Figure 3.18 – Weddell seal

Wildlife species, which are trophically associated with the land and observed there during the BAE field work, are rather small (sized about 1 mm). They live under rocks, in cracks and plant sod. These are several species of mites found during biological sampling.

At the northern and north-eastern slopes of the Mount Vechernyaya there were small colonies of Adelie penguins found, counting 500 - 600 animals. A minor colony of nesting snow petrels and south polar skua gulls was also found there.

Among mammals found within the BAE biological research area range (25 km), there were crab-eater seals and Weddell seals, sometimes leopard seals and, rarely, sea elephants were reported there. Near the Vechernyaya Bay coast of Alasheeva Gulf, bagwhales and killer whales were also observed. Nototheniids were found to be most common for the Alasheeva Gulf fish colonies.

3.7. Initial environmental situation before BAS construction

3.7.1. On-site activities before starting of BAS construction

As it was previously noted in Section 2, the BAS is planned to be deployed near the Mount Vechernyaya field base territory (approx. 100-200 m south-west), which ensured functioning of airfield for many years.

Mount Vechernyaya aerodrome was designed to land IL-18D and IL-76TD cargo aircrafts. The first IL-18D plane landed at the aerodrome in February 1980, flying from Moscow (*Molodyozhnaya Station, 1994*).

The Vechernyaya field base infrastructure was built in 1979. It was designed for year-round accommodation of technical personnel. Residential and production facilities of the Mount Vechernyaya field base comprised of 13 individual and semi-detached buildings. The landing strip was 2790 m long and 100 m wide, located on compacted snow. Usually, flights were scheduled in October-November and February. An airfield platform sized 340x140 m was made to serve 4 aircraft. When building the landing strip (layout, alignment), a significant number of motor equipment was engaged, i.e.: motorised plough, air rollers, K-700, K-701 "Kirovec" wheel tractors. Upon arrival, the aircraft was served by a fleet of up to 10 vehicles: cargo conveyors, AC-40 fire truck, MTT tractor carriers, GAZ-71 trucks. The flights were controlled by a radio navigation system.

For 10 years, until the Molodyozhnaya station temporary closing-down, Mount Vechernyaya field base operated year-round independently. Mount Vechernyaya aerodrome was closed in 1991-1992 during RAE 37; the last IL-76TD flight was performed in November 1991.

Since 2006 the field base has been used by BAE to accommodate 2-6 staff scientists in summers. Nowadays, Mount Vechernyaya RAE field base residential and production premises compose of 7 individual and semi-detached buildings; the rest facilities were dismantled by the Russian Antarctic Expedition with participation of Belarusian specialists during the period 2006-2009. The location of the major facilities of the existing field base infrastructure is depicted at Figure 3.8. The major structures include: metal block module (MBM); airfield squad facilities, including diesel power plant building, workshop, warehouse, fuel storage sites, etc.

In 2006-2009 these structures were expanded by BAE facilities, i.e.: diesel power plants, fuel storage sites, vehicle parking facilities. Main elements of preserved infrastructure of field camp are shown at Figure 3.19.

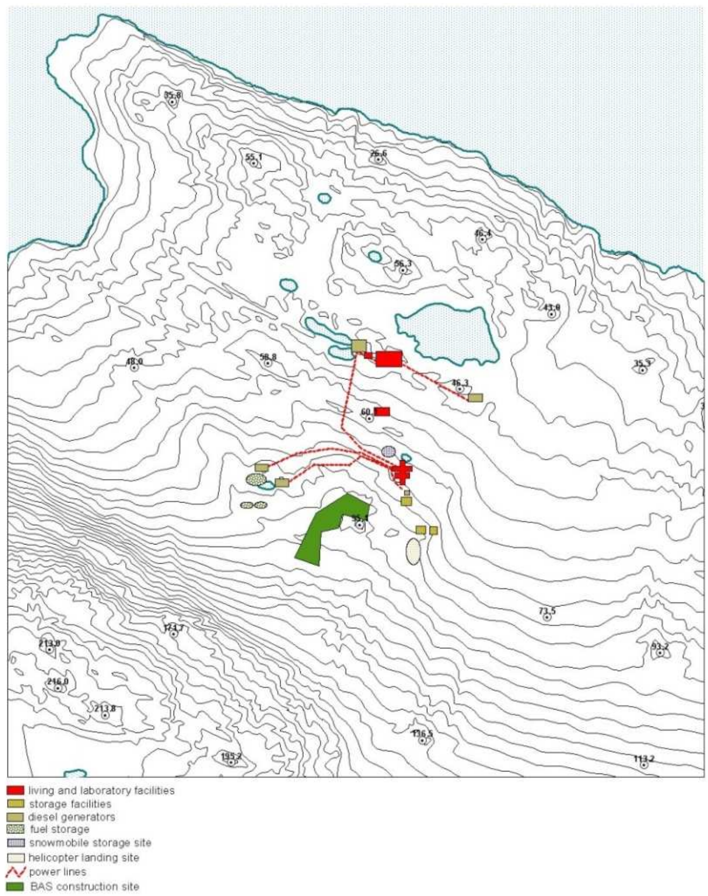

Figure 3.19 – Infrastructure of Mount Vechernyaya field camp used by Belarusian Antarctic Expedition

During the aerodrome operation, the environmental impact was caused by:
- emissions and noise from diesel generators;
- emissions from motor vehicles engaged in aerodrome services;
- emissions and noise produced by aircraft;
- mechanical impact on the ground and snow cover in connection with the preparation and operation of the landing strip, logistics and research activities;
- storage and distribution of fuels and lubricants;
- waste water, accumulation facilities and discharge points;
- solid wastes and their storage facility;
- radio navigation equipment.

Currently, the sources of exposure in connection with the field base structures operation by BAE include:

- emissions and noise from diesel generators;
- emissions and mechanical impact produced by motor vehicles;
- storage and distribution of fuels and lubricants;
- waste water, accumulation facilities and discharge points;
- solid wastes and their storage facility.

The other field base facilities, either operated or not, are also a source of pollution as a result of metal surface corrosion and destruction of other materials (Figure 3.20).

Figure 3.20 – View of the metal block module at Mount Vechernyaya field base

The paint peeling from the surfaces of facilities and equipment and metal corrosion results in release of contaminants into snow and open rocks and soil, followed by their dissolution in melt water and spreading into watercourses and ponds. Such contaminants may contain dangerous substances, such as heavy metals (lead, zinc, cadmium) that are normally included in the paints for coating metal structures for protective anti-corrosion properties.

As probable sources of pollution may serve fuel & lubricants for diesel generators, tractor and off-road equipment storage sites. Fuel (diesel, petroleum) and lubricants are supplied to the field base in standard barrels of 200 liters capacity. The storage was and is currently organised at outdoor platforms; the barrels stand on wooden pallets or directly on rocks (Figure 3.21). The fuel & lubricants consumption is about 2-3 tons per season (see Section 4.1).

А) Б)

Figure 3.21 – General view of the storage locations of metal barrels for fuel:
a) on rocks, and b) on wooden pallets

During the BAE field season, the estimated volume of wastewater counts 5-6 m^3 monthly; the sewage dumped into the sea, which had a definite impact on the marine environment.

As a result of BAE activities from 2006 to 2013 the following amount of wastes has been accumulated: empty fuel barrels - 80 pcs.; glass (broken), packed in barrels - 0.5 t; compacted cans (tins), packed in empty barrels - 0.5 t. A part of wastes was transferred to the mainland.

For the moment, it is difficult to assess and compare the current and past environmental impacts; however, accounting past and current staff and the number of motor vehicles involved, impacts can be considered to decrease significantly. The investigations held in 2011-2013 focused on the environmental assessment issues due to man-caused exposures at the field base location.

3.7.2. Environmental assessment investigations methodology

To assess the environmental conditions in the vicinity of the proposed BAS construction, the 4th BAE (2011-2012) and 5th BAE (2012-2013) performed environmental and geochemical studies in the area of the planned Belarusian Antarctic station deployment. The environmental and geochemical studies included sampling of snow, surface water, bottom sediments, soils / ground.

The research was aimed at establishing of the background concentrations of pollutants in the natural environment components prior to the Belarusian Antarctic station construction.

The sampling plan is given at Figure 3.22.

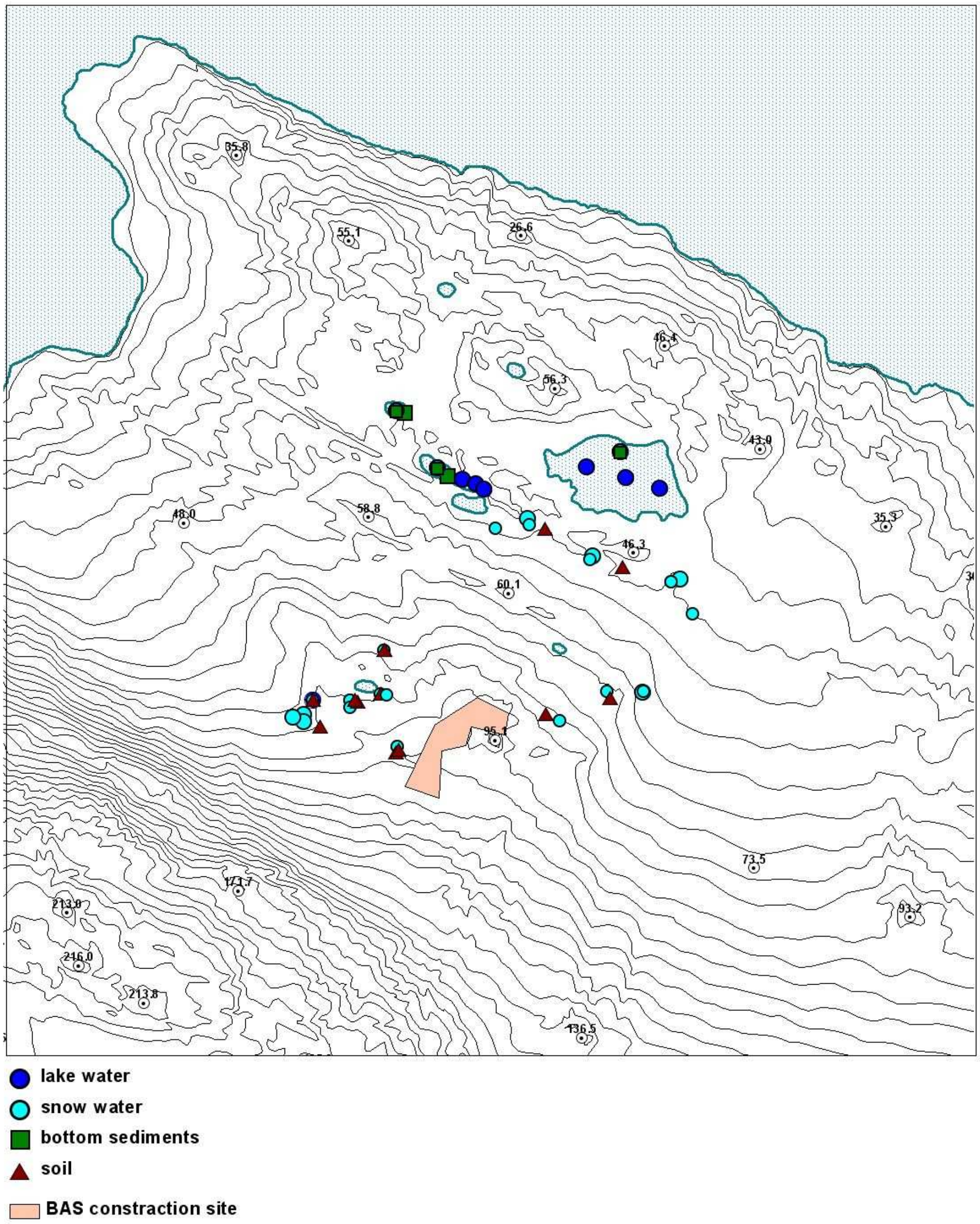

Figure 3.22 – Sampling plan of snow, surface water, bottom sediments and soils at the Mount Vechernyaya field base location

The sampling points were selected taking into account the locations of possible pollution sources.

In total at the 4th BAE in 2011-2012 17 samples at 8 points in the vicinity of the Mount Vechernyaya field base location, including 14 water samples (surface and snow waters), 2 bottom sediment samples, one soil sample were taken.

During the 5th BAE 23 samples of snow waters were taken, including 18 samples at the Mount Vechernyaya field base location and 5 samples at the ice cap slope at max. 5 km distance from the field base, 1 sample of water ice on the Hayes glacier. 4 samples of surface water from lakes, 3 sediment samples and 13 samples of solid substrates (soil, colluvial & dealluvial deposits, etc.) were also taken.

When sampling the precipitations, the determination of major ions and trace elements was performed. The surface water samples were tested for major ions, trace elements, oil products. The sediment samples and soil was investigated for contents of macro-elements, heavy metals, oil products, PAHs and PCBs. When performing the chemical tests, the scientists used the test methods, as generally approved for environmental analytical control in the Republic of Belarus (*Guidelines for pollution control..., 1991*).

3.7.3. Chemical composition of snow water

The content of major ions in snow water is shown in Table 3.2 below.

According to 2012 sampling, the pH value of snow waters ranged 5.96 to 6.39 (Table 3.5), conductivity values ranged 9.0 to 20.7 mS/cm.

The content of sulfates in snow waters ranges from 0.17 to 0.54 mg S/l (mean - 0.36 mg S/l), chlorides - 1.9 to 4.0 mg/l (mean - 2.9 mg/l), sodium ions – from 0.76 to 2.00 mg/l (mean - 1.41 mg/l).

According to the 2012 sample tests, the snow water mineralisation ranged 4.06 to 81 mg/l at 6.93 mg/l average.

According to the 2013 tests, the pH values of snow waters ranged 5.10 to 6.10, the conductivity values – 4.8 to 21.0 μSm/cm. The content of sulfates in snow waters ranged from values below the detection limit to about 0.20 mg S/l with 0.1 mg S/l average. In samples taken from the ice cap slopes (except Sample No. 35), the sulfate content was below the detection limit.

The chloride content varied in the range 1.1-2.4 mg/l, with 1.5 mg/l average value. In snow samples taken from the ice cap slopes, the average chloride content counted 1.5 mg/l.

The content of sodium ions in snow waters ranged 0.3 to 1.1 mg/l, with 0.57 mg/l average. In samples taken along the slope, the average sodium content was 0.46 mg/l.

Anions in all samples were dominated by chlorides (37.6-57.1%). Cations in most samples predominated by sodium ions (22.9-72.9%). The total mineralisation of snow waters in 2013 ranged 1.46 to 8.43 mg/l, with 3.08 mg/l average. The top mineralisation value was detected in Sample No. 26-2 taken from the snowfield behind the fuel depot. In samples taken along the slope, the average mineralisation value amounted to 1.82 mg/l.

Table 3.5 - Contents of major ions in snow water samples at the Mount Vechernyaya field base location, mg/l

Sample No.	Year	Cl^-	SO_4^{2-}, мг S	NO_3^-, N	NH_4^+, N	Ca^{2+}	Mg^{2+}	Na^+	K^+	pH	Electrical conductivity, mSm/cm
Field base territory											
9	2012	2.7	0.54	n.d.	n.d.	0.093	0.789	1.3	0.72	5.98	15
10	2012	3.7	0.33	n.d.	0.039	0.702	0.353	1.84	0.42	5.96	20.7
11	2012	1.9	0.167	n.d.	n.d.	0.24	0.43	0.76	0.26	6.05	9.0
12	2012	4.0	0.233	n.d.	n.d.	0.069	0.266	2.0	0.26	6.39	20.2
14	2012	2.4	0.517	n.d.	0.039	1.165	1.14	1.16	0.58	6.27	14
12	2013	1,5	0,166	n.d.	n.d.	0,12	0,03	0.5	0.2	5.66	6.3
14	2013	1,5	0,166	n.d.	n.d.	n.d.	0,04	0.6	0.26	5.61	7.5
16	2013	1,3	0,166	n.d.	n.d.	n.d.	n.d.	0.4	0,2	5.5	5.1
22	2013	1.2	0.166	n.d.	n.d.	0.11	n.d.	0.5	0.16	5.51	6.8
23	2013	1.6	0.2	n.d.	n.d.	0.39	0.023	0.6	0.26	6.03	7.1
23-2	2013	1.5	0.166	n.d.	n.d.	0.12	0.038	0.5	0.26	5.81	6.9
26	2013	1.5	n.d.	n.d.	n.d.	н.о.	0.024	0.6	0.26	5.58	5.8
26-2	2013	1.6	0.2	n.d.	4.076	0.28	0.067	0.4	0.26	5.74	7.1
28	2013	1.8	0.2	n.d.	0.077	0.11	0.024	0.9	0.2	5.1	12.5
28-2	2013	2.1	0.2	n.d.	n.d.	0.64	0.113	0.8	0.26	6.04	11.6
32	2013	2.4	0.2	n.d.	n.d.	n.d.	0.13	1.1	0.3	5.67	9.6
17	2013	1.1	n.d.	n.d.	n.d.	n.d.	0.012	0.4	n.d.	5.62	5.9
18	2013	1.8	n.d.	n.d.	n.d.	0	0.013	0.6	n.d.	5.4	7.8
19	2013	1.5	n.d.	n.d.	n.d.	0	0.033	0.6	n.d.	5.65	7.6
30-2	2013	1.6	n.d.	n.d.	0.054	0.22	0.05	0.3	n.d.	5.55	6.4
33	2013	1.2	n.d.	n.d.	n.d.	0.24	0	0.5	n.d.	5.8	6.4
20	2013	1.3	n.d.	n.d.	n.d.	0.14	0.016	0.4	n.d.	5.75	7.6
30	2013	1.6	n.d.	n.d.	n.d.	0.16	0	0.5	n.d.	5.8	6.4
Ice cap slope											
36	2013	1.5	n.d.	n.d.	n.d.	n.d.	0.04	0.4	n.d.	5.75	6.5
37	2013	1.5	n.d.	n.d.	n.d.	n.d.	0.026	0.4	n.d.	5.7	6.3
38	2013	1.4	n.d.	n.d.	n.d.	n.d.	0.018	0.5	n.d.	5.81	5.6
39	2013	1.2	n.d.	n.d.	n.d.	n.d.	0	0.3	n.d.	5.6	4.8
Hayes glacier											
40	2013	5.3	n.d.	n.d.	n.d.	0.22	0.29	2.4	0.2	6.1	21

n.d. – not detected

The snow water mineralisation, as sampled at the ice cap at 5 km distance from BAS, was found to be on average 20% lower than the mineralisation at the station site; the main ionic elements content were reported to be less as well.

