UNEP/GEF Project:
"Support to the National Program of Action for the Protection of the Arctic Marine Environment"
Non-Commercial Organization "Polar Foundation"

FINAL REPORT

on Demonstration Project:
"ENVIRONMENTAL REMEDIATION OF THE DECOMMISSIONED MILITARY BASE ON FRANZ JOSEF LAND ARCHIPELAGO"

Moscow, 2008

Content

EXECUTIVE SUMMARY

This report presents the results of the survey of the state of the area of decommissioned sites of the Russian Federation Ministry of Defense and demonstration work to remediate the environment of the area of decommissioned site on Alexandra Islands of Franz Josef Land Archipelago.

The basis of the project was the Consulting Service Contract # CS-NPA-Arctic-1/2007 providing funds for the demonstration project 'Cleaning up of the environment at a decommissioned military base on Archipelago Franz Josef Land' of 29 August 2007, between the non-commercial organization "The Foundation of Polar Studies" (hereinafter designated as POLAR FOUNDATION or NCO "POLAR FOUNDATION") and Institution "Executive Directorate of National Pollution Abatement Facility" ("NPAF Executive Directorate"). The contract was signed under a GEF grant for the project 'Russian Federation – Support to the National Programme of Action for the Protection of the Arctic Marine Environment' of 18 July 2005.

The survey was agreed with the Ministry of Defense and Rosprirodnadzor Administration for Arkhangelsk Region.

The goal of work was as follows:

1. Reconnaissance of the present environmental state of the part of area of decommissioned site of the Russian Federation Ministry of Defense on Alexandra Island including assessment of man-made degradation and levels of soil contamination to determine the scope and composition of work on reclamation and remediation of the area in future.

2. Pilot work on the demonstration area cleanup on the area of the decommissioned military base Nagurskaya.

3. Pilot work on of the demonstration area remediation on the area of the decommissioned military base Nagurskaya the use of biological products.

4. Determination of legal and organizational procedures of the release of the contaminated areas from the Russian Federation Ministry of Defense responsibility.

5. Development of guidelines for the remediation of contaminated areas of decommissioned military sites in the Russian Arctic.

The contractor was executed by the NPO 'POLAR FOUNDATION' that was responsible for the organization and coordination of the studies involved.

State Institution "State Oceanographic Institute (GOIN)" (management of expeditionary work) and LLC "I.K.M. Engineering", Saint-Petersburg were involved as Subcontractors.

Field work was performed during the cruise of the Northern Hydrometeorological Service Administration's Research Vessel "Mikhail Somov" supplying polar stations and researches within the 2007/2008 International Polar Year Program and in the period of survey work on Alexandra Island in September-October, 2008. .

Field work and laboratory researches were based on applicable regulatory documents regulating the requirements to observations, sampling and analysis procedure.

Present state of man-made degradation of Alexandra Island

Three main regions of man-made degradation were selected on the island to conduct aerial and terrestrial survey.

Area	No. of site of land survey	Surveyed territory size km^2	Description
Alexandra Island	1	0.2	Oil and lubricant storage facility in Severnaya Bay
	9	2.9	Radar station (air defense radar post, oil and lubricant storage facility)
	10		Oil and lubricant storage facility, settlement of Nagurskoe
Total:	**3**	**3.1**	

Site 01. The site is situated on the Severnaya Bay coast near the berth on which the equipment is disembarked from water crafts. There a lot of tanks and metal drums at the area. Some tanks are now used as oil and lubricants storage facility. The drums have labels of the 50's and 80's. The drums having labels of the 50's are empty; those of the 80's are partially full of oil and lubricants.

Site 09. Several facilities having the name "Radar station", since the ruined radar facilities are the most typical structures. According to information from the helicopter crew, there was an air defense post there. The hydrometeorological station was situated near the post; however, no typical meteorological area was found there. There are several abandoned structures (one of them has a sign "ДЭС-2", wooden elevated road, tanks the content and degree of fullness of which could not be determined. The area is littered with waste metal structures and other wastes. There are a lot of traces of oil pollution on the thawed soil.

Site 10. Oil and lubricants storage facility near the settlement of Nagurskoe (there was the test site of drums cleanup and pollution consequences, at which the experimental work was performed).

Reconnaissance survey of the current environmental state of the areas of decommissioned sites of the Russian Federation Ministry of Defense on Hoffman, Graham Bell and Alexandra Islands of Franz Josef Land Archipelago allows us to make an unambiguous conclusion on a significant level soil contamination and degradation at the area under study.

On Alexandra Island, 2.55 sq . km (82 percent) of 3.1 sq . km of the surveyed area man-made degradation are littered and suffer man-made degradation of soil and vegetation cover due to organized and non-organized vehicle traffic.

Most area covered by observation is littered with iron drums with the density from 10 to 30 pieces per hectare. The area affected by this type of contamination amounted to 3. 1 sq. km on Alexandra Island

On the surveyed area, there are many ruins of technical and general purpose buildings and structures; dumps of metal scrap and domestic and construction waste; abandoned

vehicles, radar stations, tanks, cisterns with oil and lubricants on racks and even aircrafts. The number of these detected and geocoded objects is 258, including

Building, technical and general purpose structure	- 55
Rack with oil and lubricant cisterns	- 18 (194 cisterns)
Reservoir, cistern	-15
Stack of 200 l drums of oil and lubricants	- 42
Dump of drums	- 38
Radar station	- 1
Vehicle	- 12
Watercraft	- 1
Aircraft	- 1
Wooden rack	- 2
Power line	- 14 sectors (5 km)
Industrial, construction and domestic waste dump	- 34 (125. 2 thousand sq m)
Construction material and equipment storage yard	- 5
Traffic lane for vehicles	- 16 sectors (6. 7 km)

It should be taking into account that reconnaissance survey was performed in autumn in the initial phase of snow cover formation, that is why even for the surveyed territories the man-made disturbed areas are apparently significantly larger in size than the above, and with account of non-surveyed areas are multiple larger than those presented in this report.

This is also completely true for the number of geocoded objects.

The study of soil quality based on Rospotrebnadzor normative documents SanPiN 2 .1 .7 .1287-03, GN 2 .1 .7 .2041-06 and GN 2 .1 .7 .2042-06 allows to classify the level of contamination at all sites of geoecological testing on Alexandra Island as **hazardous and extra-hazardous.**

The assessment according to international standards (Neue Niederlandische Liste) showed that the contamination with oil products at the sites of testing 2-6 times exceeds the intervention level, while the average total content of polycyclic aromatic hydrocarbons 2-8 times exceeds the allowable concentration.

The results of the study of the technical liquids showed that none of the specimens is a product based on organochlorine compound; the total content of PCBs in all samples did not exceed several hundreds of micrograms per kilogram of the product. Such a level of the content of organochlorine compounds is allowable for oil and can be explained by the pollution of oil products during their production, canning, transportation and long-term storage.

Even an accidental spill of these oil products cannot cause hazardous soil contamination with of organochlorine compounds. It is confirmed the levels of PCB content in soil specimens (maximum – 12 allowable concentrations, 0. 24 mg/kg), not reaching the intervention level (1. 0 mg/kg) in any soil samples even in the most contaminated with spilled oil products. At the same time, the petroleum hydrocarbon content multiply exceeds the intervention level. The analysis of the results has not revealed any similarity of the

qualitative PCB composition in contaminated soils with that contained in technical liquids stored in the vicinity of the same site. This shows the presence of different sources of soil contamination both local (release of PCB-containing paint chips from drum and rank surfaces due to corrosion) and associated with PCB intake with atmospheric precipitation and dry precipitation due to long-distance atmospheric transport in the period of their large-scale production.

Environmental remediation on the area of the decommissioned military base Nagurskaya

Demonstration work on collection and disposal of empty drums with oil and lubricant residues and cleanup of soil from oil and lubricant residues with the use of biological products decomposing these pollutants was conducted on the area of the decommissioned military base Nagurskaya on Alexandra Island. Work was conducted from September 18 to 20 without regard to the time of loading and unloading of equipment). Delivery and evacuation of equipment and team of specialists was conducted with the use of Northern Hydrometeorological Service Administration's Research Vessel "Mikhail Somov".

Three test sites were selected to implement the demonstration project, however, the areas of test sites 2 and 3 only were cleaned up due to the impossibility to work on the test site 1 (oil and lubricant drums are itemized on the balance sheet of the frontier post).

Test sites 2 and 3 are situated on site 10.

The work layout included the following:

– clean up of the demonstration site from waste metal;

– collection of empty and partially filled with oil and lubricant residues drums from one or several sites (the total area is not more than 1 ha);

– oil and lubricant residues drainage into the cisterns available on the area;

– cleanup of the drums with a special equipment providing the cleaning fluid regeneration;

– compaction of empty drums;

– packaging of compacted drums, delivery by Research Vessel "Mikhail Somov" and transfer of waste metal to a waste metal disposal organization;

– treatment of cleaned areas with cultivator;

– introduction of two types of biological products decomposing organic pollutants on cleaned areas.

After the selection of trial cleanup sites, oil and lubricant drums were removed from the sites and compacted in trial mode with the use of a special hydraulic press with a pressure of 12 tons, control soil samples were collected from the areas to be cleaned up with biological products and two different commercial biological products Devouroil and Petrotreat and biogenic matters required for their use were introduced on these sites. A part of areas treated with the biological products were covered with special films to provide a better thermal regime for the biological products. A small number of compacted and non-compacted oil and lubricant drums were transported to Arkhangelsk by Research Vessel "Mikhail Somov" after the completion of work. The drums were stored at the Northern

Hydromet Administration's base. Unbroken drums are planned to be used for future tests of equipment that will be used for compaction in future. Compacted drums were sold for scrap to LLC "Arkhangelsk Metel Group" base.

After the completion of drums disposal, the following main conclusions can be made:

High power pressing or compacting equipment is required to compact most drums since the thickness of drum walls may reach 2 mm. Equipment with pressing force of at least 24 tons is desirable to be used.

The drums should be washed and recycling water cleaned up in a room with positive temperature since the drums are full of a frozen mixture of oil and lubricant residues and water.

To clean up drums, burning of oil and lubricant residues is probably more efficient with the use of special equipment maintaining a sufficiently high temperature of burning and low level of pollutants in gases. When using this method of drums clean up, the level of pollutants in combustion gases.

The efficiency of biological products for cleaning up contaminated soil can be estimated on the base of analysis of the samples collected at the test site. The first samples were collected before the start of work in 2007. The control survey was performed in October, 2008 during the expedition for additional study of the site territory on Alexandra Island. The samples were analyzed in a laboratory of N. N. Zubov SOI.

Averaged data on petroleum hydrocarbon content for test site 2 points 45 – 48 and 65 and test site 3 points 58 – 60 are given in Table 1.

Table 1. AVERAGED VALUES OF PETROLEUM HYDROCARBONS CONTENT IN SOILS (in mg/kg) OF TEST SITES IN 2007 AND 2008

YEAR	Test Site 2	Test Site 3
2007	3540	19150
2008	800	6130

The above table shows that concentration of petroleum hydrocarbons decreased in 2008 in comparison to 2007 by 4.5 times and at test site 2 and by 3 times at test site 3.

Apparently 1.5 times higher decrease in contamination level was due to the effect of the biological products. At the same time having such representativeness of results a 1.5 times difference may be considered insignificant.

Following the results of the experiments on soil cleanup using the biological products, the main conclusions are as follows:

- Biological products decreasing the soil contamination level should be used at the sites having high local soil contamination with petroleum hydrocarbons provided that it can be guaranteed a high effect of biological products, i.e. such areas should be defended either with natural obstacles or artificial borders to avoid washout of biological products and biogenic matters introduced on these sites.
- Biological products should be introduced in the beginning of the warm season if possible to provide the maximum possible time of action.

- To increase the effectiveness of the biological products application, various covers should be used such as special films or stationary polycarbonate greenhouses to provide the maximum possible soil warming.
- Special and apparently small in area test areas can be established where, taking into account all above activities, contaminated soils collected from other sites and delivered to the test site can be biologically cleaned up.
- It is preferable to use specialized biological products adapted to the maximum to the use in the Far North. Biological base of such products should be microorganisms cultivated from the strains bacteria which are natural biodestructors of petroleum hydrocarbons in soils of Transpolar regions.

Legal and organizational procedures for the release of cleaned up areas from the RF Ministry of Defense responsibility

In 1960s-1970s, based on the applications made by the Ministry of Defense, some land plots allotment was authorized by the Arkhangelsk Region Executive Committee of the USSR for deployment of military units on Franz Josef Land Alexandra Island:

These plots were used by the Ministry of Defense in accordance with their intentions till the early 90's of last century.

The 1990's Armed Forces' reforms contributed to the reduction of military units deployed in the Arctic region. At the same time, the property, weapons and military hardware reached their service life as well as and wastes of various classes of hazard could not be removed due to the high cost of their removal, absence of the Ministry of Defense's ice-class vessels and appropriate mooring facilities on these islands. Abandoned barracks and quarters of also reached their service life and were taken off the books. Until now the land plots have not been transferred to the balance sheet of the Arkhangelsk Region executive authority.

Due to a further absence of demand for these land plots on Franz Josef Land the RF Government organized their commercialization. In this context, the RF Government adopted by its Decree No 571-p of April, 1994 a RF Ministry of Natural Resources proposal on the establishment of the Ministry of Natural Resources' federal nature reserve Franz Josef Land.

The requirements of the RF Government Decree are the basis to start work on releasing the land plots transferred earlier to the RF Ministry of Defense situated on Franz Josef Land from the "defense and security land" category.

In accordance with the RF Ministry of Defense procedures, applications to change the target purpose of the land plots situated on Alexandra Island (release from the "defense and security land" category) are made by the Chief of the RF Ministry of Defense Billeting, Facilities and Installation Service.

The needed documents and the above applications are prepared by the Air Force General Headquarters which will be submitted for signing by the Chief of the RF Ministry of Defense Billeting, Facilities and Installation Service through the RF Ministry of Defense General Apartment Management Administration. The Air Force Commander-in-Chief appoints the respective commission to obtain needed concurrence with interested military command structures and organizations preparing the appropriate materials.

In accordance with the effective procedure, contaminated areas should be cleaned up by the Russian Federation Ministry of Defense upon which these areas can be transferred to other entity.

Based on work results and experience obtained, the guidelines for the remediation of contaminated areas of decommissioned military sites in the Russian Arctic have been developed taking into account the effective regulatory framework and current state of such sites. The wording of the guidelines is given in the report.

Conclusion

Reconnaissance survey of the current environmental state of the area of the decommissioned site of the Russian Federation Ministry of Defense on Alexandra Island of Franz Josef Land Archipelago allows us to make an unambiguous conclusion on a significant level of soil contamination and degradation at the area under study.

Man-made degradation of the territory is mainly represented by four types.

First – organized (stored) and non-organized accumulation of drums and cisterns (empty and full of oil and lubricants) on the coast, near the frontier post Nagurskaya, in vicinity of abandoned military base as well as along the road from the coast (anchorage for vessels) to the frontier post Nagurskaya.

Second – abandoned military, transport and other equipment in vicinity of the decommissioned military site. Some abandoned equipment contains technical liquids containing PCB and heavy metal.

Third – damaged pipelines from the coast (anchorage for vessels) to the frontier post Nagurskaya and to the decommissioned military site.

Forth – ruins of structures of the former frontier post Nagurskaya, decommissioned military site, construction and domestic waste.

The level of contamination at all sites of geoecological testing on Alexandra Island can be regarded as extra-hazardous.

The results of the demonstration project on cleanup of the area from empty drums with oil and lubricant residues showed the following:

- Equipment with pressing force of at least 24 tons should be used for compacting drums;
- Oil and lubricant residues should be either burnt in incinerators to clean up the drums from oil and lubricant residues for preventing environmental pollution or the drums should be washed in a specially equipped room at a positive temperature;
- Soil reclamation on Alexandra Island is highly difficult due to a large number of stones and absence of soil cover as such. In the course of cleanup soil can be treated to reach the state close to that in non-degraded areas of the island;
- Taking into consideration the geographical situation of the sites location, work should be carried out in the period of maximum positive temperatures, e.g. in August and the first decade of September.

The experience of implementation of the demonstration project showed that during implementation of a full-scale project on remediation of the area of decommissioned site of

the Russian Federation Ministry of Defense in high-altitude Arctic region, specialized and possibly unique process layout should be used, especially for disposal of hazard and extra-hazard wastes and further remediation of degraded lands.

So a series of pilot projects to test various technical solutions aimed at handling of wastes and contaminated soils are to be implemented along with the development of a full-scale project on remediation of these areas. In particular, the technology of handling drums with oil and lubricant residues should be updated till the level ensuring their complete and safe disposal.

In conclusion, it can be noted that 2007-2008 experimental project on survey and cleanup of the area of decommissioned sites of the Russian Federation Ministry of Defense on Alexandra Island has resulted in obtaining a large amount of unique information and working out the components of the procedures that can be used for planning and performance of further work on cleanup of the area of this site and similar ones. For organizational, resources' and engineering support of further work on cleanup of contaminated areas of the archipelago, close cooperation is needed with the Ministry of Defense, FSS Frontier Service of the Russian Federation, the Ministry of Economic Development, Roshydromet, Ministry of Natural Resources and Ecology of the Russian Federation and other interested agencies as well as the use of international experience and expertise to provided a needed technical level of disposal of hazard wastes and remediation of contaminated lands.

ABBREVIATIONS

AAS A2	atomic absorption spectrophotometer A2
AD Base	air defense base
APC	approximate permissible concentrations
AS	airstrip
CG with HS	chromatographic analytic system with headspace sampler
CG with ECD	chromatographic analytic system with electron capture detector
CP	code of practice
DBOFB	biphenyl dibromoctofluorine
DDT	dichlorodiphenyltrichloroethane
ECD	electron capture detector
ENDF	federal environmental regulatory documents
FJL	Franz Josef Land
FLM	fuels-lubes materials
GD	guiding document
GIS	geographic information system
HM	heavy metals
HS	headspace sampler
HS	hygienic standard
IL	interference level
IR	infrared
Kc	chemical concentration factor
MPC	maximum permissible concentrations
MR	methodological recommendations
OCC	organochlorine compounds
PAH	polycyclic aromatic hydrocarbons
PC	permissible concentration
PCB	polychlorinated biphenyls
PH	petroleum hydrocarbons
POP	persistent organic pollutant
PS	polluting substance
RPA	research and production association
RS	research ship
SanPiN	sanitary and hygienic norms and rules
TBA	tetrabutylammonium
TCN	naphthalene tetrachloride
VAH	volatile aromatic hydrocarbons
VH-2M	vibration hydrometer 2M

1. INTRODUCTION

This report presents the results of the survey of the state of the areas of decommissioned sites of the Russian Federation Ministry of Defense and those of a pilot project on the cleaning up of the environment of a decommissioned military base on Alexandra Island of Franz Josef Land Archipelago.

The basis of the project was the Consulting Service Contract # CS-NPA-Arctic-1/2007 providing funds for the demonstration project 'Cleaning up of the environment at a decommissioned military base on Archipelago Franz Josef Land' of 29 August 2007, between the non-commercial organization "The Foundation of Polar Studies" (hereinafter designated as POLAR FOUNDATION or NCO "POLAR FOUNDATION") and Institution "Executive Directorate of National Pollution Abatement Facility" ("NPAF Executive Directorate"). The contract was signed under a GEF grant for the project 'Russian Federation – Support to the National Programme of Action for the Protection of the Arctic Marine Environment' of 18 July 2005.

The project had been approved by:

- ***the Ministry of Defense, ref. No. 110/4/429 of 16.03.2007*** signed by the First Deputy Minister of Defense Yu. Baluevsky; and
- ***Rosprirodnadzor Administration for Arkhangelsk Region, ref. w/o No. of 05.09.2007*** signed by acting Head of Rosprirodnadzor Administration for Arkhangelsk Region A. