S.I.Vavilov Institute of the History of Natural Sciences and Technology,
Russian Academy of Sciences
Laboratory of Radiation Control of the Federal State Institution
«Center of Industrial Safety of the Fuel and Energy Complex»
Environmental Rights Centre (ERC) Bellona
Greenpeace Russia
The Centre of Industrial Safety

V.M. Kuznetsov, M.S. Khvostova, S.P. Kolotukhin,
V.A. Chuprov, B.A. Schukin, V.A. Moskalenko, V.V. Ponurovskaya

Final Report
Radiation Monitoring in the Rivers, Lakes in the Zone of Influence of «Mayak» Production Association

Version from 1.0 2013

Moscow-Chelyabinsk-St. Petersburg

2013

Main sources of water flow and transfer of radionuclides into the Techa river

Currently, water nutrition of the Techa river in the source is formed by runoff through left bank and right bank channels (LBC and RBC).

Hydrological measurements and control of radioactive contamination of water in channels are conducted regularly since 1960s in the framework of regular monitoring of PA "Mayak". On Fig. 1 there is simplified flow chart of material flows, which characterizes sources of water nutrition and transfer of radionuclides into the Techa river.

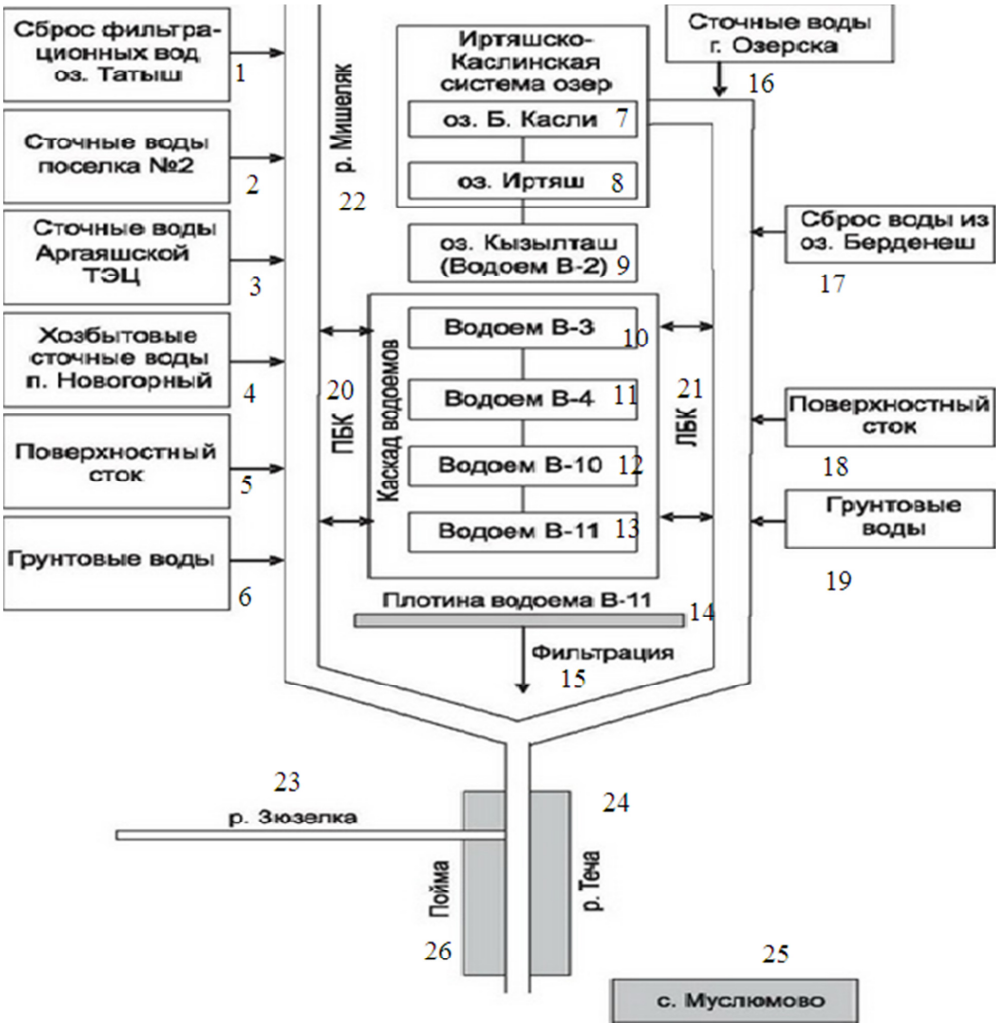


Fig 1. Simplified flow chart of water flow in upper part of the Techa river

Legend for Fig. 1.

1	Release of filtrated waters of the lake Tatysh	14	Dam of water reservoir No. 11
2	Sewage water of settlement No.2	15	Filtration
3	Sewage water of Argayashskaya Central Heating and Power Plant (CHPP)	16	Sewage water of Ozersk town
4	Domestic sewage water releases of settlement Novogorny	17	Release of water from the lake Berdenesh
5	Surface water	18	Surface water
6	Ground water	19	Ground water
7	Irtyash-Kasli system of lakes	20	RBC
	Lake Big Kasli		
8	Lake Irtyash	21	LBC
9	Lake Kyzyltash (Water reservoir No. 2)	22	Mishelyak river
10	Water reservoir No. 3	23	Zyuzelka river
11	Water reservoir No. 4	24	Techa river
12	Water reservoir No. 10	25	village Muslyumovo
13	Water reservoir No. 11	26	Floodplain

Main sources of radioactive contamination of surface layer of the atmosphere, ground water and soil on the territory of industrial site of PA "Mayak" are technological water reservoirs Nos. 9, 17, 16 and cascades of water reservoirs-storages Nos. 2, 3, 4, 10, and 11. Main parameters of some water reservoirs of Techenskiy cascade of water reservoirs (TCWR) are presented in Table 1.

Table 1

Main parameters of water reservoirs of TCWR (2012)

Parameter	Water reservoirs				
	B-3	B-4	B-10	B-11	Total
Area, km^2	0.80	1.3	18.2	46.6	67
Capacity, million m^3	0.80	3.8	80	256	341

Average annual structure of water balance of TCWR for the period of 1993–2012 is presented in Table 2.

Table 2

Average annual structure of water balance of TCWR for the period of 1993–2012

Component of water balance	Capacity, million m^3/year
1. Inflow components:	
– discharge of low-level radioactive wastes;	0.3
– discharge of domestic & fecal and storm water;	5.9
– precipitations;	31.4
– surface & slope and subsurface runoff.	4.5
Total:	42.1
2. Supply components:	
– filtration from TCWR;	13.4
– evaporations.	23.4
Total:	36.8
3. Imbalance:	5.3

The Table shows that the inflow component predominates over supply component, and therefore water level in TCWR gradually increases, which is also shown in Figure 2. Water level in TCWR depends mainly on precipitation depth during a year and thereafter on surface & slope and subsurface runoff.

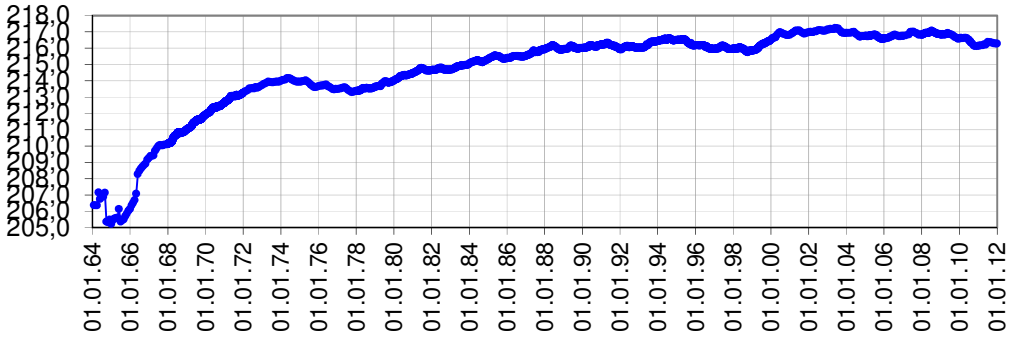


Figure 2. Change in water level (average annual) in No. 11 in the period from 1964 to 2012.

On some sites of TCWR water reservoirs Nos. 10 and 11 are closely adjacent to separation dams, which were built along channels. There is a filtration connection between channels and water reservoirs, at that, if it is higher than "zero" point (point, where water levels in channel and water reservoir are equal), filtration is directed from channel to water reservoir, and if below than "zero" point – from water reservoir to channel. Transfer of activity into waters of LBC and RBC is determined by filtration and sorption properties of soil and difference in water levels in water reservoirs Nos. 10 & 11 and in channels. Main filtration flow passes through natural geological solid mass under a base of canalside dambs at a depth of 30-40 m.

Table 3

Characteristics of sources of filtration transfer of ^{90}Sr and ^{3}H from TCWR into waters of the Techa river (2000–2012)

Parameter	Sources of filtration transfer of ^{90}Sr and ^{3}H			Total
	LBC	RBC	Filtrate under dam B-11	
Volume of filtered water, million m^3/year	3 – 6	2 – 3	5 – 8	10 – 15
Transfer with filtrate into waters of the Techa river, Ci/year (TBq/year): ^{90}Sr	10 – 40 (0.4 – 1.5)	13 – 30 (0.5 – 1.1)	0	23 – 65 (0.9 – 2.4)
Transfer with filtrate into waters of the Techa river, Ci/year (TBq/year): ^{3}H	70 – 140 (2.7 – 5.4)	50 – 70 (1.8 – 2.7)	120 – 190 (4.5 – 7.2)	240 – 360 (9 – 14)

Part of water, filtered through dam B-11, is intercepted by drainage system and returned back into water reservoir No. 11. Other part of water, filtered under the dam and through bottom of water reservoir, is not intercepted by drainage system and finally released into the Techa river. According to current estimates, total filtration losses from water reservoir No. 11 may reach 10–15 million m^3/year. Specific activity of ^{90}Sr in water reservoir No. 11 is 1300-1500 Bq/l, so every year, from water reservoir, ~400-600 Ci ^{90}Sr (15–22 TBq) is lost with filtrate through LBC and RBC, but only 23-65 Ci/year is passed into open hydrographic system of the Techa river (2000–2012) due to sorption of ^{90}Sr in soil.

Mean value of specific activity of tritium (^{3}H) in water of reservoir No. 11 is (2000–2012) ~ 900 Bq/l, thus, annually~240–360 Ci/year is passed into ground water and directly into water of the Techa river (Table 3).

Transfer of ^{137}Cs and plutonium into the Techa river with water, filtered from water reservoirs of TCWR, is negligibly small and cannot be fixed by methods of radiation control, used on PA "Mayak", due to the following reasons:

– specific activity of ^{137}Cs and sum of isotopes of plutonium (Pu) in water of reservoir No. 11 is not more than ~3 Bq/l and ~0.005 Bq/l, respectively;

– high sorption properties of ^{137}Cs and plutonium limit migration ability of these radionuclides, therefore, protective barrier in a form of loamy side diverging wall (with a width of only 10-15 m) is almost insurmountable obstacle.

Water reservoirs of TCWR have the most significant impact on the environment due to tranfer of radioactive strontium-90 into open hydrographic system of the Techa river with filtration flow. Conducted studies show (Figure 3) that dependence of total filtration transfer of strontium-90 from water reservoir No. 11 into LBC and RBC from the water level in water reservoir has a

pronounced non-linear character and increases from 57 Ci/year (when water level in water reservoir is 215.5 m) to ~ 60 Ci/year (at level of 217.0 m).

Radioactive contamination of water of the Techa river in the area of village Muslyumovo (closest settlement to the plant on the Techa river) is mainly due to content of ^{90}Sr and is determined by combination of following factors:

– transfer of ^{90}Sr in a source of the Techa river through hydrotechnical constructions (HTCs) as a result of filtration of water from water reservoirs of TCWR (mainly from water reservoir No. 11) into bypass ducts;

– sorption/desorption of ^{90}Sr at wetland of river (Asanovskiye marshes), located between HTC (dam of water reservoir No. 11) and village Muslyumovo;

– water flow of the river, which is substantially grown due to additional release of "clean" water from Irtyash lake through LBC.

In the period from 1970 to 1995, runoff of strontium in the middle of the river (village Muslyumovo) was 3-5 times higher than in a source. During this period of time, up to 70–90 % of runoff of activity of ^{90}Sr in middle and lower parts of the river was caused by process of washout of activity from Asanovskiye marshes, and total transfer through HTCs (LBC, RBC and filtrate of dam B-11) does not exceed 30 %. At that, specific activity of ^{90}Sr in water of the Techa river was almost independent from transfer of this radionuclide from HTCs, but was determined mainly by current stock of ^{90}Sr in wetland of a source of the river (Asanovskiye marshes), formed in 1950s by release of liquid radioactive wastes (LRWs) into the Techa river.

Current condition of TCWR and its impact on an environment

Monitoring results and long-term complex investigations allow characterizing radiation situation on TCWR and surrounding areas by the following indicators:

1. External dose rate above surface of water reservoirs Nos. 10 and 11 (as measured from a boat or ice) does not exceed 4-5 μR/hr, which is significantly (in 2-5 times) less than natural radiation background (10-20 μR/hr) on the territory of Russia.
2. Radiation situation in shoreland of TCWR remains stable, at that values of equivalent dose rate (EDR) in areas of water reservoirs Nos. 10 and 11 are higher than background values for Ural region only in 2-5 times.
3. Annual average volume activity of radionuclides in surface layer of air in shoreland of TCWR is less than permissible volume activity (PVA_{nas} by NRB (Radiation Safety Standards)-99/2009) by 3-4 orders.
4. Annual average values of fallout density in shoreland of TCWR are higher than background values for Ural region in not more than 2-3.5 times.
5. Transfer of radioactive substances (^{90}Sr) into the environment is occurring mainly due to filtration of contaminated water from water reservoirs Nos. 10 and 11 by natural solid mass under a base of canalside dams of bypass channels, composed by technogenic deposits (dense loams). According to current estimates, total filtration losses from water reservoirs of TCWR may reach 15 million m^3/year. At that, about 30 Ci/year of ^{90}Sr is passed with aqueous runoff from LBC and RBC into the Techa river: from LBC ~13 Ci/year, from RBC ~17 Ci/year (2011).
6. Main filtration water flow from TCWR passes on geological solid mass under a base of dam No. 11 and is discharged into floodplain of the Techa river. Transfer of ^{90}Sr into river system of the Techa river with this flow is not observed and is not expected because of high sorption properties of water-bearing materials.

7. Analysis of monitoring results and evaluation of transfer of radioactive ^{90}Sr from TCWR into a source of the Techa river show:

- with an increase of water level in water reservoir No. 11 total filtration transfer of ^{90}Sr into the Techa river from LBC and RBC increases;
- intensity of transfer of ^{90}Sr from TCWR into waters of LBC and RBC is determined by difference of water levels in water reservoirs Nos. 10 & 11 and in channels, by filtration and sorption properties of soil.

Dependence between total filtration transfer of ^{90}Sr from TCWR into channels and water level in water reservoir No. 11 is non-linear and increases from 8 Ci/year (when water level in the water reservoir is 215.5 m, 1984-1986) up to 50 Ci/year (at the level of 216.8 m), that is specified the need for lowering water level in water reservoir.

Thus, in determining strategic directions of long-term safe operation of TCWR it is necessary to take into account the following:

1. Conducting works on cleaning all accumulated volume of water and sediments of water reservoirs of TCWR (several hundred million cubic meters) is not possible on both technical and economic considerations.
2. Compete drying up of all water reservoirs of TCWR and turning them into near surface repositories of SRWs is not possible, as water reservoirs are located in a valley of the Techa river and drain surface and ground waters from water-collecting area.

Under normal natural hydrometeorological conditions and scientifically based operation of water reservoirs of TCWR, they do not represent actual radiation hazard for personnel, residents of nearby settlements and threat for activities of aquatic flora and fauna in water reservoirs.

Based on our forecast, in 100-150 years from the date of elimination of discharge of LRWs into water reservoirs, value of specific activity of radionuclides in sediments of water reservoirs Nos. 10 & 11 will fall below a limit of SRWs due to processes of natural self-purification of water reservoirs (radioactive decay, redistribution of activity in depth of sediments, etc.) Therefore, before withdrawal of SRWs from operation (exemption of facility from regulatory supervision and control), it is necessary to provide preliminary stage of long-term safe operation of water reservoirs in order to reduce the level of their potential radiological hazards, keeping condition of protective engineering safety barriers on adequate level (maintenance of all system of HTCs in operational condition, pumping stations, transportation and energy communications, etc.).

Results of environmental radiation surveys of territories in zone of influence of PA "Mayak"

Engineering and environmental survey of parts of a floodplain of the Techa river has been conducted by the Laboratory of Radiation Control of the FSE "Centre of Industrial Safety" (FSE "CIS FEC") and by researchers of the S.I. Vavilov Institute of the History of Natural Sciences and Technology of the Russian Academy of Sciences with assistance of Centre of Expertise (St. Petersburg). Members of Russian branch of Greenpeace and the Environmental Rights Centre (ERC) Bellona (St. Petersburg) took part as independent observers.

Project Team

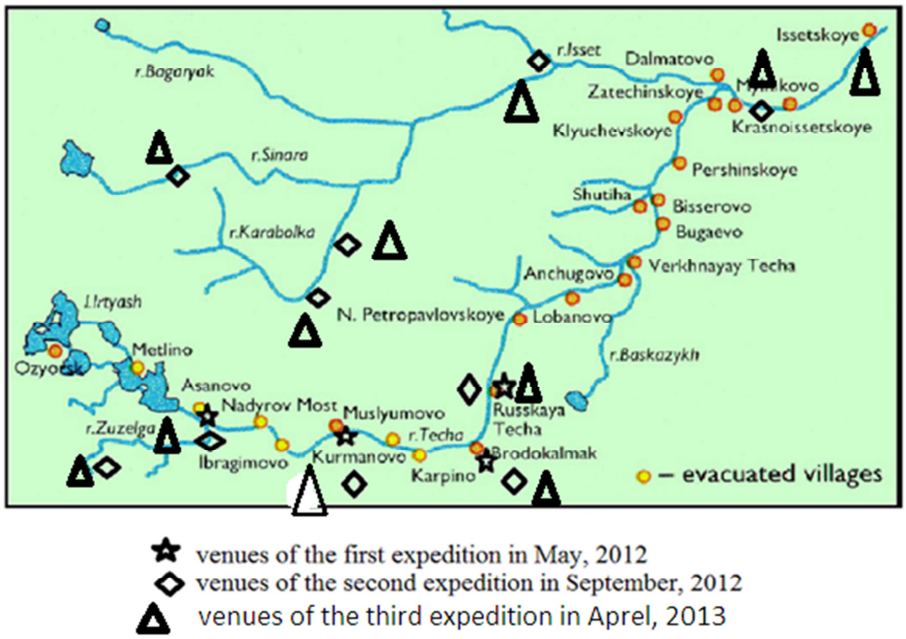
№	Person	Post, profession	Place of job
1	Kuznetsov Vladimir Mikhailovich, Project Team Leader	Doctor of Technical Sciences, Professor, Academician at the Russian Academy of Natural Sciences and Academy of Industrial Ecology, member of the Public Council of Rosatom	S.I.Vavilov Institute of the History of Natural Sciences and Technology, Russian Academy of Sciences, Moscow
2	Kolotukhin Sergey Prokopievich, member of Project Team	Candidate of Technical Sciences, laboratory head, senior research fellow	Laboratory of Radiation Control of the Federal State Institution "Center of Industrial Safety of the Fuel and Energy Complex", Moscow
3	Khvostova Marina Sergeevna, Member of Project Team	Candidate of Geographical Sciences, Senior lecturer, Senior research fellow	S.I.Vavilov Institute of the History of Natural Sciences and Technology, Russian Academy of Sciences, Moscow
4	Moskalenko Vladimir Alexeevich, Member of Project Team	Candidate of Technical Sciences, Senior lecturer, Leader expert	The Centre of Industrial Safety, St. Petersburg
5	Ponurovskaya Vera Vladimirovna, Member of Project Team	Junior research fellow, post-graduate	Laboratory of Radiation Control of the Federal State Institution "Centre of Industrial Safety of the Fuel and Energy Complex", Moscow
6	Chuprov Vladimit Alexeevich	Director of the Program	Greenpeace Russia
7	Shchukin Alexey Borisovich	Candidate of Technical Sciences	Expert in nuclear projects, Environmental Rights Centre (ERC) Bellona in St. Petersburg.