Reference to the 2012-2013 sample tests, the total mineralisation of snow waters at Mount Vechernyaya was assessed to be 1.7 times lower than in 2011-2012 tests. The snow water anionic composition pertains to chloride (37.6–57.1 %). The snow water cationic composition is more diverse with prevail of sodium (22.9–72.9 %).

The snow chemical test results, as compared to other investigations in Antarctica (*Smagin ..., 2007*) demonstrated that the snow water composition in the planned BAS deployment location is basically typical to the coastal Antarctica areas.

No significant man-caused changes in the ionic composition of the Mount Vechernyaya snow waters were revealed.

Trace elements

29 samples of snow waters were analysed for trace elements content, including 23 samples taken within the field base area (close to potential sources of pollutants), 4 samples – at the slopes to the mainland direction at 5 km distance from the base, 1 sample - on the Hayes glacier. Among 25 elements tested no beryllium was detected in snow waters; also, iron, silver, thallium, thorium, uranium were found at the detection limits levels. The content of other trace elements in snow water samples differ significantly (Table 3.6).

Table 3.6 – Trace element content in the snow cover at the Mount Vechernyaya field base location

Element	Unit	At the field base territory			At the ice cap slopes			Hayes glacier
		min.	max.	mean	min.	max.	mean	
Be	µ/l	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Na	mg/l	0.127	0.55	0.299	0.122	0.356	0.214	1.355
Mg	mg/l	0.007	0.074	0.023	0.003	0.021	0.013	0.120
Al	µ/l	n.d	45.4	8.504	0.630	8.5	3.666	n.d
K	mg/l	0.003	0.14	0.033	0.004	0.032	0.013	0.037
Ca	mg/l	0.022	0.46	0.124	0.012	0.091	0.064	0.173
V	µ/l	0.02	0.44	0.122	0.015	0.066	0.035	0.097
Cr	µ/l	0.009	1.76	0.293	0.006	0.043	0.025	0.013
Mn	µ/l	0.32	2.283	0.809	0.258	0.854	0.559	1.315
Fe	mg/l	n.d	0.016	0.002	n.d	n.d	n.d	n.d
Co	µ/l	0.002	0.05	0.017	0.005	0.011	0.008	0.013
Ni	µ/l	0.003	0.335	0.075	n.d	0.056	0.022	0.037
Cu	µ/l	0.008	6.872	1.022	0.000	0.403	0.220	0.126
Zn	µ/l	1.68	491.3	113.37	17.47	31.51	25.33	84.28
As	µ/l	0.004	0.427	0.084	0.002	0.016	0.009	0.028
Se	µ/l	0.006	1.29	0.533	0.035	0.63	0.349	0.976
Mo	µ/l	n.d	0.198	0.065	0.001	0.03	0.011	0.019
Ag	µ/l	n.d	0.029	0.002	n.d	n.d	n.d	0.001
Cd	µ/l	0.017	3.487	0.347	0.030	0.091	0.054	0.142
Sb	µ/l	0.003	0.06	0.017	0.005	0.01	0.007	0.018
Ba	µ/l	0.14	20.1	2.171	0.127	2.003	0.723	1.021
Tl	µ/l	n.d	0.005	0.001	0.001	0.001	0.001	0.001
Pb	µ/l	0.006	5.326	0.474	0.000	0.244	0.116	n.d
Th	µ/l	n.d	0.05	0.018	0.006	0.008	0.007	0.008
U	µ/l	n.d	0.01	0.002	n.d	n.d	n.d	0.001

Considerable variability of trace elements was found in the samples taken at the field base (close to the sources of exposure) and at the cap slopes.

The studies performed evidence the reduction of heavy metal content in the snow cover at certain distance from the base. At 5 km distance from the base, the trace elements concentration in snow is low, counting: lead - 0.24 µg/l, cadmium - 0.09 µg/l, arsenic - 0.003 µg/l, chromium - 0.04 µg/l, vanadium – 0.012 µg/l, nickel - 0.023 µg/l, zinc - 31.5 µg/l. The snow water samples collected at the field base territory and beyond contained 2 times more vanadium, chromium, nickel, copper, zinc, arsenic, molybdenum, cadmium and lead than samples taken at 2 km or more distance; the average ratio of trace element content in snow at the field base territory and at 2 km or more distance ranged 1.4 to 11.7 times (Figure 3.23).

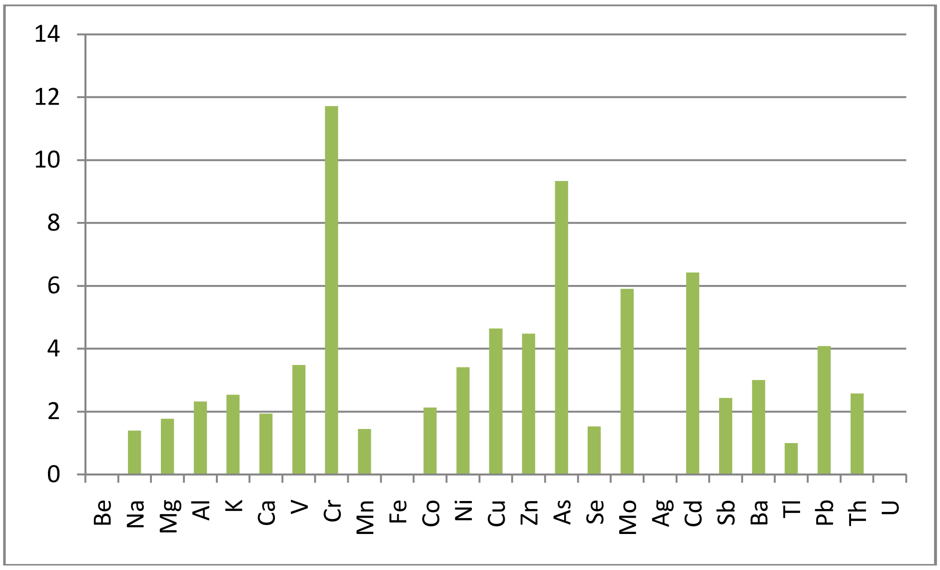

Figure 3.13 - Multiple excess of trace elements in snow water samples taken at the Mount Vechernyaya field base location, as compared to samples taken at 2 km or more distance from the field base

3.7.4. Chemical composition of surface waters

The major ions content in surface waters are given in Table 3.7 below.

Table 3.7 – Major ions content in the lake waters at the Mount Vechernyaya field base location, mg/l

Sample No.	Lake name	Year of sampling	Cl^-	SO_4^{2-}, мг S	NO_3^-, N	NH_4^+, N	Ca^{2+}	Mg^{2+}	Na^+	K^+	pH
13	Nizhneye Lake	2012	15.6	1.63	0.018	0.08	0.289	0.458	10	1.66	74.9
4	Nizhneye Lake	2013	6.3	0.63	n.d	0.00	0.31	0.43	3	0.34	26.4
15	Verkhneye Lake	2012	8.0	0.88	n.d	0.00	0.124	0.475	4.6	0.5	38.5
7	Verkhneye Lake	2013	4.2	0.37	n.d	0.05	n.d	0.3	2.4	0.3	19.3
4	No Name Lake	2012	18.1	1.50	n.d	0.19	0.61	1.29	15	2.3	95.8
10	No Name Lake	2013	9.9	0.60	n.d	n.d	0.26	0.59	4.7	0.4	37.2

Reference to the 2012 sample tests, pH values in the lake waters close to Mount Vechernyaya (Verkhneye Lake, Nizhneye Lake, No Name Lake) ranged 6.26 to 6.54, conductivity – 38.5 to 95.8 mSm/cm. The content of sulfates in the lake waters ranged 0.89 to 1.63 mg S/l (mean - 1.34 mg S/l), chlorides - 8.0 to 18.1 mg/l (mean - 13.9 mg/l), sodium ions – 4.6 to 15.0 mg/l (mean - 9.9 mg/l).

The average lake waters salinity was 29.3 mg/l, ranging 15.9 to 42.1 mg/l. Anions in all samples were dominated by chlorides, amounting to 62.5-86.4%, with sulfates being second among anions (13.6-16.4%). Cations in most samples predominated by sodium (67.0-81.2%). The magnesium content shared 7.0-16.2%.

According to the 2013 tests, pH value in the lake waters in the Mount Vechernyaya vicinity ranged 5.74-6.24, conductivity – 19.3-37.2 mSm/cm. The sulfate content ranged 0.37 – 0.63 mg S/l (mean - 0.53 mg S/l), chlorides - 4.2 to 9.9 mg/l (mean - 6.8 mg/l), sodium ions – 2.4 to 4.7 mg/l (mean - 3.4 mg/l).

Anions in all samples were dominated by chlorides (67.7-88.6%), cations are mainly represented by sodium ions (sharing 67.0-81.2%).

The total salinity of the lake waters in the Mount Vechernyaya vicinity ranged 11.5 to 27.0 mg/l, with an average of 16.9 mg/l, which is higher than that of snow waters.

In general, the level of salinity in the lakes near Mount Vechernyaya is somewhat similar to the salinity of low-mineralised waters of the Schirmacher oasis and slightly higher than the level of the Lagernoye Lake (Molodyozhnaya Station).

The total mineralisation of the lakes near Mount Vechernyaya in 2012-2013 was 2 times lower than the total salinity of surface waters in 2011-2012.

No significant man-caused changes in the ionic composition of lake waters at the Mount Vechernyaya were revealed.

All in all, the ion balance demonstrates a significant influence of the ocean water on the lake water chemical composition, which is explainable by their near-coast location.

Trace element content

The trace element content in the lake waters in the Mount Vechernyaya vicinity is given in Table 3.8 below.

Reference to the investigations made, the most trace elements content in water are reported to range from below the detection limit to 10 μg/l (lead – from below detection limit to max. 1.88 μg/l, cadmium – from 0.012 to 0.53 μg/l, nickel – from 0.21 to 0.69 μg/l, cobalt – from 0.02 to 0.29 μg/l, arsenic – from 0.06 to 0.39 μg/l, copper – from 0.48 to 2.17 μg/l, chromium – from 0.05 to 1.40 μg/l.

The iron content in the lake waters ranged 0.005 - 0.104 mg/l; the highest concentration of this element was traced in the Nizhneye Lake waters. Moreover, the Nizhneye Lake waters proved to reveal higher concentrations of manganese, aluminum, zinc, barium and some other elements, as compared to other lake waters (Table 3.8).

Table 3.8 – Trace element content in the lake waters at the Mount Vechernyaya field base location

Element	Unit	Nizhneye Lake		Verkhneye Lake		No Name Lake	
		2012	2013	2012	2013	2012	2013
Be	µ/l	n.d	n.d	n.d	n.d	n.d	0.004
Na	mg/l	2.574	2.405	1.651	1.614	4.357	3.089
Mg	mg/l	0.336	0.288	0.229	0.164	0.489	0.280
Al	µ/l	7.764	16.650	4.35	н.о.	9.655	11.462
K	mg/l	0.373	0.152	0.114	0.089	0.326	0.187
Ca	mg/l	0.24	0.438	0.139	0.185	0.256	0.333
V	µ/l	0.249	0.224	0.19	0.190	0.596	0.228
Cr	µ/l	1.051	0.066	0.321	0.044	1.395	0.046
Mn	µ/l	31.177	15.749	2.311	5.374	0.567	1.389
Fe	mg/l	0.104	0.046	0.017	0.005	0.031	0.018
Co	µ/l	0.286	0.070	0.016	0.046	0.024	0.027
Ni	µ/l	0.626	0.380	0.271	0.213	0.688	0.240
Cu	µ/l	1.109	0.716	0.665	0.482	2.171	0.651
Zn	µ/l	181.818	3.669	0.118	1.109	4.46	n.d
As	µ/l	0.18	0.052	0.102	0.058	0.391	0.071
Se	µ/l	0.032	1.476	0.064	1.739	0.2	1.314
Mo	µ/l	0.028	1.603	0.009	0.765	0.126	0.514
Ag	µ/l	0.003	0.027	0.003	0.013	0.006	0.011
Cd	µ/l	0.215	0.038	0.014	0.031	0.553	0.012
Sb	µ/l	0.022	0.036	0.007	0.022	0.018	0.014
Ba	µ/l	9.067	3.031	1.214	0.755	1.083	0.891
Tl	µ/l	0.003	0.030	n.d	0.008	n.d	0.010
Pb	µ/l	1.875	0.227	0.306	0.221	0.202	n.d
Th	µ/l	0.002	0.356	n.d	0.168	0.002	0.126
U	µ/l	0.003	0.012	0.001	0.007	0.004	0.011

Content of oil products

The chemical analysis results as related to oil product content in surface waters are shown in Table 3.9.

Oil content in the lake water in 3 of 4 samples appeared to be close to the maximum permissible concentration (MPC) for potable water (0.1 mg/l). The oil content in waters of the stream flowing out of the lake near the fuel depot was 1.4 times higher than in lake water.

Elevated concentrations of oil products in the lake waters are probably the result of the previous activities.

Table 3.9 – Oil product content in surface water samples taken at the Mount Vechernyaya field base location, mg/kg dry matter

Sample No.	Object of analysis	Year of sampling	Oil product content, mg/l
17	Nizhneye Lake	2012	0.017
4		2013	0.086
16	Verkhneye Lake	2012	0.076
7		2013	0.083
32	Stream flowing out of the lake near the fuel depot	2013	0.118

3.7.5. Chemical composition of bottom sediments and soils

Bottom sediments and soils (developing on colluvial and fluvioglacial sediments) were analysed on content of heavy metals, oil products and some POPs (PAHs and PCBs).

Bottom sediments

Heavy metals

Sediments from two lakes – Verkhneye Lake and No Name Lake – were subject to analysis. The content of heavy metals was tested by AAS method.

The content of heavy metals in the bottom sediments is shown in Table 3.10 below. The Verkhneye Lake sediments contained copper ranging 42.9-65.1 mg/kg, zinc – 139.7-162.8 mg/kg, nickel – 31.5-33.3 mg/kg, chromium – 12.5-32.7 mg/kg, lead - 33.9 -36.3 mg/kg, cadmium – 1.85-2.42 mg/kg. In the No Name Lake sediments, the copper content ranged 16.4-78.5 mg/kg, zinc – 65.4-89.0 mg/kg, nickel – 25.2-37.5 mg/kg, chromium – 42.0-43.5 mg/kg, lead – 15.8-18.2 mg/kg, cadmium – 1.22-1.57 mg/kg.

The differences found in the last two years of research indicate the heterogeneous nature of heavy metal accumulation in the lake sediments in the Mount Vechernyaya vicinity. Thus, the Verkhneye Lake sediments were reported to contain zinc 2-3 times, lead 2 times, cadmium 1.5 times more than in the No Name Lake sediments.

Table 3.10 – Concentration of heavy metals in the lake sediments in the Mount Vechernyaya field base vicinity, mg/kg dry matter

Sample No.	Place of sampling	Year	Cu	Zn	Ni	Cr	Pb	Cd
6	Verkhneye Lake	2012	42.9	139.7	31.5	12.5	36.3	1.85
8	Verkhneye Lake	2013	65.1	162.8	33.3	32.7	34.0	2.42
8	No Name Lake	2012	16.4	65.4	25.2	42.1	15.8	1.22
11	No Name Lake	2013	78.5	89.0	37.5	43.5	18.2	1.57

The content of heavy metals in the lake sediments were reported to be significantly higher than in the Mount Vechernyaya soils; e.g., the Verkhneye Lake sediments contained the excess of copper - 3.5 times, zinc - 2.2 times, nickel - 1.6 times, lead - 1.5 times and cadmium - 1.2 times. In the No Name Lake sediments, the copper content was tested to be 4.5 times, nickel - 1.8 times and zinc - 1.2 times higher than that in local soils.

High concentrations of oil products were also reported with the Verkhneye Lake sediment samples, resulting most probably from earlier activities.

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls

The following PAH compounds were identified in the Verkhneye Lake sediments, i.e.: naphthalene - 0.16 mg/kg, anthracene - 0.068 mg/kg, pyrene - 0.074 mg/kg (Table 3.11). Other PAH compounds and PCBs were not detected (below the detection limit).

