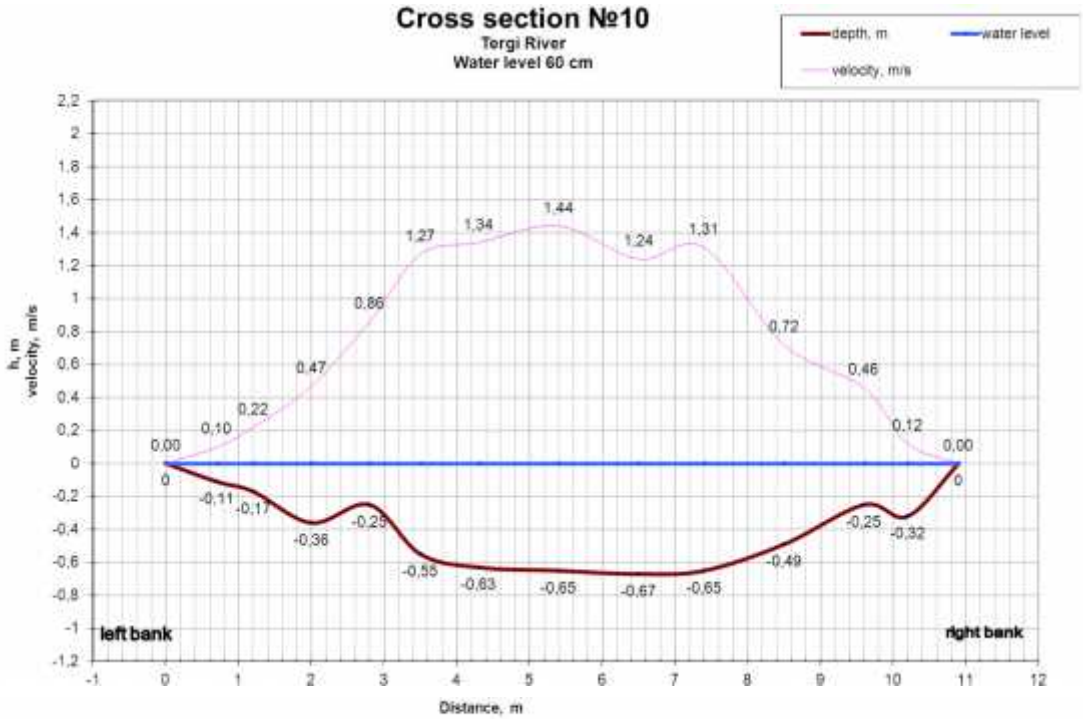

Cross section №5
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

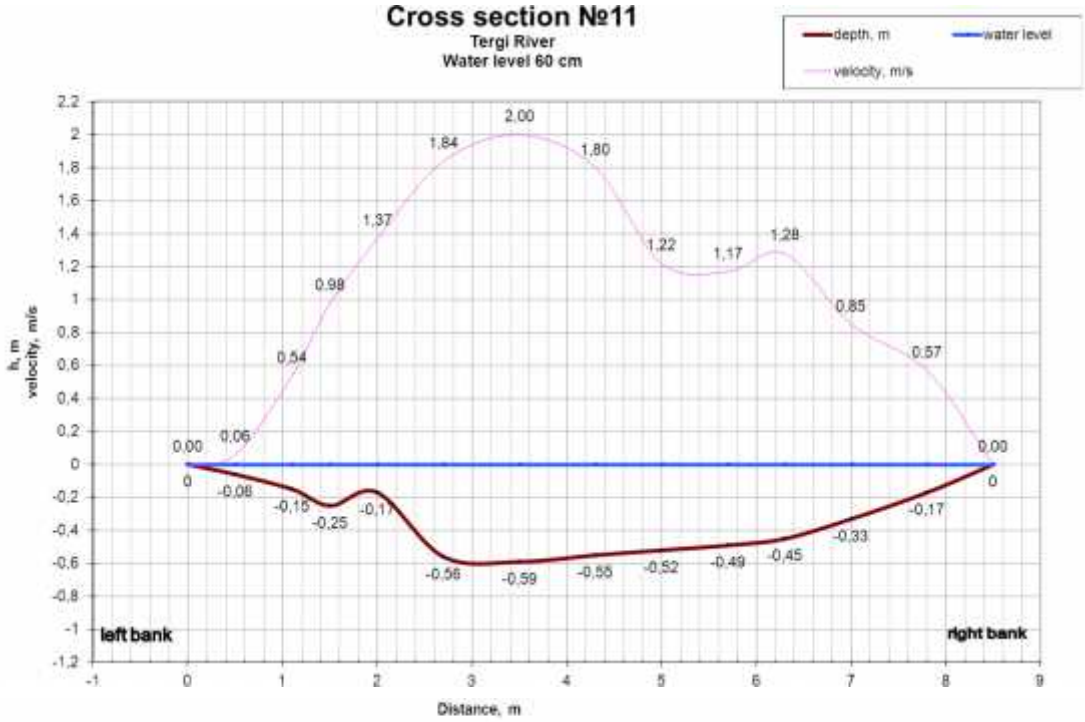

Cross section 6
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

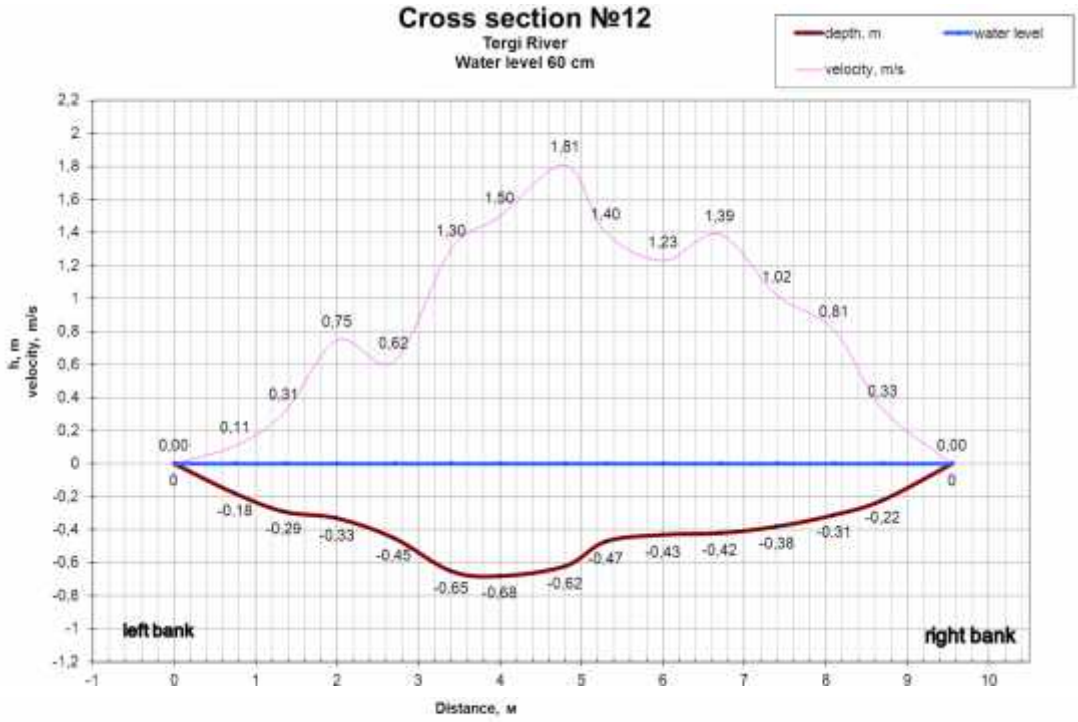

Cross section №7
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h,m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,87
1,13
1,33
1,56
1,46
0,83
0,98
0,78
0,37
0,00
0
-0,49
-0,55
-0,65
-0,8
-0,81
-0,65
-0,37
-0,43
-0,22
0


Cross section №8
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,48
0,78
1,19
1,78
1,86
1,95
1,78
1,15
0,97
0,00
0
-0,18
-0,39
-0,49
-0,46
-0,69
-0,6
-0,58
-0,44
-0,37
0

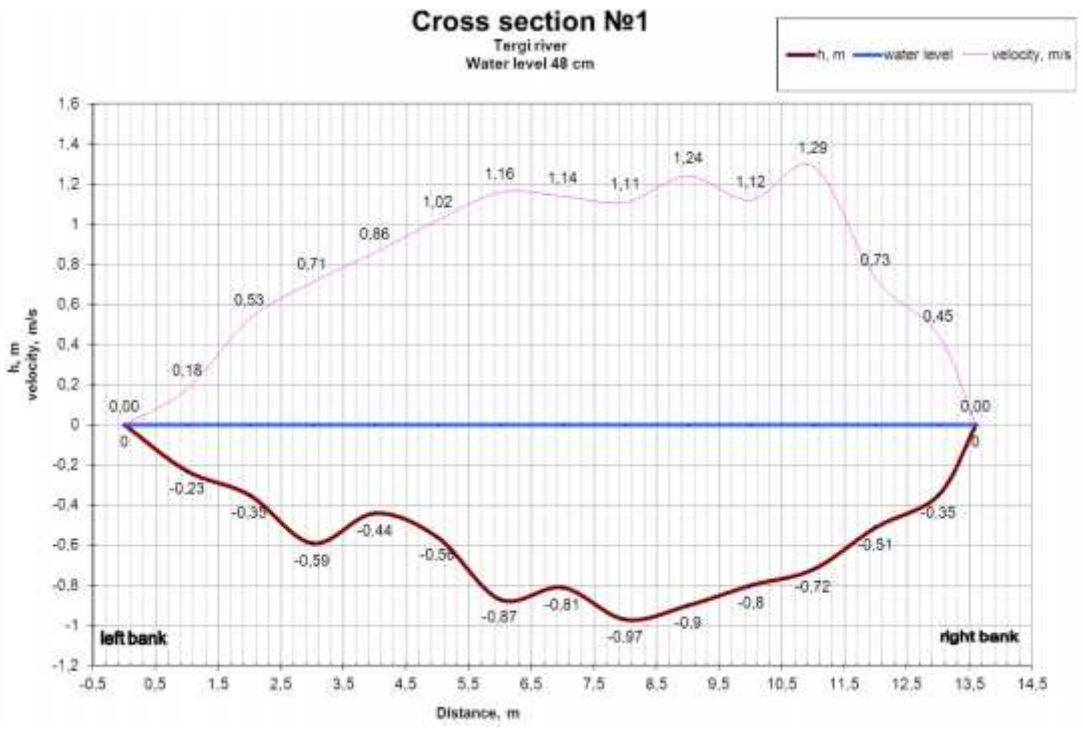

Cross section №9
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,09
0,37
0,68
0,84
1,57
1,29
1,68
1,22
0,94
0,72
0,55
0,00
0
-0,08
-0,21
-0,27
-0,33
-0,48
-0,45
-0,57
-0,58
-0,5
-0,46
-0,46
0