Equipment used:

- Scintillation radiometer SRP-88H, serial number 1084, calibration certificate № 210-191/12, valid until 24 May 2014
- Dosimeter-radiometer MKS-AT1117M, serial number 12735, test certificate number 41150.A079, valid until 18 September 2014
- Dosimeter RKSb-104, serial number7390, verification certificate № 210-190/12, valid until 27 July 2014
- Specialized radiometric equipment URS-71 on the basis of a Ge-Li semiconductor detector, serial number 71, test certificate number № 58 16.F638, valid until 25 May 2013

The radio-ecological survey was done in shorelands of rural settlements (settlement Novogorny, Old and New Muslyumovo, Krasnoisetskoe, Tatarskaya Karabolka, Ust-Karabolka, settlement Argayash); lands of the State Forest Fund; areas closed for access due to radiation

levels; rivers: Techa, Zyuzelka, Sinara, Iset, Karabolka and their floodplains (Fig.3); lakes – Ulagach, Argayash and number of lakes, located in zone of influence of PA "Mayak".



Comment [A1]: Mistake in legend to the map in the word 'April'. Font should be changed too.

Fig. 3. Map of measurements and samplings in May, September 2012 and in April 2013.

Surfaces of surveyed objects were valleys overgrown by brushes and trees, partly marshy, and also the rivers flowing through them.

Dates of the survey:

18-28 April 2013 (settlement Novogorny, Old and New Muslyumovo, Krasnoisetskoe, Tatarskaya Karabolka, Ust-Karabolka and others), lands of the State Forest Fund, areas closed for access due to radiation levels; and in the areas of the rivers Techa, Zyuzelka, Sinara, Iset, and Karabolka), and also lake Argayash.

Weather conditions:

18 April 2013 – temperature 14-16°C, clear, light wind;
19 April 2013 – temperature 16-18°C, partly cloudy, precipitations in some places, weak wind with blasts;
20 April 2013 – temperature 14-16°C, clear, light wind;
21 April 2013 – temperature 18-20°C, clear, light wind;
22 April 2013 – temperature 18-20°C, clear, light wind;
23 April 2013 – temperature 18-20°C, clear, light wind;
24 April 2013 – temperature 16-18°C, partly cloudy, precipitations in some places, weak wind with blasts;
25 April 2013 – temperature 14-15°C, partly cloudy, precipitations in some places, strong wind with blasts;
26 April 2013 – temperature 14-15°C, partly cloudy, strong wind with blasts;
27 April 2013 – temperature 15-16°C, partly cloudy, strong wind with blasts;

Dates of the survey: 20-27 May 2013 (rivers Iset, Tobol, Irtysh, and Ob)

Weather conditions:
20 – 27 May 2013
20 May 2013 – temperature 4-6°C, cloudy, light wind;
21 May 2013 – temperature 3-4°C, cloudy, light rain;
22 May 2013 – temperature 6°C, cloudy, light wind;
23 May 2013 – temperature 6°C, cloudy, light wind;
24 May 2013 – temperature 8°C, cloudy;
25 May 2013 – temperature 12°C, clear;
26 May 2013 – temperature 14°C, partly cloudy, precipitations in some places, weak wind with blasts;
27 May 2013 – temperature 18°C, partly cloudy, precipitations in some places, strong wind with blasts.

Work included:
- gamma measurements to detect radiation anomalies;
- measurements of exposure dose rates (EDR) and beta-particle flux density
- at characteristic points in the floodplain of rivers and lakes (siltation areas in the rivers and lakes, wetlands, and flooded areas near and away from the river valley) samples were taken to determine their radionuclide composition with the stationary gamma-ray spectrometer URS-71.

I. Techa river, Asanovskiye marshes.

Name and purpose of land area: areas closed for access due to radiation levels; hunting reserve.

Characterization and area of the site: surface is smooth, floodplain of the Techa river is swampy, partly overgrown by bushes and trees, the site is crossed by the motorway Chelyabinsk – Ekaterinburg, area of the site is 78 hectares.

Results of measurements of Exposed Dose Rate (EDR) of external gamma-radiation in the open area at 0.1 m above soil at characteristic points.

No.	Number of measurement points	Maximum EDR (**N**) (μSv/h)	Average EDR (**A**) (μSv/h)
1	6	20	8
2	32	0.72	0.4
3	97	0.45	0.14

Results of measurements of beta-particle flux power in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity ($\mathbf{H}_\beta$), (particles/(cm^2*min)	Average value of beta-radiation intensity ($\mathbf{A}_\beta$) (particles/(cm^2*min)
1	6	440	290
2	17	16.8	11
3	46	3.9	3.9

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ (Bq/kg)
1	2	3	4	5
2	River silt	0.1 -0.2	Ra-226	64 ± 9.3
			Th-232	58 ± 7.3
			K-40	366 ± 160
			Cs-137	12770 ± 1740
			Co-60	11.2 ± 5.8
			Sr-90	27 ± 12
3	Marsh silt	0.2 – 0.3	Ra-226	260 ± 46
			Th-232	122 ± 26
			K-40	9 ± 9
			Cs-137	56900 ± 7760
			Sr-90	14 ± 5.4

Specific activity of radionuclides in water samples of the Techa river:

No. of sample	$A_{spec} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
2в	26.1 ± 24%	2.8 ± 95%	1250± 56%
3в	27.2 ± 25%	4.5 ± 100%	1100 ± 48%

Conclusion:

1. External dose rate (EDR) of external gamma-radiation at the site has a pronounced non-uniformity and varies from 0.08 to 20 μSv/h.

Within the swampy floodplain of the Techa river, measured average maximum EDR is reached 12.9 μSv/h, which is significantly higher than the natural gamma background of the area.

The EDR decreases with increasing distance from the river; outside of the river floodplain the EDR does not exceed 0.152 μSv/h, which is within the limits of fluctuations of the natural gamma background appropriate for that area.

2. Beta-particle flux density at the site is not uniform and varies from 0.8 particles/(cm^2*min) outside floodplain of the river up to 440 particles/(cm^2*min) at the shore of the Techa river (swampy part).

Average flow rate of beta-radiation at the river shore (swamp land) is not higher than 393 particles/(cm^2*min).

This value exceeds the minimum permissible level of contamination by beta-particles for professional staff of 200 particles/(cm^2*min) (NRB-99/2009, table 8.9).

3. Technogenic radionuclides (Cs-137, Co-60, and Sr-90) are found in the silt sample.

In taken samples of silt along shore of swamp, Cs-137 has maximal activity, specific activity of which varies from 12,770 to 56,900 Bq/kg. This value of specific activity does not exceed the level of specific activity, at which unlimited use of materials is allowed – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

The specific activity of natural radionuclides in sample of silt No. 3 exceeds the level, which is characteristic for Chelyabinsk region, and control level of Aeff - 370 Bq/kg (NRB -99/2009, paragraph 5.3.4).
4. Technogenic radionuclides (Sr-90, Cs-137, and H-3) are found in water samples from the Techa river.
Specific activity of Cs-137 (1.3– 6.2 Bq/l) and H-3 (1250 – 1500 Bq/l) is less than the intervention level (IL) for adult population in drinking water (IL_{Cs-137} = 11 Bq/l, IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in all samples (26.1 – 27.2 Bq/l) exceeds IL_{Sr-90} = 4.9 Bq/l for more than 5 times (NRB-99/2009, Appendix 2a).
Appendix 1:
1. Average values of EDR on the open area at 0.1 m above soil surface and in characteristic points at the Techa river near the Asanovskiye marshes.
2. Average values of beta-particle flux density at the Techa river near the Asanovskiye marshes.
3. Points of measurements of EDR and sampling at the Techa river near the Asanovskiye marshes.
4. Points of measurements of beta particle flux power at the Techa river near the Asanovskiye marshes.

II. Lakes located in the zone of influence of the PA "Mayak"

Monitoring results of radionuclide composition of water of lakes, located in a zone of influence of PA "Mayak" are shown in the table. The table shows that the volumetric activity of ^{90}Sr in water of these lakes varies from less than 0.03 to 0.14 Bq/l, and volumetric activity of ^{137}Cs in water of all lakes was less than 0.2 Bq/l. Maximum obtained values of volumetric activities of ^{90}Sr и ^{137}Cs in water of lakes are 35 and 55 times less than IL according NRB-99/2009 for mentioned radionuclides in drinking water, respectively. Lakes Irtyash and Big Akulya are sources of drinking water for the town of Ozersk. Content of ^{90}Sr in lakes Big Akulya and Irtyash was 2 orders lower than IL, but 5.5 and 8 times higher than in lake Hanka, which is located in Asian part of Russia (APR), respectively, and 15 and 23 times higher than in lakes in European part of Russia (EPR), respectively.

Table

Volumetric activity of radionuclides in lakes, located in a zone of influence of the PA "Mayak", Bq/l

Lake[1]	Volumetric activity		
	^{90}Sr	^{137}Cs	H-3
Silach	<0.03	<0.2	100
Sungul	<0.03	<0.2	110
Kirety	<0.03	<0.2	85
Big Kasli	<0.03	<0.2	130
Small Kisli	<0.03	<0.2	120
Kutashi	<0.03	<0.2	100
Irtyash	0.06	<0.2	90
Big Nanoga	0.04	<0.2	100
Small Nanoga	0.14	<0.2	95
Big Akulya	0.04	<0.2	120

[1]To determine the value of volumetric activity in lakes it was taken by 4 samples (in each lake). Total 48 water samples.

Akakul	<0.03	<0.2	100
Uvildy	<0.03	<0.2	110
IL according to NRB-99/2009	4.9	11	7600

Appendix 2 – was not composed, because measurements of values of EDR and values of beta-particle flux density were not carried out.

III. Rivers Karabolka (village Tatarskaya Karabolka, village Ust Karabolka), Sinara (mouth of river)

In waters of Karabolka-Sinara river system, content of tritium has increased for more than tenfold. Content of ^{90}Sr and ^{137}Cs in the Sinara river is increased, compared with 2012, by 1.2 and 3.7 times, respectively. Content of ^{90}Sr in the Karabolka river is increased by 1.3 times, and content of ^{137}Cs is decreased by 1.1 times, compared with 2012. It should be noted that volumetric activity of radionuclides in water of rivers Karabolka and Sinara in 2013 did not exceed IL according to NRB -99/2009: volumetric activity of ^{90}Sr was by 2 times less than IL.

The results of radionuclide analysis of water samples from the rivers Karabolka and Sinara (mouth of rivers) are given in the table.

Table

Volumetric activity of radionuclides in rivers of Karabolka and Sinara (settlement Nikitinskoe, mouth of river), Bq/l

Month	river Karabolka village Tatarskaya Karabolka			river Karabolka village Ust Karabolka			river Sinara mouth of river		
April 2013	H-3	Cs-137	Sr-90	H-3	Cs-137	Sr-90	H-3	Cs-137	Sr-90
	43	0.01	below detection level (b.d.l.)	b.d.l.	b.d.l.	2.48	60	0.01	0.13
IL	7600	11	4.9	7600	11	4.9	7600	11	4.9

To determine one value of volumetric activity in river water, 3 samples were taken (for each river). A total of 9 water samples were taken.

Appendix 3 – was not composed, because measurements of values of EDR and values of beta-particle flux density were not carried out.

IV. Village Muslyumovo

Characterization and area of the site: rough site, partly overgrown by bushes, raising 2-4 m over the Techa river, a floodplain of the river is filled by broken stones with a thickness of 0.5 m, area of the site is 20 hectares.

Background gamma-radiation: average EDR of background external gamma-radiation at the site with a confidence level of 0.95 is 0.08 ± 0.01 μSv/h.

Results of measurements of EDR of external gamma-radiation in the open area at 0.1 m above soil at characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	26	0.73	0.6
2	15	0.19	0.2
3	34	0.15	0.11

Results of measurements of beta-particle flux power in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β), (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	15	75.2	54.7
2	8	20.1	4.0
3	24	15.3	1.6

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ (Bq/kg)
1	2	3	4	5
1	Silt deposit	0.1 – 0.2	Ra-226	51 ± 5.48
			Th-232	69.1 ± 11.3
			K-40	0 ± 0
			Cs-137	13690 ± 1880
			Sr-90	1.5 ± 1.5

Specific activity of radionuclides in water samples of the Techa river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
1	23.2 ± 5.5%	b.d.l.	810 ± 46%

Conclusion:

1. External dose rate (EDR) of external gamma-radiation at the site has a pronounced non-uniformity and varies from 0.08 to 0.73 μSv/h.

At shore of the Techa river, average EDR reaches 0.63 μSv/h, which is higher than natural gamma-background of the area.

EDR rapidly decreases with increasing distance from the river. At a distance from the river 10 – 20 m (by the bank) average EDR is 0.2 μSv/h, at distance of 30-40 m and more, average EDR is 0.12 μSv/h, which is within fluctuations of natural gamma-background appropriate for the area.

2. Flow rate of beta-radiation at the site is not uniform and varies from 0.9 particles/(cm^2*min) at the distance of 30-40 m and more from the river and to 75.2 particles/(cm^2*min) at shore of the Techa river.

Average flow rate of beta-radiation at shore of the river will not exceed 58.5 particles/(cm^2*min).

3. Technogenic radionuclides (Cs-137 and Sr-90) are found in samples of silt.

In sample of silt, Cs-137 has the highest activity, specific activity of which is 13,690 Bq/kg and within confidence interval 0.95 specific activity of Cs-137 will not exceed 15,570 Bq/kg. This level of specific activity does not exceed the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

The specific activity of natural radionuclides in samples of silt and soil does not exceed the level, which is characteristic for the Chelyabinsk region.
4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Techa river.
Levels of specific activity of H-3 (810 Bq/l) are less than IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in the sample (23.2 Bq/l) exceeds IL_{Sr-90} = 4.9 Bq/l for more than 4 times (NRB-99/2009, Appendix 2a).
Appendix 4:
1. Average values of EDR on the open area at 0.1 m above soil surface and in characteristic points of the site in the area of village Muslyumovo.
2. Average values of beta particle flux density in the area of village Muslyumovo.
3. Points of measurements of EDR and sampling in the area of village Muslyumovo.
4. Points of measurements of beta particle flux power in the area of village Muslyumovo.

V. Source of Sinara river (settlement Tyubuk, road bridge)

Name and purpose of land area: agricultural land.
Address of the site: Chelyabinsk region, Sinara river, road bridge of motorway Chelyabinsk – Ekaterinburg.
Characterization and area of the site: the site is along banks of the Sinara river, partly overgrown by bushes and trees, the area of the site is 12.8 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.08 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	26	0.21	0.16
2	52	0.14	0.11

Results of measurements of beta-particle flux power in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity ($\mathbf{H}_\beta$) (particles/(cm^2*min)	Average value of beta-radiation intensity ($\mathbf{A}_\beta$) (particles/(cm^2*min)
1	26	4.5	2.6
2	28	2.2	1.4

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg
1	2	3	4	5
2	Silt deposit	0.1 – 0.2	Ra-226	40.9 ± 4.36
			Th-232	26.2 ± 3.5
			Cs-137	9 ± 3.5
			Co-60	4.4 ± 4.3
			Sr-90	b.d.l.

Specific activity of radionuclides in water samples of the Sinara river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
25	3.1 ± 24.1%	b.d.l.	110±85

Conclusion:

1. EDR of external gamma-radiation at the site varies from 0.08 to 0.21 μSv/h.

At shore of the Sinara river, average EDR does not exceed 0.17 μSv/h, which is within fluctuations of natural gamma-background of the area.

EDR decreases with increasing distance from the river and at a distance of 20 m and more it is equal 0.11 μSv/h, which is within fluctuations of natural gamma-background, appropriate for the area.

2. Flow rate of beta-radiation at the site varies from 0.9 particles/(cm^2*min) at the distance of 20 m and more from the river and to 4.5 particles/(cm^2*min) at shore of the Techa river.

Average flow rate of beta-radiation at shore of the river will not exceed 2.84 particles/(cm^2*min).

The average flow rate of beta-radiation at the distance of 20 m from the river will not exceed 1.52 particles/(cm^2*min), which is within fluctuations of beta-radiation of Chelyabinsk region.

3. Technogenic radionuclides (Cs-137 and Co-60) are found in samples of silt.

In samples of silt, Cs-137 has the highest activity, specific activity of which is 9 Bq/kg and within confidence interval 0.95 will not exceed 12.5 Bq/kg. This level of specific activity does not exceed the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

The specific activity of natural radionuclides in samples of silt and soil does not exceed the level, which is characteristic for the Chelyabinsk region.

4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Techa river.

Specific activity of Sr-90 in the sample is 3.1 Bq/l.

The maximum specific activity of Sr-90 does not exceed IL_{Sr-90} = 4.9 Bq/l (NRB-99/2009, Appendix 2a).