Table 3.11 - Contents of PAHs and PCBs in the Verkhneye Lake sediments, mg/kg

Substance	Content
Naphthalene	0.16
Acenaphthene	n.d.
Fluorene	n.d.
Phenanthrene	n.d.
Anthracene	0.068
Fluoranthene	n.d.
Pyrene	0.074
Benzo(a)anthracene	n.d.
Chrysene	n.d.
Benzo(b)fluoranthene	n.d.
Benzo(k)fluoranthene	n.d.
Benzo(a)pyrene	n.d.
Dibenzo(a, h)anthracene	n.d.
Benzo(g, h, i)perylene	n.d.
Indeno(1.2.3-cd)pyrene	n.d.
PCB 28	n.d.
PCB 52	n.d.
PCB 101	n.d.
PCB 118	n.d.
PCB 138	n.d.
PCB 153	n.d.
PCB 180	n.d.
PCBs (total)	n.d.

Oil products

The Verkhneye Lake bottom sediments were found to contain elevated concentrations of oil products - 392.2 mg/kg; the No Name Lake sediments proved to have inconsiderable content (4.23 mg/kg) (Table 3.12). The findings suggest that man-caused oil spills fall into the Verkhneye Lake (a diesel power plant now empty which worked during operation of aerodrome base Mount Vechernyaya from 1979 to 1989 is located nearby).

Table 3.12 – Content of oil products in the lake bottom sediments of the Mount Vechernyaya field base location, mg/kg dry matter

Sample No.	Year	Place of sampling	Oil product content
8	2013	Verkhneye Lake	392.2
11	2013	No Name Lake	4.23

Soil and loose substrates

8 samples were tested to determine heavy metals content (by atomic absorption spectroscopy), 9 samples were analysed for oil content determination; 3 samples - the content of polycyclic aromatic hydrocarbons (PAHs), and 1 sample - PCBs.

Heavy metals

The results of heavy metal content determination are shown in Table 3.13 below.

Table 3.13 – Heavy metal content in soil samples, mg/kg

Year	Sample No	Cu	Zn	Ni	Cr	Pb	Cd
2012	1	21.85	77.37	27.24	57.93	17.58	1.32
2013	1	30.23	172.90	30.71	54.00	22.80	2.09
	13	17.38	82.84	20.87	46.67	21.47	1.93
	25	19.81	75.00	22.06	48.00	22.67	1.71
	27	19.37	69.78	20.95	44.00	22.27	1.75
	29	19.13	66.79	21.19	47.33	22.40	1.96
	31	17.67	83.02	21.75	48.00	22.40	2.00
	34	18.45	72.95	19.80	45.33	22.27	1.79

The zinc content in soils ranges 66.89 to 172.9 mg/kg of air-dry residue, chromium – 32.7 to 54.0 mg/kg, lead – 18.3 to 36.37 mg/kg, nickel – 19.80 to 31.54 mg/kg, copper – 17.38 to 42.9 mg/kg, cadmium – 1.57 to 2.09 mg/kg.

Among the solid substrate samples, one sample was taken from the temporary stream sediments, represented mainly by coarse sand, the rest samples - loose moraine substrate. According to the atomic absorption spectroscopy readings, the highest content of heavy metals was found to be characteristic to the temporary stream alluvial deposits: zinc content – 172.9 mg/kg, copper – 30.2 mg/kg, nickel – 30.7 mg/kg, chromium – 54 mg/kg, lead – 22.8 mg/kg, cadmium – 2.09 mg/kg. The detected values of heavy metals in the fluvioglacial sediments were similar to the content in the lake sediments tested. This may indicate a redistribution of pollutants by meltwater and their accumulation in depressions, hollows, lakes.

In general, the distribution of heavy metals in soils proved to be rather uniform, which apparently shows the decisive influence of heavy metals in soil-forming rocks (gneiss weathering products).

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls

The soils samples were detected to contain inconsiderable amounts of two PAH compounds, i.e.: anthracene (ranging 0.003-0.006 mg/kg) and pyrene (from below the detection limit to 0.004 mg/kg) (Table 3.14). The other PAH and PCB compounds were found below the detection limit.

Table 3.14 – Contents of PAHs and PCBs in soils of the Mount Vechernyaya field base location, mg/kg

Substance	Sample No.		
	27	31	34
Naphthalene	n.d.	n.d.	n.d.
Acenaphthene	n.d.	n.d.	n.d.
Fluorene	n.d.	n.d.	n.d.
Phenanthrene	n.d.	n.d.	n.d.
Anthracene	0.006	0.003	0.005
Fluoranthene	n.d.	n.d.	n.d.
Pyrene	0.004	n.d.	0.004
Benzo (a) anthracene	n.d.	n.d.	n.d.
Benzo (b) fluoranthene	n.d.	n.d.	n.d.
Benzo (k) fluoranthene	n.d.	n.d.	n.d.
Chrysene	n.d.	n.d.	n.d.
Benzo (a) pyrene	n.d.	n.d.	n.d.
Dibenzo (a, h) anthracene	n.d.	n.d.	n.d.
Benzo (g, h, i) perylene	n.d.	n.d.	n.d.
Indeno (1.2.3-cd) pyrene	n.d.	n.d.	n.d.
PCB 28	n.d.	n.d.	n.d.
PCB 52	n.d.	n.d.	n.d.
PCB 101	n.d.	n.d.	n.d.
PCB 118	n.d.	n.d.	n.d.
PCB 138	n.d.	n.d.	n.d.
PCB 153	n.d.	n.d.	n.d.
PCB 180	n.d.	n.d.	n.d.
∑ of 7 PCBs	n.d.	n.d.	n.d.

Oil products

The oil product content in soil samples taken at the field base location is given in Table 3.15 below.

The oil product content in soils ranges from 2.5 mg/kg to 28.9 mg/kg. The oil product content in the vicinity of BAE diesel generators DG-20 and DG-60 and actual BAE fuel depot locations was found to be rather low, ranging 2.5-12.6 mg/kg. Elevated oil content (28.9 mg/kg) was detected in the soil substrate close to the MBM location.

The maximum values, reaching 7413.8 mg/kg, were recorded in the temporary stream alluvial sediments flowing close to AMRS into the Nizhneye Lake. Such levels of oil products are probably resulted from fuel leaks due to previous man-caused activities.

Table 3.15 – Oil product content in the soils of the Mount Vechernyaya field base location, mg/kg

Sample No	Oil content, mg/kg
1	9.42
2	7413.8
13	28.9
15	5.9
25	11.1
27	6.0
29	10.2
31	2.5
34	12.6

Basically, the environmental and geochemical studies performed have demonstrated that the chemical composition of snow and lake waters in the area of the planned BAS deployment do not revealed any significant anthropogenic changes, although the content of microelements increased. Presence of oil products in the lake waters, sediments and soils, as well as increased content of heavy metals in the lake sediments was also detected. High concentrations of heavy metals and oil products in some soil areas tested result most probably from previous man-caused activities: closely to MBM in 1979-1989 there were an open ground of heavy transport and temporary depot of fuel and lubricants in barrels for cross-country vehicles GTT, ATT.

3.7.6. Biotic components

Reference to investigations performed, the previous production and scientific activities at the Mount Vechernyaya field base location are proved to cause no visible damage to the local biotic components: nesting birds, mosses and lichens. Possibly, there were some changes in the composition of water cenoses, but no monitoring findings prior to the field base construction are available to reliably identify such changes, if any.

3.7.7. Aesthetic value of the landscape and natural surroundings

The aesthetic value of the landscape in the field base location and its naturalness declined slightly due to man-caused activities: e.g., construction works, waste accumulation. However, the aesthetic value of the area is still high.

3.7.8. Projection of the state of environment in absence of the proposed activity

As shown above, the Mount Vechernyaya surroundings were largely transformed by the influence of the past activities, and nowadays activities cause a lesser impact. In these circumstances, the absence of the proposed activity (BAS construction), while maintaining the environmental impact at the current level, will lead to changes comparable with the changes due to the proposed activity.

4. Environmental impact assessment of the planned activity

4.1. Sources of impact

4.1.1. Sources of impact at station construction

4.1.1.1. Station construction phases

Station design concept

As it was previously mentioned in Section 2.4, the construction technology involves the station to be installed on-site from pre-assembled block modules. The components (wagon sections, basements, stairs, ladders, etc.) are expected to be delivered to Molodyozhnaya Station raid by RAE vessels, then transported by helicopter to the station construction site (see Chapter 2). The modules are planned to be installed by helicopters directly on bedrocks without excavations, piling and other works that may cause a substantial impact on the environment.

No heavy construction equipment (bulldozers, cranes, etc.), trucks, snowmobiles and/or welding and paint works are planned to be performed on site.

Main construction phases:

- *preparatory phase*
- *first construction phase*
- *second construction phase*

At the preparatory and first construction phases applied and will keep on applying the Mount Vechernyaya RAE / BAE field camp infrastructure (MBM, power lines, warehouses, storage platforms, etc.), as well as the available equipment: diesel generators, motor vehicles, etc. (with relocation, if required).

The following works were fulfilled at the preparatory phase (2012-2013):

- station design elaboration;
- station site (alternative sites) selection;
- major facilities location;
- field environmental studies (environmental evaluation, on-site surveys of the deployment places for the planned facilities and guarded objects);
- IEE and CEE drafting.

Any impacts that may arise during the preparatory phase are mainly related to the scientific and domestic activities in the field camp (field studies) and will not practically differ from impacts during normal field seasons.

During the *first construction phase* (2014-2018), 8 residential & production modules and service-specific pavilions and boxes will be delivered and deployed: laboratory & residential building, single-storey; service & residential building, single-storey; laboratory & residential building, two-storey; production & residential building, two-storey; sanitary & hygiene premises; heated and unheated warehouses; garage & storage facilities. Modules specifications are given in Chapter 2.

The major activities, as planned for this period, shall be:

- site preparation for first-stage facilities installation (markings, removal of stones, etc.);
- delivery of station modules, equipment and materials on Academician Fedorov and Academician Treshnikov vessels of the Russian Federal Service for Hydrometeorology and Environmental Monitoring;
- transfer of facilities, equipment and materials to the construction site by helicopters;
- installation of the module basements;
- installation of modules to the basements, assembly works;
- relocation of the diesel generators.

During the period 2014-2018, fuel and lubricants will be stored in barrels at an outdoor platform. Fuel storage facilities are scheduled for the second construction phase.

At the *second construction phase* (2019-2020 and until 2025), the following facilities will be delivered and deployed, i.e.:

- non-magnetic geophysical pavilion;
- fuel & lubricant tanks (2 tanks of 50 m^3 each, 1 tank of 25 m^3, 2 tanks of 3-5 m^3 each);
- 2 diesel power stations of 100 kVA capacity each;
- incinerator (waste disposal burner);
- press for empty fuel barrels disposal;
- jet dump device with sewage collector for water waste disposal to the coastal marine area;
- water supply system (to buildings);
- 2 refuel pumps (diesel/petrol) for motor vehicles.

The major activities, as planned for the second construction phase:

- site preparation for second-stage facilities installation (markings, removal of stones, etc.);
- delivery of station modules, equipment and materials on vessels;
- transfer of facilities, equipment and materials to the construction site by helicopters;
- installation of the modules (facilities);
- assembly works;
- installation and assembly of life support systems (diesel generators, water supply and disposal systems, solid waste & wastewater storage and disposal systems);
- site preparation (platform construction) and installation of fuel storage tanks;
- site preparation and installation of an incinerator (waste disposal burner);
- piping (fuel supply, sewage).

4.1.1.2. Impacts on sea delivery of the station modules, equipment and cargo

For delivery purposes, Academician Fedorov and Academician Treshnikov vessels of the Russian Federal Service for Hydrometeorology and Environmental Monitoring are planned to be used.

The major characteristics of the vessels are given in Table 4.1 below. Referring to the environmental impact (emissions, wastes generation, discharge, etc.), the vessels comply with the requirements of the Protocol on environmental protection and MARPOL. The major cargo deliveries to the BAS construction site will be affected by the vessels to accompany the cargo deliveries to the Russian Antarctic stations.

Table 4.1 – Major characteristics of Academician Fedorov and Academician Treshnikov RAE vessels

Parameter	Academician Fedorov	Academician Treshnikov
Displacement	16 336 t	16 336 t
Length	141.2 m	133.59 m
Width	23.5 m	23.0 m
Height	13.3 m	13.5 m
Draft	8.5 m	8.5 m
Engines	2 x Wärtsilä 16V32D, 2 x Wärtsilä 6R32D	3 Wärtsilä main diesel generators
Capacity	2 x 6000 kW, 2 x 2250 kW	2x6300 kW, 1x4200 kW
Speed	16.5 knots	16.0 knots
Crew	90 people	60 people

4.1.1.3. Impacts at cargo vessel-to-site transfers and station assembly works

Given the planned construction technology, the environmental impact caused by the major source of exposure, Ka-32 helicopter, as well as by activities related to fuel storage facilities and wastewater discharge collector construction, was subject to assessment.
The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, screwdrivers, perforators, etc.) will be insignificant and was not subjected to assessment.

Sources of pollutants emission

The main source of air polluting emissions during the BAS construction will be the helicopter to deliver the modules from Molodyozhnaya Station. The calculation of helicopter-caused emissions is based on the helicopter's specifications, number of takeoff and landing cycles, specific fuel consumption in accordance with the Calculation Methodology (*Calculation Methodology..., 2008*). The Ka-32 helicopter performance characteristics are given in Table 4.2 below.
Ka-32 helicopter is equipped with two 2200 HP TV3-117 engines, fueled by T-1, TS-1, RT aviation kerosene (Table 4.3).
Engine's specific fuel consumption, kg/hp•h: takeoff mode – 0.21-0.23, cruise mode – 0.25-0.27.

Table 4.2 – Ka-32 helicopter major performance characteristics (*Ka-32 Helicopter Flight Manual*)

Parameters	Unit	Ka-32
Maximum takeoff weight	kg	11000
Empty weight	kg	3240
Number and diameter of rotors	n x m	2x15,9
Helicopter's total length with rotors	m	15,9
Main fuel tank capacity	l	3450
Extra fuel tank capacity	l	1310
Type of engines	-	TVZ-117
Number and takeoff capacity of engines	n x HP	2x2200
Hourly fuel consumption at cruising speed (h=500 m)	kg/h	270
Cruising range fuel capacity (30 min. flight)	kg	140
Cruising speed (h = 500 m)	km/h	220
Maximum speed	km/h	230
Flight range without extra fuel tanks added (h=500 m)	km	600
Flight range with extra fuel tanks (h=500 m)	km	1100
Maximum flight altitude	m	3500
Maximum cargo weight:		
- on-board load	kg	3700
- external load	kg	5000

Table 4.3 – Major performance characteristics of Ka-32 helicopter's TVZ-117 engines (*according to manufacturer's specifications*)

Parameter	TVZ-117B	TVZ-117BMA
Power at emergency mode	2200 HP	2400 HP
Power at takeoff	2000 HP	2200 HP
Specific fuel consumption	0.220 kg/HP•h	0.215 kg/HP•h
Power at cruising	1500 HP	
Dry weight	295 kg	
Assigned life	7500 flight hours	

Emission calculation

The calculation of helicopter emissions is made in accordance with the (*Calculation Methodology..., 2008*). The emission factors applied are given in Table 4.4 below.

Table 4.4 – Ka-32 helicopter emission factors, based on ICAO standard (*Calculation Methodology..., 2008*)

Engine type	Polluting emissions per standard flight cycle (kg)			
	CH	CO	NO_x	Smoke (particulate matter)
TVZ-117	0.17	0.95	1.5	0.032

Each helicopter run (flight cycle) is assumed to deliver and install one module platform or one wagon section of production & residential or laboratory & residential module. Consequently, two flights will be required to transfer one complete module. Thus, during the station construction 4-6 helicopter flights will be performed annually for module deliveries and 3-5 extra flights to deliver procurement & instrumentation. The average total for the first construction phase will be about 10 Ka-32 helicopter flights annually. Based on this number of flights, polluting emissions during the construction phase is assessed (per year) as follows: nitrogen oxides - 30 kg, carbon oxides - 19 kg, hydrocarbons - 3.4 kg, particulate matter - 0.64 kg (Table 4.5).

Thus, the share of this air polluting source is assessed to be minor.

Table 4.5 – Ka-32 helicopter emissions during the BAS construction (first phase), kg/year

Engine type	Polluting emissions per standard flight cycle (kg)			
	CH	CO	NO_x	Smoke (particulate matter)
TVZ-117	3.4	19	30	0.64

Mechanical impact

The mechanical impact on soils, ground and rocks at the construction stage will be associated with placement of the station structures: block modules, platforms for fuel tanks, as well as central collector piping.

For installation of block modules, platforms, metal tanks, movement of collector pipes and supports, motor vehicles will be used. During the construction works, no extraction (disturbance) of rocks is planned to be effected.

The mechanical impact during the construction works will be limited in time.

Noise

Noise during the construction works will be primarily caused by machinery and equipment. The sources of noise comprise of:

- noise that comes from moving components of engines (mechanical noise) due to constant vibration;
- noise of exhaust gases;
- noise of air circulation in engine's forced air cooling system;
- electromagnetic noise and other noise sources.

The most significant source of noise during the BAS construction will be helicopter, used to transfer the station modules and other cargo.

The Ka-32 helicopter noise characteristics are acknowledged to be permissible and complying with the applicable requirements of the international environmental standards.

Reference to EASA certificate issued in 2009, the effective perceived noise level (EPNL) of this helicopter conforms to the permissible limits and amounts to 100.4 dBA for takeoff, 99.4 dBA for cruising and 101.4 dBA for landing. These parameter readings were obtained during the Ka-

32 helicopter flight tests in the operating modes and flight path patterns, as regulated by ICAO, and did not exceed the limits as applicable for helicopters with full flight weights of 11.000 kg (Table 4.6).