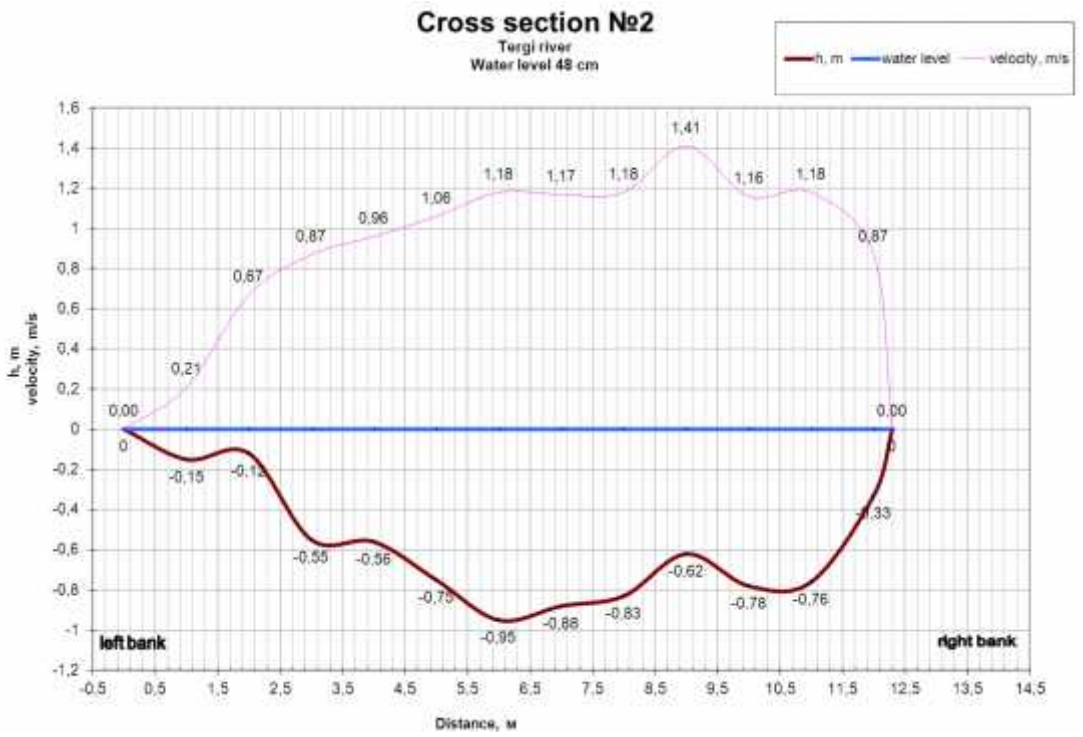

Cross section №10
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,10
0,22
0,47
0,86
1,27
1,34
1,44
1,24
1,31
0,72
0,46
0,12
0,00
0
-0,11
-0,17
-0,36
-0,25
-0,55
-0,63
-0,65
-0,67
-0,65
-0,49
-0,25
-0,32
0

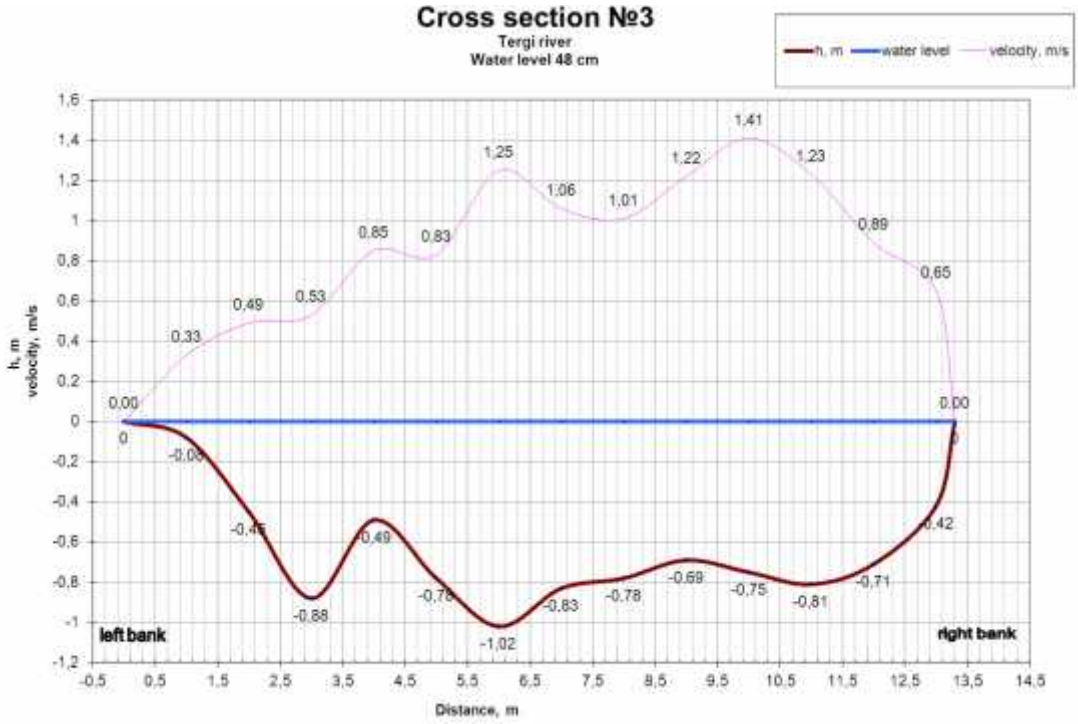

Cross section №11
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,00
0,06
0,54
0,99
1,37
1,84
2,00
1,80
1,22
1,17
1,28
0,85
0,57
0,00
0
-0,08
-0,15
-0,25
-0,17
-0,56
-0,59
-0,55
-0,52
-0,49
-0,45
-0,33
-0,17
0

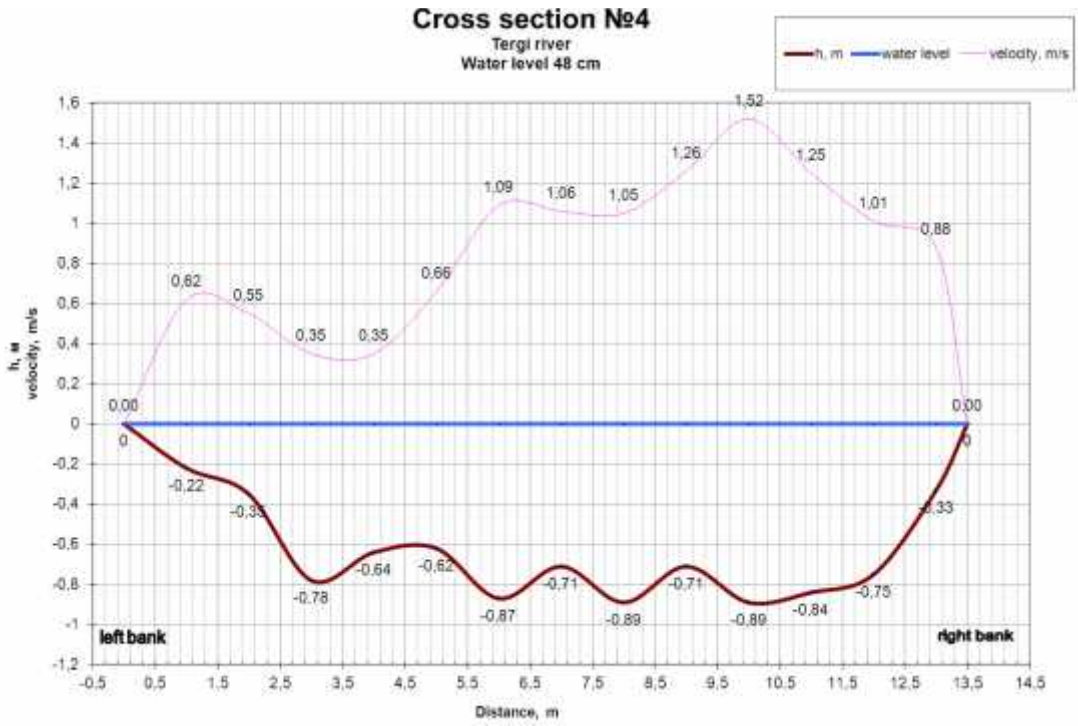

Cross section №12
Tergi River
Water level 60 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, м
left bank
right bank
0,00
0,11
0,31
0,75
0,62
1,30
1,50
1,61
1,40
1,23
1,39
1,02
0,81
0,33
0,00
0
-0,18
-0,29
-0,33
-0,45
-0,65
-0,68
-0,62
-0,47
-0,43
-0,42
-0,38
-0,31
-0,22
0