Appendix 5:

1. Average values of EDR at the Sinara river, in the area of road bridge, at 0.1 m above soil surface.

2. Average values of beta-particle flux density at the Sinara river, near the road bridge, close to soil surface.

3. Points of measurements of EDR and sampling at the Sinara river, near the road bridge, at 0.1 m above soil surface.

4. Points of measurements of beta-particle flux density at the Sinara river near the road bridge.

VI. Techa river, near settlement Brodokalmak (road bridge)

Characterization and area of the site: the site is along high bank of the Techa river, partly overgrown by bushes and trees, area of the site is 13 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation in the open area at 0.1 m above soil surface at characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	20	0.89	0.77
2	19	0.34	0.27
3	39	0.13	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	20	32.2	23.9
2	9	4.5	3.7
3	19	1.2	1.0

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg
1	2	3	4	5
			Ra-226	98 ± 10.2
8	Silt deposit	0.1 -0.2	Th-232	35.6 ± 15.0
			K-40	202 ± 200
			Cs-137	6930 ± 950

Specific activity of radionuclides in water samples of the Techa river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
8в	19.6 ± 24%	b.d.l.	610 ± 60%

Conclusion:
1. EDR of external gamma-radiation at the site varies from 0.09 to 0.89 μSv/h.
At shore of the Techa river, average EDR does not exceed 0.8 μSv/h, which is higher than the natural gamma-background of the area. EDR decreases with increasing distance from the river.
At distance of 35 m and more, maximum average EDR will not exceed 0.12 μSv/h, which is within fluctuations of the natural gamma-background appropriate for that area.
2. Beta-particle flux density at the site is not uniform and varies from 0.09 particles/(cm^2*min) at a distance of 35 m and more from the river and to 32.2 particles/(cm^2*min) at shore of the Techa river.
Average flow rate of beta-radiation at shore of the river will not exceed 25.8 particles/(cm^2*min).
3. Technogenic radionuclide Cs-137 is found in sample of silt, specific activity of which is 6,930 Bq/kg. Within confidence interval 0.95, average specific activity of sample will not exceed 7,880 Bq/kg. Specific activity of Cs-137 significantly exceeds the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).
The specific activity of natural radionuclides in samples of silt does not exceed the level, which is characteristic for the Chelyabinsk region.
4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Techa river.
Specific activity of H-3 (610 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in the sample (19.6 Bq/l) exceeds IL_{Sr-90} = 4.9 Bq/l for more than 3 times (NRB-99/2009, Appendix 2a).
Appendix 6:
1. Average values of EDR at the Techa river, in the area of road bridge, near settlement Brodokalmak, at 0.1 m above soil surface.
2. Average values of beta-particle flux density, in the area of road bridge, near settlement Brodokalmak, close to soil surface.
3. Points of measurements of EDR and sampling at the Techa river, in the area of road bridge, near settlement Brodokalmak, at 0.1 m above soil surface.
4. Points of measurements of beta-particle flux density, in the area of road bridge, near settlement Brodokalmak, close to soil surface.

VII. Settlement Russkaya Techa, broad bridge

Characterization and area of the site: the site is along the high bank of the Techa river, partly overgrown by bushes and trees, area of the site is 5 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation in the open area at 0.1 m above soil at characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	20	0.95	0.81
2	18	0.2	0.17
3	36	0.19	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	20	36.2	17.3
2	10	4.1	3.2
3	30	1.5	1.0

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement Ai ± $\Delta_{0.95}$ Bq/kg
7	Silt deposit	0.1 – 0.2	Ra-226	47.8 ± 4.62
			Th-232	40.5 ± 6.7
			K-40	299 ± 187
			Cs-137	1670 ± 119

Specific activity of radionuclides in water samples of the Techa river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
7в	13.6 ± 24%	b.d.l.	390 ± 59 %

Conclusion:

1. EDR of external gamma-radiation at the site has a pronounced non-unifromity and varies from 0.08 to 0.95 μSv/h.

At shore of the Techa river, average EDR will not exceed 0.84 μSv/h, which is higher than natural gamma-background of the area.

The EDR decreases with increasing distance from the river and at distance of 35 m and more, it is equal 0.12 μSv/h, which is within fluctuations of the natural gamma-background appropriate for the area.

2. Flow rate of beta-radiation at the site is not uniform and varies from 0.6 particles/(cm^2*min) at distance of 35 m and more from the river and to 36.2 particles/(cm^2*min) at shore of the Techa river.

The average flow rate of beta-radiation at shore of the river does not exceed 18.9 particles/(cm^2*min).

3. Technogenic radionuclide Cs-137 is found in sample of silt, specific activity of which is 1,670 Bq/kg. Specific activity of Cs-137 significantly exceeds the level of specific activity, at which unlimited use of materials is allowed – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

Specific activity of natural radionuclides in samples of silt and soil does not exceed the level, characteristic for Chelyabinsk region.

4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Techa river.

Specific activity of H-3 (390 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in the sample (13.6 Bq/l) exceeds IL_{Sr-90} = 4.9 Bq/l for more than 2 times (NRB-99/2009, Appendix 2a).
Appendix 7:
1. Average values of EDR at the Techa river, in the area of road bridge, near settlement Russkaya Techa, at 0.1 m above soil surface.
2. Average values of beta-particle flux density at the Techa river, in the area of road bridge, near settlement Russkaya Techa, close to soil surface.
3. Points of sampling and measurements of EDR at the Techa river, in the area of road bridge, near settlement Russkaya Techa, at 0.1 m above soil surface.
4. Points of measurements of beta-particle flux density at the Techa river, in the area of road bridge, settlement Russkaya Techa, close to soil surface.

VIII. Source of the Iset river, road bridge (settlement Kamensk-Uralskiy)

Characterization and area of the site: the site is along bank of the Iset river, partly overgrown by bushes and trees, the area of the site is 5 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (**N**) (μSv/h)	Average EDR (**A**) (μSv/h)
1	15	0.22	0.17
2	43	0.15	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity ($\mathbf{H}_\beta$) (particles/(cm^2*min))	Average value of beta-radiation intensity ($\mathbf{A}_\beta$) (particles/(cm^2*min))
1	15	2.6	1.3
2	22	1.3	1.0

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg		
1	2	3	4	5		
			Ra-226	22.2	±	2.01
5	Silt deposit	0.1 -0.2	Th-232	20	±	2.5
			K-40	291	±	101
			Cs-137	3	±	1.7

Specific activity of radionuclides in water samples of the Iset river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
5в	0.4 ± 24%	0.03±15 %	75±14 %

Conclusion:

1. EDR of external gamma-radiation at the site varies from 0.09 to 0.22 μSv/h.

At shore of the Iset river, average EDR is 0.18 μSv/h, which does not exceed natural gamma-background of the area. EDR decreases with increasing distance from the river.

At distance of 25 m and more, maximum average EDR will not exceed 0.12 μSv/h, which is within fluctuations of natural gamma-background appropriate for that area.

2. Beta-particle flux density at the site varies from 0.6 particles/(cm^2*min) at a distance of 35 m and more from the river and to 2.6 particles/(cm^2*min) at shore of the Iset river.

The average flow rate of beta-radiation at shore of the river is 1.5 particles/(cm^2*min).

3. Technogenic radionuclide Cs-137 is found in samples of silt, specific activity of which is 3.7 Bq/kg. Within confidence interval 0.95 maximum specific activity of the sample will not exceed 4.7 Bq/kg. Maximum specific activity of Cs-137 does not exceed the level of specific activity, at which unlimited use of materials is allowed – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

Specific activity of natural radionuclides in samples of silt does not exceed the level, characteristic for Chelyabinsk region.

4. Technogenic radionuclides (Sr-90, Cs-137, and H-3) are found in water samples from the Iset river.

Specific activity of Sr-90 in the sample is 0.4 Bq/l, which does not exceed IL_{Sr-90} = 4.9 Bq/l (NRB-99/2009, Appendix 2a).

Appendix 8:

1. Average values of EDR at the Iset river, in the area of road bridge, at the confluence with the Techa river, at 0.1 m above soil surface.

2. Average values of beta-particle flux density at the Iset river, near the road bridge, at the confluence with the Techa river, close to soil surface.

3. Points of sampling and measurements of EDR at the Iset river, in the area of road bridge, at the confluence with the Techa river, at 0.1 m above soil surface.

4. Points of measurements of beta-particle flux density at the Iset river, in the area of road bridge, at the confluence with the Techa river, close to soil surface.

IX. Iset river, settlement Krasnoisetskoe

Characterization and area of the site: the site is along bank of the Iset river, partly overgrown by bushes and trees, the area of the site is 4 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	17	0.21	0.17
2	54	0.14	0.12

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	13	2.6	1.9
2	29	1.3	1.1

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg
1	2	3	4	5
			Ra-226	21.1 ± 1.76
6	Silt deposit	0.1 -0.2	Th-232	21.8 ± 2.2
			K-40	183 ± 113
			Cs-137	9 ± 3.6
			Co-60	b.d.l.
			Sr-90	b.d.l.

Specific activity of radionuclides in water samples of the Iset river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
6в	8.7 ± 24%	b.d.l.	170 ± 60%

Conclusion:
1. EDR of external gamma-radiation at the site varies from 0.09 to 0.21 μSv/h.

At shore of the Iset river, maximum average EDR does not exceed 0.18 μSv/h, which does not exceed natural gamma-background of the area.
At distance of 20 m and more, maximum average EDR does not exceed 0.144 μSv/h, which is within fluctuations of the natural gamma-background appropriate for the area.
2. Flow rate of beta-radiation at the site varies from 0.7 particles/(cm2*min) at distance of 20 m and more from the river and to 2.6 particles/(cm2*min) at shore of the Iset river.
The average flow rate of beta-radiation at shore of the river does not exceed 2.1 particles/(cm2*min).
3. Technogenic radionuclide Cs-137 is found in the silt sample, whose specific activity is 9 Bq/kg. Maximum specific activity of samples within a confidence interval of 0.95 does not exceed 12.6 Bq/kg. Maximum specific activity of Cs-137 does not exceed the level of specific activity, at which unlimited use of materials is allowed – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).
Specific activity of natural radionuclides in samples of silt does not exceed the level, characteristic for Chelyabinsk region.
4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Iset river.
Levels of specific activity of H-3 (170 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7,600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in the sample (8.7 Bq/l; maximum specific activity of Sr-90 and taking into account the uncertainty interval of measurement ($A + \Delta_{0.95}$), within a confidence interval of 0.95, does not exceed 8.7 Bq/l, which exceeds IL_{Sr-90} = 4.9 Bq/l (NRB-99/2009, Appendix 2a).
Appendix 9:
1. Average values of EDR at site of the Iset river, in the area of settlement Krasnoisetskoe, at 0.1 m above soil surface.
2. Average values of beta-particle flux density at site of the Iset river, in the area of settlement Krasnoisetskoe, close to soil surface.
3. Points of sampling and measurements of EDR at site of the Iset river, in the area of settlement Krasnoisetskoe, at 0.1 m above soil.
4. Points of measurements of beta-particle flux density at site of the Iset river, in the area of settlement Krasnoisetskoe, close to soil surface.

X. Ulagach lake, settlement Novogorny.

Characterization and area of the site: land of urban settlement, site on the shore of Ulagach lake, partly overgrown by bushes and trees. The area of the site is 3 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (**N**) (μSv/h)	Average EDR (**A**) (μSv/h)
1	20	0.22	0.15
2	53	0.13	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity ($\mathbf{H}_\beta$) (particles/(cm^2*min)	Average value of beta-radiation intensity ($\mathbf{A}_\beta$) (particles/(cm^2*min)
1	20	2.2	1.71
2	26	1.3	1.1

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg		
1	2	3	4	5		
			Ra-226	45.2	±	4.1
9	Silt deposit	0,1-0,2	Th-232	28.5	±	3.6
			K-40	165	±	146
			Cs-137	50	±	11
			Co-60		b.d.l.	
			Sr-90		b.d.l.	
			Ra-226	24.1	±	4.09
11	Silt deposit	0.1-0.2	Th-232	20.9	±	2.0
			K-40	279	±	94.4
			Cs-137	154	±	23
			Co-60		b.d.l.	
			Sr-90		b.d.l.	
			Ra-226	40.3	±	4.1
9Гр	Soil	0.3-0.3	Th-232	28.5	±	3.6
			K-40	279	±	145.8
			Cs-137	50	±	10.7
			Co-60		b.d.l.	
			Sr-90		b.d.l.	

Specific activity of radionuclides in water samples of Ulagach lake:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
9в	3.6 ± 24%	b.d.l.	240 ± 68%
10в	3.8 ± 24%	b.d.l.	210 ± 62%

Conclusion:

1. EDR of external gamma-radiation at the site varies from 0.08 to 0.22 μSv/h.

At shore of the lake average maximum EDR is not higher than 0.16 μSv/h, which does not exceed the natural gamma-background of the area.

At distance of 2 m and more, maximum average EDR does not exceed 0.114 μSv/h, which is within fluctuations of natural gamma-background appropriate for that area.
2. Beta-particle flux density at the site varies from 0.7 particles/(cm^2*min) at a distance of 10 m and more from the lake and to 2.2 particles/(cm2*min) at shore of the lake.
Average beta-particle flux density at shore will not exceed 1.83 particles/(cm^2*min).
3. Technogenic radionuclide Cs-137 is found in sample of silt and soil. Within confidence interval 0.95 maximum average specific activity of samples will not exceed 127 Bq/kg, which is higher than the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).
The specific activity of natural radionuclides in samples of silt does not exceed the level, which is characteristic for the Chelyabinsk region.
4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from Ulagach lake.
Specific activity of H-3 (240 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in samples is 3.6 – 3.8 Bq/l. Average maximum specific activity of Sr-90, taking into account the uncertainty interval of measurement ($A + \Delta_{0.95}$), within a confidence interval of 0.95, is not higher than 4.854 Bq/l, which does not exceed IL_{Sr-90} = 4.9 Бк/л (NRB-99/2009, Appendix 2a).
Appendix 10:
1**.** Average values of EDR at Ulagach lake, in the area of settlement Novogorny, at 0.1 m above soil surface.
2. Average values of beta-particle flux density at Ulagach lake, near the settlement Novogorny, close to soil surface.
3. Points of sampling and measurements of EDR at Ulagach lake, near the settlement Novogorny, at 0.1 m above soil surface.
4. Points of measurements of beta-particle flux density at Ulagach lake, near the settlement Novogorny, close to soil surface.

XI. River Zyuzelka – bridge on the road to settlement Novogornyi – city of Chelyabinsk

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 3 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.17	0.15
2	45	0.13	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.2	1.64
2	24	1.1	0.8

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg
1	2	3	4	5
			Ra-226	19.1 ± 2.61
12	Silt deposit	0.1-0.2	Th-232	14.4 ± 1.8
			K-40	b.d.l.
			Cs-137	17 ± 4.6
			Co-60	2.61 ± 2.6
			Sr-90	b.d.l.

Specific activity of radionuclides in water samples of the Zyuzelka river:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
11в	1.0 ± 24%	b.d.l.	150 ± 65 %

Conclusion:

1. EDR of external gamma-radiation at the site varies from 0.08 to 0.17 μSv/h.

At shore of the river, average maximum EDR is not higher than 0.16 μSv/h, which does not exceed natural gamma-background of the area.

At distance of 20 m and more, maximum average EDR will not exceed 0.144 μSv/h, which is within fluctuations of the natural gamma-background appropriate for the area.

2. Flow rate of beta-radiation at the site varies from 0.5 particles/(cm^2*min) at distance of 20 m and more from the river and to 2.2 particles/(cm^2*min) at shore of the river.

Average values of beta-particle flux density at shore maximum average power will not exceed 1.82 particles/(cm^2*min).

3. Technogenic radionuclides Cs-137 and Co-60 are found in sample of silt.

In samples of silt, Cs-137 has the highest activity, specific activity of which is 17.6 Bq/kg. Maximum specific activity of Cs-137 at the site, within confidence interval 0.95, will not exceed 21.6 Bq/kg. Maximum specific activity of Cs-137 is lower than the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

The specific activity of natural radionuclides in sample of silt does not exceed the level, which is characteristic for the Chelyabinsk region.
4. Technogenic radionuclides (Sr-90 and H-3) are found in water samples from the Zyuzelka river.
Specific activity of H-3 (240 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).
Specific activity of Sr-90 in sample (1,0 Bq/l); maximum average specific activity of Sr-90, taking into account the uncertainty interval of measurement ($A + \Delta_{0.95}$), within a confidence interval of 0.95, is not higher than 1.24 Bq/l, which does not exceed IL_{Sr-90} = 4.9 Бк/л (NRB-99/2009, Appendix 2a).
Appendix 11:
1. Average values of EDR at the site of the Zyuzelka river, near road bridge, at 0.1 m above soil surface.
2. Average values of beta-particle flux density at the site of the Zyuzelka river, near road bridge, close to soil surface.
3. Points of sampling and measurements of EDR at the site of the Zyuzelka river, near road bridge, at 0.1 m above soil surface.
4. Points of measurements of beta-particle flux density at the site of the Zyuzelka river, near road bridge, close to soil surface.

XII. Argayash lake, near settlement Argayash

Characterization and area of the site: land of urban settlement, site on shore of Argayash lake, flat, without woody vegetation and bushes, area of the site is 2 hectares.
The background gamma-radiation: average EDR of background external gamma-radiation at the site with a confidence level of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation in the open area at 0.1 m above soil at characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	10	0.13	0.11
2	40	0.12	0.1

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β), (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	10	2.2	1.71
2	20	1.1	0.93

Results of measurements of specific activity of natural and technogenic radionuclides in samples of silt and soil:

No. of sample	Type of soil	Sampling depth (m)	Nuclide	Specific activity of nuclide ± uncertainty interval of measurement $A_i \pm \Delta_{0.95}$ Bq/kg		
1	2	3	4	5		
			Ra-226	29.8	±	2.78
13	Silt deposit	0.1 – 0.2	Th-232	28.4	±	3.8
			K-40	162	±	160
			Cs-137	45	±	10.7
			Co-60	6.3	±	6.0
			Sr-90	b.d.l.		

Specific activity of radionuclides in water samples of Argayash lake:

No. of sample	$A_{spec.} \pm \Delta_{0.95}$ (Bq/l)		
	Sr-90	Cs-137	H-3
12в	1.0 ± 23.8%	b.d.l.	100 ± 80%

Conclusion:

1. EDR of external gamma-radiation at the site varies from 0.08 to 0.22 μSv/h.

At the shore of the lake average maximum EDR is not higher than 0.12 μSv/h, which does not exceed the natural gamma-background of the area.

At distance of 20 m and more, maximum average EDR does not exceed 0.093 μSv/h, which is within fluctuations of natural gamma-background appropriate for that area.

2. The beta-particle flux density at the site varies from 0.5 particles/(cm^2*min) at a distance of 20 m and more from the lake and to 2.2 particles/(cm^2*min) at the shore of the lake.

Average beta-particle flux density at the shore maximum average power will not exceed 1.3 particles/(cm^2*min).

3. Technogenic radionuclides Cs-137 and Co-60 are found in sample of silt. Cs-137 has maximal activity in the sample, specific activity of which is 45 Bq/kg, within confidence interval 0.95 maximum average activity of Cs-137 will not exceed 55.7 Bq/kg, which is lower than the level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (OSPORB 99/2010, Appendix 3).

The specific activity of natural radionuclides in sample of silt does not exceed the level, which is characteristic for the Chelyabinsk region.

4. Technogenic radionuclides (Sr-90 and H-3) are found in water sample from the Argayash lake.

Specific activity of H-3 (100 Bq/l) is less than the IL for adult population in drinking water (IL_{H-3} = 7600 Bq/l, NRB-99/2009, Appendix 2a).

Specific activity of Sr-90 in sample is 1.0 Bq/l. Average maximum specific activity of Sr-90, taking into account the uncertainty interval of measurement ($A + \Delta_{0.95}$), within a confidence interval of 0.95, is not higher than 1.24 Bq/l, which does not exceed IL_{Sr-90} = 4.9 Бк/л (NRB-99/2009, Appendix 2a).

Appendix 12:

1. Average values of EDR at Argayash lake, near settlement Argayash, at 0.1 m above soil surface.

2. Average values of beta-particle flux density at Argayash lake, near settlement Argayash, close to soil surface.

3. Points of sampling and measurements of EDR at the at Argayash lake, near settlement Argayash, at 0.1 m above soil surface.
4. Points of measurements of beta-particle flux density at Argayash lake, near settlement Argayash, close to soil surface.

XIII. Iset – Tobol – Irtysh – Ob river system

Radioactive wastes of PA "Mayak" are carried out along the Iset – Tobol – Irtysh – Ob river system. Lack of rational methods of handling with large amounts of radioactive wastes, formed in the initial period of activities of the enterprise, led to input of radionuclides into the environment.