Table 4.6 – EASA noise certificate, issued to Kamov manufacturers for Ka-32 helicopter *(EASA Type-Certificate.., 2009)*

EASA file No.	Max. weight		Takeoff, EPNL		Cruising, EPNL		Landing, EPNL	
	Takeoff (kg)	Landing (kg)	Value*	Limit	Value*	Limit	Value*	Limit
D302	11000		100.4	100.4	99.4	99.4	101.4	101.4

The noise caused by helicopters can be harmful, if flying over the places of nesting penguins and other birds. In this connection, the routes shall be scheduled most optimally (see Section 4.2).

The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, etc.) will be insignificant and local.

Wastes generation

According to the station construction plan modules of station will be build in parallel with their functioning with minimal attract of additional builders. Therefore estimate of household wastes generation (and wastewaters) at station operation account their formation at station construction on the assumption of BAE staff for 2014-2018 – 5-6 man in seasonal variant of station operation; part of them will be involved in construction of station (chapter 4.1.2).

During the construction a certain amount of other wastes will be generated, mainly from packing and fastening materials. However, the amounts are assessed to be insignificant. The wastes will be sorted out and stored (or disposed of) separately with subsequent transportation of residues to the mainland or partially transported to the vessel by helicopter during unloading operations.

Fuel and lubricant spills upon helicopter refuel and maintenance

The helicopters are expected to be refueled and maintained on board the vessels; in this connection, the possibility of fuel spills or other leaks at the BAS construction territory trends to minimum.

Sewage

Any sewage will be generated basically from operation of the staff engaged in the station construction. For waste water storage and treatment, the appropriate tanks currently existing at the BAE field base will be used. As mentioned above an estimate of waste water load for 2014-2018 was made in assumption of the BAE staff 5-6 men in seasonal mode. The expected increase of sewages will be basically proportionate to the staff increase, as compared to the current amounts.

Impact on the aesthetics of the landscape and natural surroundings

Given the significant disturbance of the natural landscape at the BAS construction site, the planned construction will not deteriorate, but is expected to improve the aesthetic features of the landscape. The station construction is anticipated to blend seamlessly into the Mount Vechernyaya landscape.

Generally, the construction works will impact:

- soils, ground, rocks (upon block module deployment); the aggregate hard surface area to be covered by the residential & production facilities of the 1st stage of station will amount to approx. 150 m^2; certain area will be covered by auxiliary facilities, platforms and communications;
- ambient air (due to emissions from cargo deliveries by helicopters);
- snow & ice cover (upon cargo transportations, fuel and collector piping).

The block modules and other structures are not planned to be installed at areas with developed lichens or mosses; in this respect, the impact on biota will be minimal.

The overall impact during the construction works (except for polluting emissions and noise) will be localised within the site boundaries.

4.1.1.4. Activities for reduction of impacts during station construction

At station construction the following measures on impacts reduction will be applied:

- on board of the vessels, during cargo and module deliveries: compliance with MARPOL and other regulatory requirements, time-saving schedule to reduce the duration of stay in the Antarctic waters;
- at helicopter operation: flight route optimisation, tough scheduling of the construction and handling operations, optimal helicopter loads, flight time minimisation, reduced flight cycles;
- at site preparation: prevention of dust generation upon site ground works, drilling holes;
- mechanical assembly works: high efficiency, speed and quality of works being performed, which would benefit to reduction of polluting emissions and noise exposure;
- piping and power cable line laying: soil and ground disturbance minimisation, in particular, in respect of vegetation-covered areas;
- use of motor vehicles: optimal routes scheduling;
- sewage treatment, waste management: solid and liquid wastes minimisation, waste transfers to the mainland.

4.1.2. Sources of impacts during the station operation

When operating the station, the following devices will serve as sources of environmental impact, i.e.:

a) power supply systems and mechanisms (diesel generators, heating devices);
b) motor vehicles;
c) fuel storage and distribution facilities (storage tanks, fuel pipes, refuel systems);
d) water supply and sewerage systems;
e) solid waste management systems;
f) scientific equipment and instrumentation;
g) communication facilities;
h) auxiliary mechanisms;
i) station supply and procurement systems (vessels, helicopters).

The operation of most equipment and machinery will be accompanied by emissions, discharges, waste generation, noise, electromagnetic exposures. In addition, spills and leaks of fuel, lubricants, coolants, wastewaters and liquid wastes are also possible.
The environmental impact analysis was done by types of exposure and includes both quantitative and semi-quantitative assessment of air pollution, impact on surface waters due to discharges and leaks, impact on soil due to leaks and accumulation of wastes, impact of noise and electromagnetic interference, mechanical (physical) impact on the ground (soils).

4.1.2.1. Air emission sources

The impact assessment at the first years of station operation is based on the planned use of basically the same mechanisms that are currently available at the Mount Vechernyaya field base:
- diesel generators - 3 pieces, currently in operation; diesel generator types: DG-20 AD16-T400-2RP, DG-60 AD60-T48C-2RP and GEKO 6401 (Figure 4.1); specific fuel consumption – 1.43 to 15.5 l/h, diesel-fueled;
- generators with petrol engines (3 pcs.), in occasional operation, basically in standby mode;
- diesel-operated blow heaters, occasional operation;
- motorised saw, occasional operation.

The specifications of the permanent sources of pollution are given in Tables 2.2-2.3 (Section 2).
The second construction phase will involve additionally the startup and commissioning of wastes incinerator of 50 kg/h capacity (presently, KTO50.K20 type incinerator is planned to be installed) (Figure 4.2); operation frequency – once a week (5-8 operating hours). Two DG-100 diesel generators will be additionally installed and will work alternately.

Figure 4.1 Diesel generators at Mount Vechernyaya field base

Figure 4.2 Incinerator KTO50 (picture from producer site)

BAS will also use the following motor vehicles: petrol-propelled Lynx YETI PRO-800 and YETI TUV-1300 snowcats and Outlander MAX 4X-800 quadricycle, as well as diesel-propelled GAZ-3409 BOBR all-terrain vehicle.

The specifications of the mobile sources of pollution are given in Table 4.7 below.

The wastes will be incinerated in compliance with Annex III to the Protocol on Environmental Protection.

Table 4.7 – Characteristics of motor vehicles and machinery used at Mount Vechernyaya BAE field camp

Type of motor vehicle or machinery	Fuel consumption, depending on output, ref. to the manufacturer's specifications		Type of fuel	Actual fuel consumption in Antarctic conditions
	% output/kW	l/h		
GAZ-3409 BOBR all-terrain vehicle	l/h per 100 km	5.0 61.5	diesel	6.00 79.8
YETI PRO-800 snowcat	per 100 km		petroleum	50.0
YETI TUV-1300 snowcat	per 100 km		petroleum	70.0
MAX 4X-800 quadricycle	per 100 km		petroleum	60.0
2.4 kW MAKITA saw		0.75	petroleum	0.83

The consumption of various fuels at Mount Vechernyaya field base for 2011-2012 field season is shown in Table 4.8 below.

Pollutants emission assessment

The main sources of emissions during the station operation are combustion processes of the stationary engines and motor vehicles, and in future - burning of solid wastes. Fuel storage and distribution, liquid waste and sewerage systems are also considered as sources of emissions; however, their contribution to the total emissions is insignificant due to the Antarctic climatic conditions and was not counted.

Table 4.8 – Consumption of fuel by vehicles and mechanisms for 2011-2012 BAE field season *(according to the 4th BAE Report)*

Fuel type and grade	Motor vehicle or mechanism	Run (km), operation (hours)	Fuel & lubricant consumption, l (actual value)
Diesel fuel	GAZ-3409 BOBR	30	24
	DG-20 (kVA-20)	350	1396
	DG-60 (kVA-60)	12	96
	Geko 6401ED-AA	310	620
	20 kW blow heater	37	70
	44 kW blow heater	37	150
	Total		2356
Petroleum A-95	Quadricycle	14	4
	V-1300 snowcat	-	-
	V-800 snowcat	1320	354
	V-800 snowcat	962	260
	Geko 7401	26	50
	Geko 1001	44	28
	Total		696
Petroleum H-80	2.4 kW motorised saw	8	6
	Geko 7401	58	194
	Total		200

For CEE purposes, gross emissions (per field season and per year) and maximum emission values (g/season) were calculated. Gross emissions are used for general and comparative characteristics of the sources of exposure, maximum emissions are applied to assess the impact on the environment using AERMOD model (Section 4.2).

The emissions are calculated subject to two different scenarios:

- Scenario 1 – station seasonal operation; the overall fuel consumption by the stationary and mobile sources per field season is assumed as 2:1 ratio to the current consumption values;

- Scenario 2 – year-round operation; the overall fuel consumption by the stationary and mobile sources per field season is assumed as 8:1 ratio to the current consumption values.

According to the first scenario, the fuel consumption will be as follows: diesel - 4.2 thous. litres; petroleum - 1.2 thous. litres, waste incineration – 300 kg (wastes will be not incinerated on-site at the first stage - see chapter 4.2.6). According to the second scenario: diesel - 16.8 thous. litres, petroleum - 4.8 thous. litres, waste incineration - 1600 kg.

The calculation of pollutants emission from diesel generators is made by the approved method (*Calculation methodology..., 2001*) (Table 4.9). The emissions from mobile sources and incinerator are based on emission factors, as specified by the EMEP/EEA Emission Inventory Guidebook (*Atmospheric Air Pollutant Emission ..., 2009*) (Table 4.10 - 4.11); Tier 1 approach used. The emissions from petrol-fueled generators, blow heaters, motorised saw was not counted due to their occasional operation.

Table 4.9 – Emission factors for stationary diesel installations, g/kg fuel (*Calculation methodology..., 2001*)

Group	Emission factor, g/kg fuel					
	CO	NO_x	CH	Particulate matter	SO_2	Benzo(a)pyrene
A	30	43	15.0	3.0	4.5	$5.5\ 10^{-5}$

The methodology states that any fixed diesel installation of foreign brands, meeting the requirements of the environmental laws of EEC, United States, Japan the emission factors can be reduced for CO – 2 times; NO_2 and NO – 2.5 times; CH, particulate matter and benzo(a)pyrene - 3.5 times respectively. Therefore, the actual emissions can be significantly lower than those as estimated.

Table 4.10 – Emission factors for domestic waste combustion (*Atmospheric Air Pollutant ..., 2009*)

Substance	Measurement unit	Tier 1 emission factor
CO	g/kg	0.7
NO_x	g/kg	1.8
CH	g/kg	0.02
SO_2	g/kg	0.4
TSP	g/kg	0.3
PM10	g/kg	0.23
PM2.5	g/kg	0.15
Pb	g/kg	0.0008
Cd	g/kg	0.0001
Hg	g/kg	0.0011
PCDD/F	µg TEQ/kg	0.35

Results of emission calculations are summarised below in Tables 4.12 and 4.13.

In total during the BAS operation the total air pollutants emissions will amount to 1090.6 kg/season (seasonal mode) or 4363.6 kg/year (wintering mode), sharing 72.5% for motor vehicles and 27.3% for diesel generators.

The main pollutants are: carbon monoxide (60% of total emissions), volatile organic compounds (24%) and nitrogen oxides (12%). Particle matter emissions are expected to amount to 8.4 kg/season or 33.5 kg/year.

Table 4.11 – Emission factors for non-road transport
(*Atmospheric Air Pollutant ..., 2009*), g/t

Substance	Emission factor
CH_4	2200
CO	620793
NH_3	3
VOC	242197
NOx	2765
TSP	3762
PM10	3762
PM2.5	3762
Cd	0.01
Benzo(a)pyrene	0.04
PCDD/F	0.1 μg I-TEQ

*- Standardised Toolkit for Identification and Quantification of Dioxin and Furan Releases, 2005

Among toxic pollutants a particular place belongs to PAHs and dioxins/furans, which will be are emitted from fuel combustion and waste incineration, but their emissions due to expected low amounts of incinerated wastes will be negligible.

Table 4.12 – Pollutants air emission at BAS operation, kg/season
Scenario 1, seasonal mode

Substance	Diesel generators	Motor vehicles	Incinerators	Total
CO	90.3	558.7	0.21	649.2
NOx	125.0	2.49	0.54	128.0
SO_2	15.9	-	0.12	16.0
VOC	41.8	218.0	0.006	259.8
TSP	8.4	3.39	0.09	11.9
PM10	8.4	3.39	0.069	11.9
PM2.5	8.4	3.39	0.045	11.8
NH_3	-	0.003	-	0.0
CH_4	-	1.98	-	2.0
Pb	-	-	0.24 g	0.24 g
Cd	-	0.01 g	0.003 g	0.013 g
Hg	-	-	0.033 g	0.033 g
Benzo(a)pyrene	1.5 г	0.036 g	0.001 g	1.537 g
PCDD / F		0.09 μg I-TEQ	0.105 μg I-TEQ	0.195 μg I-TEQ
Total	**298.2**	**791.3**	**1.1**	**1090.6**

Maximum emissions

The maximum emission levels are calculated for main stationary sources that make a considerable contribution to total emissions. Primarily, these are diesel generators. The calculation is performed for the maximum actual fuel consumption (full capacity operation).

Table 4.13 – Pollutants air emission at BAS operation, kg/year
Scenario 2, wintering mode

Substance	Diesel generators	Motor vehicles	Incinerator	Total
CO	361.2	2234.9	1.12	2597.22
NOx	499.9	9.95	2.88	512.73
SO_2	63.5	-	0.64	64.2
VOC	167.4	871.9	0.032	1039.33
TSP	33.5	13.5	0.48	47.48
PM10	33.5	13.5	0.368	47.368
PM2.5	33.5	13.5	0.24	47.24
NH_3	-	0.01	-	0.01
CH_4	-	7.92	-	7.92
Pb	-	-	1.28 g	1.28 g
Cd	-	0.04 г	0.016 g	0.056 g
Hg	-	-	0.176 g	0.176 g
Benzo(a)pyrene	6.1 г	0.14 г	0.007 g	6.147 g
PCDD / F	-	0.36 μg I-TEQ	0.56 μg I-TEQ	0.92 μg I-TEQ
Total	**1192.5**	**3165.2**	**5.8**	**4363.5**

Measures to reduce the air pollutant emissions and impacts

Measures to reduce the air emissions and to minimise the negative impact include:

- organisational measures;
- primary and secondary measures.

Organisational measures:

- transport route optimisation to reduce the vehicle mileage travelled;
- consideration of factors influencing pollutant dispersion;
- consideration of emission sources placement in respect of sensitive ecosystems;
- emission control (monitoring).

The primary measures shall include:

- use of high-quality fuel, regular maintenance;
- fuel, power and heat saving technologies.

The secondary measures shall include:

- the emission sources to be equipped with emission abatement systems;
- installation of stacks of optimum height.

4.1.2.2. Noise exposure sources

The major and permanent noise exposure sources at the BAS territory are diesel generators, primarily, DG-60 AD60-T48C-2RP. Geko 6401ED-AA and DG-20 AD16-T400-2RP generators were not taken into account, as they will operate as standby for DG-60 reserve. The other stationary sources (pumps, motorised saw, etc.) will produce considerably lower and irregular emissions, and they were also neglected for calculation purposes. In future, DG-100 plant is expected to be installed, having noise parameters similar to those of DG-60. The equipment noise characteristics are summarised in Table 4.14 below.

Table 4.14 - Noise characteristics of diesel generators, dB

Octave bands, Hz	63	125	250	500	1000	2000	4000	8000	дБ(А)
Sound pressure levels, dB	74.9	74	67.5	62	57.7	53.4	48.6	44.3	65

Noise exposure, as generated by motor vehicles, will be spread out over a large territory and will be not too high. Nesting birds will be out of the range of influence.

Helicopter noise impact in the station operation range will be short in time (cargo deliveries to the station early in the season and waste removal at the season closing) and will cover the area approximately coincident to the construction impact area. The Ka-32 noise characteristics are shown in Table 4.6 above.

Measures to reduce the noise exposure

The noise-reducing measures can be grouped into:

1. Organisational
2. Architectural
3. Engineering

Engineering measures can be divided into 2 groups:

1) reduction at the source of generation;
2) reduction on the noise pathway.

Organisational activities shall include control and limitation of traffic routes (primarily, helicopter flights, in particular, in areas sensitive to noise - for example, nesting birds) - flight routing, scheduling and altitude selection, taking into account the impact on birds, optimal arrangement of noise sources in relation to the sensitive receptors, optimal placement of production and residential buildings with respect to noise sources.

Architectural measures shall include: zoning, avoidance of redundant transport routes, creation of noise barriers (if necessary).

The methods aimed at noise spreading reduction shall include acoustic insulation and sound absorption applications.

Engineering measures to apply depend on the nature of the noise produced. Mechanical noise is reduced by top precision machining and assembly of components, use of protective covers. Aerodynamic noises are suppressed by mufflers.

Noise spreading suppression can be achieved by:

1. Acoustic insulation. The technology is based on noise reduction features due to reflection of sound waves from an obstacle. For this purpose, partitions can be established at the noise paths.

2. Sound absorption. The technology is based on noise reduction features due to transfer of sound energy into heat in absorbing material pores. It can be applied in residential and production module construction. Noise produced by constant engine vibration, mechanical noise, forced cooling system operation noise can be reduced by use of sound-absorbing jackets or by application of sound absorbing materials for the premises decoration, i.e.: foam, wooden lining, perforated soundproof panels.

Noise produced by exhaust gases can be reduced by using various extra mufflers: standard mufflers for diesel engines can reduce the exhaust noise by 29 or 40 dB. DG-60 is equipped with soundproof enclosure (Euro-cover) and standard silencer (29 dB). Besides, it features a low-speed design with relatively low noise exposure.

4.1.2.3. Fuel storage and distribution

Presently, fuel and lubricants (diesel, gasoline) are stored in 200-litre barrels located at two open-air platforms areas on pallets and on rocks in the vicinity of the planned BAS deployment site (see Section 3). Lubricating oils and antifreeze liquids are stored in 5 and 20 liters canisters in indoor warehouse; diesel generators and other equipment will be refueled manually. This fuel storage and distribution plan will be used for the entire first phase operation of the station.

For the BAS seasonal operation, it is planned to install special tanks for diesel fuel of 50 m^3 and 25 m^3 capacity and to use metal barrels for petroleum storage on a specially equipped platform. Oil, antifreeze, brake fluid and other oil products will be stored in specially designed closed (storage) facilities. The expected storage amounts of diesel fuel – max. 20 t, petroleum – max. 2 thous. l, lub oil – max. 0.5 t, antifreeze and other commercial fluids – max. 0.2 t.

In case of year-round (wintering) option of the BAS operation, it is planned to install an extra tank for diesel fuel of 50 m^3 capacity; the expected storage amounts will increase substantially: diesel fuel - up to 180 t, petroleum – max. 5,000 l, lub oil – max. 1 t, antifreeze and other commercial fluids – max. 200 l.

Oil spills and leaks

When operating the station, leaks and spills of diesel fuel, petroleum, lub oils, oil sludge may occur. The most likely locations of leaks are on-site fuel & lubricant storage tanks, vehicle refuel points. To prevent leaks and spills, special measures will be taken during vehicle refueling and fuel supply to the diesel generators. In case of accidental spills and unauthorised use of oil products, oil sorbents are expected to be applied, in particular, Oil Split agent in various forms - granules, powder, liquid, as well as installation of protective barriers and other facilities to localise and neutralise fuel spills. It is also planned to have some reserves of peat-based oil sorbent, as developed by the Institute for Nature Management of the National Academy of Sciences of Belarus. These measures and other remedies will ensure:

- prevention of oil infiltration deep into the soils and grounds, rapid elimination of leaks, collection of spilled oil products;
- prevention of oil products migration into surface waters and sea.

As evidenced by the investigations made (Section 3), oil spills used to occur during previous operations of Soviet Antarctic Expeditions in 1979-1989.

4.1.2.4. Water supply and sewage disposal

Water consumption

Water consumption estimated according to applicable rules and regulations in force, depending on the internal sanitary and engineering arrangement of the station premises, as well as based on the previous experience of the Vechernyaya Field Base operation.

According to the station layout and based on the field base operation practice, the required minimum amount of fresh water during the BAS seasonal operation (5-6 people) will be 5-6 m^3 per month, water consumption may increase to 10-12 m^3; the required minimum amount of water for 10-12 people during all-year-round operation will be 9-10 m^3 per month, while, under certain circumstances, it may raise up to 18-20 m^3 per month.

Intake, pumping and water management facilities

Potable and domestic use water will be basically supplied from the Nizhneye Lake, being selected the principal water supply source. During two months (December-January), water will be pumped from the nearby temporary lakes into water storage metal containers. During the other months, water will be transported in tanks from the Nizhneye Lake. The water pumping and management containers are specified in Section 2 above. The potable water quality generally complies with the applicable sanitary standards. The Nizhneye Lake waters will be subject to certain impact due to water intake.

Wastewater disposal

The first-phase station operation will apply the local (independent) sewerage system. Pursuant to the existing building rules and regulations, self-contained sewage systems shall provide for the wastewater collection from residential and other premises, wastewater transfer to the accumulation or treatment facilities, as well as storage or treatment in accordance with the sanitary and environmental requirements and further disposal.

Wastewater disposal standards

Pursuant to the applicable standards, the average daily volume of domestic wastewater shall be equal to the estimated average daily water consumption; however, these values may be adjusted to suit the particular arrangements of the house, individual arrangements and household specifics. The possibility of separate domestic wastewater (from kitchen sinks, bathtubs, sinks, etc.) and fecal sewage shall be ensured. Fecal sewage volume shall be approximately assumed to count 30% of the standard wastewater disposal volume.

Wastewater volume for 5-6 explorers and BAS seasonal operation wastewaters are estimated to range 4.5-5.0 m^3 to 9-10 m^3 per month; for 10-12 explorers at BAS year-round operation – ranging 7.5-9.0 m^3 to 15-18 m^3 per month.

Sewage facilities and external pipelines

Sewage facilities and external pipelines will be designed in accordance with the sanitary standards SNiP 2.04.01-85 and SNiP 2.04.03-85.

According to the station construction design, wastewaters will be collected in heated storage tanks of 200-250 or 400 l capacity, fitted under each module. Each tank will be equipped with self-contained hydraulic pump, and, upon accumulation, domestic wastewaters will be transported to the seacoast and discharged via special hose-pipe (up to 100 m long) into the sea at places of adequate mixing and rapid dissipation.

In future, storage tanks of individual modules will be connected in an integrated sewerage system with automatic discharge of domestic wastewaters into the central collector.

Wastewater collectors and treatment facilities

Wastewater discharges will comply with the sanitary standard SanPiN 2.1.2.12-33-2005 – Sanitary requirements for surface waters protection from pollution, as well as the requirements of SanPiN 4630-88 and Protocol on Environmental Protection to the Antarctic Treaty.

Pursuant to Article 5 of the Protocol on Environmental Protection, sewage and domestic liquid wastes may be discharged directly into the sea, taking into account the assimilative capacity of the receiving marine environment, provided that:

a) such discharges are organised, if possible, in areas, which are reported to fit for waste waters initial dilution and rapid dispersal; and

b) large quantities of such wastes (generally produced at the station at austral summers with weekly average staff of 30 people or more) are treated at least by maceration.

The first-phase BAS operation does not plan to engage construction of wastewater treatment facilities. Wastewaters will be discharged from the collecting tanks into the central collector. The collector is expected to be piped to a streambed (natural ravine), which entry into the Terpeniya Bay near the Dostupny Cape, which is consistent with the provisions of Article 5, Schedule 3 of the Protocol. In such case, the sewerage pipe will be 150-200 m long (Figure 4.3).

The collector's alternative option shall be piping directly from the collector site to the seacoast at the Terpeniya Bay near the Dostupny Cape. In this case, the length of collector pipeline might range 800 to 1000 m. The pipeline will be laid at the top surface points, with supports mounted on bedrocks. The second (alternative) option increases the project costs significantly, and contributes to the risk of pollution in case of emergencies, such as ruptures and freezing of pipes due to adverse natural effects - landslides, erosion and thawing of moraine deposits, mud snowfields, major snowdrifts etc.

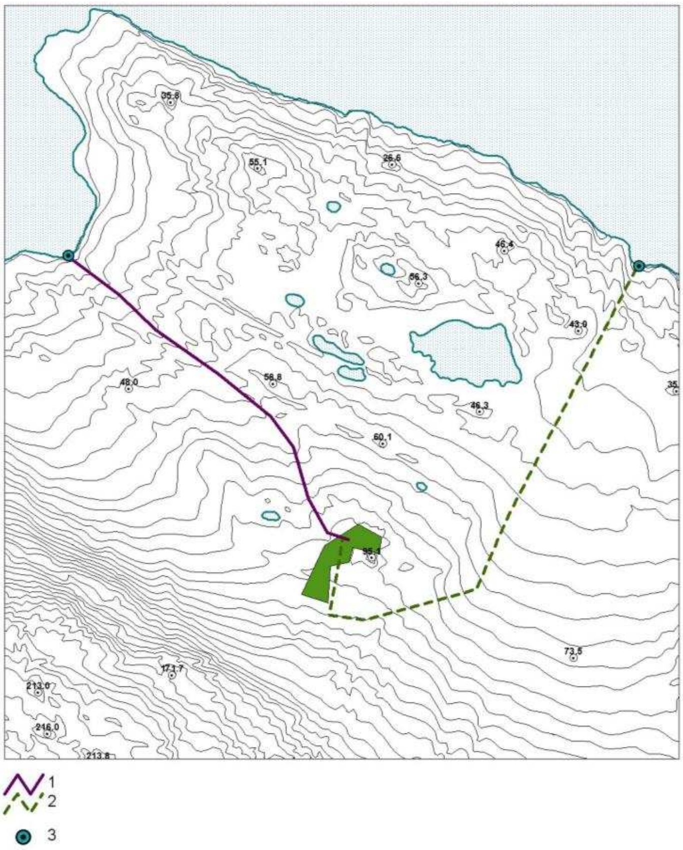

Figure 4.3 – BAS domestic wastewater collector layout (1 – main option, 2 – alternative option, 3 – discharge point)

Pursuant to the construction regulations, the adequate insulation system to prevent freezing will be arranged.

When designing self-contained (local) sewage systems, the applicable sewage sanitary requirements for self-contained (local) water supply systems and engineering solutions of the facilities subject to sewage will be taken into consideration. In particular, it will be necessary to avoid any possible sewage contamination (either from storage tanks or pipelines due to leaks) of ponds, glaciers and snowfields, as stipulated by the applicable regulations.

Fecal wastes treatment

Every person produces annually about 50 l of faeces and 500 l of urine in average. A conventional toilet system consumes 12,000 l of water to drain these wastes annually. Every person annually excretes about 60 l of faeces, if added with toilet paper, which contain 0.55 kg of nitrogen and 0.18 kg of phosphorus.

Fecal wastes will be burned by Incinolets, being installed at each module. The planned amounts of fecal wastes to be incinerated for 5-6 staff explorers are assessed to be 25-30 kg/month., or

100-120 kg per season (in case of BAS seasonal operation option), or 300-360 kg/year (in case of all-year-round operation).

Incinolets will have some impact on the environment, but no quantitative estimation of emissions was performed due to unavailable reference data.

4.1.2.5. Assessment of the environmental impact due to wastewater generation and discharge

To assess the environmental impact, as related to wastewater generation, the content of pollutants in wastewater is required. No sampling of wastewaters at the BAE field camp was made. When assessing the environmental impact, the averaged composition of wastewaters was taken into consideration according to the (*Methodological Recommendations for calculations.., 2001*) (Table 4.15).

Table 4.15 – Averaged characteristics of domestic wastewaters from settlements (*Methodological Recommendations for calculations.., 2001*)

Pollutant	Concentration, mg/l
Suspended solids	110
$BOD_{complete}$	180
COD	250
Fats	40
Ammonia nitrogen	18
Chlorides	45
Sulfates	40
Dry residue	300
Oil products	1.0
Surfactants (anionic)	2.5
Phenols	0.005
Iron, total	2.2
Copper	0.02
Nickel	0.005
Zinc	0.1
Chromium (+3)	0.003
Chromium (+6)	0.0003
Lead	0.004
Cadmium	0.0002
Mercury	0.0001
Aluminum	0.5
Manganese	0.1
Fluorides	0.08
Phosphorus in phosphates	2.0

Assumed volume of wastewaters – 40 m^3 for seasonal option and 216 m^3 for wintering option. The results of calculation are shown in Table 4.16.

Table 4.16 - Estimated gross pollutants discharges into the sea with sewage during BAS operation, kg/season and kg/year

Pollutant	Seasonal mode	Wintering mode
Suspended solids	4.4	23.76
$BOD_{complete}$	7.2	38.88
COD	10	54
Fats	1.6	8.64
Ammonia nitrogen	0.72	3.888
Chlorides	1.8	9.72
Sulfates	1.6	8.64
Dry residue	12	64.8
Oil products	0.04	0.216
Surfactants (anionic)	0.1	0.54
Phenols	0.0002	0.001
Iron total	0.088	0.475
Copper	0.0008	0.0044
Nickel	0.0002	0.001
Zinc	0.004	0.0216
Chromium (3+)	0.0002	0.001
Chromium (6+)	0	0
Lead	0.0002	0.001
Cadmium	0	0
Mercury	0	0
Aluminum	0.02	0.108
Manganese	0.004	0.0216
Fluorides	0.0032	0.0172
Phosphorus in phosphates	0.08	0.432

Reference to the calculations made, the wastewaters, as generated by the first-phase BAS operation, will be produce 4.4 kg of suspended solids, 7.2 kg of organic matters ($BOD_{complete}$), 0.72 kg of ammonium nitrogen, 1.8 kg of chlorides, 1.6 kg of sulfates, 0.04 kg of oil products, 0.1 kg of surfactants, 0.09 kg of iron, and other pollutants. For the BAS wintering operation, the amounts of pollutants will increase in 5.4 times. The assessment of the environmental impact, as resulted from such amounts of pollutants, on the sea water composition is described in Section 4.2.

Measures to reduce the impact of wastewaters on the environment

The wastewater management system as implemented will be aimed at:

- reduction of water consumption, water-saving solutions, water recycling, in future;
- separate collection of different types of wastewaters;
- wastewater accumulation and sedimentation before discharge;

- monitoring of dilution parameters in the wastewater discharges;
- prevention of wastewater penetration (infiltration) into surface waters.

When elaborating the internal rules for sewage system use, measures to avoid the discharge of large-scale food wastes, waters from vehicle washing, hazardous chemicals, single large amounts of surfactants from laundry, cleaning, dishwashing, etc. into the sewage system will be implemented.

When selecting the point of wastewater discharge into the sea, the wastewater mixing conditions at the discharge point will be taken into consideration.

4.1.2.6. Solid wastes generation and disposal

The station operation will be accompanied by solid wastes formation. In failure to properly organise a waste management system, their accumulation can cause environmental problems.

Domestic wastes

The structure of municipal solid wastes was assumed according to TCP 17.11-02-2009 as follows: food wastes - 30-38%, paper and cardboard - 25-30%, other wastes - 32-45%. According to estimates volumes of domestic wastes generation may be up to 1.2-1.3 kg per day per person, including food wastes 0.3-0.4 kg per day per person, wastes which can be utilized by combustible according to the Article 4 of the Annex 3 to the Protocol on Environmental Protection – 0.4-0.5 kg per day per person. For 5-6 person staff the volume of domestic wastes will amount 700-1000 kg per season, including food wastes 180 – 290 kg, combustible wastes – 240-300 kg (Table 4.17). At wintering mode and 10-12 person staff the volume of wastes will be approximately 6 times higher. Assuming average density of domestic wastes as 200 kgr/m^3 *(according to TCP* 17.11-02-2009), accumulation of domestic wastes in volume units will amount 3.6-5.0 m^3 per season (seasonal mode) or 21.6-30.2 м^3 per year (wintering mode) (Table 4.17).

Table 4.17 – Projected amount of domestic wastes generation at BAS

Type of waste	Seasonal variant		Wintering variant	
	Wastes weight, kg	Wastes volume, м^3	Wastes weight, kg	Wastes volume, м^3
Domestic	720-1008	3.6-5.04	4320-6048	21.6-30.24
Food wastes	180-288		1080-1728	
Combustible	240-300		1440-1800	

It should be noted that values of wastes generation shown above mark the upper limit of their accumulation; in Antarctic conditions according to experience wastes accumulation is usually lower.

Other wastes

In addition to domestic wastes, a certain amount of other wastes will be produced during the BAS operation.

For equipment and vehicles operation and maintenance, a significant amount of industrial wastes, including packaging of fuel, lubricants, antifreeze, defective parts of engines and equipment, etc., will be produced. In particular, the annual accumulation of empty fuel barrels is expected to count 15-20 pieces for the first-phase operation of the station.

Resulting from diesel generators and mobile equipment maintenance, oil sludge (waste oils) and antifreeze will be generated. The total amount of sludge is estimated at 100 l per month; about the same amount of waste antifreeze is additionally expected.

Small amounts of medical wastes are estimated to generate. No mercury wastes are expected due to avoidance of fluorescent lamps and/or mercury containing devices at the station. No radioactive wastes are expected either.

Wastes of scientific activities (laboratory wastes, batteries, failed equipment, etc.) will be generated from time to time and basically in low quantities.

It is planned to organise separate waste collection, including food, combustible, non-combustible, medical, oil sludge, fuel barrels, etc., in accordance with the requirements of the Protocol on Environmental Protection. Combustible wastes that can be disposed of by incineration in accordance with the Protocol on Environmental Protection, will be incinerated upon accumulation; non-combustible wastes, including hazardous substances, will be stored on-site in containers and barrels, followed by subsequent transfer to the mainland. Food wastes will be dumped into the sea, subject to the requirements of the Protocol on Environmental Protection. Waste antifreeze will also be accumulated and transported to the mainland.

For waste incineration KTO50.K20 incinerator is planned to be installed (manufactured by Bezopasnye Tekhnologii JSC, Saint Petersburg, Russian Federation), equipped with two-stage waste gases abatement system. Incinerator's maximum capacity – 50 kg/h, operation periodicity – once a week (5-8 hours). The incinerator specifications are shown in Chapter 4.2.2.

Ash will be generated from wastes combustion; its amount will depend on ash content in wastes. Assuming average ash content 10-20%, anticipated generation of ashes from incineration will be 24-60 kg per season (seasonal mode) and 144-360 kg per year (wintering mode). The accumulated ash will be transported outside the Antarctic aboard on-board of vessels.

Until the waste incinerator installation, combustible wastes are supposed to be burnt at Molodyozhnaya RAE field base incinerator.

Measures to reduce the environmental impact from solid waste disposal

- Waste Management Plan (instruction) elaboration, waste reporting;
- prevention of waste dispersal/liquid waste leakage to the environment;
- separate collection and storage, compaction;
- waste temporary storage arrangement;
- regular removal of wastes;
- incineration of non-hazardous combustible waste, subject to the provisions of Article 3, Schedule 4 of the Protocol on Environmental Protection.

4.1.2.7. Other impacts

Electromagnetic radiation
Diesel generators, radio equipment, particularly, radio stations, will serve as sources of electromagnetic radiation. However, large sources of electromagnetic radiation will not be operated at the station. The radiation will not exceed the established limits.

Measures to reduce electromagnetic impacts on the environment

These measures will basically include strict compliance with the regulations of tools and devices operation and regular maintenance.

Physical (mechanical) disturbances
The station will cover the area of about 7.15 thous. m^2, including first-phase laboratory & residential and production & residential modules and utility modules - 154.4 m^2. The aforesaid territory will be subject to irreversible environmental changes. In addition fuel storage facilities, open-air storage platforms, pipelines and power transmission lines will occupy the area of a few hundred m^2. At the same time, reference to the approved construction layout, the disturbance will affect only rock surfaces.
When engaging in research activities, a mechanical impact on snow & ice cover and soil will be observed. However, this impact will be negligible due to use of light snowmobiles when driving on snow and ice; bare surfaces will be walked on feet only.

Measures to reduce the mechanical impact to the environment
- compact arrangement of the station premises, thus minimising the station infrastructure area;
- use of environmentally friendly vehicles (snowcats), minimising the impact on the snow and ice cover;
- route optimisation;
- monitoring of mechanical impact (erosion) of soils and snow & ice cover.

4.2. Exposure analysis

4.2.1. Exposure identification at the station construction

The identification of the environmental impact during the station construction embraces the analysis of all the changing elements or environmental issues affected by the station operation.

4.2.1.1. Ambient air exposure

The main source of air pollutants emission during the BAS construction will be Ka-32 helicopter, which planned to be used for delivering of the modules from shipboards. The calculation of helicopter-caused emissions is based on the helicopter's specifications, number of takeoff and landing cycles, specific fuel consumption and emission factors (Section 4.1.1).

As depicted in Section 4.1.1, based on the assumed Ka-32 helicopter 10 flights annually during the first-phase construction, pollutants emission from the construction phase is assessed as follows: nitrogen oxides – 30 kg, carbon oxide – 19 kg, hydrocarbons – 3.4 kg, particulate matter – 0.64 kg. The helicopter flight share for the field base construction is minor, as compared to the total number of helicopter flights during RAE ship unloading. Thus, the contribution of this source in air pollution will be minor and limited in time. The expected increase in pollutant concentration will not get to the surface air layer, and will be limited in time as well.

4.2.1.2. Noise exposure

Noise is one of the environmental factors which affect adversely the health conditions of humans and living organisms.

Due to the adverse effects of noise exposure, specific rules and regulations were adopted to control noise exposure. They establish mandatory requirements to be met in the design, construction and operation of various buildings, planning and development of settlements in order to protect from noise and ensure the standard acoustic environment in industrial, residential and public buildings and residential areas.

The most significant source of noise during the BAS construction (and in future operation) will be helicopter. In this regard, when quantifying the noise exposure during the BAS construction, a particular attention is paid to helicopter-caused noise estimation, using the NMSim model.

Calculation of helicopter-caused noise exposure with NMSim model

To assess the helicopter-caused noise impact, NMSim v.3.0 model was applied. NMSim (Noise Model SIMulation) was developed by Wyle Laboratory. This model generates time-based diagrams of noise exposure from moving or stationary sources, taking into account the influence of terrain environments on sound propagation.

<u>The reference data for calculating the sound level using NMSim model are:</u>

- hypsometric map, based on 1:25000 topographic map;
- conventional flight route, with start (takeoff) on-board the ship standing at 3-4 km distance from the shore, hangover at the BAS construction site and return on board the ship, with the readings of the flight speed, altitude, engine operation, route being applied. The flight route was selected with approximation, based on the actual conditions of discharge at BAE site in 2011-2012 (Section 2.1).

The checkpoints to assess the noise pollution parameters: BAS and Gnezdovoy Cape.

Calculation results

The noise level simulation yielded the following results:

- noise level charts (Figures 4.4-4.7);
- noise-changing graphs at the checkpoints: BAS site, Gnezdovoy Cap (Figures 4.8-4.9);
- noise spectra in 1/3-octave bands at the checkpoints (Figures 4.10-4.11).

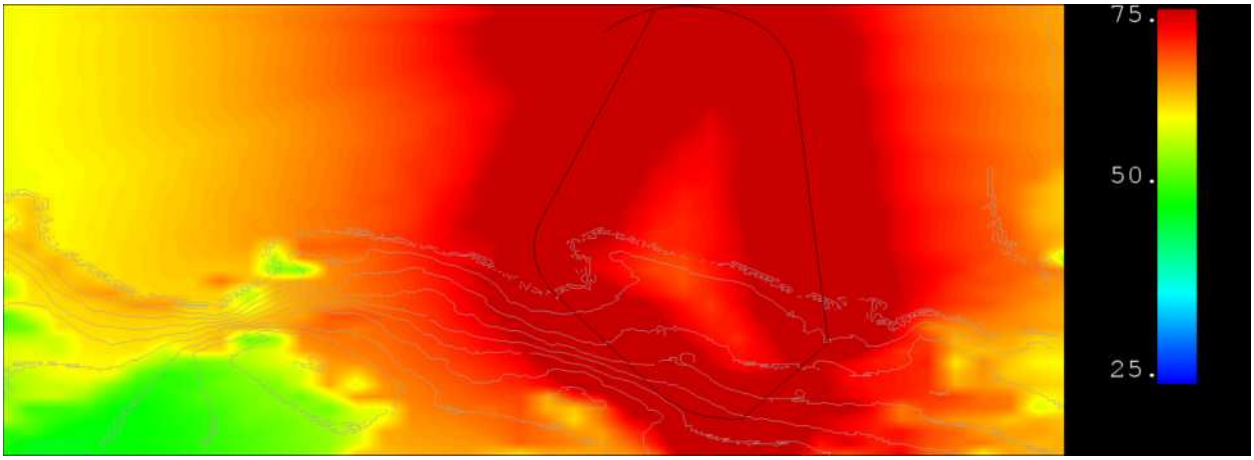

Figure 4.4 - Flat -weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

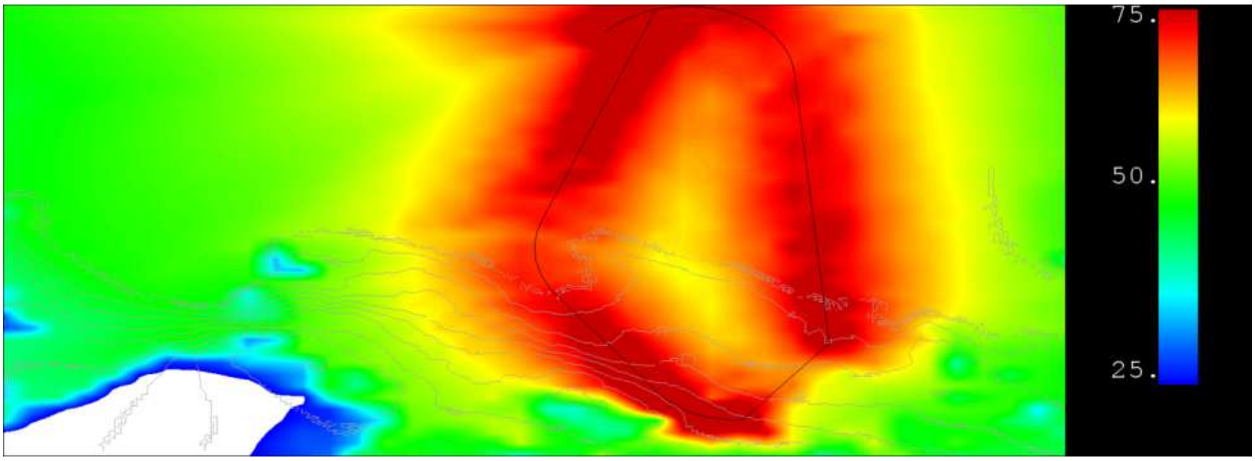

Figure 4.5 – A-weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

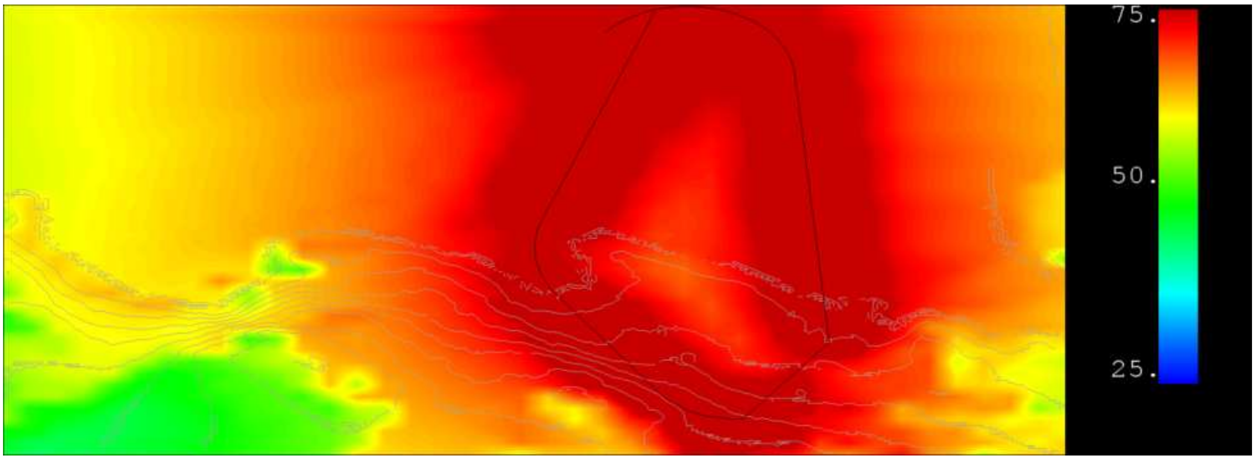

Figure 4.6 – C -weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

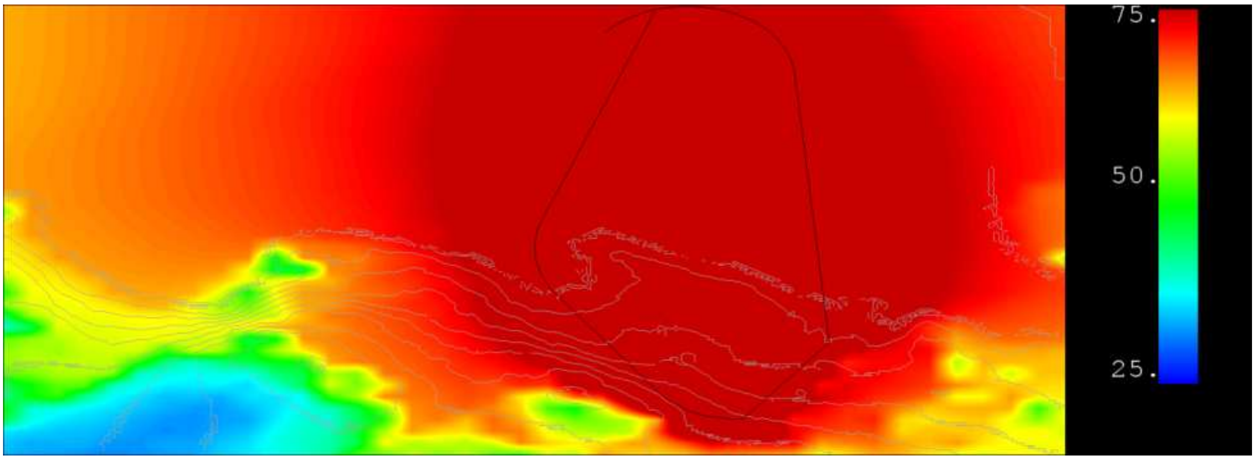

Figure 4.7 - Noise exposure chart (1 sec. scale) (SEL) at delivering cargo to BAS, single flight

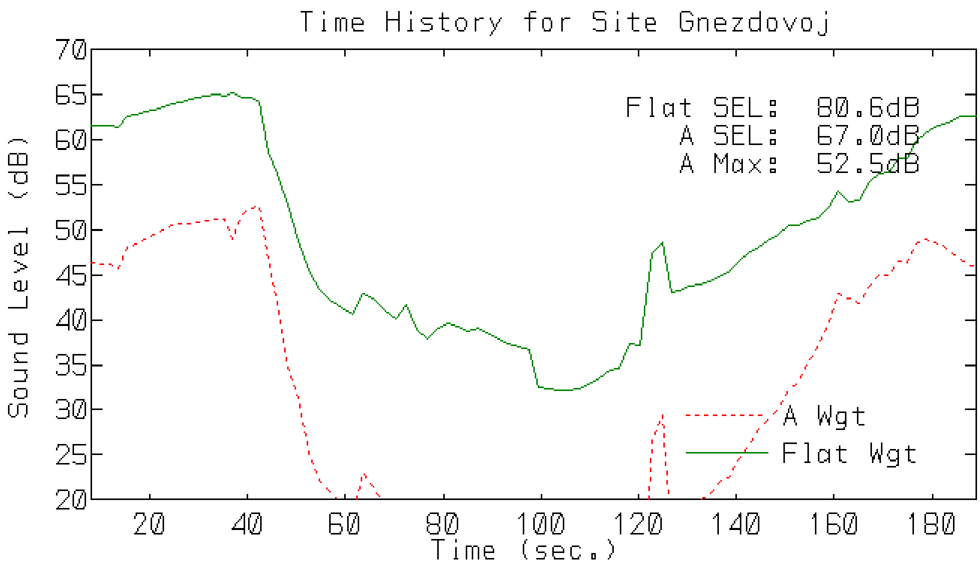

Figure 4.8 – Noise level graph at helicopter flight, Gnezdovoy Cap vicinity

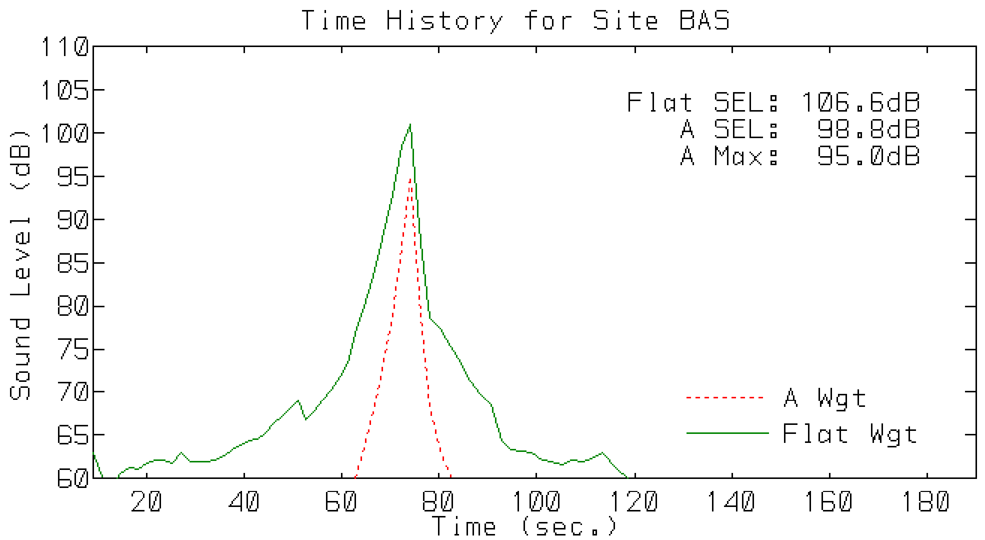

Figure 4.9 – Noise level graph at helicopter flight, BAS site

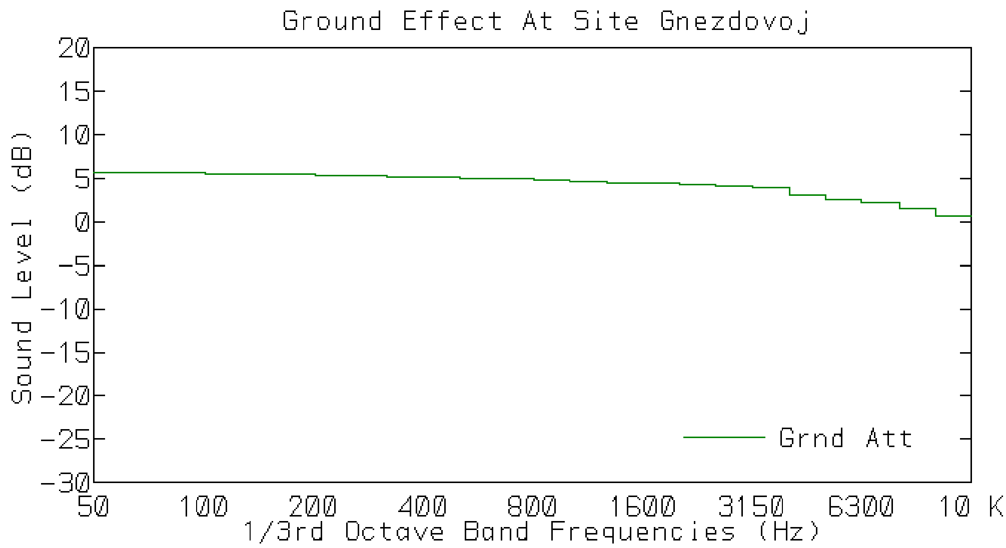

Figure 4.10 – Noise spectra at helicopter flight, Gnezdovoy Cap vicinity

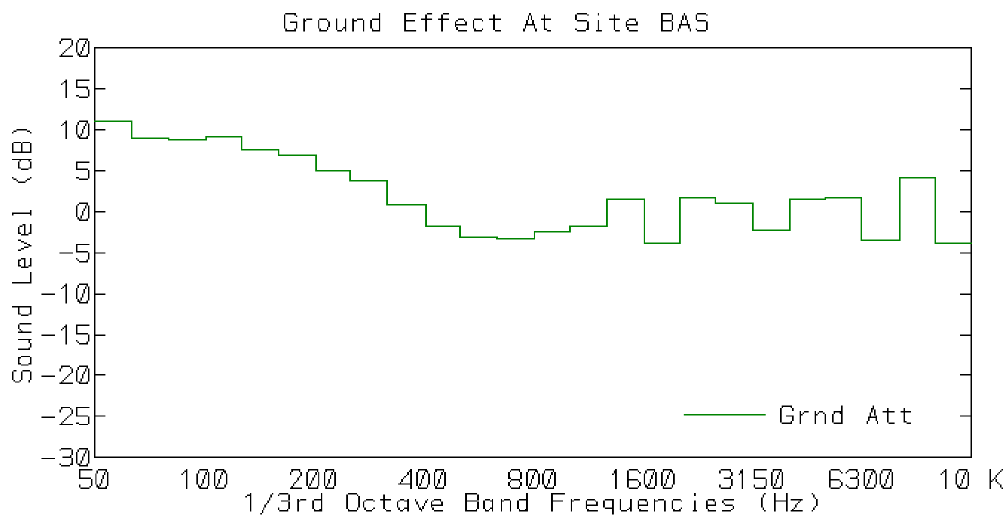

Figure 4.11 –- Noise spectra at helicopter flight, BAS site

Reference to the calculations made, the linear-weighted noise levels at Gnezdovoy Cap vicinity (where the penguin colony is situated and which is potentially prone to noise exposure) will not exceed 65 dB, A-weighted - 55 dB. The maximum noise levels at BAS site can reach 95 dBA, but these levels will be short-timed, and therefore the equivalent noise level Leq and LDN levels will not exceed 50-60 dBA, which meet the existing standards applicable to residential areas.

The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, etc.) will be minor (and exposed locally).

4.2.1.3. Exposure on soils and rocks

Deposition of pollutants on ground surface during the station construction will be minimal (less than minor). This is due to small amounts of pollutants emission and their dissipation; in general, the exposure will result only to a very slight increase in contaminant content in soils.

Mechanical impact on soils, ground and rocks at the first construction phase will be associated with placement of the station block modules, while the second phase will engage the construction of platforms for fuel tanks, as well as central collector piping.

For installation of block modules, platforms, metal tanks, movement of collector pipes and supports, motor vehicles (helicopter) will be used.

During the construction works, no extraction (disturbance) of rocks is planned to be effected.

The mechanical impact during the construction works will be limited in time.

Solid wastes exposure during the station construction will be minor and limited in time. During the construction a certain amount of solid wastes will be generated, mainly from packing and fastening materials and food wastes. The wastes will be sorted out and stored (or disposed of) separately with subsequent transportation of residues to the mainland.

Any sewage will be generated basically from operation of the staff and equipment engaged in the station construction. For wastewater treatment, the appropriate tanks currently existing at the BAE field base will be used. The possibility of leaks will be minimised.

Oil spills / leaks on helicopter refuel and maintenance. The helicopters are expected to be refueled and maintained on board the vessels; in this connection, the possibility of fuel spills or other leaks at the BAS construction territory trends to minimum.

4.2.1.4. Exposure on surface waters, snow and ice cover

Impact on surface waters will be caused mainly through the water intake for domestic purposes, but water consumption per season during the construction stage is assessed to be minor. No sewage is expected to penetrate surface waters, and therefore the impact on ponds and snow & ice cover during the construction will be minimal. The risk of leaks and washing contaminants from soils and their penetration into ponds and snow & ice cover during the station construction will be insignificant.

During the station construction, direct mechanical impact on the ice sheet will not be made due to helicopter-engaged construction technology. Negligible impact on the snow & ice cover is expected only in the immediate vicinity of the construction site.

Exposure to water ponds and snow & ice cover due to pollutant-carrying atmospheric precipitations during the station construction will be minor and limited in time.

Wastes, noise, heat and electromagnetic exposure during the construction are expected as having less than a minor and limited in time impact on waters and snow & ice cover.

4.2.1.5. Exposure on biota, marine environment and marine ecosystems

The station's major facilities will be built beyond the existing moss and lichen cenoses and/or nesting birds. The mechanical destruction of epiphytic lichen cenoses will only occur directly at the construction site.

Atmospheric depositions to the marine area will be negligible. No substantial increase of wastewaters dumping into the sea is expected, therefore, the impact on marine ecosystems during the construction stage will be minimal.

Pollutant penetration into the sea due to leaks and/or washing from contaminated surfaces is possible, but will be minimised through remedial actions being implemented.

As described in Section 4.2.2.2, noise impact will be limited in time. Heat and electromagnetic exposures are identified as having less than a minor impact on biota, marine environment and marine ecosystems.

4.2.1.6. Impact on aesthetic features of the landscape and natural surroundings

Given the significant disturbance of the natural landscape at the BAS construction site, the planned construction will not deteriorate, but is expected to improve the aesthetic features of the landscape. The station construction is anticipated to blend seamlessly into the Mount Vechernyaya landscape.

The overall impact during the construction works (except for polluting emissions and noise) will be localised within the site boundaries. The block modules and other structures are not planned to be installed at areas with developed lichens or mosses; in this respect, the impact on biota will be minimal.

Measures to reduce the environmental impact during construction:

- on board the vessels: compliance with MARPOL requirements, time-saving schedule to reduce the duration of stay in the Antarctic waters;
- helicopter operation: flight route optimisation, tough scheduling, optimal helicopter loads, flight time minimisation, reduced flight cycles;
- site preparation: prevention of excess dust generation upon site ground works, drilling holes;

- mechanical assembly works: high efficiency, speed and quality of works being performed, which would benefit to reduction of polluting emissions and noise exposure;
- piping and power cable line laying: soil and ground disturbance minimisation, in particular, in respect of vegetation-covered areas;
- use of motor vehicles: optimal routes scheduling;
- sewage treatment, waste management: solid and liquid wastes minimisation, waste transfers to the mainland.

4.2.2. Identification of environmental exposure at station operation

The environmental impact identification involves the analysis of all the major characteristics of environmental components and valuables that are subject to change due to various exposures caused by the Mount Vechernyaya Belarusian Antarctic station operation.

4.2.2.1. Ambient air exposure

When operating the station, the ambient air will be subjected to pollutants emission from diesel generators, vehicles, incinerator. To assess the ambient air impact caused by the Mount Vechernyaya BAS operation, simulation-based calculations of pollutant dispersion in ambient air, caused by major permanent sources, were performed. Atmospheric dispersion of emissions from mobile sources was not subject to quantitative assessment due to rather limited number of all-terrain sources to be used (mainly snowmobiles), and such emissions will be spread over a large area.

Modelling of dispersion of pollutants emission from stationary sources at the BAS operation using AERMOD

The dispersion of pollutants from stationary sources was assessed using the AERMOD model, Version 12345, developed by the U.S. Environmental Protection Agency (US EPA) and the American Meteorological Society in collaboration with Lakes Environmental (Canada) and BREEZE (USA) companies.

Computational grid

The simulation of pollutant dispersion in the atmospheric air surface layer during the BAS operation was performed using the Cartesian coordinate system. A uniform grid 3000 x 1800 m with 20 m grid sells was taken for analysis. As its reference point (bottom left corner of the lattice) became the point with geographic coordinates -67°40’00” S and 46°07’00” E, and, accordingly, 547350.6518 m and m 2493871.8114 of the UTM coordinate system. The major sources of emission and assumed BAS deployment site are located close to the model area grid centre.

Exposed objects (receptors)

A network of 20x20 m grid cells (total number – 1350) was considered as the major objects (receptors) of pollutants dispersion modeling. In addition pollutant concentrations were also estimated for a number of locations within the grid specifically sensitive to air quality. As such locations the laboratory & residential and production & residential modules and protected area (moss and lichen cenose) were selected. The calculated coordinates of the receptors' centre points in the UTM system and conventional coordinate system are shown in Table 4.18 below.

Table 4.18 – Receptors' centre points in the UTM system and conventional coordinate system

Receptor description	Longitude, UTM coordinates, m	Latitude, UTM coordinates, m	X-axis distance in the conventional coordinate system, m	Y-axis distance in the conventional coordinate system, m
Service & residential module, single-storey (module 1)	548750.8	2494550.2	1400.1	678.4
Laboratory & residential and production & residential block module, two-storey (module 2)	548777.3	2494531.3	1426.7	659.5
Laboratory & residential module, single-storey (module 3)	548746.3	2494532.8	1395.7	661.0
Production & residential module, two-storey (module 4)	548731.4	2494510.5	1380.8	638.6
Protected area	548758.4	2494509.3	1407.7	637.5

Emission sources

During the BAS operation, pollutants will be emitted due to fuel combustion by stationary engines and vehicles, as well as incineration of domestic wastes.

The major sources of air pollutants at the BAS first-phase construction and operation will be the existing 2 diesel generators of 60 and 20 kVA capacity in alternate operation, i.e.: DG-20 AD16-T400-2RP and DG-60 AD60-T48C-2RP. At later stages, 2 diesel generators (DG-100 ADS) of 100 kVA capacity and KTO50.K20 incinerator will be installed. Initially, the pollutant concentrations are calculated with adjustment to the said stationary emission sources, i.e. diesel generators and incinerator.

The performance characteristics were obtained from the devices' engineering specifications and manufacturer's manuals. Some parameters were estimated based on the engineering specifications and operation logs; certain parameters for KTO-50.K20 incinerator were based on performance data of similar installations.

Parameters of buildings and structures

Reference to the station design, the laboratory & residential and production & residential modules will be single-storey or two-storey. The modules' heights are estimated to be 2.4 m for single-storey modules and 4.9 m for two-storey modules. The modules' low-fit design will not significantly affect the pollutant dispersion parameters. In this regard, BPIP application for building / structure parameters assessment is not required at this stage.

Meteorological data

The AERMOD model uses 3 groups of initial reference meteorological data, i.e.: 1 – surface weather station monitoring data, 2 – atmospheric edge-reading sounding data, 3 – data obtained from specialised local instrument observations (*on-site data*).

Atmospheric sensing is not performed by all meteorological stations, or such data are not available. Among WMO network stations dealing with such scientific observations, the Japanese Antarctic station Syowa (WMO index 895320) stands most close to the proposed BAS construction site. It is located about 308 km from the proposed BAS site. This station has been dealing with a series of scientific observations since 1994.

Data obtained from ground-based observations are more detailed. The possibility to use observation data obtained by two WMO Antarctic stations was considered: Japanese Syowa and Russian Molodyozhnaya. Data communicated by M-49M automatic weather station (AWS), located at the Vechernyaya field base of BAE in the immediate vicinity of the proposed BAS construction site was also accounted.

Reference to several AERMOD test runs using different meteorological information the choice was made in favor of Molodyozhnaya station data.

Surface characteristics

For AERMET pre-processor calculation such simulated area characteristics as annual average surface roughness, diffuse reflectance (albedo) and Bowen ratio should be introduced. This work phase was performed subject to simplified pattern. The adjacent area was divided into four sectors, having different combinations of rocky areas, glaciers and snowfields. Albedo, Bowen ratio and roughness coefficient for each sector were identified under AERSURFACE Guide (*EPA, 2008)*.

Resulting from this phase of work, AERMET made several pairs of meteorological SFC and PFL-files, containing the reference meteorological data for AERMOD simulation. The files were obtained for different time periods: summer season, a year, five-year.

Digital description of the topography of territory adjacent to the BAS site

Topographic features have a significant impact on pollutant dispersion in the atmospheric air. For the Mount Vechernyaya BAS construction site no necessary DEM-data with the required resolution (20 m) was available. Therefore the AERMAP phase was preceded by a preparatory stage, including a digital elevation model generation. Topographic map of 1:25000 scale (hypsometry layer) became the basis for the digital elevation model.

Results of pollutant dispersion modeling from BAS emission sources

The dispersion of pollutants from the BAS emission sources in the ambient air over the adjacent territory was calculated under two scenarios. For the both scenarios, concentrations of the following substances were calculated, i.e.: NO_2, SO_2, CO, soot as PM10, hydrocarbons.

The topographic features of the receptor territories were taken into consideration. Any influence of the existing buildings and structures in respect of pollutant dispersion was ignored. The initial (background) concentration was assumed to be equal to zero for all substances.

The estimations were made in respect of the following exposed objects (receptors): four laboratory and residential, service & residential and production & residential modules and protected area, as well as for the regular receptor network with 20 m grid sells.

The maximum hourly, 8-hourly and daily concentrations of pollutants, as well as hourly mean, 8-hour mean, daily and monthly mean concentrations were calculated for the reporting period. The scenario-based simulation results description is given below.

Scenario 1

Source of pollution – 1: diesel generator DG-60 AD60-T48C-2RP of 60 kVA capacity; reference to the scenario, the diesel generator will operate daily and continuously at full power. In fact, a diesel generator DG-20 AD16-T400-2RP of 20 kVA capacity will operate alternately, but, to estimate the maximum possible levels of ambient air impacts, the calculation was performed for full-time DG-60 operation.

DG-60 power station parameters are as follows:

Stack height - 3.5 m;
Stack diameter - 0.08 m;
Flue gas temperature - 350ºC;
Flue gas flow - 39.8 m/sec.

The reporting period shall be the summer season (December-March). This scenario is valid for the seasonal BAS operation mode.

The maximum short-term and long-term evaluations of the surface pollutant concentrations at the BAS site, reference to Scenario 1, are presented in Tables 4.19 (5 receptors) and 4.20 (for the regular grid of receptors), as well as at Figures 4.11-4.25. The regulatory standards for ambient air pollutant concentrations, as applicable in Belarus, EU and United States, are given in Table 4.21 below.

Table 4.19 – Modelled air pollutants concentrations for selected receptors from the BAS stationary emission sources operation. Scenario 1, μg/m^3

Parameter and averaging period	Module 1	Module 2	Module 3	Module 4	Protected area
Carbon oxide (CO)					
Maximum 1-hour average	55.53	55.96	67.42	82.50	100.86
Mean 1-hour average	1.09	1.02	1.44	1.98	1.65
Maximum 24-hour average	13.26	14.78	17.42	23.38	23.62
Mean 24-hour average	1.35	1.27	1.78	2.44	2.06
Maximum 1-month average	2.82	2.88	3.77	5.01	4.58
Mean 1-month average	1.40	1.32	1.85	2.55	2.13
Nitrogen dioxide (NO_2)					
Maximum 1-hour average	67.04	61.00	77.23	73.79	101.21
Mean 1-hour average	1.54	1.33	1.99	2.68	2.09
Maximum 24-hour average	16.41	15.95	21.52	27.84	24.77
Mean 24-hour average	1.92	1.66	2.47	3.31	2.61
Maximum 1-month average	3.97	3.55	5.12	6.64	5.44
Mean 1-month average	1.98	1.72	2.56	3.45	2.70
Sulfur dioxide (SO_2)					
Maximum 1-hour average	8.15	8.21	9.90	12.11	14.80
Mean 1-hour average	0.16	0.15	0.21	0.29	0.24
Maximum 24-hour average	1.95	2.17	2.56	3.43	3.47
Mean 24-hour average	0.20	0.19	0.26	0.36	0.30
Maximum 1-month average	0.41	0.42	0.55	0.74	0.67
Mean 1-month average	0.21	0.19	0.27	0.37	0.31
PM10					
Maximum 1-hour average	5.60	5.65	6.80	8.33	10.18
Mean 1-hour average	0.11	0.10	0.14	0.20	0.17
Maximum 24-hour average	1.34	1.49	1.76	2.36	2.38
Mean 24-hour average	0.14	0.13	0.18	0.25	0.21
Maximum 1-month average	0.29	0.29	0.38	0.51	0.46
Mean 1-month average	0.14	0.13	0.19	0.26	0.21
Hydrocarbons (CH)					
Maximum 1-hour average	27.51	27.72	33.40	40.87	49.97
Mean 1-hour average	0.54	0.51	0.71	0.98	0.82
Maximum 24-hour average	6.57	7.32	8.63	11.58	11.70
Mean 24-hour average	0.67	0.63	0.88	1.21	1.02
Maximum 1-month average	1.40	1.42	1.87	2.48	2.27
Mean 1-month average	0.70	0.65	0.92	1.26	1.05

Table 4.20 – Maximum modelled air pollutants concentrations for selected receptors during the BAS stationary emission sources operation. Scenario 1, µg/m^3

Pollutant	Maximum concentrations			Maximum average concentrations		
	1 h	24 h	Month	1 h	24 h	Month
Carbon monoxide (CO)	234.0	106.4	42.2	24.6	26.7	29.3
Nitrogen dioxide (NO_2)	272.0	145.4	60.3	35.2	38.2	41.9
Sulfur dioxide (SO_2)	34.5	15.6	6.2	3.6	3.9	4.3
PM10	23.7	10.7	4.3	2.5	2.7	3.0
Hydrocarbons	116.4	52.7	20.9	12.2	13.2	14.5

As calculated on the regular grid, the maximum hourly concentrations for all substances, except NO_2, was observed at the point with coordinates: x = 1320, y = 560, and for NO_2 - at x = 1320, y = 580. The maximum 24-h and monthly averaged concentrations for all substances were found at x = 1320, y = 600; the same point was reported to have the maximum gain of the average concentrations of these substances for all the averaging periods.

Table 4.21 - Regulatory standards for ambient air pollutant concentrations, µg/m^3

Substance	Belarus		EC		United States	
	Reference value	Averaging period	Reference value	Averaging period	Reference value	Averaging period
NO_2	250	20 min.	200	1 hourc	100 ppb	1 hour
	100	24 hours	40	1 year	53 ppb	1 year
	40	1 year	-	-	-	-
SO_2	500	20 min.	350	1 hour	75 ppb	1 hourc
	200	24 hours	125	24 hour	-	-
	50	1 year	-	-	-	-
PM10	150	20 min.	50	24 hours	150	24 hours
	50	24 hours	40	1 year	-	-
	40	1 year	-	-	-	-
CO	5000	20 min.	10000	8 hours	35 ppm	1 hourc
	3000	24 hours	-	-	9 ppm	8 hours
	500	1 year	-	-	-	-

Carbon monoxide

Hourly average concentrations

The maximum hourly carbon monoxide concentration is expected to be 234.9 µg/m^3 and possibly detectable on a small area at 110-130 m distance SSW of the emission source (Figure 4.11). This area is also characterised with the maximum mean hourly average concentrations - up to 24.7 µg/m^3.

At the laboratory & residential modules territory, the maximum hourly concentrations of carbon monoxide will amount 55.5-82.5 μg/m^3, at the protected area - 100.9 μg/m^3 (Figure 4.12), the average hourly CO concentrations at these sites - 1.0-2.0 μg/m^3.

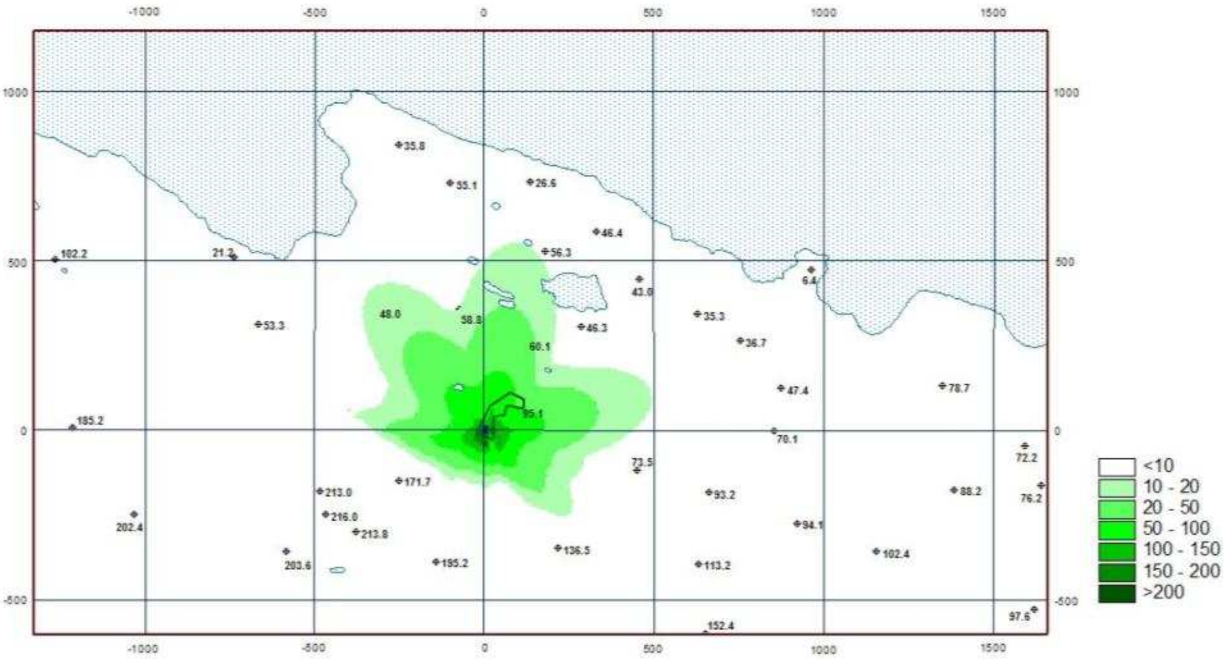

Figure 4.12 - Distribution of maximum 1-hour CO concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

The calculated values of the maximum hourly CO concentrations at the receptor locations are negligible: their maximum level will reach 1-2% of the Maximum Permissible Concentration (MPC), as effective in Belarus (5000 μg/m^3).

Daily average concentrations

The highest 24-hour CO concentration was assessed to reach 106.4 μg/m^3; it will be registered 20-30 m SSW of the emission source (Figure 4.12). The maximum daily concentration (26.7 μg/m^3) is also expected there.

At the laboratory & residential module locations, reference to Scenario 1 calculations the mean daily CO concentration shall not exceed 13.3-23.4 μg/m^3, at the protected area – 23.6 μg/m^3 (Figure 4.13). On average the 24-hour CO air concentration at these sites will increase by 1.4 - 2.4 μg/m^3.

The calculated values of the 24-hour CO concentrations can be assessed as less than minor, as their maximum level will not exceed 1% of the Maximum Permissible Concentration (MPC) value, as established in Belarus (3000 μg/m^3).

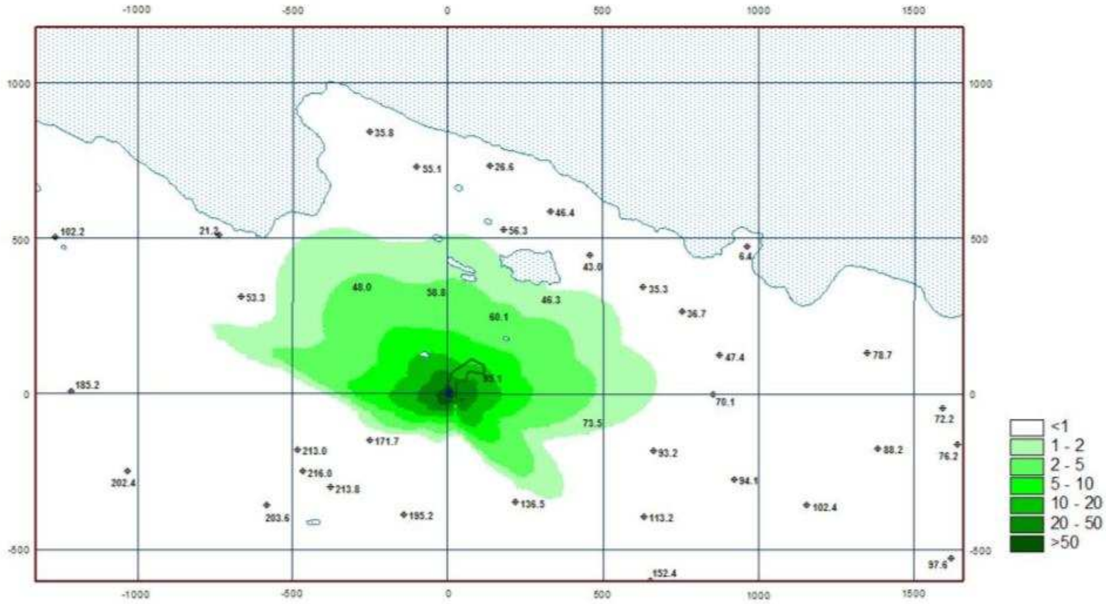

Figure 4.13 – Distribution of maximum 24-hour CO concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

At summer seasons (December-March), the maximum monthly average CO concentration will amount to 42.2 μg/m^3 (Figure 4.14) and can be detected 20-30 m SW from DG-60. The monthly average CO concentration at this point will be 29.3 μg/m^3.

At the receptor site locations, the maximum increase of monthly average CO concentrations can make 2.8-5.0 μg/m^3, mean - 1.4-2.6 μg/m^3 (Figure 4.14). These values are significantly below the MPC values, as established for the yearly average values (500 μg/m^3).

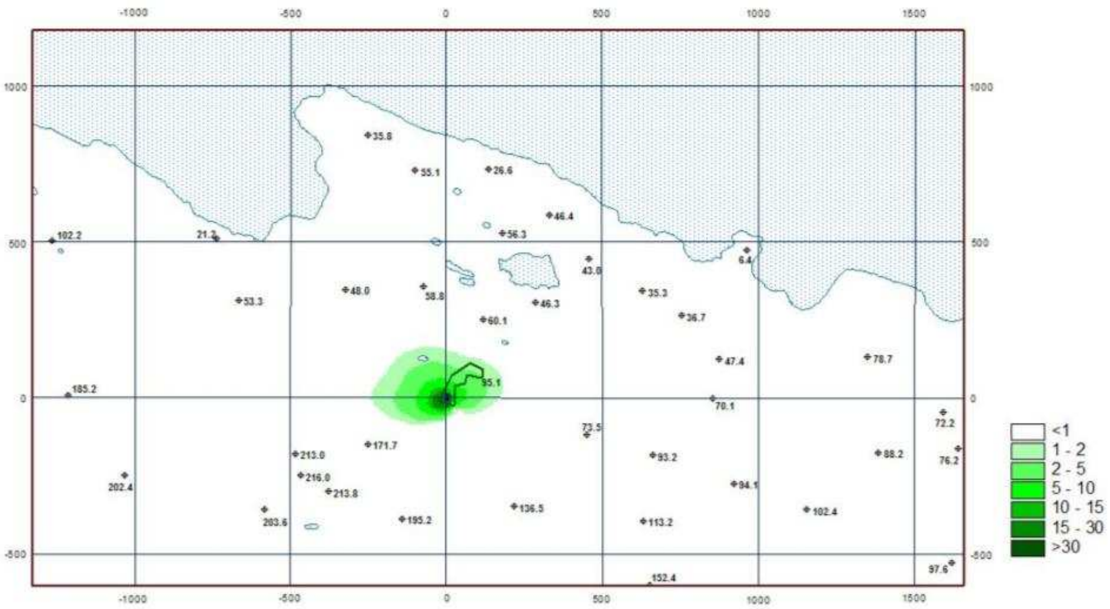

Figure 4.14 – Distribution of monthly average CO concentrations in atmospheric air from BAS stationary sources operation, averaged for summer seasons (December-March), μg/m^3, Scenario 1

Nitrogen dioxide

Hourly average concentrations

The maximum hourly nitrogen dioxide concentrations can reach 272 µg/m^3, exceeding the MPC limit as established in Belarus (250 µg/m^3). Excessive hourly nitrogen dioxide concentrations may be observed in 4 cells of the receptor grid (i.e., within the area of 160 m^2) at several sites SSW and SE from the emission source. The repeatability of such high concentrations is assessed as minor. Thus, at point (x = 560; y = 1320), the hourly NO_2 concentrations above 250 µg/m^3 can occur twice during summer seasons, at point (x = 1320; y = 580) – 4 times, at point (x = 1320; y = 600) - 7 times, at point (x = 1340; y = 600) – 14 times.

At the other points of the regular receptor grid, no MPC elevation will be registered (Figure 4.15). The maximum hourly NO_2 concentrations are estimated for point with coordinates x = 1320; y = 600, at 20-30 m distance SW from DG-60 location (35.2 µg/m^3).

The maximum hourly nitrogen dioxide concentrations at the laboratory & residential module locations will be 67.0-77.2 µg/m^3, at the protected area – 101.2 µg/m^3 (Figure 4.15), which is 2.5-3 times lower than MPC. The average hourly NO_2 concentrations for these objects – 1.3-2.7 µg/m^3.

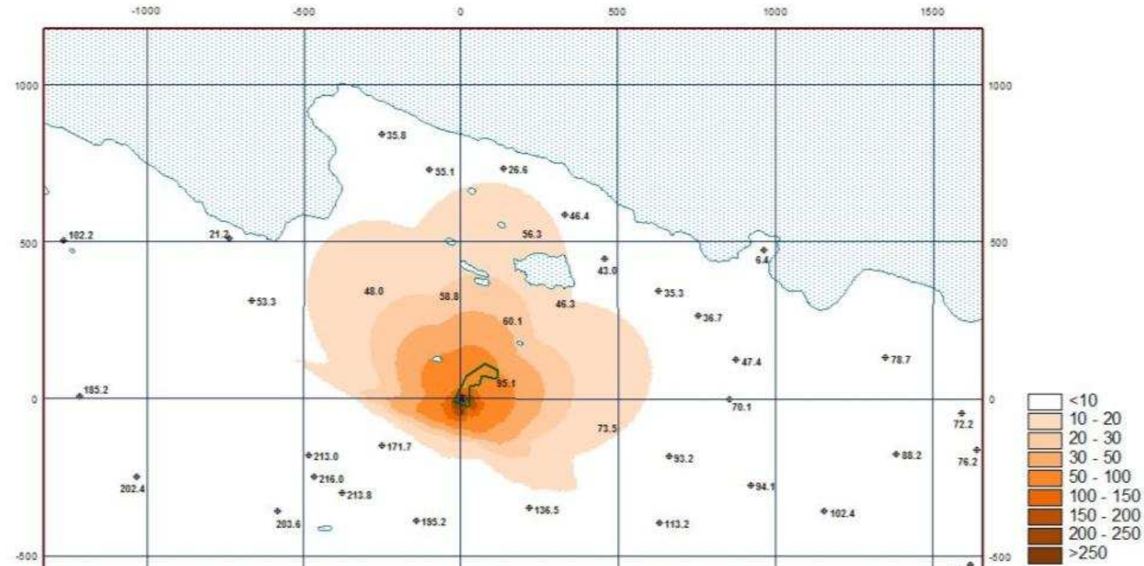

Figure 4.15 – Distribution of maximum hourly NO_2 concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 1

24-hour average concentrations

The maximum daily NO_2 concentration as calculated for the regular grid is 145.4 µg/m^3, which exceeds the MPC value (100 µg/m^3). The area of highest NO_2 concentration will be located southwest of the emission source, starting in the immediate vicinity and extending to about 100 m distance (Figure 4.16). The highest repeatability of such concentrations will be at points with coordinates (x = 1320; y = 580) and (x = 1320; y = 600) and will not exceed 8 days.

At the laboratory & residential module locations the average daily NO_2 concentrations may increase by max. 15.9-27.8 μg/m^3, at the protected area – 24.8 μg/m^3 (Figure 4.16). These values are several times lower than the MPC values. The mean daily NO_2 concentrations for the receptor sites at DG-60 operation will increase by 1.7 - 3.3 μg/m^3.

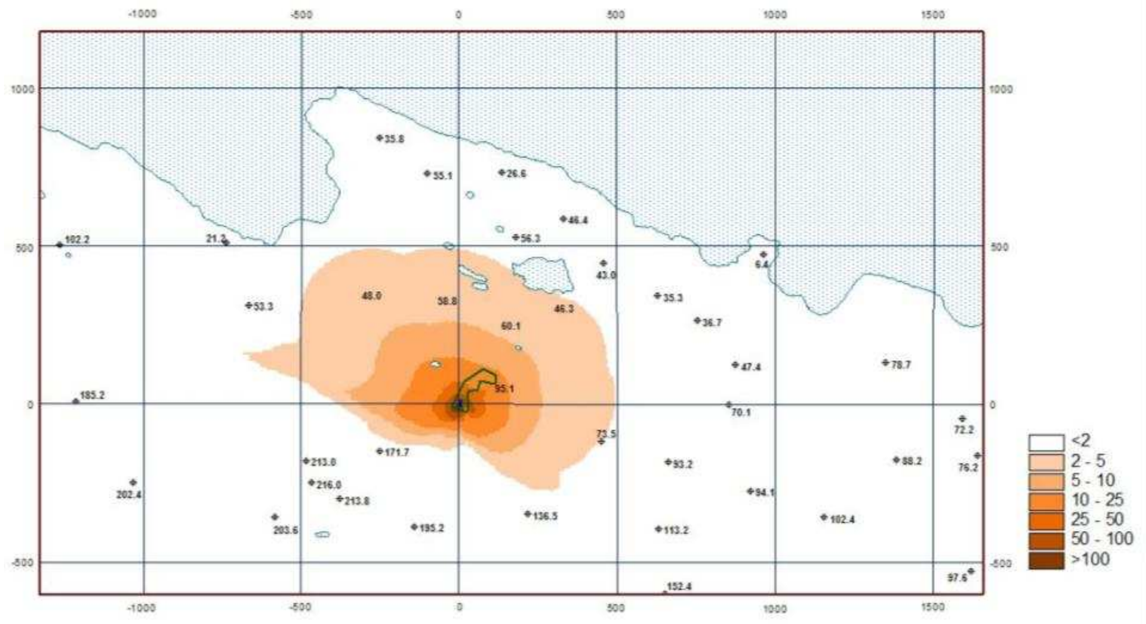

Figure 4.16 - Distribution of maximum 24-hour NO_2 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

The maximum monthly average NO_2 concentrations during summer seasons (December-March) will amount to 60.3 μg/m^3, which exceed the established MPC for year mean. The values which excess the established limit of 40 μg/m^3 is expected SW of DG-60 location at four points of the regular grid (Figure 4.17). At the laboratory & residential module locations and within the protected area, the maximum monthly average NO_2 concentrations will reach 3.6 - 6.6 μg/m^3 (Figure 4.17), being significantly lower than MPC.