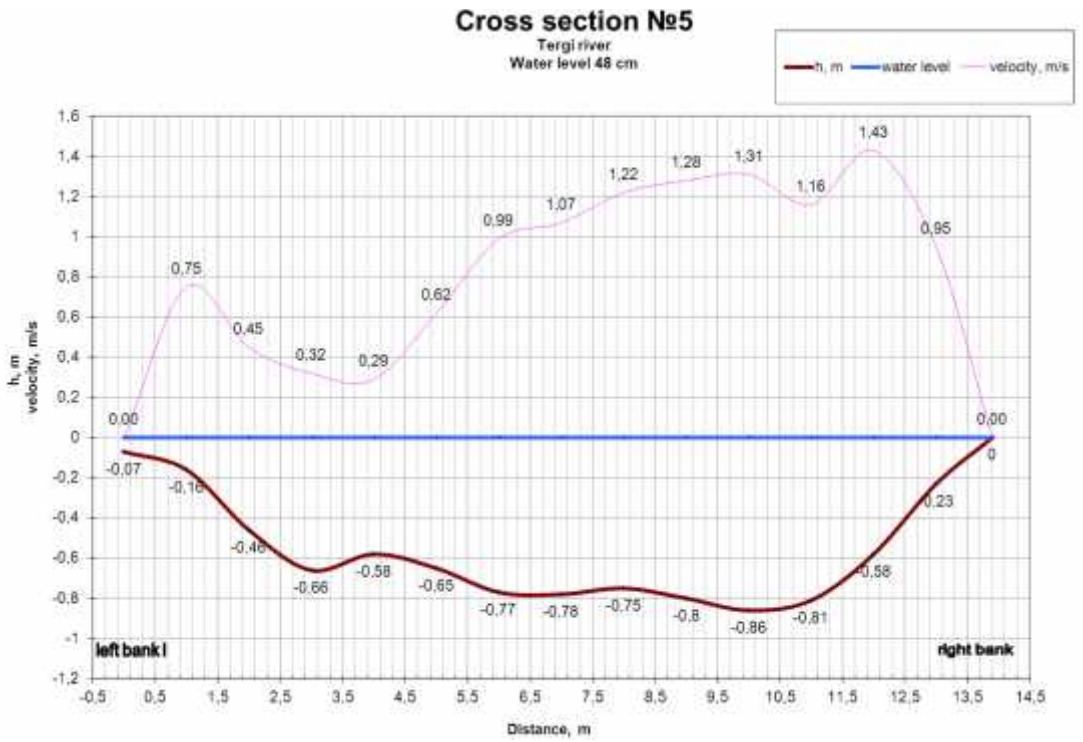
Monitoring station 4 – **Tergi downstream the Dariali headworks (single thread section)**



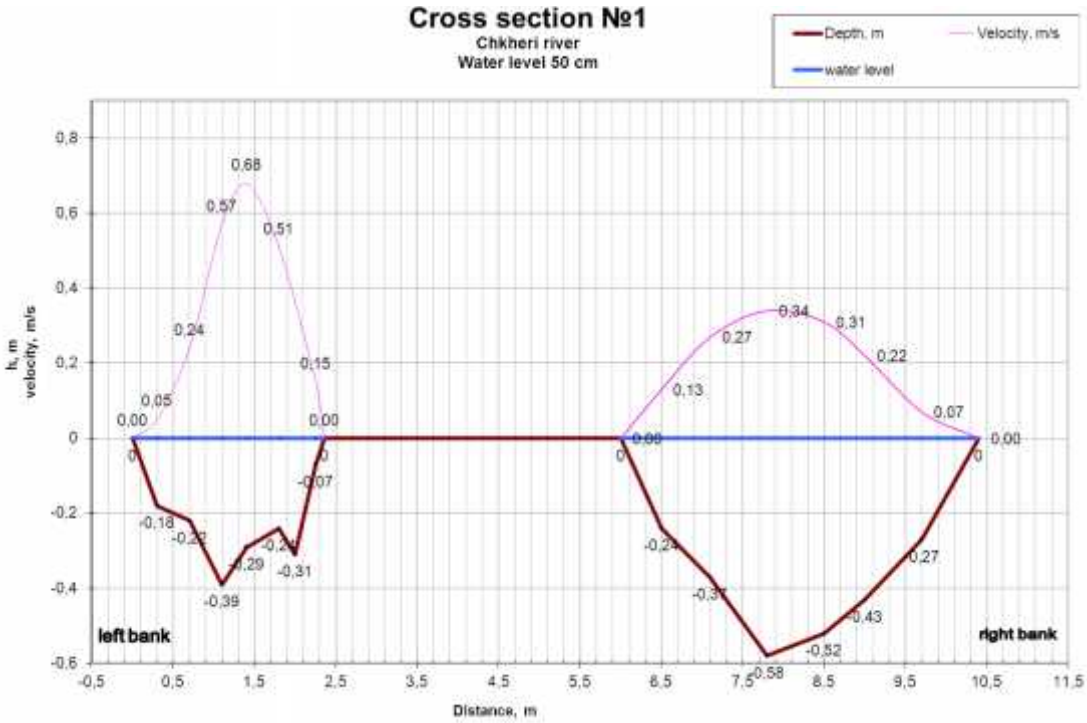


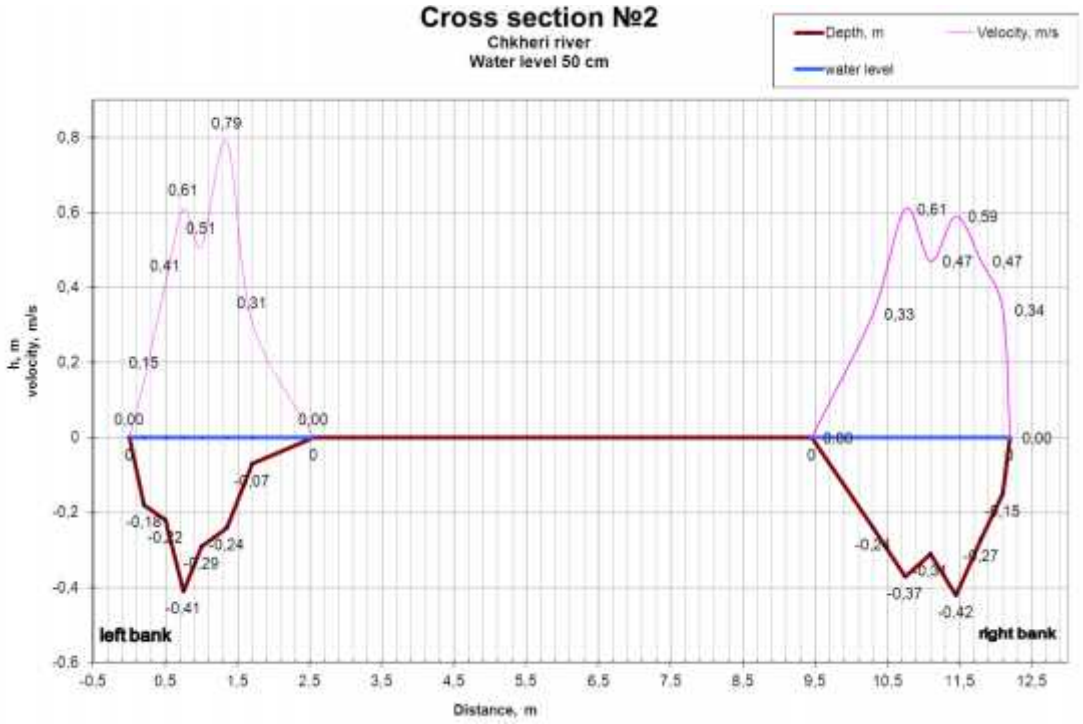

Cross section №3
Tergi river
Water level 48 cm
h, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

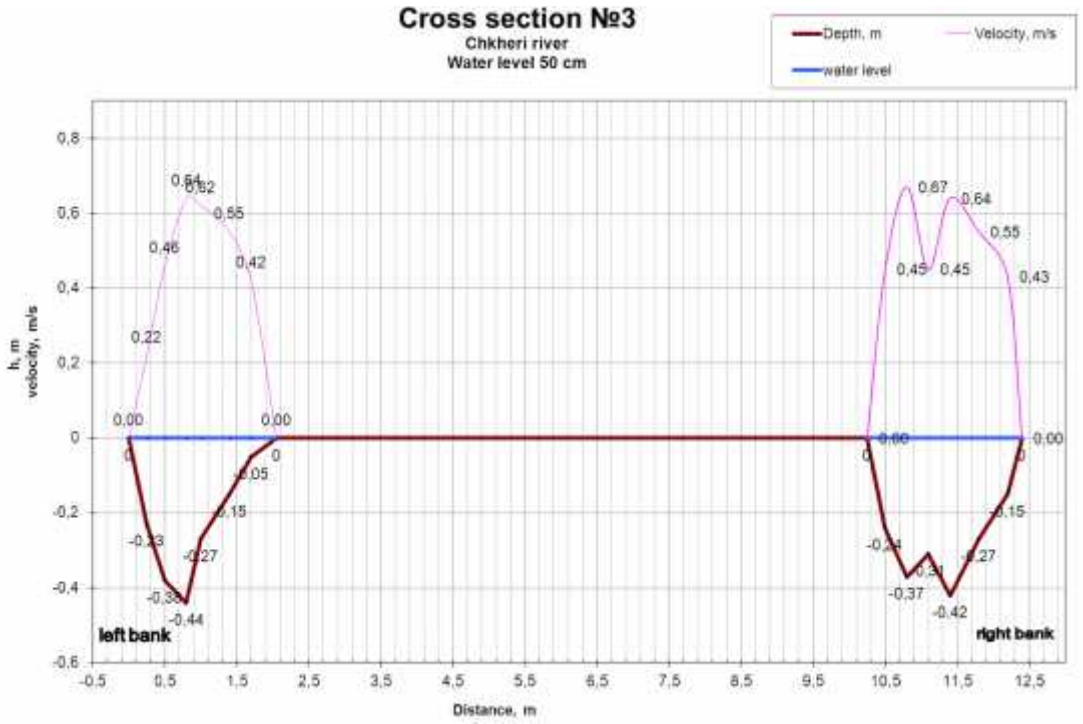

Cross section №4
Tergi river
Water level 48 cm
h, m
water level
velocity, m/s
h, м
velocity, m/s
Distance, m
left bank
right bank

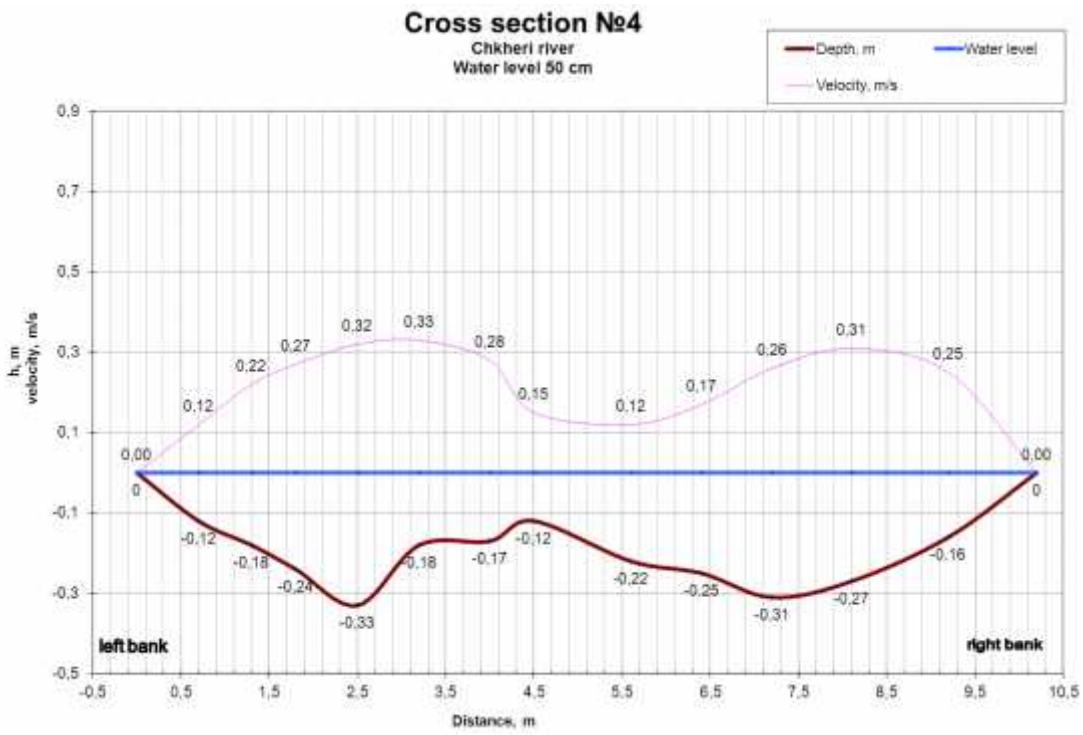


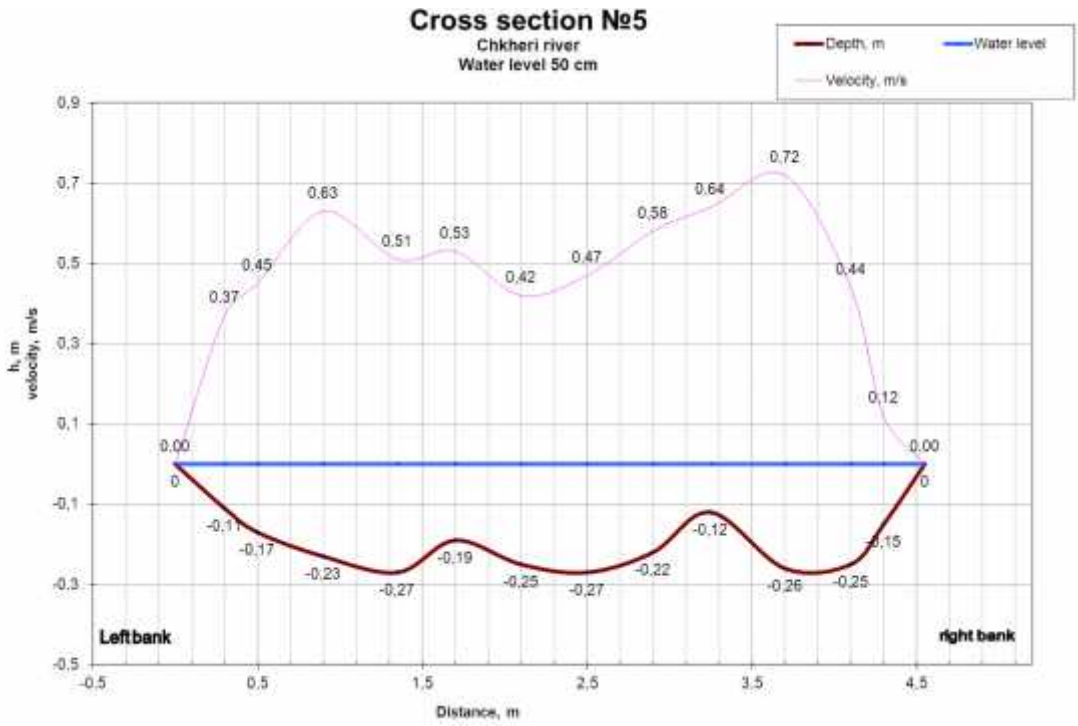
Monitoring station 9 – **Chkheri mouth**



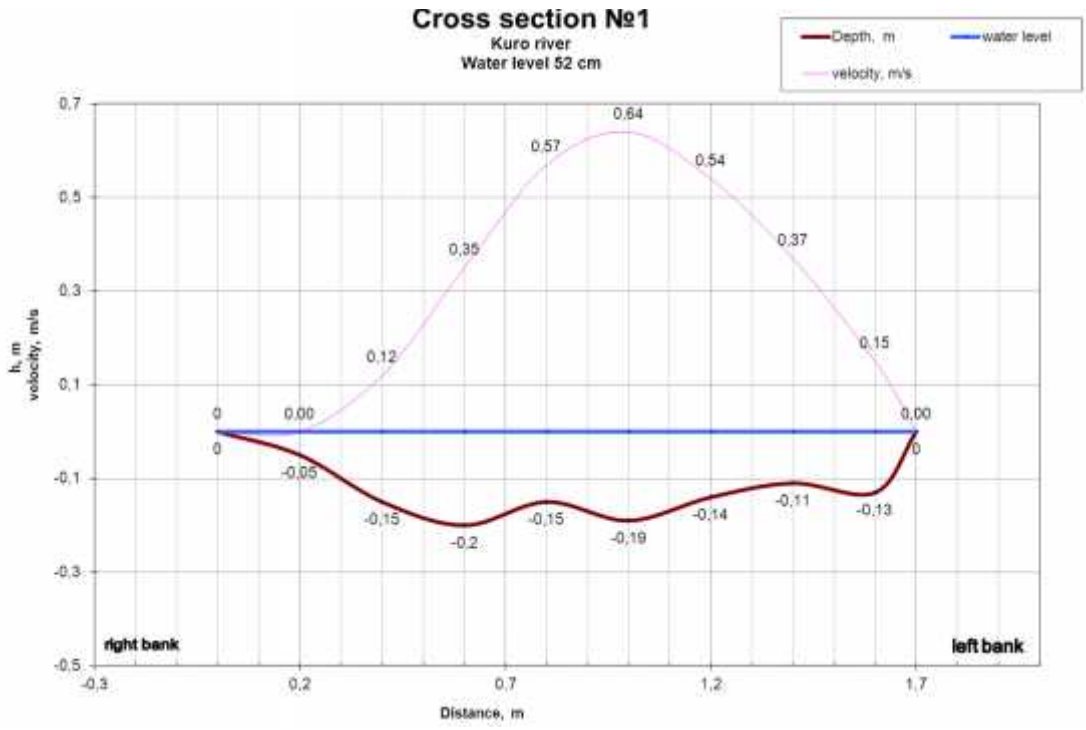

Cross section №2
Chkheri river
Water level 50 cm
Depth, m
Velocity, m/s
water level
h, m
velocity, m/s
Distance, m
left bank
right bank

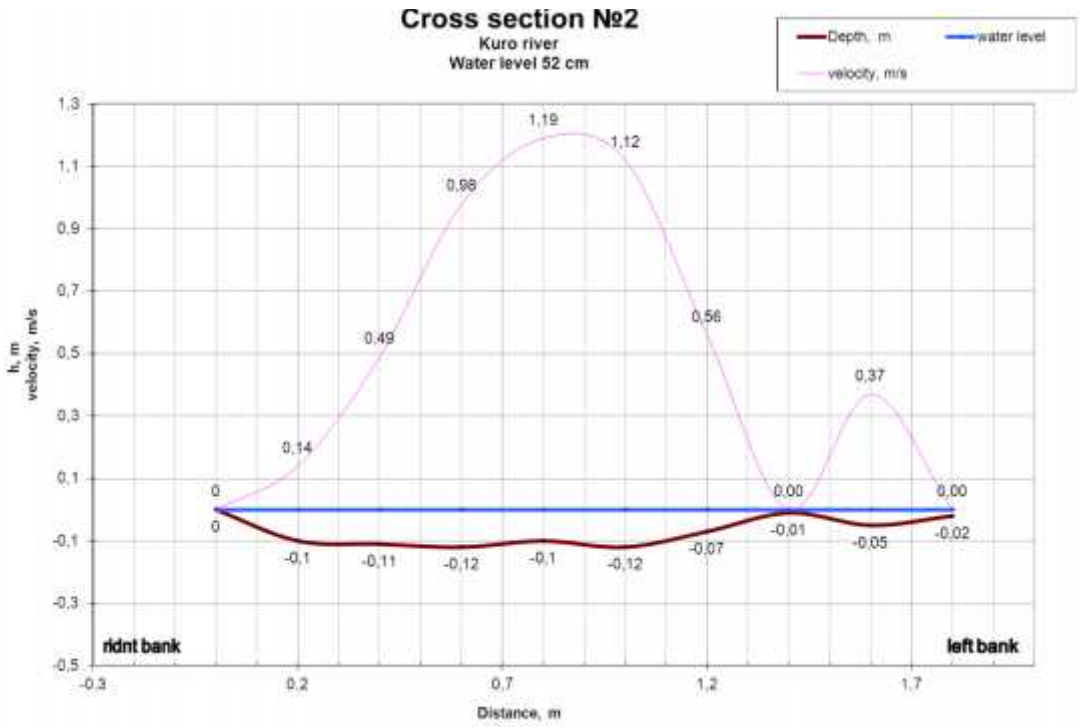

Cross section №3
Chkheri river
Water level 50 cm
Depth, m
Velocity, m/s
water level
h, m
velocity, m/s
Distance, m
left bank
right bank

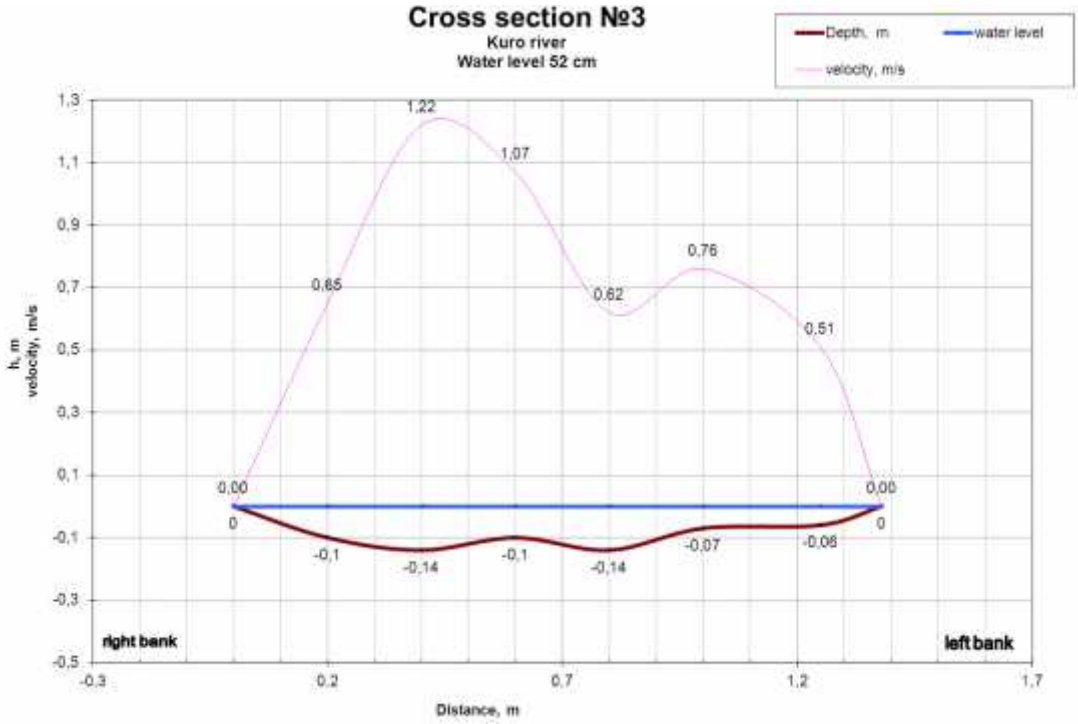

Cross section №4
Chkheri river
Water level 50 cm
Depth, m
Water level
Velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

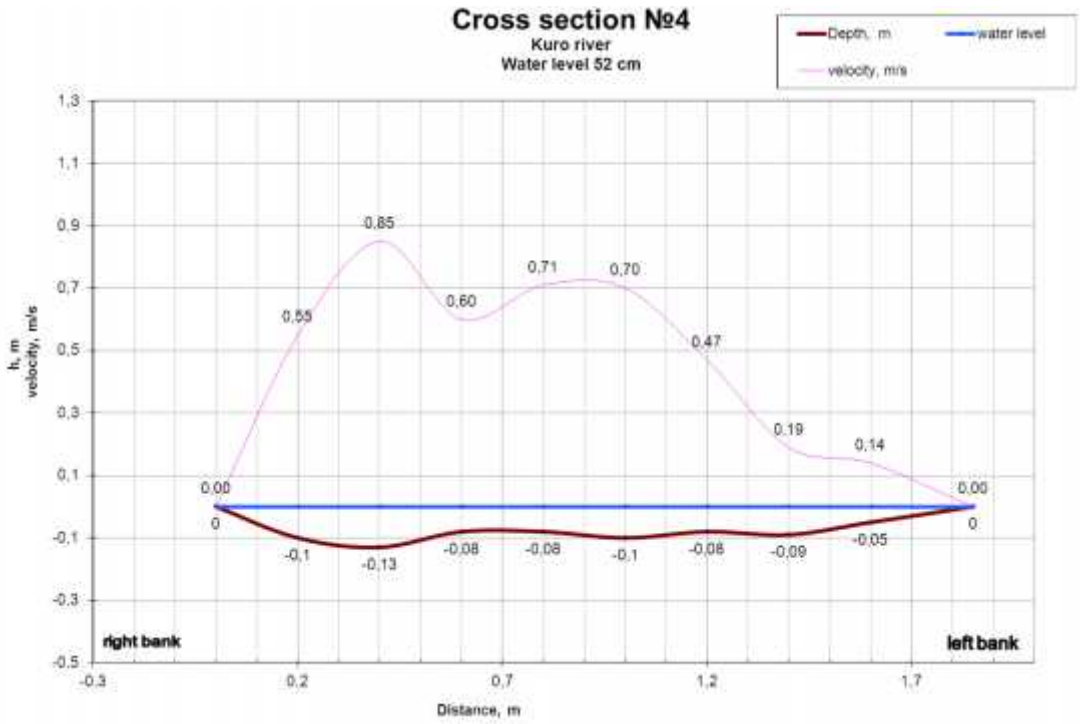

Cross section №5
Chkheri river
Water level 50 cm
Depth, m
Water level
Velocity, m/s
h, m
velocity, m/s
Distance, m
Left bank
right bank

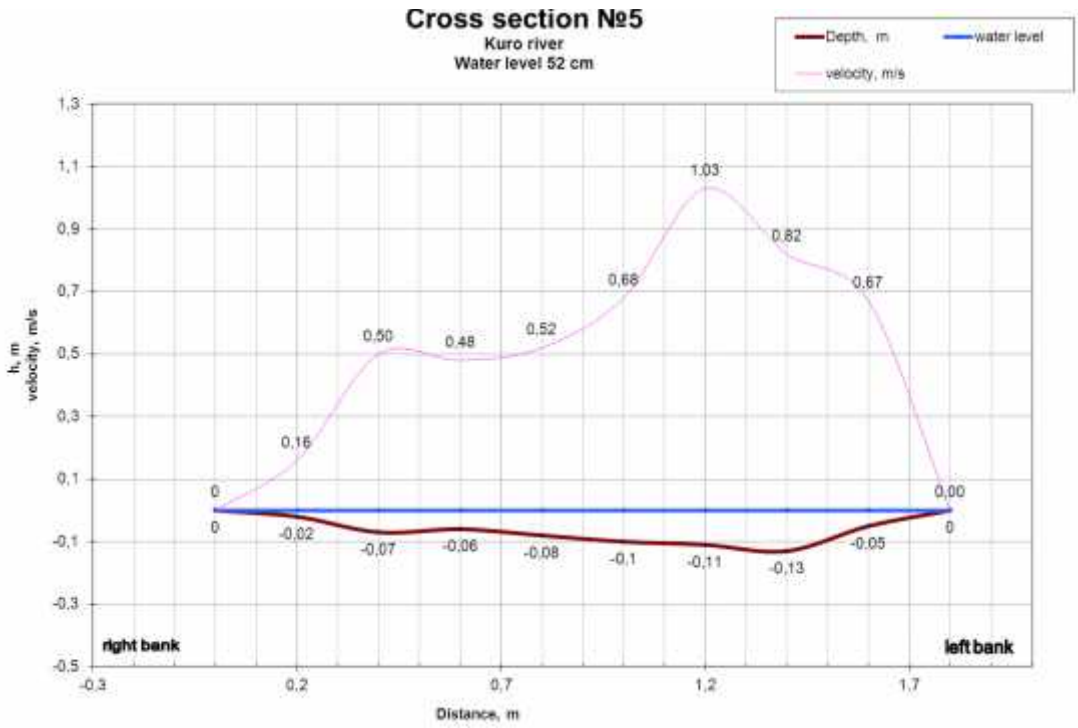
Monitoring station 10 – **Kuro mouth**

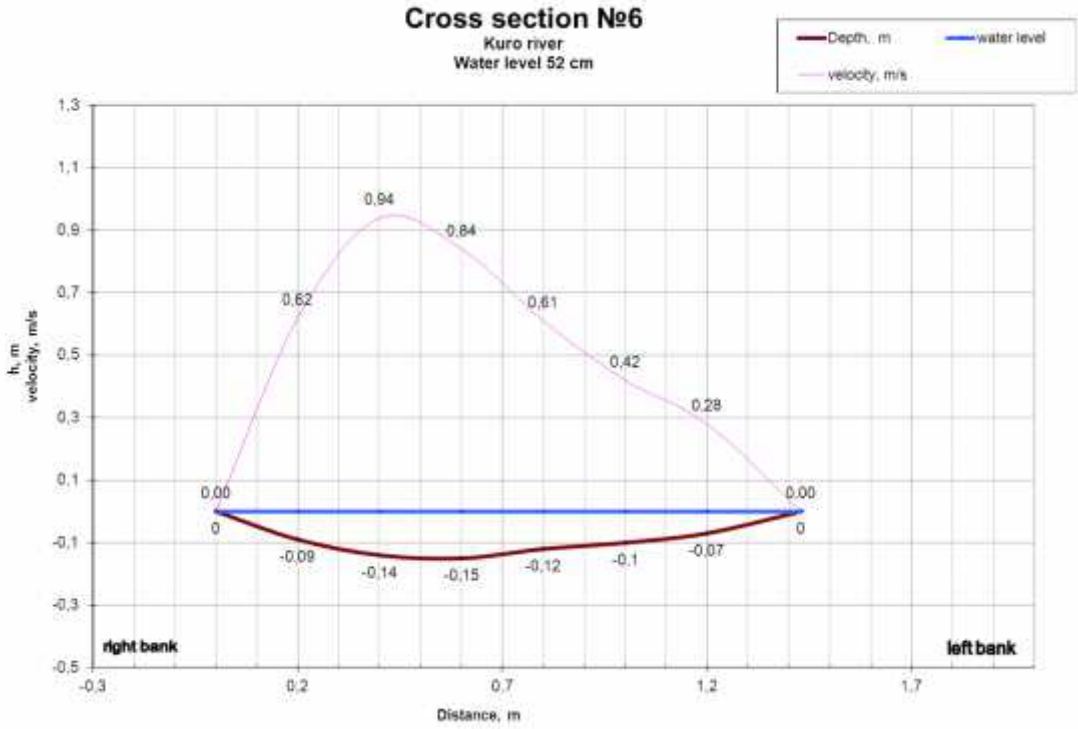


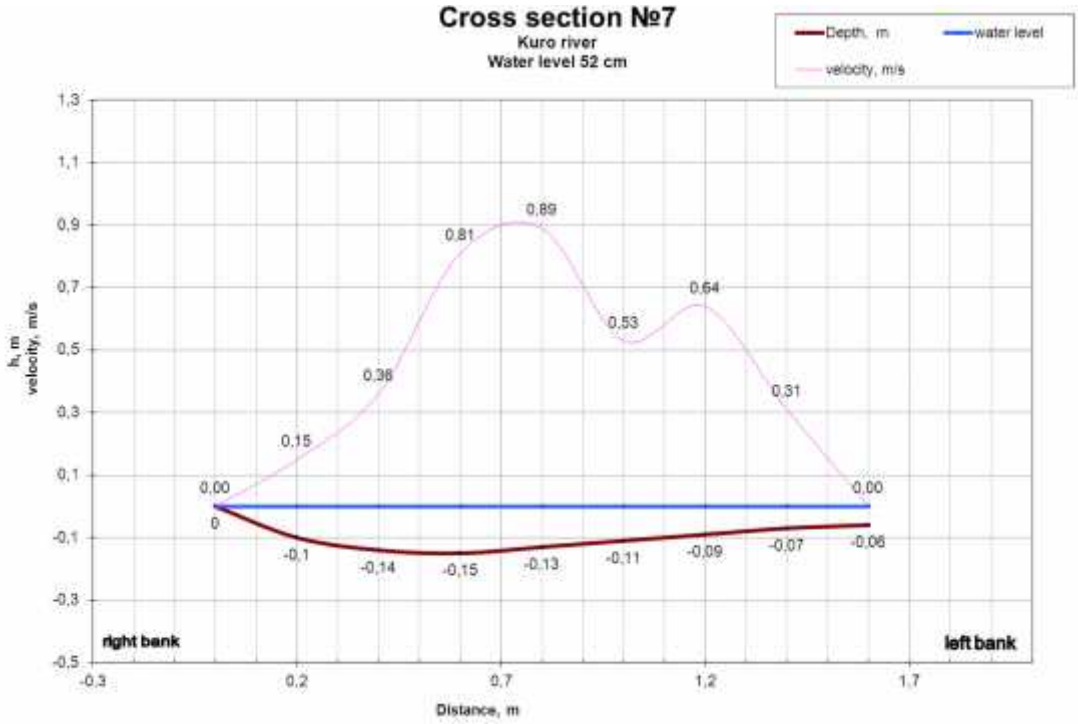



Cross section №3
Kuro river
Water level 52 cm
Depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
right bank
left bank
1,22
1,07
0,85
0,62
0,76
0,51
0,00
0,00
0
0
-0,1
-0,14
-0,1
-0,14
-0,07
-0,06

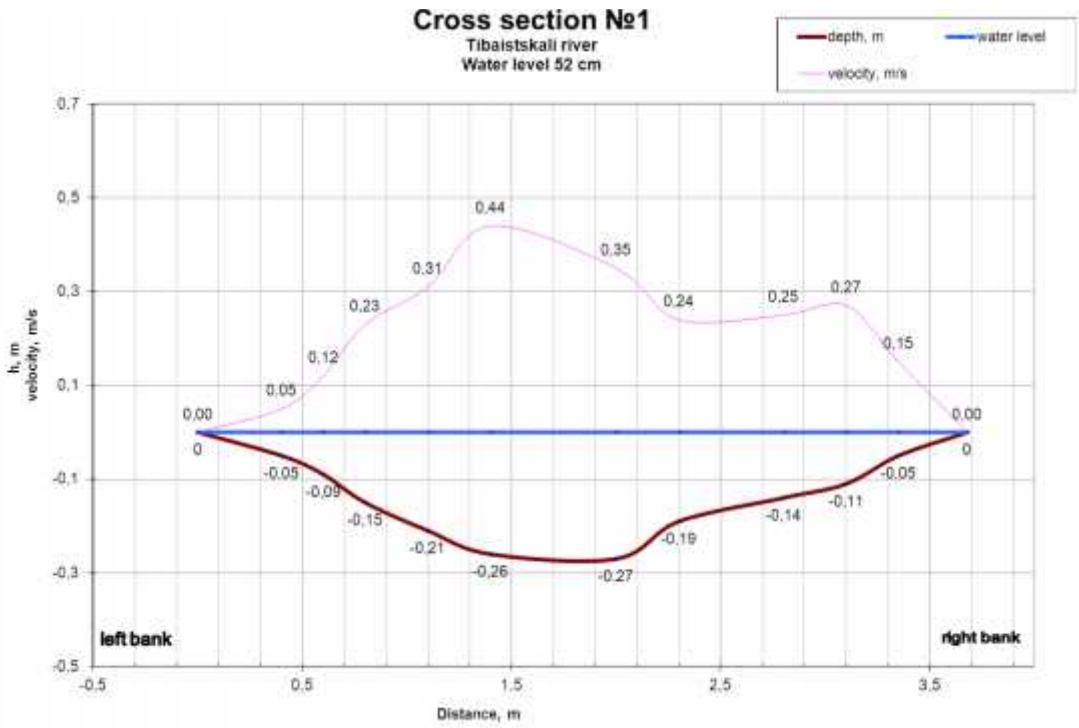

Cross section №4
Kuro river
Water level 52 cm
Depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
right bank
left bank
0,85
0,71
0,70
0,60
0,55
0,47
0,19
0,14
0,00
0,00
0
0
-0,1
-0,13
-0,08
-0,08
-0,1
-0,08
-0,09
-0,05

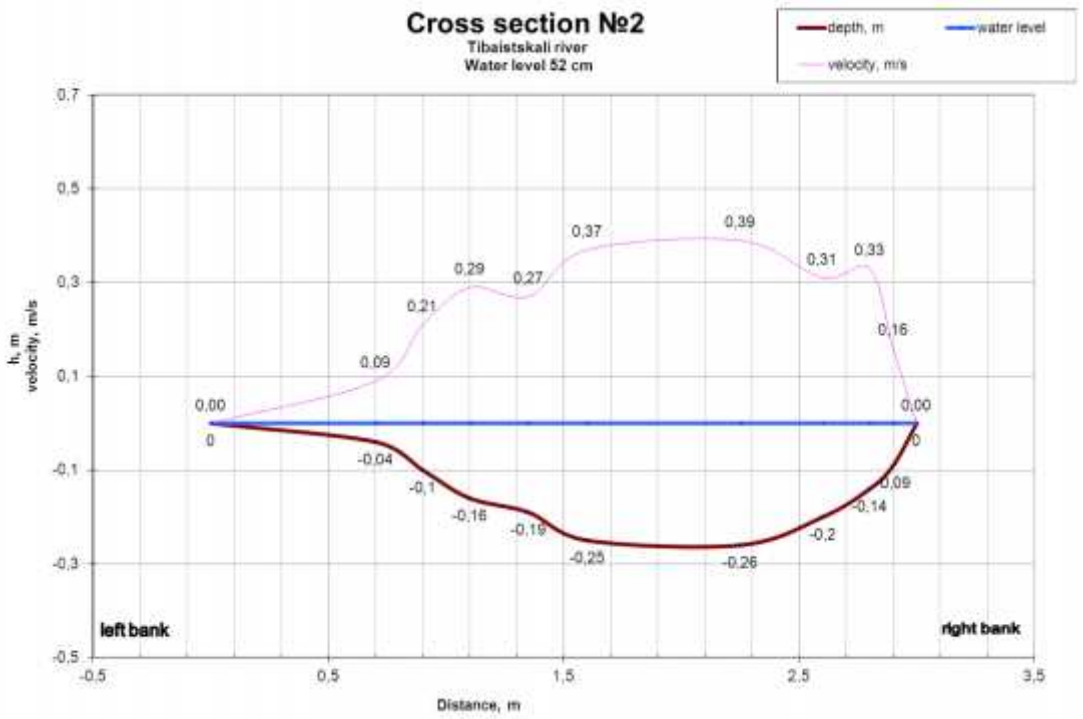

Cross section №5
Kuro river
Water level 52 cm
Depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
right bank
left bank
1,3
1,1
0,9
0,7
0,5
0,3
0,1
-0,1
-0,3
-0,5
-0,3
0,2
0,7
1,2
1,7
0
0,16
0,50
0,48
0,52
0,68
1,03
0,82
0,67
0,00
0
-0,02
-0,07
-0,06
-0,08
-0,1
-0,11
-0,13
-0,05
0

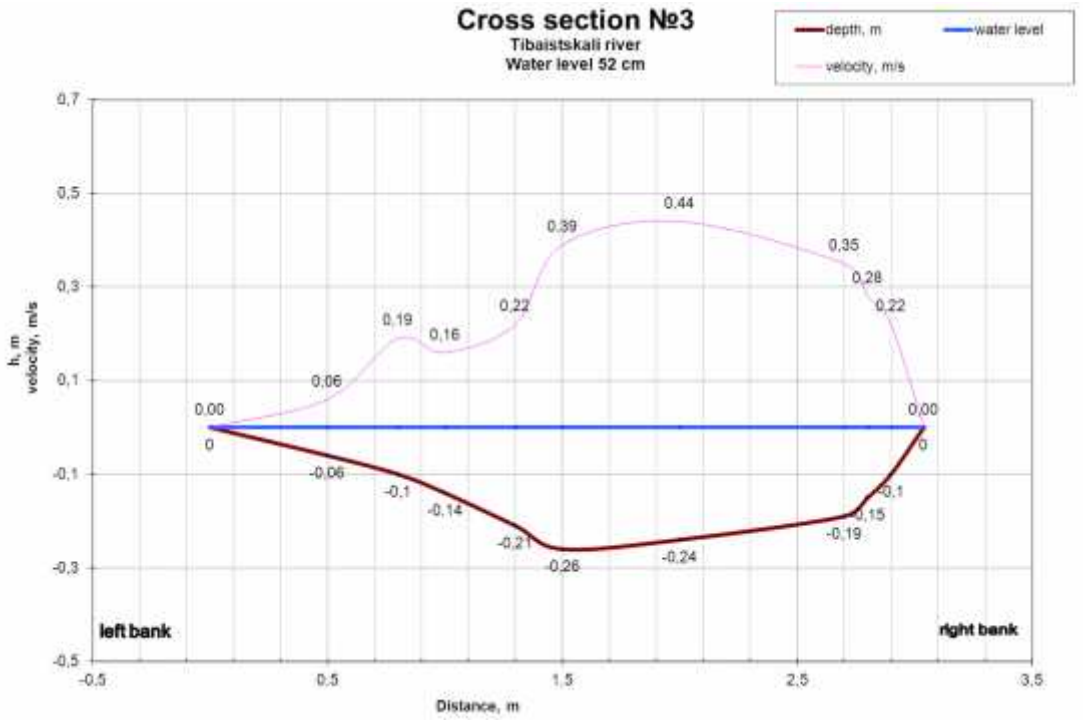

Cross section №6
Kuro river
Water level 52 cm
Depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
right bank
left bank
1,3
1,1
0,9
0,7
0,5
0,3
0,1
-0,1
-0,3
-0,5
-0,3
0,2
0,7
1,2
1,7
0,00
0,62
0,94
0,84
0,61
0,42
0,28
0,00
0
-0,09
-0,14
-0,15
-0,12
-0,1
-0,07
0

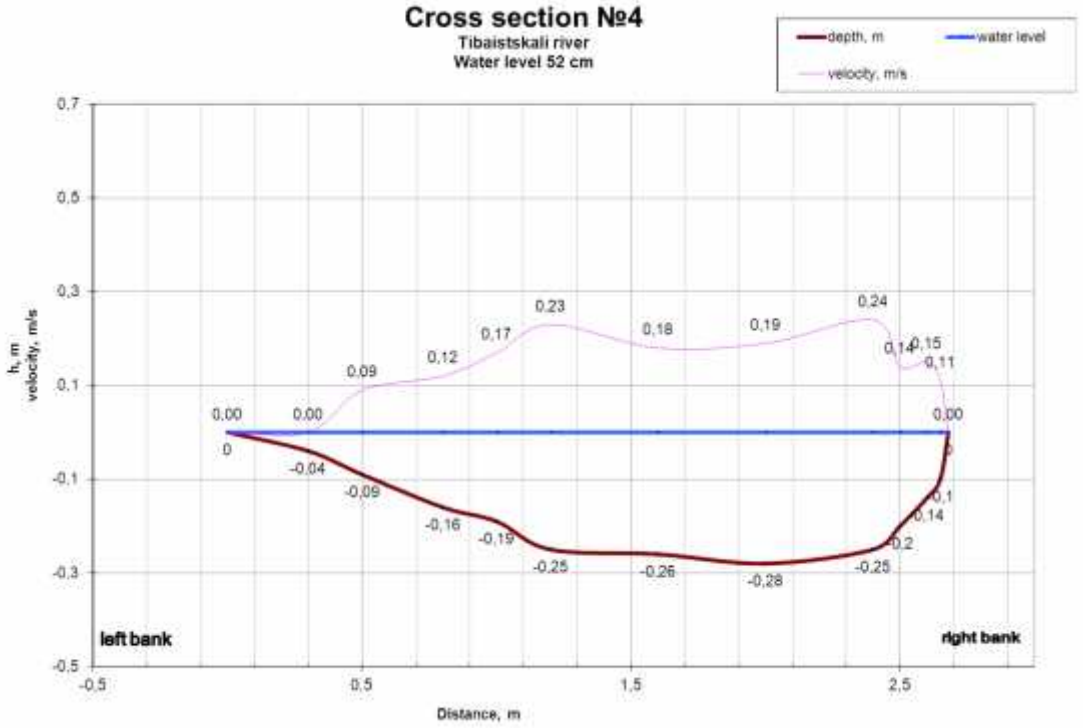


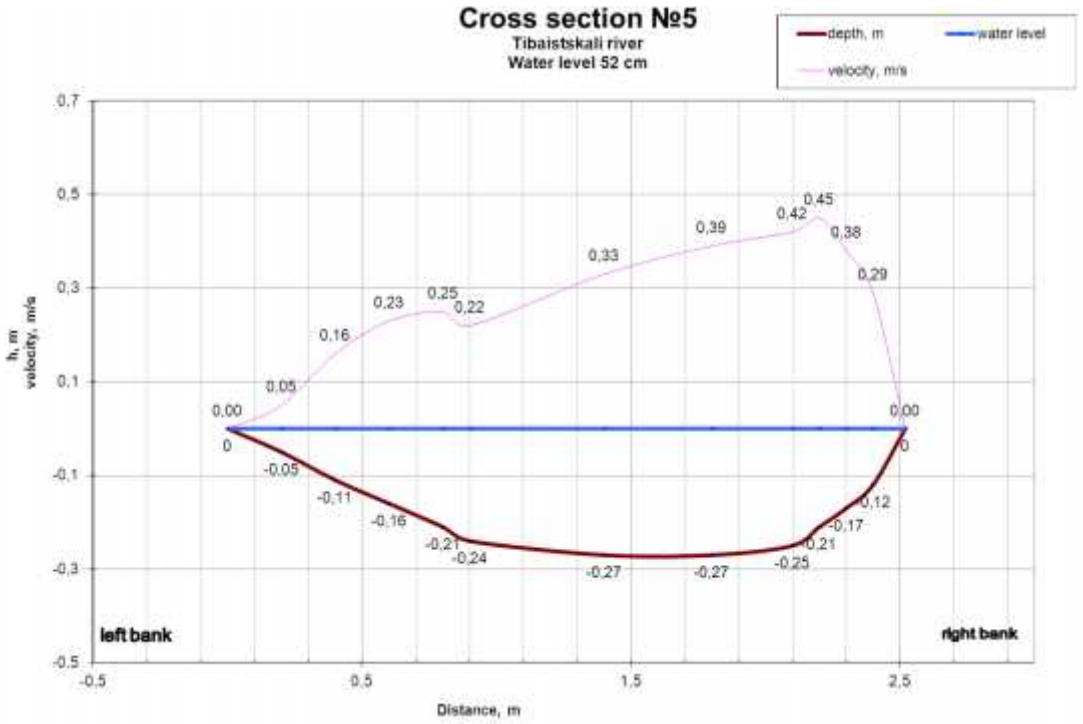
Monitoring station 11 – **Tibaitskali mouth**



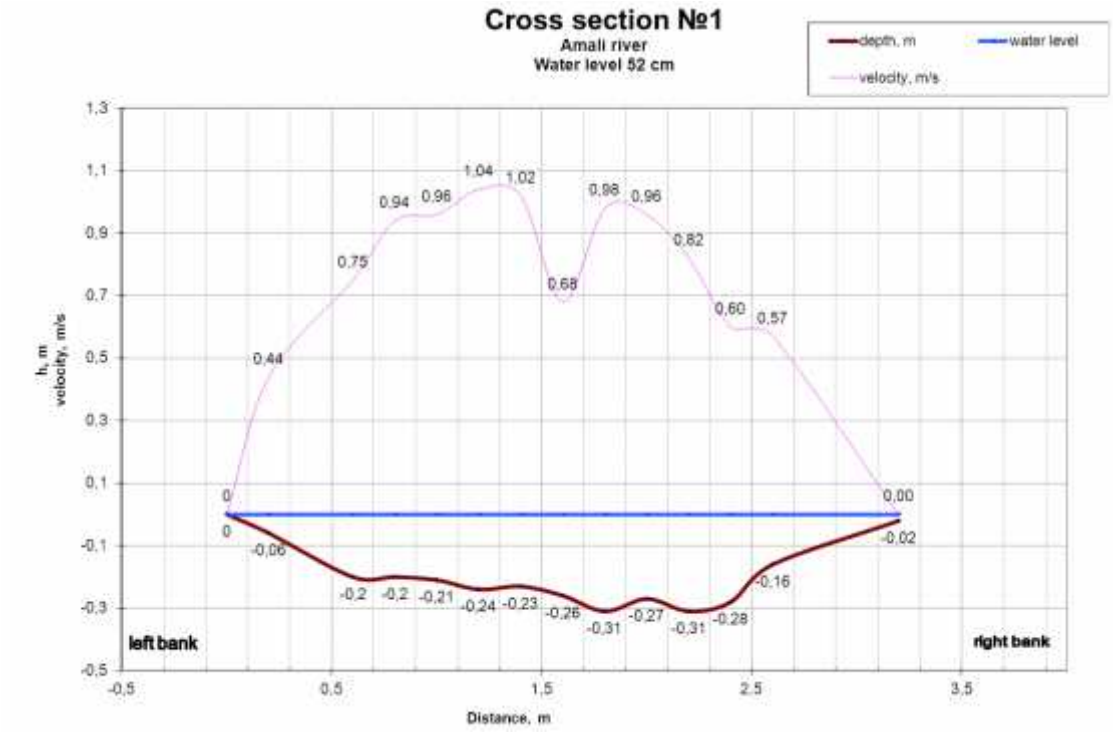

Cross section №2
Tibaistskali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,7
0,5
0,3
0,1
-0,1
-0,3
-0,5
-0,5
0,5
1,5
2,5
3,5
0,00
0,09
0,21
0,29
0,27
0,37
0,39
0,31
0,33
0,16
0,00
0
-0,04
-0,1
-0,16
-0,19
-0,25
-0,26
-0,2
-0,14
0,09
0

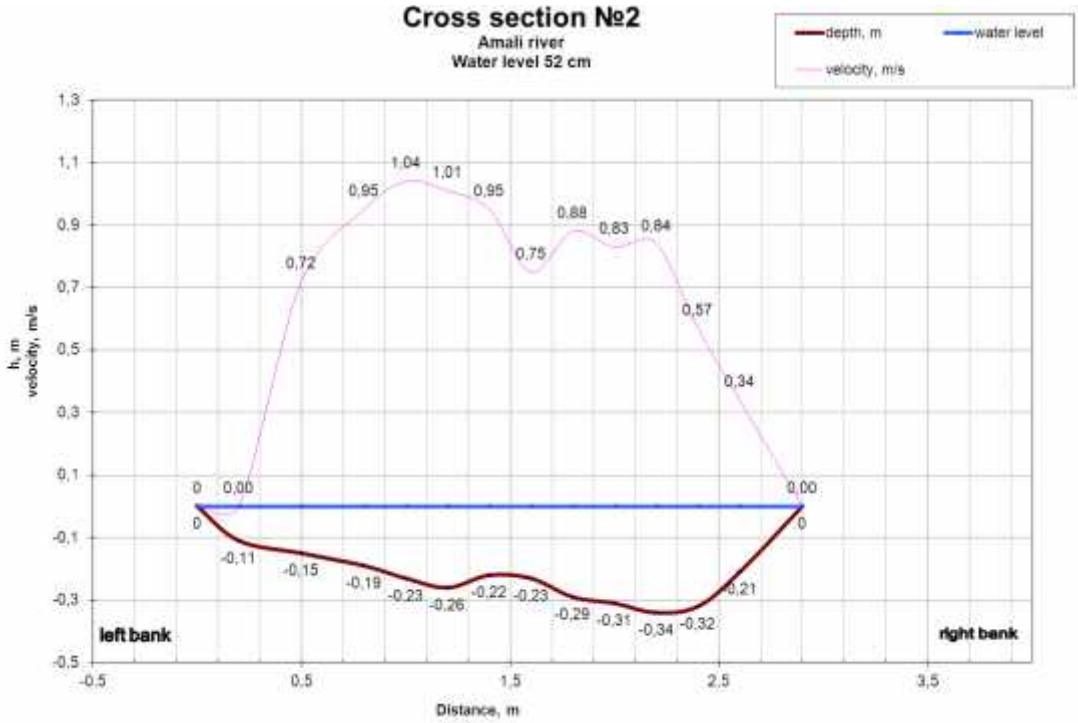

Cross section №3
Tibaistskali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0,7
0,5
0,3
0,1
-0,1
-0,3
-0,5
-0,5
0,5
1,5
2,5
3,5
0,00
0,06
0,19
0,16
0,22
0,39
0,44
0,35
0,28
0,22
0,00
0
-0,06
-0,1
-0,14
-0,21
-0,26
-0,24
-0,19
-0,15
-0,1
0

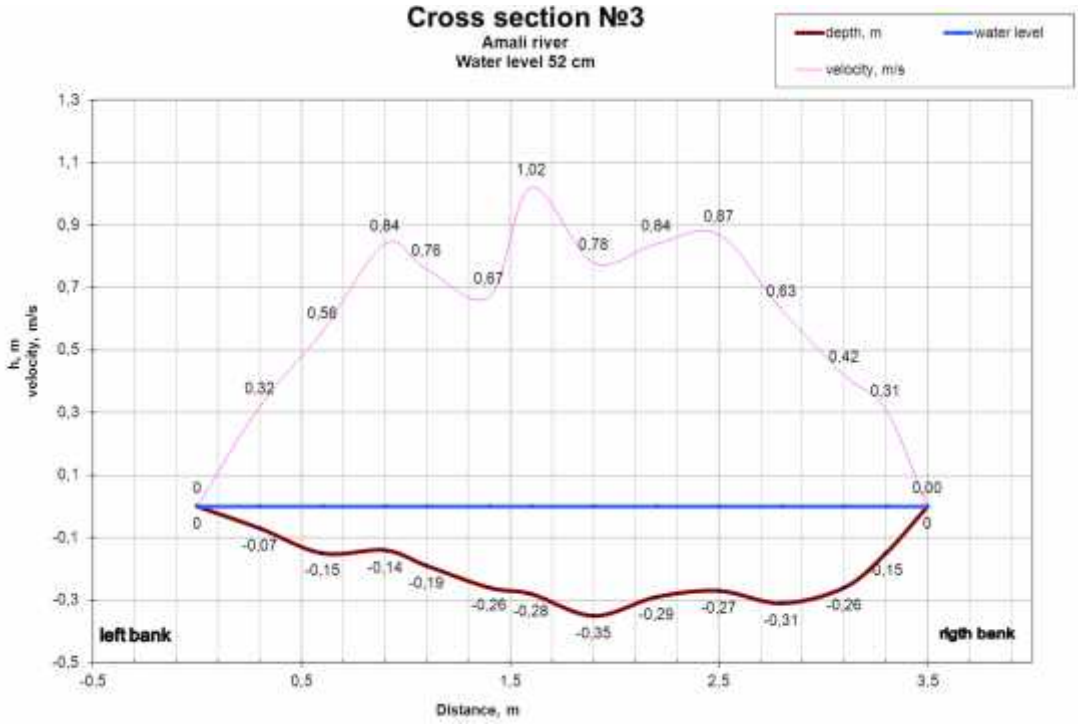

Cross section №4
Tibaistskali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

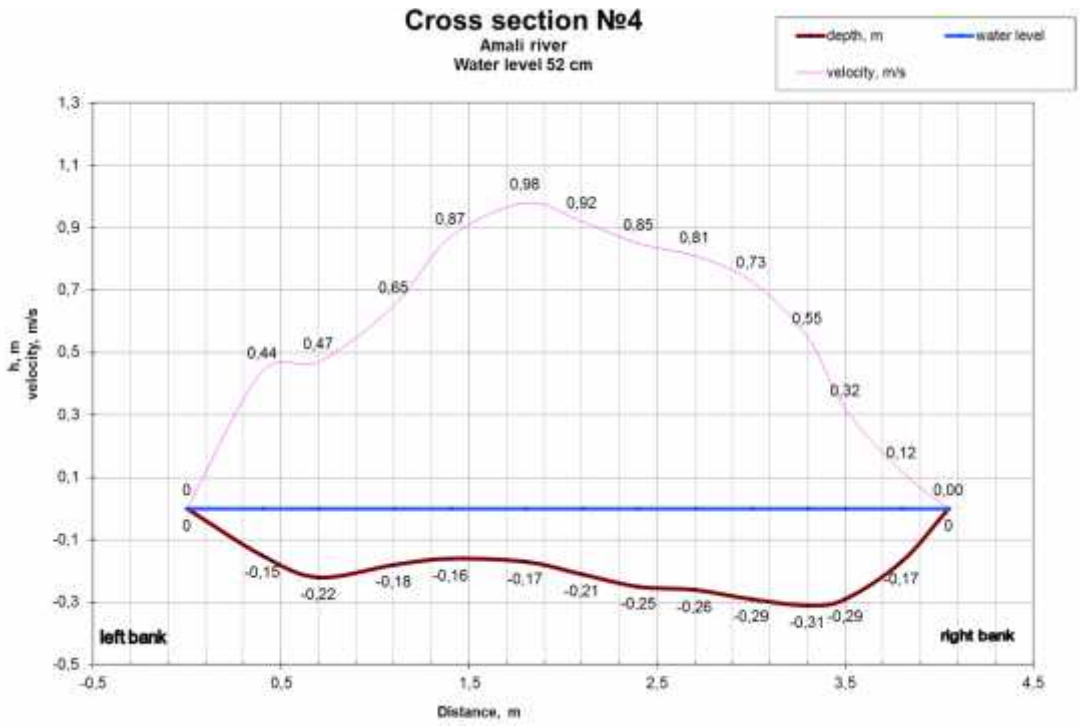

Cross section №5
Tibaistskali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank

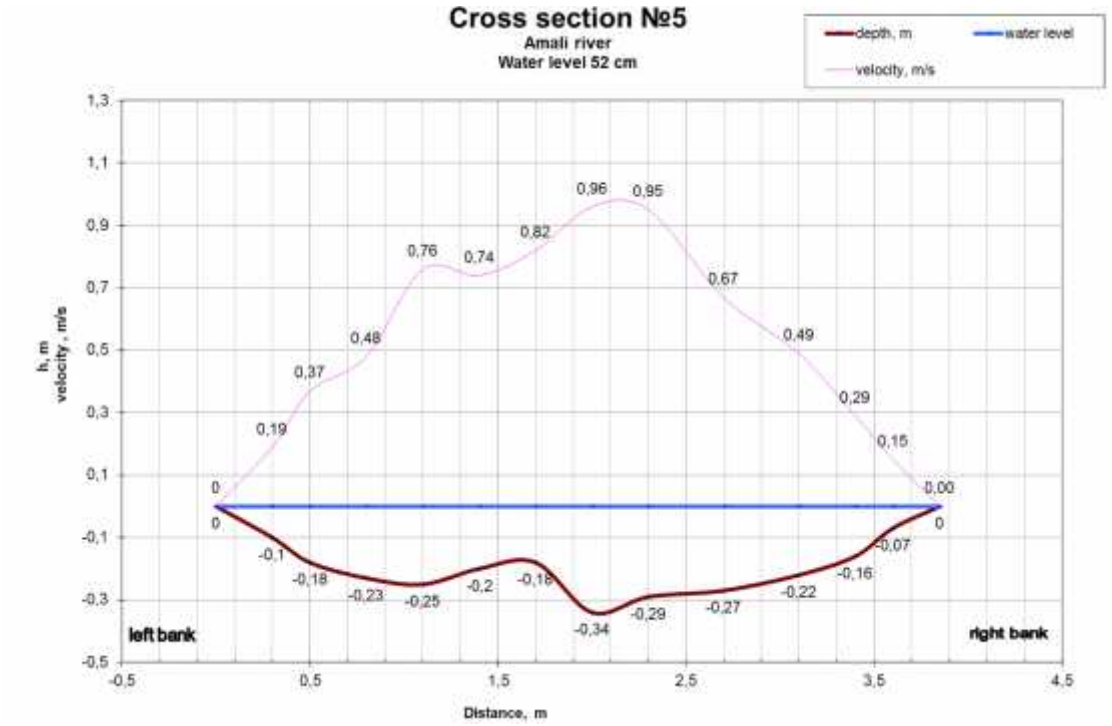
Monitoring station 12 – **Amali mouth**






Cross section №3
Amali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
rigth bank
0
0,32
0,56
0,84
0,76
0,67
1,02
0,78
0,84
0,87
0,63
0,42
0,31
0,00
0
-0,07
-0,15
-0,14
-0,19
-0,26
-0,28
-0,35
-0,29
-0,27
-0,31
-0,26
-0,15
0


Cross section №4
Amali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0
0,44
0,47
0,65
0,87
0,98
0,92
0,85
0,81
0,73
0,55
0,32
0,12
0,00
0
-0,15
-0,22
-0,18
-0,16
-0,17
-0,21
-0,25
-0,26
-0,29
-0,31
-0,29
-0,17
0


Cross section №5
Amali river
Water level 52 cm
depth, m
water level
velocity, m/s
h, m
velocity, m/s
Distance, m
left bank
right bank
0
0,19
0,37
0,48
0,76
0,74
0,82
0,96
0,95
0,67
0,49
0,29
0,15
0,00
0
-0,1
-0,18
-0,23
-0,25
-0,2
-0,16
-0,34
-0,29
-0,27
-0,22
-0,16
-0,07
0