To date, studies on effects of radioactive wastes of PA "Mayak" on water pollution have been done. However, most of these studies are conducted in relatively close proximity to the source – on rivers Techa and Karabolka, and there are practically no such data on Iset-Tobol-Irtysh-Ob part of system.

Analysis of available data from two previous expeditions in 2012 on monitoring radioactive contamination of rivers Techa and Iset has led to conclusion that the main tracer of distribution of radioactive wastes of PA "Mayak" in waters of rivers Tobol and Irtysh is 90Sr.

The best option for field research was to study the river system Iset – Tobol – Irtysh – Ob on the boat, with sampling and measuring content of 137Cs, 90Sr, H-3 and sum of plutonium isotopes in them (see Fig.4).

There is an excess of background level of 90Sr in river water over vast area of river system with length of more than 1000 km, down to the confluence of Irtysh with Ob river. The reason for the formation of this "strontium" trace is the work of PA "Mayak", especially radioactive discharges into the Techa river in early period of its activity. Throughout all "strontium" trace, with the exception of the Techa river (for which restrictions on water use are introduced), the specific activity of 90Sr is less than the intervention level by NRB-99/2009.

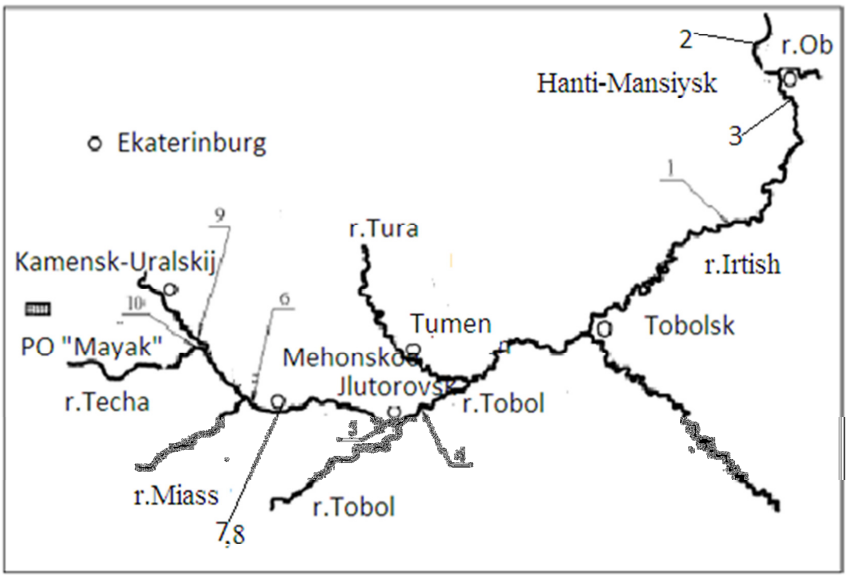


Fig. 4. Points of sampling on hydrographic Techa-Iset-Tobol-Irtysh-Ob river system

Table

Specific activity of radionuclides in water of Techa-Iset-Tobol-Irtysh-Ob river system (Bq/l)

Points[2] of sampling	River	^{3}H	^{90}Sr	^{137}Cs	$^{239,240}Pu$
p.9	Iset river, below Kamensk-Uralskiy	75	0.4	0.03	$2.1*10^{-6}$
p.10	Techa river (mouth)	200	7.0	0.26	$4.3*10^{-5}$
p.7, 8	Iset river, village Mehonskoe	150	6.5	0.022	$4.25*10^{-6}$
p.6	Iset river after confluence of Miass river	170	4.5	0.0007	$4.2*10^{-6}$
p.5	Iset river (10 km upstream of confluence into Tobol), in the vicinity of Yalutorovsk	130	2.0	0.0004	$4.1*´10^{-6}$
p.4	Tobol river (before confluence into Irtysh)	60	0.072	0.0003	$7.5*10^{-6}$
p.1	Irtysh river (below of Tobolsk town 260 km)	4.4	0.026	0.0004	$6.6*10^{-6}$
p.3	Ob river (below the confluence of Irtysh)	3.5	0.015	0.0006	$6.3*10^{-6}$
p.2	Ob river (above the confluence of Irtysh)	2.6	0.006	0.0003	$6.1*10^{-6}$
	Regional background	5	0.005	0.0005	10^{-5}
	Other rivers of Russia (average)	2-8	0.005-0.006	0.001-0.003	10^{-5}
	IL	7700	5	11	0.56

[2]At each point of sampling, 5 samples were taken, a total of 40 samples. Averaged data on activity of sample are given in the table.

Iset river, below Kamensk-Uralskiy (point 9)
Information is presented in the section XIII.
Techa river (mouth) (point 10)
Information is presented in the section IX.
Iset river after confluence of Miass river (point 6)
Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 4 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.07 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.16	0.14
2	45	0.15	0.12

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	1.8	1.64
2	45	1.1	0.8

Iset river, village Mehonskoe (points 7, 8)
Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 5 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.09 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1 (point 7)	9	0.17	0.15
2 (point 8)	45	0.13	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1 (point 7)	9	2.2	1.64
2 (point 8)	45	1.1	0.8

Iset river (10 km upstream of confluence into Tobol), in the vicinity of Yalutorovsk (point 5)

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 8 hectares.

Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.08 ± 0.01 01 μSv/h.

Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.16	0.15
2	45	0.14	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β), (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.3	1.76
2	45	1.3	0.9

Tobol river (before confluence into Irtysh) (point 4)

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 2 hectares.

Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.09 ± 0.01 μSv/h.

Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.18	0.15
2	45	0.14	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.5	1.7
2	45	2.2	0.9

Irtysh river (below of Tobolsk town 260 km (point 1)

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 8 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.09 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.18	0.14
2	45	0.16	0.12

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.2	1.6
2	45	1.4	0.8

Ob river (below the confluence of Irtysh) (point 3)

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 4 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.08 ± 0.01 01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.17	0.14
2	45	0.13	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β), (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.7	1.8
2	45	2.4	1.9

Ob river (above the confluence of Irtysh) (point 2)

Characterization and area of the site: agricultural land, partly overgrown by bushes and trees, area of the site is 5 hectares.
Background gamma-radiation: average EDR of background external gamma-radiation at the site within a confidence interval of 0.95 is 0.09 ± 0.01 μSv/h.
Results of measurements of EDR of external gamma-radiation at the open area at 0.1 m above soil surface in characteristic points.

No.	Number of measurement points	Maximum EDR (N) (μSv/h)	Average EDR (A) (μSv/h)
1	9	0.18	0.14
2	45	0.14	0.11

Results of measurements of beta-particle flux density in the open area close to soil surface at characteristic points.

No.	Number of measurement points	Maximum value of beta-radiation intensity (H_β) (particles/(cm^2*min)	Average value of beta-radiation intensity (A_β) (particles/(cm^2*min)
1	9	2.1	1.8
2	45	1.8	1.6

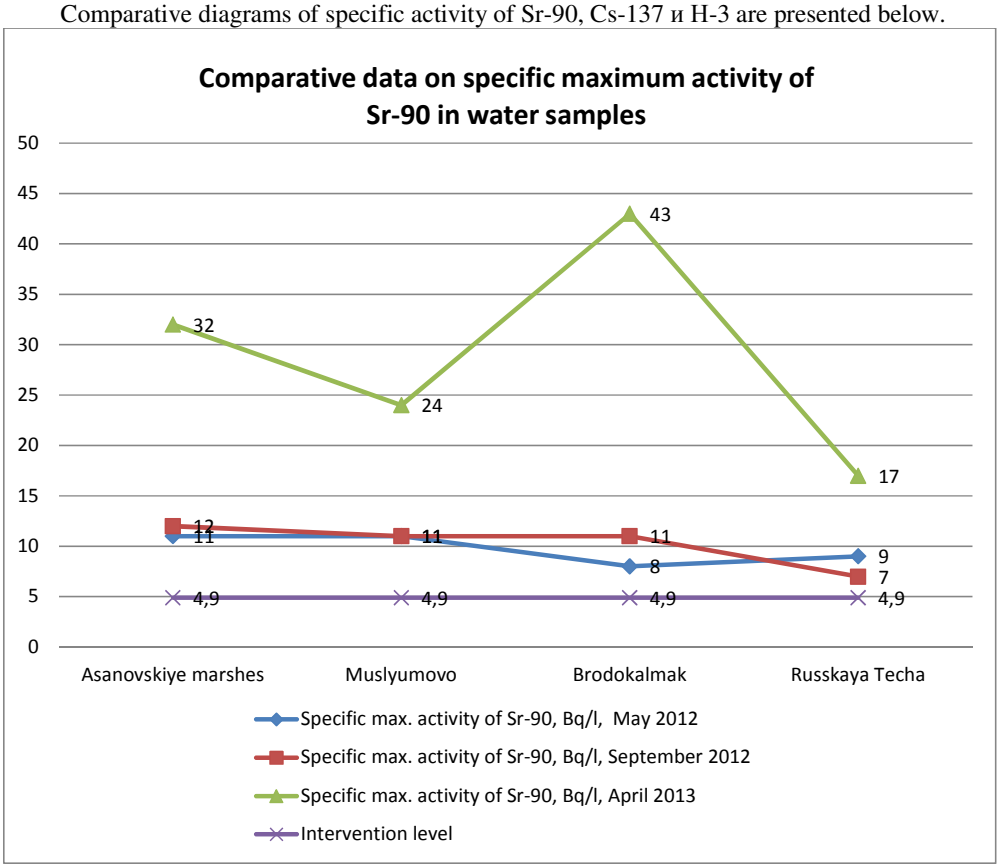
Analyzing results of maximum and average values of EDR, as well as maximum and average values of beta-radiation in considered above points of sampling, results of measurements are within fluctuations of the natural background.
Throughout Iset – Tobol – Irtysh – Ob river system, in places of sampling, exceeding the level of intervention on Sr-90 was fixed in points 7 and 8 (village Mehonskoe) – 6.5 Bq/l, that exceeds $IL_{Sr\text{-}90}$ = 4.9 Bq/l (NRB-99/2009, Appendix 2a) by 1.33 times.

Conclusions and recommendations

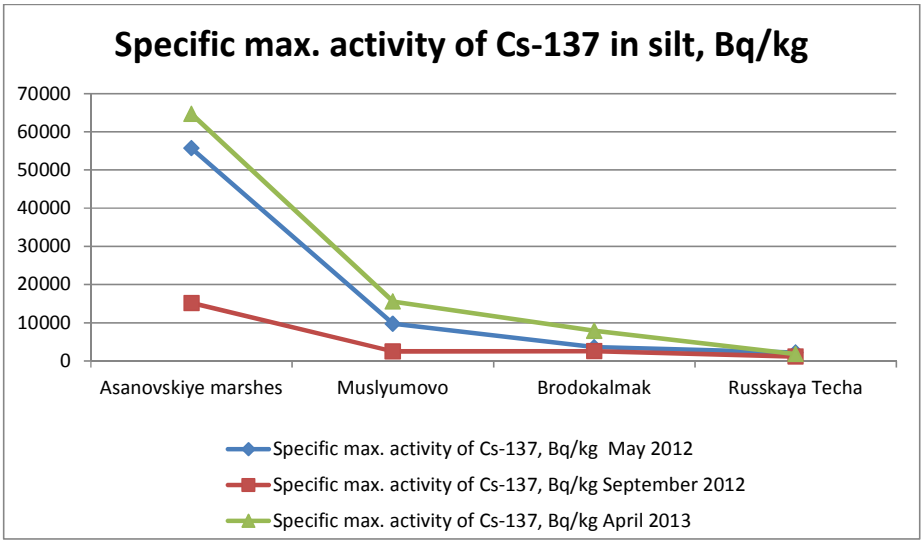
1. Third expedition was in scheduled period and consisted of two stages. First stage:
   18 – 28 April 2013 (settlements Novogorny, Old and New Muslyumovo, Krasnoisetskoe, Tatarskaya Karabolka, Ust-Karabolka and others), lands of the State Forest Fund, areas closed for access due to radiation levels; rivers: Techa, Zyuzelka, Sinara, Iset, Karabolka), and also Lake Argayash.
   Second stage:
   20-27 May 2013 (rivers Iset, Tobol, Irtysh, Ob and their floodplains.

2. During studies 1089 (in budget - 700) measurements of Exposed Dose Rate (EDR) of external gamma-radiation, 815 (in budget - 700) measurements of beta-particle flux density have been done. 122 (in budget – 115) water samples, as well as samples of marsh, river and lake silt have been taken and analyzed.

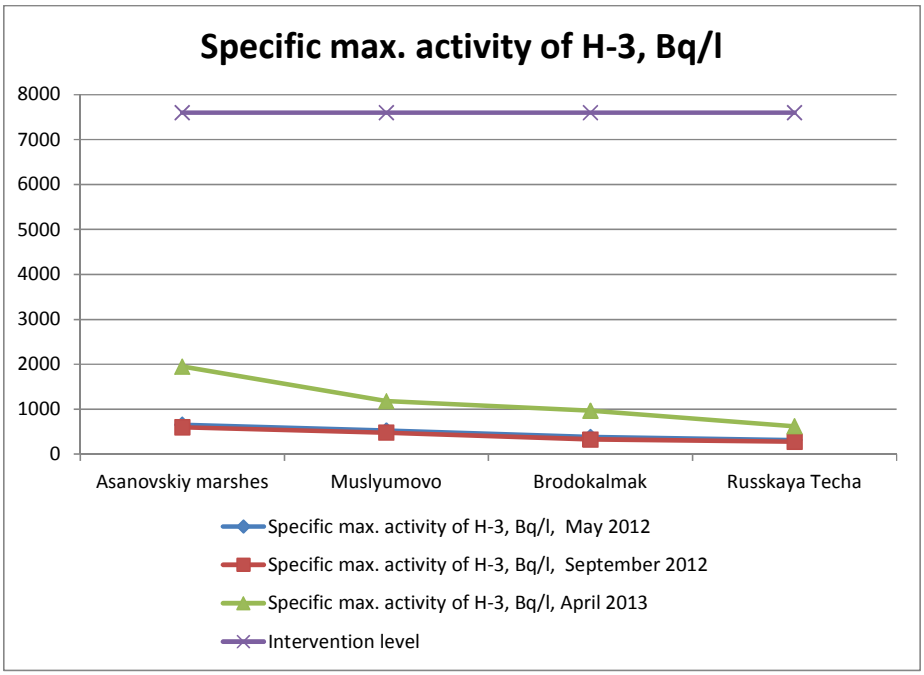
3. Based on practice of expedition during 2012-2013, it should be concluded that data of samples on activity of water, silt and soil have significant differences. During expedition (18 – 28 April 2013), data on activity of samples of water and silt are significantly higher than that of samples of previous expeditions.
   Comparative diagrams of specific activity of Sr-90, Cs-137 и H-3 are presented below.



Specific maximum activity of Sr-90 in water samples during expedition period, April 2013, in Asanovskiye marshes, Muslyumovo, Brodokalmak, and Russkaya Techa exceeds the level of intervention level (4.9 Bq/l) by 7, 5, 9 и 3.5 times, respectively.

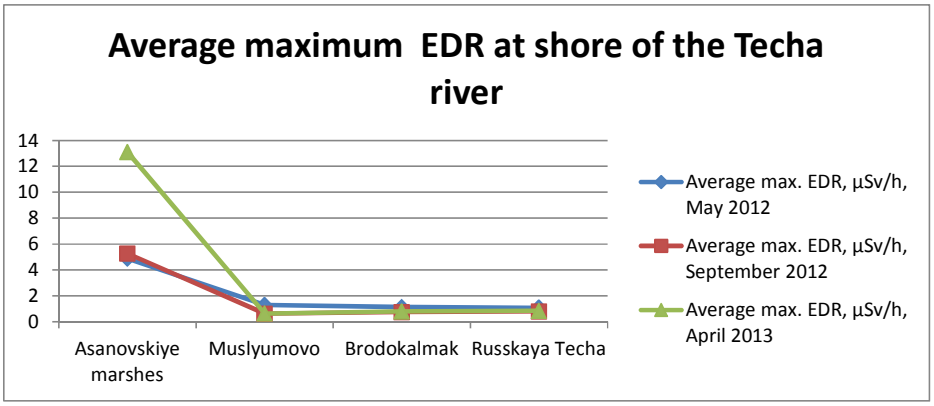


Maximum specific activity of Cs-137 in all samples is higher than level of specific activity allowed for unrestricted use of materials – 0.1 Bq/g (100 Bq/kg) (OSPORB 99/2010, Appendix 3). Exceeding maximum specific activity of Cs-137 in water samples, in April 2013, in Asanovskiye marshes, Muslyumovo, Brodokalmak and Russkaya Techa is by 646, 157, 79 and 18 times, respectively.



Specific maximum activity of H-3 in water samples of all three expeditions is significantly below the intervention level for H-3 (7,600 Bq/l).

This is largely due to the amount of precipitation (snow, rain water) in autumn-winter 2012-2013, when there was accumulation of water in TCWR, which leads to increase of level in TCWR, as a consequence to increase of filtration of water through dams into LBC and RBC bypass channels. Main external factors that determine the specific activity of water and radioactive sewage off the Techa river (in liquid and solid forms) are regime of aqueous runoff and power of source of transfer of activity with water through hydrotechnical constructions. Breakaway releases of radioactivity with melt water lead to sedimentation of radioactive substances in marshes, further swamping new territories, as well as leaching of previously accumulated radioactive substances from marshes with new melt water. In this case, snowy winter in the period of 2012-2013 is indicative.



In this regard, it is necessary to continue research in summer and autumn of 2013, as data in September 2012 on the Techa-Iset river system may be not indicative. In addition, it is necessary to continue the radiation monitoring of Iset-Tobol-Irtysh-Ob river system, as the data on obtained statistics are not sufficient and could not be typical, especially after the winter of 2012-2013, taking into account the length of Iset-Irtysh-Ob river system and possibility of increasing specific activity of samples.

Analyzing results of maximum and averages values of EDR, as well as maximum and average values of beta-radiation in considered above points of sampling, results of measurement are within fluctuations of the natural background.

Throughout Iset – Tobol – Irtysh – Ob river system, in places of sampling, exceeding the level of intervention on Sr-90 was fixed in points 7 and 8 (village Mehonskoe) – 6.5 Bq/l, that exceeds $IL_{Sr\text{-}90}$ = 4.9 Bq/l (NRB-99/2009, Appendix 2a) by 1.33 times. Taking into account obtained data, it is hard to escape a conclusion that Russian sanitary and epidemiological services should conduct constant monitoring on this site of the Iset river in order to exclude or confirm the need for measures to limit water use.

Thus, throughout all length of “strontium” trace, with the exception of the Techa river (for which restrictions on water use have been introduced) and place of sampling in village Mehonskoe, specific activity of 90Sr is below the intervention level by NRB -99/2009.

Significantly reduce transfer of 90Sr into open hydrographic system of the Techa river, if reduce the amount of filtration losses from TCWR into LBC and RBC. This can be achieved by creating impermeable membranes in bodies of by-pass dams or by constructing special retaining structures (thresholds-regulators), equalizing water levels in channels and in water reservoirs.

It should be kept in mind, that implementation of these measures will inevitably lead to a further increase of water level in water reservoirs of TCWR.

4. In waters of Karabolkd-Sinara river system, content of tritium has increased for more than tenfold. Content of 90Sr and 137Cs in the Sinara river has increased, compared to 2012, by 1.2 and 3.7 times, respectively. Content of 90Sr in the Karabolka river has increased by 1.3 times, and content of 137Cs has decreased by 1.1 times, compared to 2012. It should be noted that volumetric activity of radionuclides in water of Karabolka and Sinara rivers in 2013 does not exceed IL by NRB-99/2009: volumetric activity of 90Sr was lower IL by 2 times.

5. Study of lakes, located in the zone of influence of PA "Mayak" (April 2013) showed insignificant deviations from results, obtained in September 2012. All specific activities of samples are within requirements of regulatory documents.

7. On circumstances where there is no possibility to stop use of water reservoirs of LRWs simultaneously and eliminate them, it should be found solutions, directed on implementation of the following main tasks, namely:

- prevention of accidents and protection of workers (personnel), population and environment from consequences of potential accidents. Ongoing activities should be based on analysis of hazards (risks) due to water reservoirs-storages of LRWs and optimization studies (assessing an impact of alternative options on safety and an environment), directed on reducing risk.
- elimination of discharges into water reservoirs-storages of LRWs. Thorough analysis of sources of forming discharges should be conducted, detailed programs to reduce amount of discharges, up to their elimination, should be developed.

8. Rehabilitation of territories, occupied by water reservoirs-storages of LRWs, and which are subject to their impact, involves the solution of two interrelated problems:

– taking short-term and long-term measures to restore an environment, directed to reduce or, if possible, elimination of the most significant hazards (risks), such as those related to wind drift and migration of radionuclides in soil and ground water;
– taking long-term measures to address the management of accumulated LRWs and also LRWs, formed during rehabilitation of areas.

Work on management of LRWs and rehabilitation of territories should be planned in such a way as to combine a reduction of short-term risks while minimizing long-term risks.

Problems of maintenance of current level of safety and long-term safety of water reservoirs-storages of LRWs are science-based problems. There are a number of unresolved issues related to safety of water reservoirs-storages of LRWs.

Below, only some of them are given as an example:

- study of behavior of radionuclides in water reservoirs-storages of LRWs, including study of mechanism of radiation chemical reactions of macrocomponents of LRWs in liquid phase and bottom deposits.
- study of migration routes of radionuclides from water reservoirs-storages of LRWs into the environment.
- study of process of carryover of radioactive aerosols, formed over water mirror of water reservoir-storages of LRWs, into the surface layer of the atmosphere and wind drift of radionuclides from foreshore of water reservoirs-storages of LRWs.

- forecast of long-term behavior of artificial and natural barriers, as well as possible radiation effects in normal evolution of closed water reservoir-storage of LRWs and in case of adverse scenarios.

The following necessary work should be included to scientific and technical issues:

– development of methods and systems for processing and conditioning LRWs, accumulated in water reservoirs-storages;

– development of methods of processing bottom deposits and aqueous phase;

– development of methods and technologies for decommissioning water reservoirs-storages of LRWs;

– identification of methods and amount of radiation control at all stages of decommissioning of water-reservoirs-storages of LRWs and after their decommissioning.

Proposals

1. It is necessary to conduct detailed studies of qualitative and quantitative radionuclide composition of LRWs in water reservoirs-storages, as well as morphological, hydrological and biological characteristics of water reservoirs-storages of LRWs. As the work with archives shows, PA "Mayak" does not have required full information on water reservoirs-storages of LRWs. Even data on total activity, accumulated in water reservoirs-storages of LRWs, specific activities of certain radionuclides, radionuclide composition of aqueous phase and sediments have not been adequately studied, as far as there is conflicting information in different sources of information.

2. For complete understanding of situation of radioactive contamination of the Techa river, it is necessary to have data on stocks of certain technogenic radionuclides in floodplain of the river and in sediments, as well as on their three-dimensional distribution (depth, width, length) in floodplain soil.

3. The practice of engaging independent organizations and experts from public organizations to studies fully justified itself. It promotes formation of open minded dealings to radioecological problems of Ural region, independent evaluation of our results, as well as raising professional level of independent non-governmental organizations on radiation safety assurance.

This practice should be repeated in case of expedition in summer-autumn period of 2013.

4. For promoting results of studies it is necessary broader to use mass media, tools of scientific conferences, and also to consider the possibility of organizing parliamentary hearings with active involvement of deputies of "green" trend.

Appendices 1-13

Appendix 1

Average values of EDR at the site of the Techa river near Asanovskiye marshes at 0.1 m above soil surface, (μSv/h)

	A	B	C	D	E	F	G	H	I
1	0.09	0,09						0.32	0.09
2	0.1	0.09	0.41					0.44	0.11
3	0.11	0.08	0.51					0.36	0.08
4	0.12	0.1	0.39					0.45	0.09
5	0.09	0.11	0.42					0.67	0.11
6	0.09	0.12	0.39					0.62	0.11
7	0.1	0.08	0.29					0.51	0.12
8	0.11	0.11	0.23				0.55	0.3	0.09
9	0.11	0.11	0.33				0.72	0.22	0.08
10	0.12	0.11	0.22					0.44	0.12
11	0.11	0.13	0.18	0.63					0.38
12	0.1	0.1	0.12	0.22	8.5	5.5	6.1	20	0.74
13	0.09	0.12	0.11	0.11	5.5	2.8	0.29	0.21	0.23
14	0.09	0.11	0.08	0.12			0.16	0.25	0.18
15	0.08	0.12	0.13	0.19			0.49	0.29	0.15
16	0.1	0.13	0.13	0.38				0.45	0.15
17	0.11	0.1	0.21					0.52	0.19
18	0.1	0.11	0.23					0.55	0.13
19	0.12	0.14	0.19					0.6	0.13
20	0.13	0.11	0.2					0.71	0.18
21	0.1	0.15	0.22						0.17
22	0.13	0.13	0.19						0.21
23	0.1	0.1	0.14						0.15
24	0.1	0.11	0.13						0.17
25	0.09	0.1	0.11	0.4					0.18

Total number of control points: 135

The range of variation of EDR values in control points at 0.1 m above soil surface:

from 0.08 to 20 μSv/h.

Average EDR with a confidence level of 0.95 at 0.1 m above soil surface:

at the river shore (swamp land): 8.1 ± 4.90 μSv/h.

within floodplain of the river (swamp land): 0.4 ± 0.05 μSv/h.

outside of the river floodplain: 0.14 ± 0.012 μSv/h.

Average values of beta-particle flux density at the Techa river near the Asanovskiye marshes particles/(cm^2*min)

1

	A	B	C	D	E	F	G	H	I
1									
2	1.6	2.1	16.7					8.9	1.5
3									
4	1.1	1.1	7.4					15.2	1.1
5									
6	0.8	1	8.9					12.8	1.2
7									
8	1	1.2	9.3				6.6	8.2	2.5
9									
10	0.9	1	16.8					13.1	3.3
11									
12	1.1	1.5	1	2.1	360	265	155	362	29.3
13	1.1	1	1.1	1.9	390	129	3.8	1.9	2
14									
15	1.1	1.1	2.5	7.6			5.1	1.3	1
16									
17	1	1.3	2.6					4.2	2
18									
19	0.8	2.2	3.3					12.5	2.9
20									
21	0.9	1.8	3.9						1.8
22									
23	1.1	1.9	2.9						2.2
24									
25									

Total number of control points: 69

The range of variation of beta-particle flux density close to soil surface:

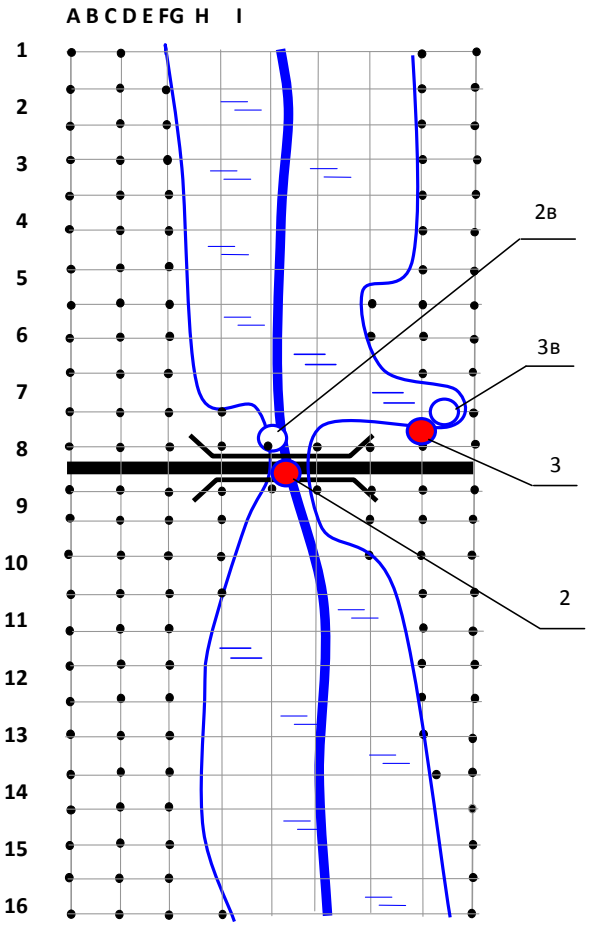
from 1 to 440 particles/(cm^2*min)

Average values of beta-particle flux density with a confidence level of 0.95:

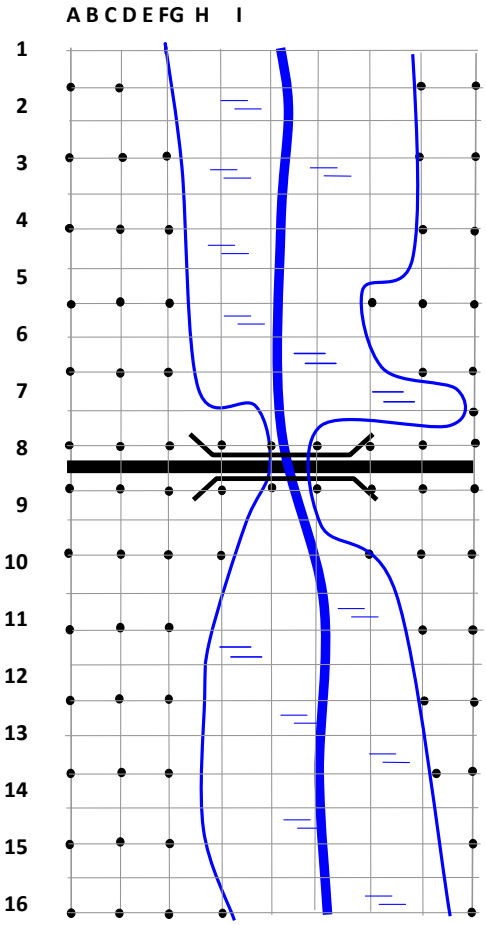
at the river shore: 290 ± 102.6 particles/(cm^2*min)

within floodplain of the river (swamp land): 11.0 ± 3.0 particles/(cm^2*min)

outside of the river floodplain: 1.6 ± 0.22 particles/(cm^2*min)



Points of measurements of EDR and sampling at the site of the Techa river near Asanovskiye marshes



Mesh size of measurement of
beta-particle flux density
50x50 м

Points of measurement of beta-particle flux density at the site of the Techa river near Asanovskiye marshes

Appendix 2

Measurements of values of EDR and values of beta-particle flux density were not carried out.

Appendix 3

Measurements of values of EDR and values of beta-particle flux density were not carried out.

Appendix 4

Average values of EDR at the site of the Techa river, in the area of road bridge, near village Muslyumovo, at 0.1 m m above soil surface
(μSv/h)

	A	B	C	D	E
1	0.55	0.13	0.11	0.15	0.09
2	0.56	0.14	0.12	0.11	0.12
3	0.63	0.12	0.13	0.13	0.11
4	0.58	0.16	0.1	0.11	0.11
5	0.55	0.14	0.08	0.12	0.13
6	0.49	0.18	0.13	0.1	0.11
7	0.56	0.13	0.13	0.1	0.11
8	0.64	0.15	0.11	0.09	0.1
9	0.63	0.16	0.11	0.13	0.1
10	0.73	0.14	0.12	0.1	0.09
11	0.61	0.12	0.11	0.1	0.09
12	0.57	0.18	0.11	0.09	0.1
13	0.55	0.23	0.1	0.12	0.1
14	0.58	0.19	0.15	0.12	0.12
15	0.56	0.19	0.09	0.1	0.12

Total number of control points: 75

The range of variation of EDR values in control points at 0.1 m above soil surface:
from 0.08 to 0.73 μSv/h.

Average EDR with a confidence level of 0.95 at 0.1 m above soil surface:

at the river shore: 0.6 ± 0.03 μSv/h.

within the bank: 0.2 ± 0.02 μSv/h.

behind the bank: 0.11 ± 0.005 μSv/h.

Average values of beta-particle flux density at the site of the Techa river, in the area of road bridge, near village Muslyumovo, close to soil surface (particles/(cm^2*min)

	A	B	C	D	E
1	75.2	2.6	2.3	3.3	1.1
2	63				
3	56.6	3.8	3.1	1.2	0.9
4	49.5				
5	63.3	4.6	3.3	0.9	1.1
6	59.7				
7	61	3.3	2.4	1.3	1.5
8	55.5				
9	58.1	5	1.9	0.9	0.9
10	43.9				
11	60.2	3.9	1.7	1.2	1
12	63.2				
13	58.2	4.2	1.2	0.9	0.9
14	47.9				
15	59.3	4.6	2.1	1.1	1.3

Total number of control points: 47

The range of variation of beta-particle flux density in control points close to soil surface:

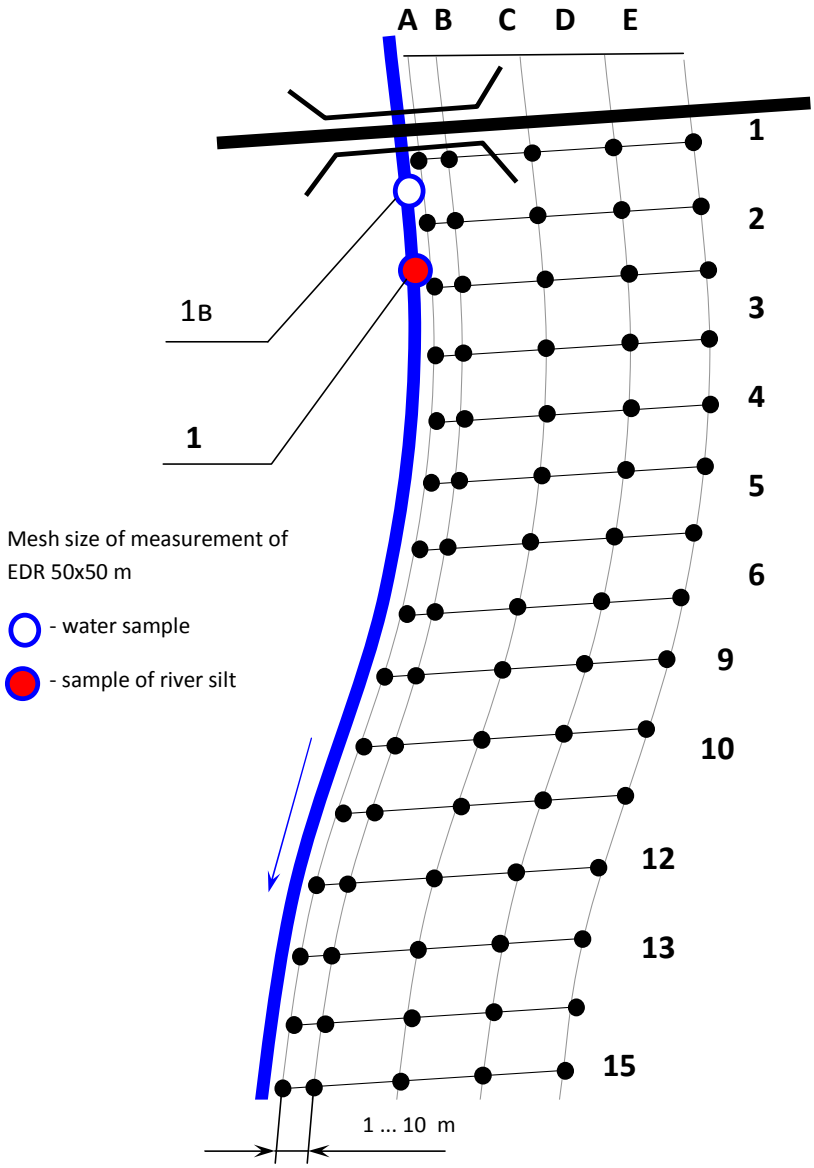
from 0.9 to 75.2

Average beta-particle flux density with a confidence level of 0.95 at 0.1 m above soil surface:

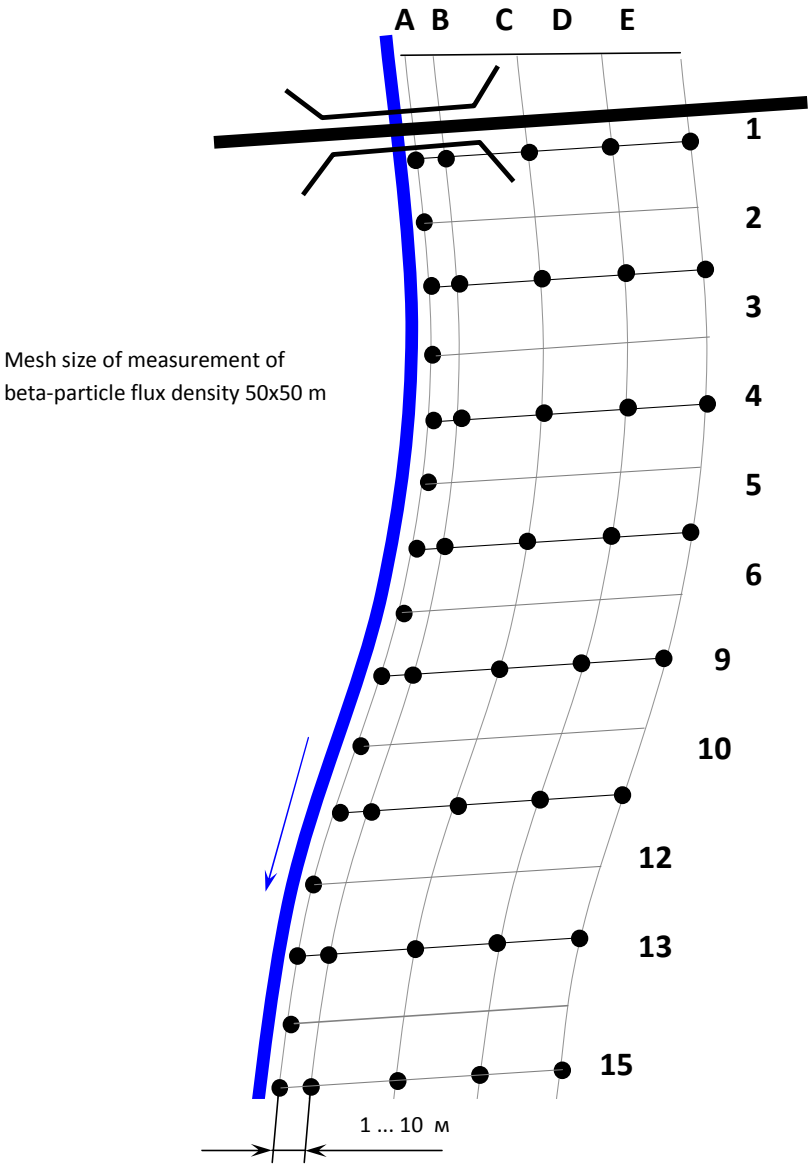
at the river shore: 54.7 ± 3.76

within the bank: 4.0 ± 0.54

behind the bank: 1.56 ± 0.314 .



Points of measurement of EDR and sampling at the site of the Techa river, in the area of road bridge, near village Muslyumovo



Points of measurement of beta-particle flux density at the site of the Techa river, in the area of road bridge, near village Muslyumovo

Appendix 5

Average values of EDR at the site of the Sinara river, in the area of road bridge, at 0.1 m above soil surface
(μSv/h)

	A	B	C	D	E	F
1	0.09	0.12	0.15	0.12	0.13	0.11
2	0.09	0.12	0.13	0.19	0.11	0.1
3	0.11	0.11	0.16	0.18	0.13	0.1
4	0.1	0.11	0.13	0.13	0.1	0.12
5	0.1	0.13	0.16	0.15	0.14	0.1
6	0.09	0.12	0.19	0.13	0.09	0.09
7	0.08	0.1	0.21	0.16	0.13	0.13
8	0.11	0.1	0.21	0.16	0.12	0.13
9	0.12	0.14	0.25	0.17	0.1	0.09
10	0.12	0.11	0.14	0.15	0.1	0.09
11	0.13	0.1	0.13	0.13	0.13	0.08
12	0.12	0.11	0.11	0.12	0.15	0.1
13	0.1	0.13	0.15	0.16	0.11	0.11

Total number of control points: 78

The range of variation of EDR values in control points at 0.1 m above soil surface

from 0.08 to 0.25 μSv/h.

Average EDR with a confidence level of 0.95 at 0.1 m above soil surface:

at the river shore: 0.16 ± 0.01 μSv/h.

on the banks of the river: 0.11 ± 0.004 μSv/h.

Average values of beta-particle flux density at the site of the Sinara river, in the area of road bridge, close to soil surface (particles/(cm^2*min)

	A	B	C	D	E	F
1	1.1	1.1	2.7	2.3	1.3	1
2						
3	1.3	1.2	2.2	2.6	1	0.9
4			1.9	3.2		
5	1.1	1.3	2	3.3	1.5	1.1
6			2.7	3.5		
7	1	1.1	2.2	2.9	1.2	1.2
8			2.7	2.8		
9	2.1	1.4	2.5	3	1.5	1.3
10			1.9	3.3		
11	1.2	1.6	2.1	3.5	1.6	1.3
12			4.5	2.9		
13	1.9	2.2	3.6	2	1.8	1.6

1

Total number of control points: 54

The range of variation of beta-particle flux density in control points close to soil surface:

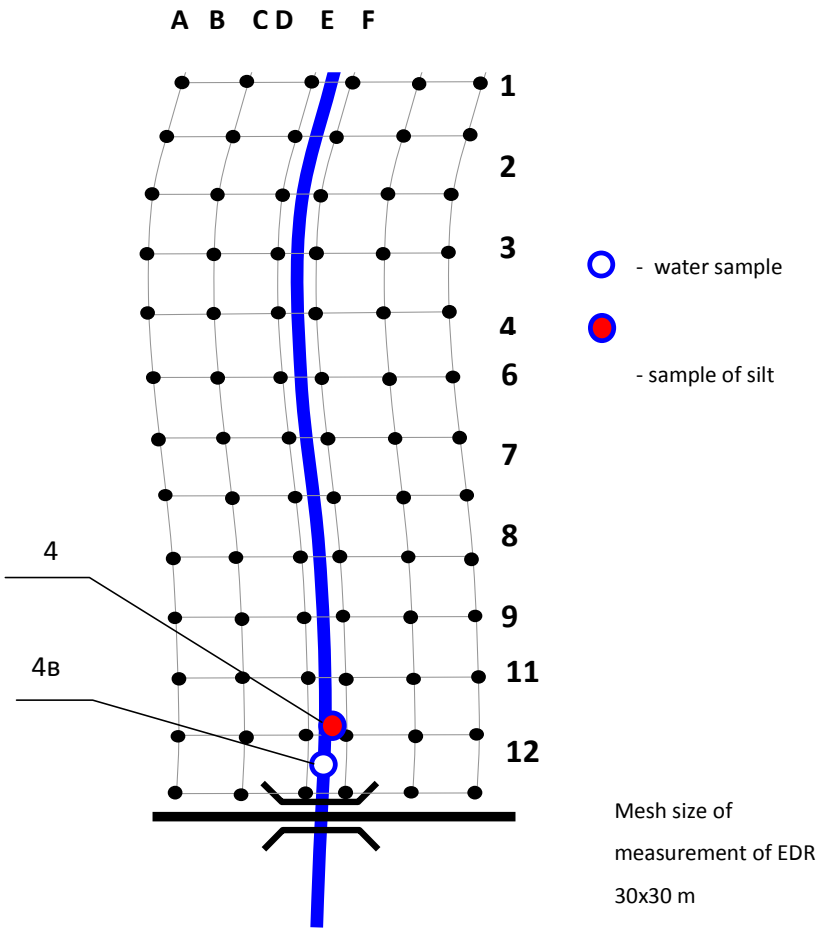
: from 0.9 to 4.5 particles/(cm^2*min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

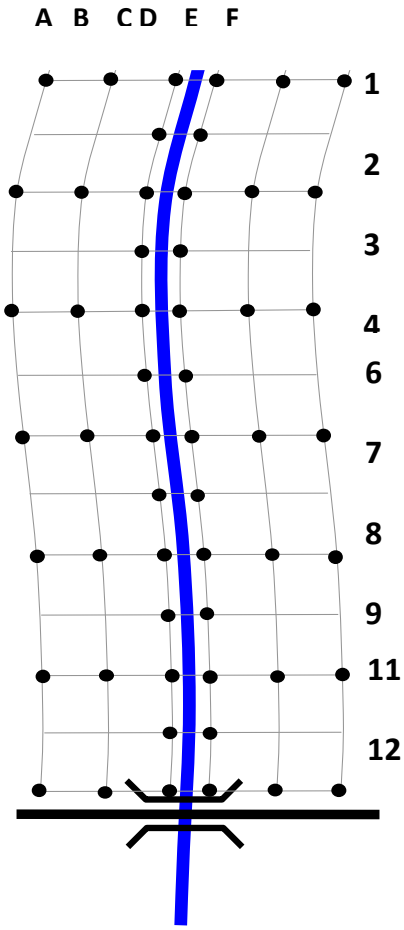
at the river shore: 2.6 ± 0.24 particles/(cm^2*min)

along banks of the river: 1.4 ± 0.12 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of the Sinara river
in the area of road bridge
at 0.1 m above soil surface



Points of measurement of beta-particle flux density at the site of the Sinara river, in the area of road bridge



Mesh size of measurement of beta-particle flux density 30x30 m

Appendix 6

Average values of EDR at the site of the Techa river
in the area of road bridge, near settlement Brodokalmak
at 0.1 m above soil surface
μSv/h

	A	B	C	D
1	0.73			0.11
2	0.7	0.29	0.1	0.12
3	0.76	0.27	0.1	0.1
4	0.79	0.2	0.13	0.12
5	0.72	0.22	0.13	0.12
6	0.73	0.29	0.09	0.1
7	0.83	0.34	0.11	0.1
8	0.85	0.3	0.1	0.09
9	0.77	0.29	0.12	0.11
10	0.82	0.27	0.13	0.12
11	0.69	0.24	0.13	0.1
12	0.78	0.22	0.09	0.1
13	0.72	0.22	0.12	0.09
14	0.89	0.3	0.11	0.1
15	0.87	0.34	0.1	0.11
16	0.72	0.29	0.3	0.13
17	0.73	0.28	0.12	0.11
18	0.74	0.27	0.13	0.12
19	0.74	0.26	0.11	0.1
20	0.75	0.26	0.1	0.1

Total number of control points: 78

The range of variation of beta-particle flux density in control points close to soil surface:

from 0.09 to 0.89 μSv/h

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

at the river shore: 0.77 ± 0.03 μSv/h

at a distance of 10 m from the river: 0.27 ± 0.02 μSv/h

along banks of the river: 0.11 ± 0.010 μSv/h

Average values of beta-particle flux density at the site of the Techa river
in the area of road bridge, near settlement Brodokalmak
close to soil surface
particles/(cm^2*min)

	A	B	C	D
1	18.2			0.8
2	19.2			
3	19	4.5	1.2	1
4	17.8			
5	22.5	3.2	1.3	1.1
6	24.5			
7	26.8	2.9	1.1	0.8
8	31			
9	29.5	3.6	1	1
10	28.8			
11	24.6	3.9	1.1	0.9
12	25.1			
13	22.9	3	1.2	0.8
14	28.8			
15	32.2	4.1	0.9	0.8
16	27			
17	25.5	3.9	1	1.1
18	24.8			
19	26.3	4.4	0.9	0.9
20	27.2			

Total number of control points: 48

The range of variation of beta-particle flux density in control points close to soil surface:

from 0.09 to 32.2 particles/(cm^2*min)

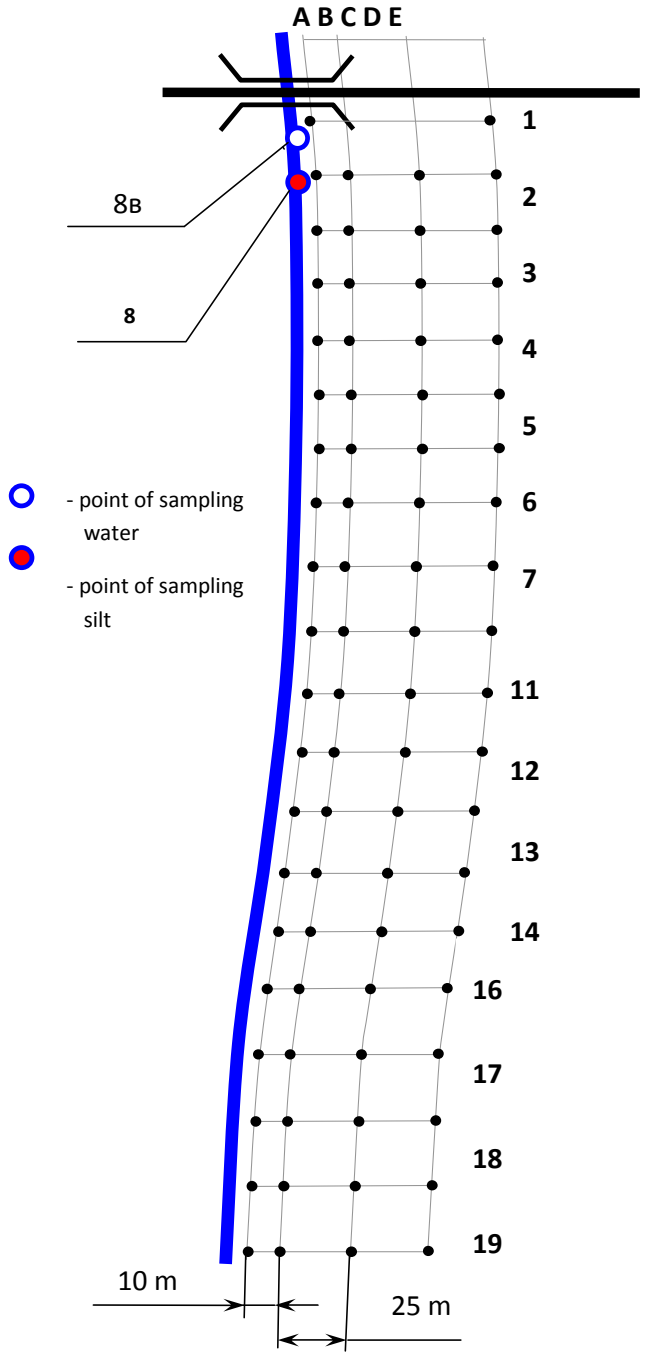
Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

at the river shore: 23.9 ± 1.83 particles/(cm^2*min)

at a distance of 10 m from the river: 3.7 ± 0.38 particles/(cm^2*min)

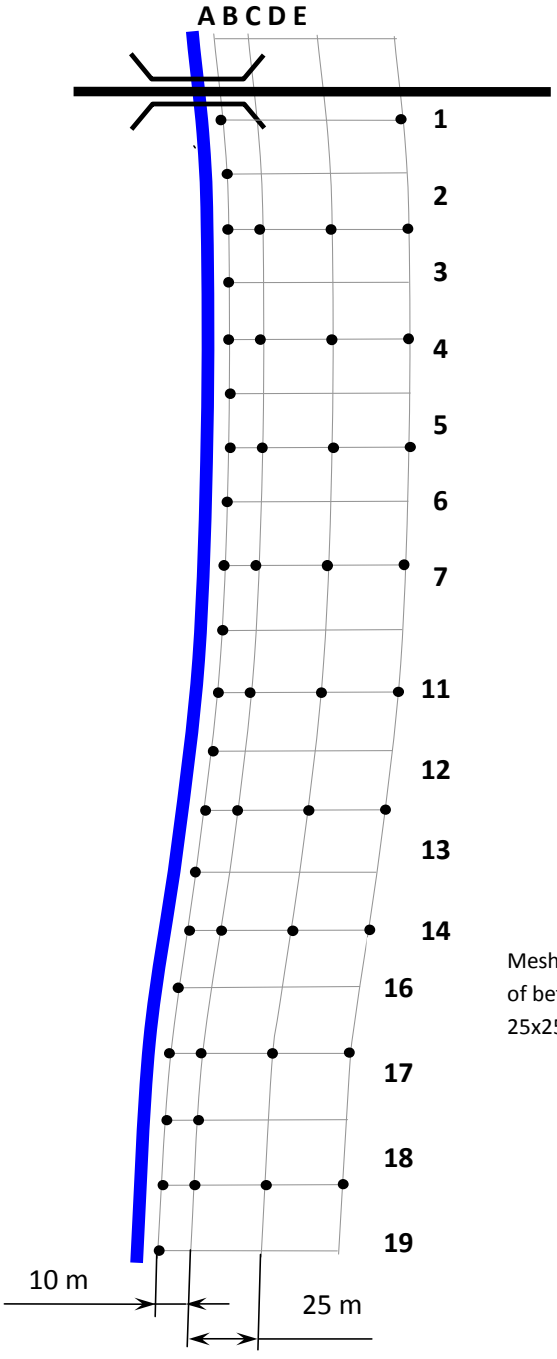
along bank of the river: 1.0 ± 0.12 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of the Techa river, in the area of road bridge, near settlement Brodokalmak, at 0.1m above soil surface



Mesh size of measurement of EDR 25x25 m

Points of measurements of beta-particle flux density at the site of the Techa river in the area of road bridge, near settlement Brodokalmak, close to soil surface



Mesh size of measurement of beta-particle flux density 25x25 m

Appendix 7

Average values of EDR at the site of the Techa river
in the area of road bridge, near settlement Russkaya Techa
at 0.1 m above soil surface
μSv/h

	A	B	C	D	E
1	0.77	0.16	0.11	0.1	
2	0.75	0.15	0.1	0.09	
3	0.8	0.19	0.1	0.11	
4	0.69	0.15	0.11	0.12	
5	0.76	0.15	0.1	0.13	
6	0.85	0.13	0.13	0.1	
7	0.92	0.15	0.1	0.1	
8	0.89	0.19	0.09	0.09	
9	0.66	0.17	0.1	0.08	
10	0.95				
11	0.88				
12	0.85	0.18	0.16	0.08	
13	0.8	0.19	0.11	0.09	
14	0.79	0.16	0.11	0.11	
15	0.74	0.14	0.1	0.12	
16	0.79	0.15	0.09	0.13	
17	0.88	0.22	0.08	0.1	
18	0.8	0.15	0.19	0.1	
19	0.79	0.2	0.1	0.09	
20	0.85	0.14	0.11	0.09	

Total number of control points: 74

The range of variation of beta-particle flux density in control points close to soil surface:

from 0.08 to 0.95 μSv/h

Average EDR with a confidence level of 0.95 close to soil surface:

at the river shore: 0.81 ± 0.03 μSv/h

at a distance of 10 m from the river: 0.17 ± 0.01 μSv/h

along banks of the river: 0.11 ± 0.005 μSv/h

Average values of beta-particle flux density at the site of the Techa river
in the area of road bridge, near settlement Russkaya Techa
close to soil surface
particles/(cm^2*min)

	A	B	C	D	E
1	12.2	3.1	1.1	1.2	0.9
2	10				
3	12.5	4.5	1	1	0.8
4	18.8				
5	16.5	3	0.9	1.1	1
6	15.3				
7	19.8	2.5	0.8	1.3	1
8	22.2				
9	20.5	2.6	0.8	0.9	1.1
10	16.8				
11	16.8				
12	17.8	1.3	0.9	1	0.9
13	26.2				
14	19	3.3	1.2	1	1.1
15	18.2				
16	16.2	3.8	1.3	0.9	1.1
17	17.5				
18	16.1	3.9	1.5	0.8	1
19	15.8				
20	18.3	4.1	1.3	0.9	0.6

Total number of control points: 60

Range of variation of beta-particle flux density in control points close to soil surface:

from 0.6 to 26.2 particles/(cm^2*min)

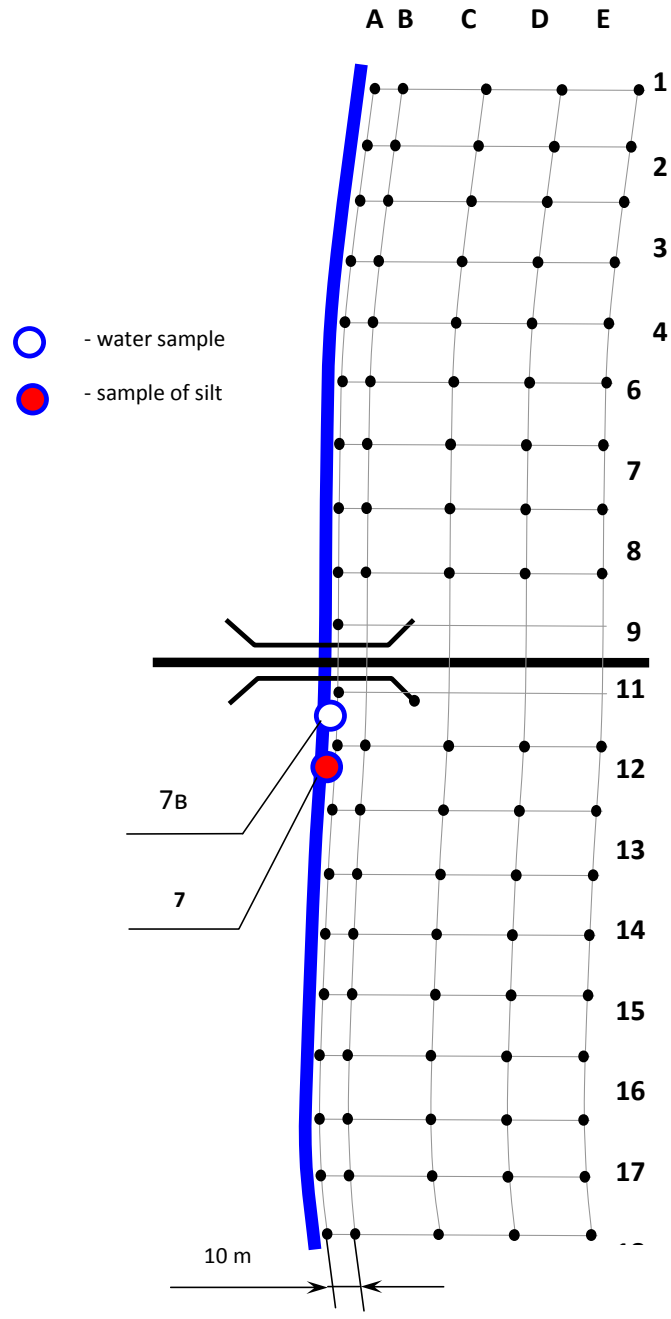
Average beta-particle flux with a confidence level of 0.95 close to soil surface:

at the river shore: 17.33 ± 1.56 particles/(cm^2*min)

at a distance of 10 m from the river: 3.21 ± 0.58 particles/(cm^2*min)

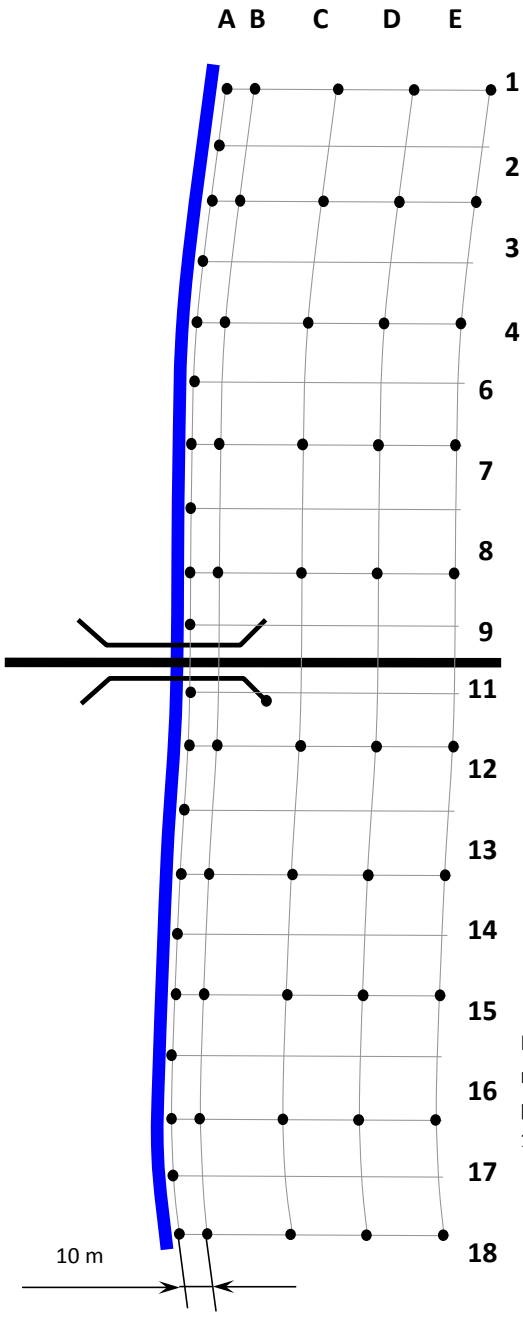
along banks of the river: 1.01 ± 0.068 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of the Techa river
in the area of road bridge, near settlement Russkaya Techa, at 0.1m above soil surface



Mesh size of measurement of EDR 25x25 m

Points of measurement of beta-particle flux power at the site of the Techa river, in the area of road bridge, near settlement Russkaya Techa



Mesh size of measurement of beta-particle flux density 25x25 m

Appendix 8

Average values of EDR at the site of the Iset river
in the area of road bridge
above the confluence of the Techa river, close to soil surface

μSv/h

	A	B	C	D
1	0.22	0.12	0.11	0.11
2	0.21	0.12	0.1	0.1
3	0.18	0.1	0.09	0.1
4	0.19	0.15	0.12	0.12
5	0.17	0.14	0.13	0.12
6	0.15	0.11	0.09	0.1
7	0.17	0.11	0.09	0.1
8	0.18	0.13	0.1	0.09
9	0.16	0.1	0.12	0.13
10	0.15	0.09	0.11	0.12
11	0.15	0.1	0.13	0.15
12	0.16	0.09	0.09	0.1
13	0.2	0.12	0.11	0.11
14	0.18	0.13	0.11	0.12
15	0.19	0.14		

Total number of control points: 58

The range of variation of beta-particle flux density in control points close to soil surface:

from 0.09 to 0.22

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

at the river shore: 0.17 ± 0.01

along bank of the river: 0.11 ± 0.005

Average values of beta-particle flux density at the site of the Iset river in the area of road bridge, above the confluence of the Techa river close to soil surface

particles/(cm^2*min)

	A	B	C	D
1	1.3	1.1	0.9	1.2
2	2.6			
3	1.4	0.9	0.9	1
4	1.5			
5	1.4	1	1.1	1.2
6	1.2			
7	1.5	0.9	0.8	1
8	1.1			
9	1.2	1	0.7	0.8
10	1			
11	0.9	1.3	1	1.1
12	1.3			
13	1.5	1	1.1	1.3
14	1.4			
15	1.3	0.6		

Total number of control points: 37

The range of variation of beta-particle flux density in control points close to soil surface

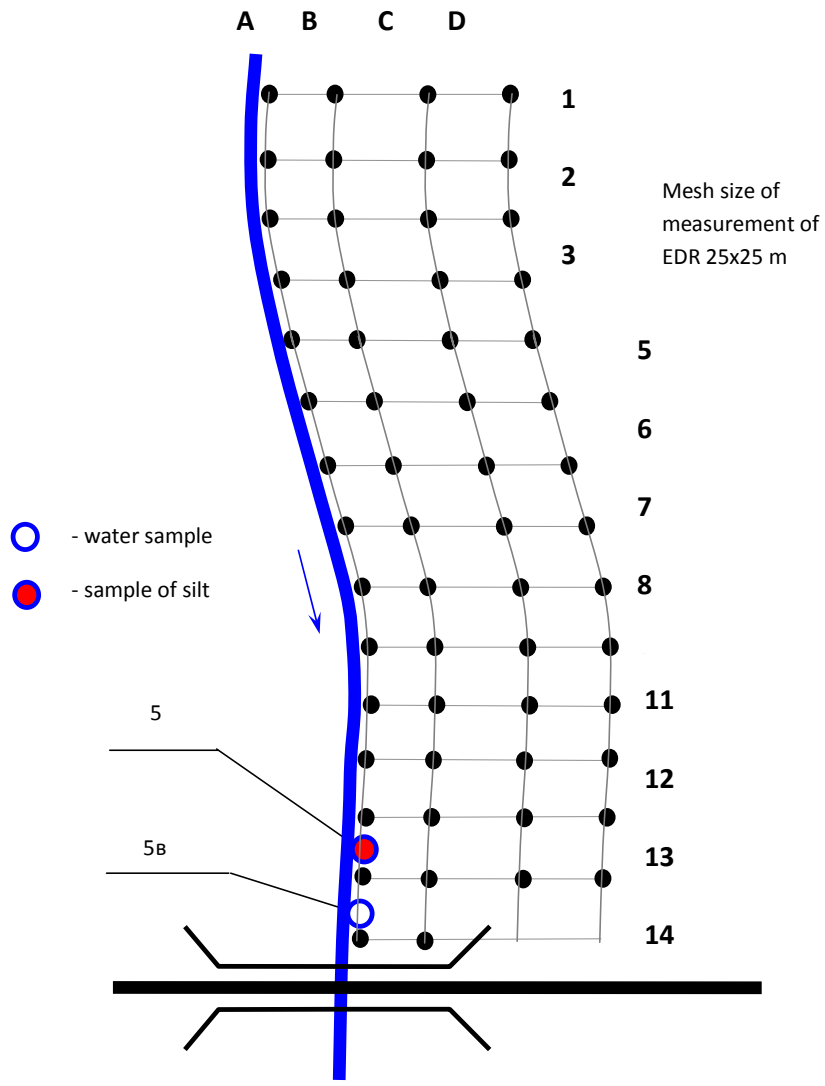
from 0.6 to 2.6 particles/(cm^2*min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

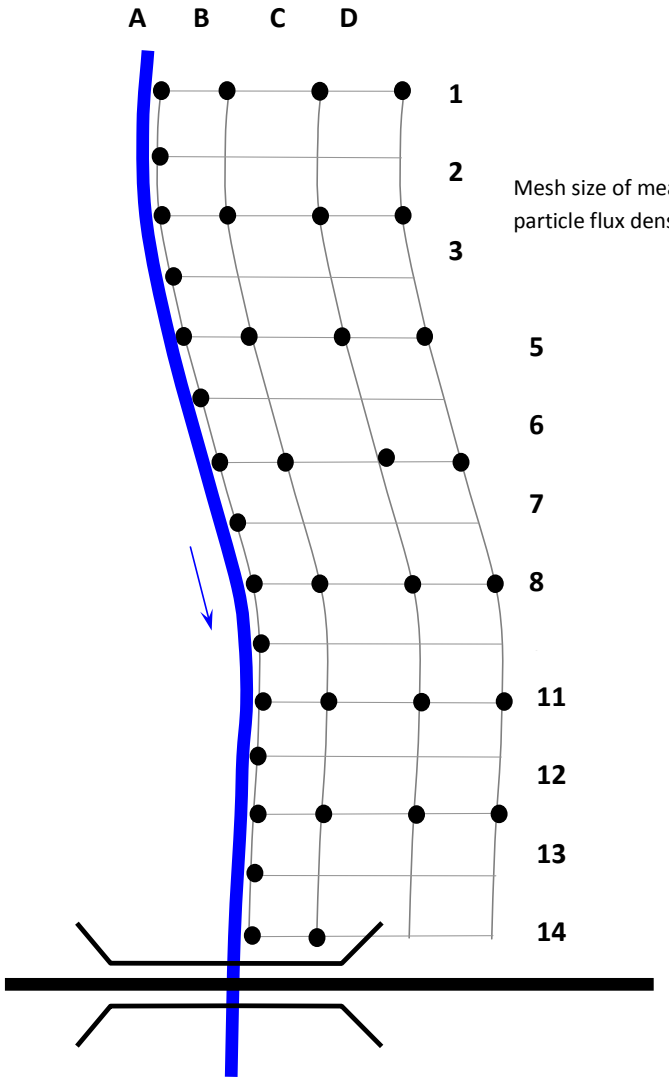
at the river shore: 1.29 ± 0.19 particles/(cm^2*min)

along banks of the river: 1.0 ± 0.07 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of the Iset river
in the area of road bridge above the confluence of the Techa river
at 0.1m above soil surface



Points of measurement of beta-particle flux power at the site of the Iset river in the area of road bridge, above the confluence of the Techa river close to soil surface



Mesh size of measurement of beta-particle flux density 25x25 m

Appendix 9

Average values of EDR at the site of the Iset river
in the area of settlement of Krasnoisetskoe
at 0.1 m above soil surface
μSv/h

	A	B	C	D
1	0.1	0.09	0.11	
2	0.11	0.12	0.13	0.17
3	0.09	0.12	0.12	0.16
4		0.13	0.13	0.18
5	0.11	0.11	0.13	0.17
6	0.13	0.09	0.14	0.16
7	0.12	0.13	0.11	0.19
8	0.11	0.14	0.12	0.18
9		0.12	0.13	0.17
10		0.13	0.11	0.21
11	0.11	0.09	0.13	0.19
12	0.09	0.11	0.11	0.16
13	0.11	0.14	0.11	
14	0.12	0.11	0.12	
15	0.11	0.12	0.11	0.15
16	0.13	0.12	0.12	0.14
17	0.11	0.13	0.11	0.15
18	0.12	0.1	0.1	0.17
19		0.11	0.13	0.15
20		0.09	0.1	0.14

Total number of control points: 72

The range of variation of EDR values in control points at 0.1 m above soil surface:
from 0.09 to 0.21 μSv/h..

Average EDR with a confidence level of 0.95 at 0.1 m above soil surface:

at the river shore: 0.17 ± 0.01 μSv/h..

on the banks of the river: 0.12 ± 0.012 μSv/h..

Average values of beta-particle flux density at the site of the Techa river in the area of settlement of Krasnoisetskoe close to soil surface, particles/(cm^2* min)

	A	B	C	D
1	0.9	0.8	1.3	
2				2.3
3		0.9	1.3	1.8
4				1.7
5	1	1.1	1.1	2.2
6				2.3
7	1	1.1	1.3	2.2
8				1.4
9		1.2	1	1.6
10		1.5	1.3	2.6
11	1	1.3	1	2.6
12	1.1	1.2	1	1.8
13				
14	0.9	0.7	1.2	
15				1.8
16	1.1	1.8	0.8	1.9
17				2
18	1.2	0.8	0.7	2
19				1.5
20		1.1	1	1.7

Total number of control points: **46**

The range of variation of beta-particle flux density in control points close to soil surface:

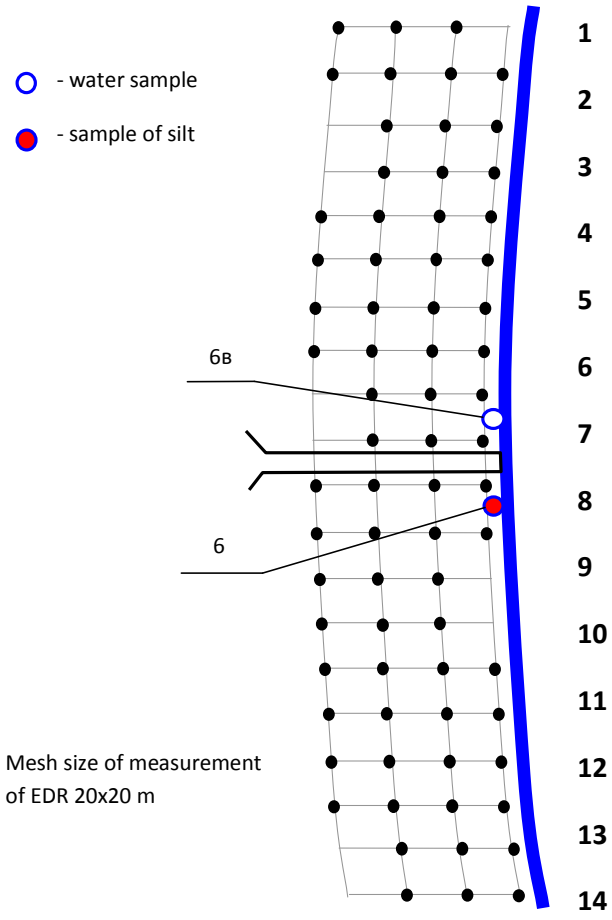
from 0.7 to 2.6 particles /(cm^2* min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

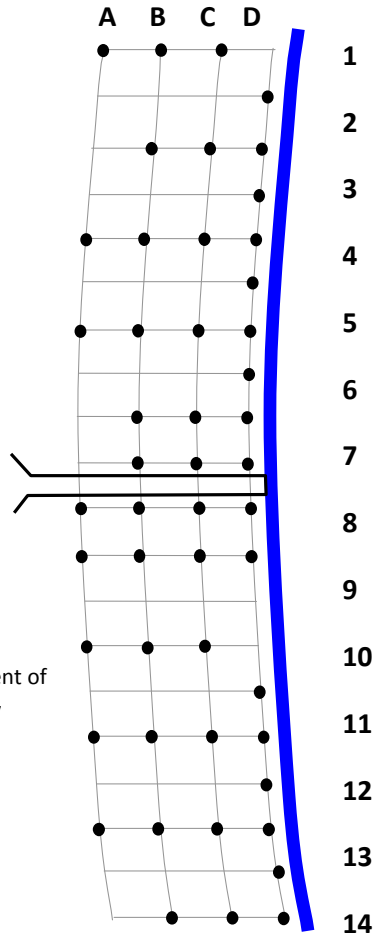
at the river shore: **1.9 ± 0.17 particles /(cm^2* min)**

along banks of the river: **1.1 ± 0.08 particles /(cm^2* min)**

Points of sampling and measurement of EDR at the site of the Iset river, in the area of settlement of Krasnoisetskoe at 0.1 m above soil surface
μSv/h



Points of measurement of beta-particle flux at the Iset river, in the area of settlement of Krasnoisetskoe close to soil surface
particles/(cm^2* min)



Mesh size of measurement of beta-particle flux density 20x20 m

Appendix 10

Average values of EDR at the site of Ulagach lake, near settlement Novogorny
at 0.1 m above soil surface.
μSv/h

	A	B	C	D
1	0.22	0.11	0.12	
2	0.2	0.13	0.1	
3	0.16	0.11	0.12	
4	0.16	0.1	0.09	
5	0.15	0.11	0.08	
6	0.13	0.11	0.12	0.1
7	0.13	0.13	0.11	0.11
8	0.15	0.12	0.1	0.09
9	0.19	0.13	0.11	0.1
10	0.12	0.11	0.1	0.08
11	0.16	0.11	0.12	0.11
12	0.11	0.1	0.12	0.12
13	0.15	0.12	0.12	0.1
14	0.12	0.11	0.09	0.09
15	0.17	0.12	0.13	0.1
16	0.16	0.13	0.11	0.1
17	0.16	0.12	0.09	0.09
18	0.15	0.11	0.1	0.09
19	0.12	0.11	0.11	
20	0.11	0.09	0.1	

Total number of control points: 73

The range of variation of EDR values in control points close to soil surface:

from 0.08 to 0.22 μSv/h

Average EDR with a confidence level of 0.95 close to soil surface:

at the lake shore: 0.15 ± 0.01 μSv/h

along bank of the lake: 0.11 ± 0.004 μSv/h

Average values of beta-particle flux density at the site of Ulagach lake
in the area of settlement Novogorny close to soil surface
particles/(cm^2*min)

	A	B	C	D
1	2.1			
2	2	0.9	1	
3	1.5			
4	1.6	1.1	1.1	
5	2.2			
6	1.9	0.8	1	
7	1.8			
8	1.9	0.9	1.2	1.3
9	1.5			
10	2	1.3	1.1	1.1
11	1.7	1.2	1	1
12	1.6			
13	1.8	1.1	0.9	0.9
14	1.9			
15	2	1.3	0.8	0.9
16	2.2			
17	1.7	1	1.1	1.1
18	1.9			
19	1.5	1.3	1.3	
20	1.2			

Total number of control points: 46

The range of variation of beta-particle flux density in control points close to soil surface:

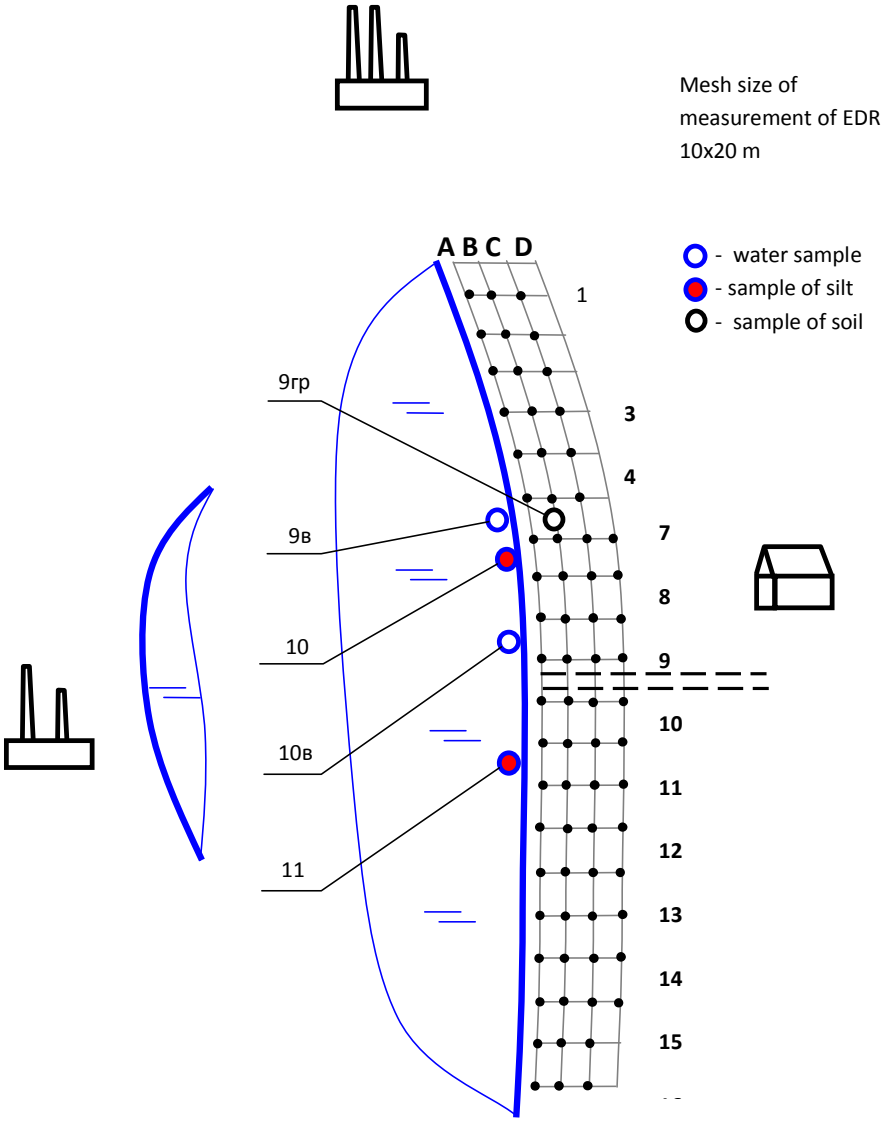
from 0.08 to 2.2 particles/(cm^2*min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

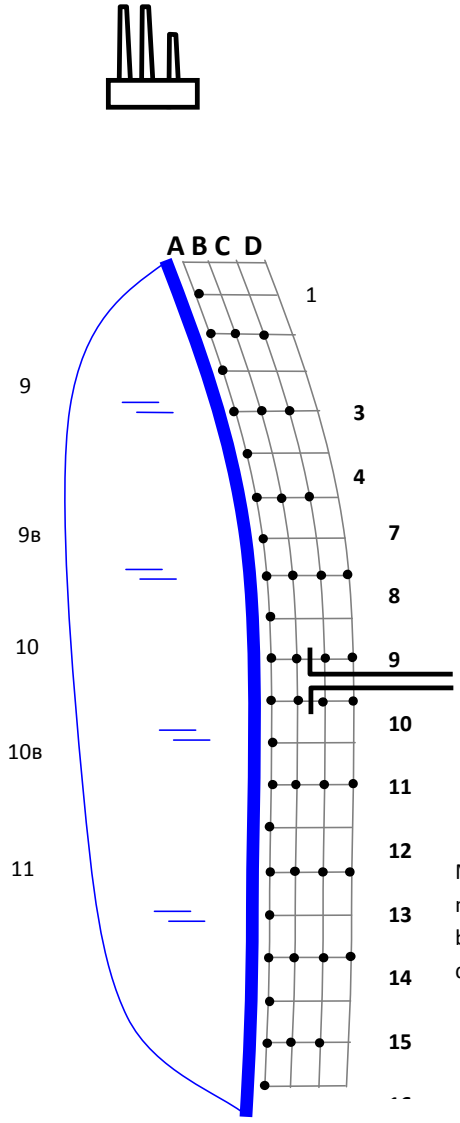
at the lake shore: 1.71 ± 0.11 particles/(cm^2*min)

along bank of the lake: 1.1 ± 0.06 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of Ulagach lake
near settlement Novogorny
at 0.1 m above soil surface



Points of measurement of beta-particle flux power at the site of Ulagach lake, near settlement Novogorny



Mesh size of measurement of beta-particle flux density 10x20 m

Appendix 11

Average values of EDR at the site of the Zyuzelka river
in the area of road bridge.
μSv/h

	A	B	C	D
1	0.13	0.11	0.12	0.1
2	0.14	0.12	0.1	0.1
3		0.1	0.1	0.09
4		0.09	0.09	0.09
5	0.16	0.13	0.09	0.09
6		0.11	0.1	0.1
7		0.1	0.1	0.1
8	0.16	0.12	0.13	0.12
9	0.13	0.12	0.1	0.1
10	0.13	0.09	0.1	0.09
11		0.09	0.11	0.09
12		0.08	0.11	0.08
13	0.16	0.1	0.12	0.12
14	0.16	0.13	0.12	0.13
15	0.17	0.13	0.12	0.1

Total number of control points: 54

The range of variation of EDR values in control points close to soil surface:

from 0.08 to 0.17 μSv/h

Average EDR with a confidence level of 0.95 close to soil surface:

at the river shore: 0.15 ± 0.01 μSv/h

on the bank of the river: 0.11 ± 0.004 μSv/h

Average values of beta-particle flux density at the site of the Zyuzelka river
in the area of road bridge
close to soil surface
particles/(cm^2*min)

	A	B	C	D
1	1.6	0.9	0.6	1
2	1.5			
3		0.5	0.6	0.5
4				
5	2.2	0.9	0.5	0.8
6				
7		1.1	0.7	0.7
8	2			
9	1.9	0.9	0.8	0.7
10	1.5			
11		1	0.6	0.6
12				
13	1.6	0.8	0.9	0.8
14	1.9			
15	2.2	1.1	0.8	0.6

Total number of control points: 33

The range of variation of beta-particle flux density in control points close to soil surface:

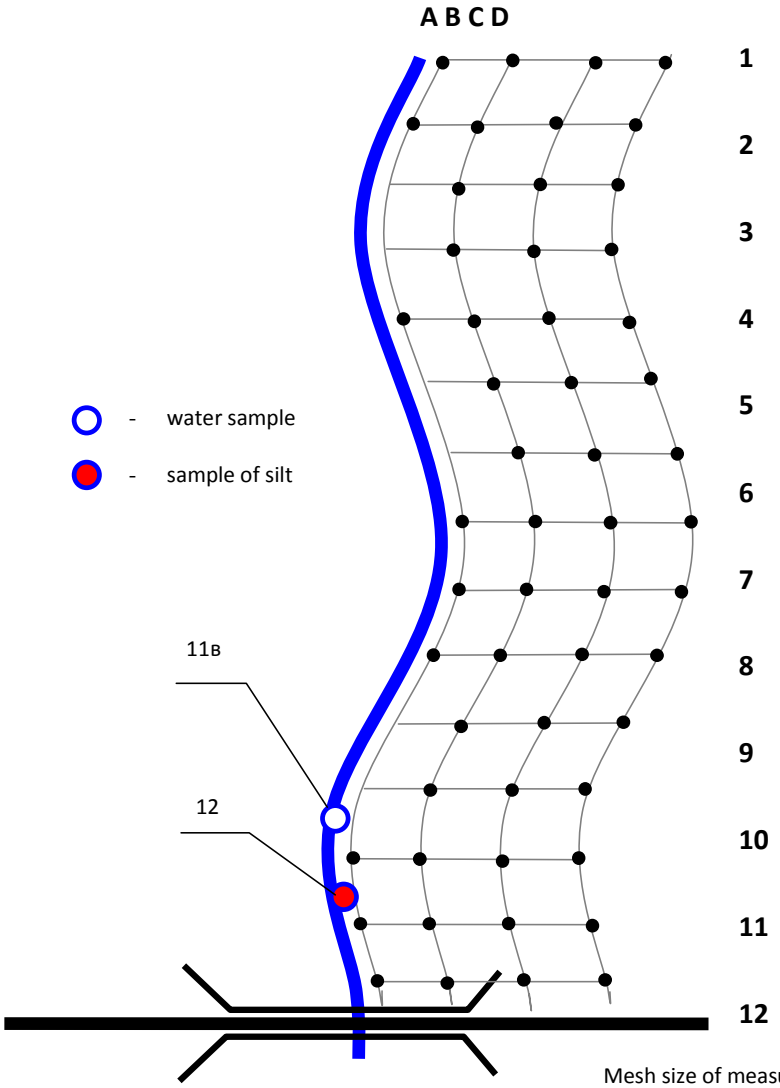
from 0.5 to 2.2 particles/(cm^2*min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

at the river shore: 1.64 ± 0.18 particles/(cm^2*min)

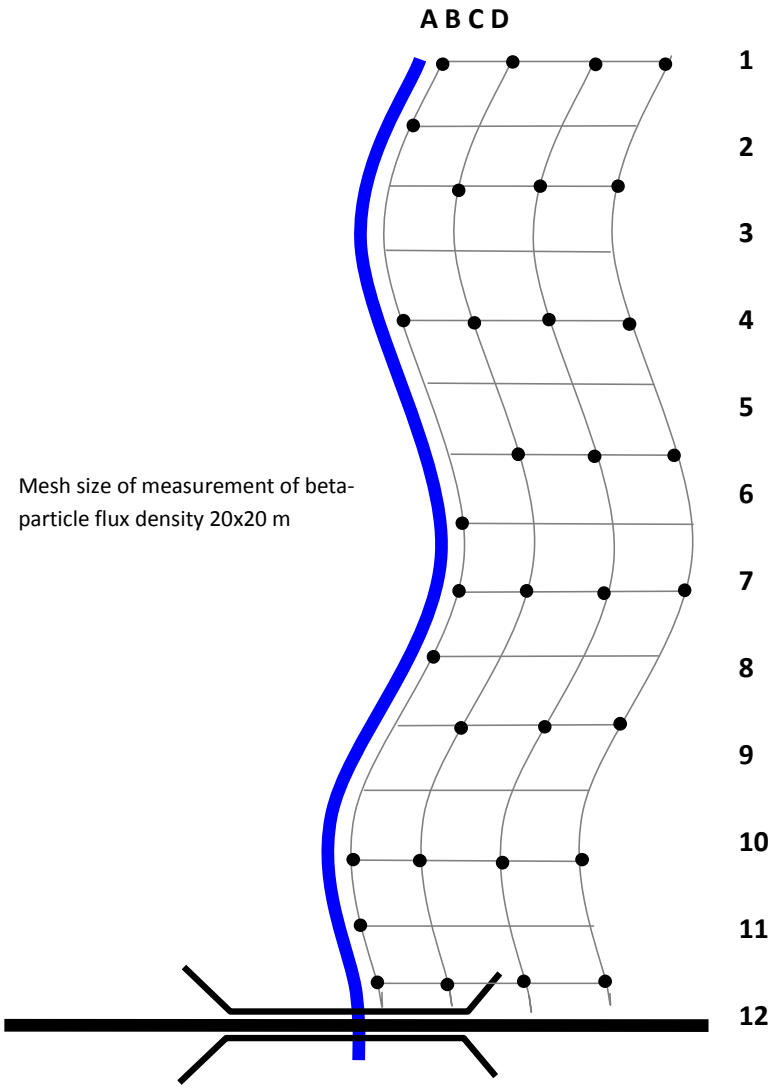
on the bank of the river: 0.8 ± 0.07 particles/(cm^2*min)

Points of sampling and measurement of EDR at the site of the Zyuzelka river in the area of road bridge at 0.1 m above soil surface



Mesh size of measurement of EDR 20x20 m

Points of measurement of beta-particle flux power at the site of the Zyuzelka river in the area of road bridge



Appendix 12

Average values of EDR at the site of Argayash lake
near settlement Argayash at 0.1 m above soil surface
μSv/h

	A	B	C	D	E
1	0.12	0.11	0.09	0.1	0.11
2	0.12	0.09	0.1	0.09	0.1
3	0.1	0.08	0.11	0.09	0.09
4	0.11	0.1	0.08	0.12	0.09
5	0.13	0.1	0.07	0.13	0.12
6	0.11	0.11	0.09	0.1	0.12
7	0.09	0.12	0.1	0.11	0.11
8	0.1	0.12	0.1	0.12	0.1
9	0.12	0.1	0.11	0.1	0.11
10	0.13	0.09	0.1	0.11	0.12

Total number of control points: 50

The range of variation of EDR in control points close to soil surface:

from 0.07 to 0.13 μSv/h

Average EDR with a confidence level of 0.95 close to soil surface:

at the lake shore: 0.11 ± 0.01 μSv/h

along bank of the lake: 0.10 ± 0.005 μSv/h

Average values of beta-particle flux density at the site of Argayash lake near settlement Argayash close to soil surface particles/(cm^2*min)

	A	B	C	D	E
1	0.9	0.9	0.8	0.5	0.6
2	0.8				
3	1.1	1	0.8	0.9	1
4	1				
5	1	0.9	1	2	1.2
6	1.1				
7	1.3	0.8	0.9	1.1	1
8	1.5				
9	1	1.1	0.8	0.5	0.8
10	1.1				

Total number of control points: **30**

range of variation of beta-particle flux density in control points close to soil surface:

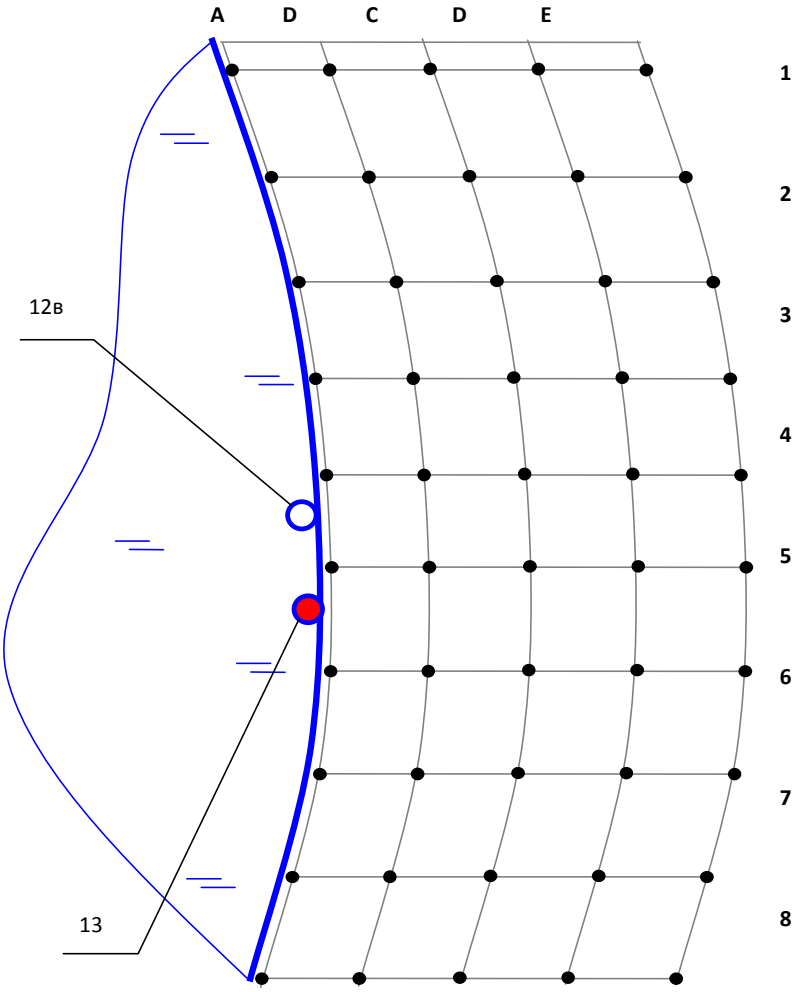
from 0.5 to 2.2 particles/(cm^2*min)

Average beta-particle flux density with a confidence level of 0.95 close to soil surface:

at the river shore: **1.08 ± 0.12 particles/(cm^2*min)**

on the bank of the river: **0.93 ± 0.137 particles/(cm^2*min)**

Points of sampling and measurement of EDR at the site of Argayash lake near settlement Argayash at 0.1 m above soil surface

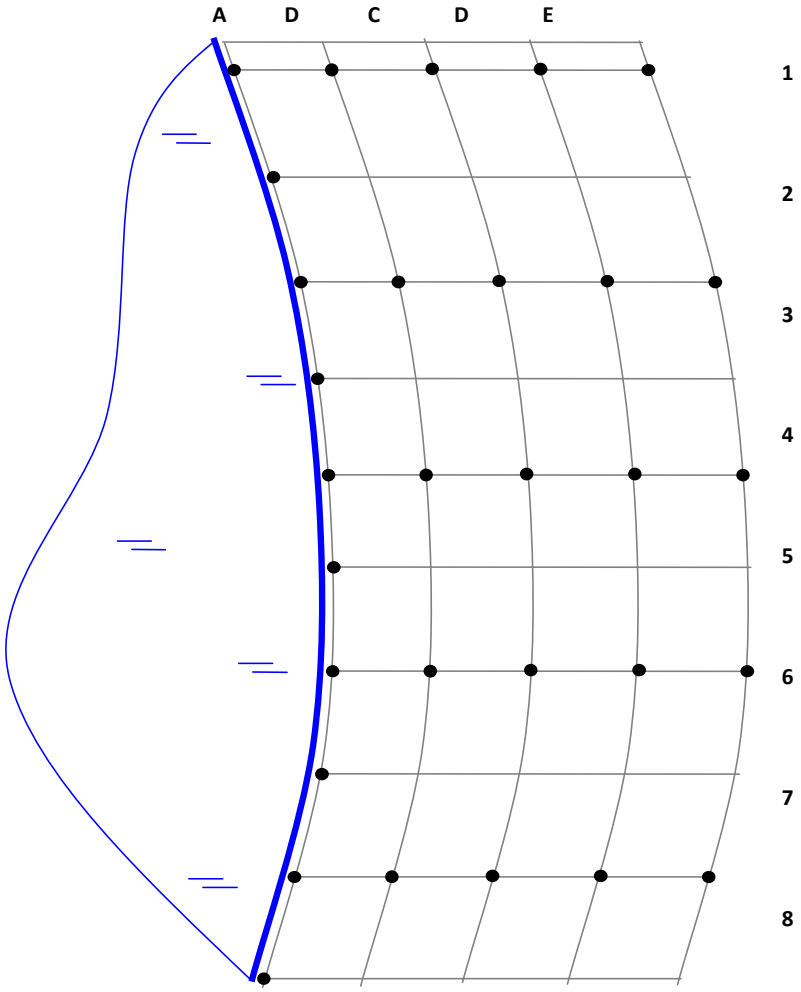


- water sample

- sample of silt

Mesh size of measurement of EDR 20x20 m

Points of sampling and measurement of EDR at the site of Argayash lake near settlement Argayash at 0.1 m above soil surface



Mesh size of measurement of beta-particle flux density 20x20 м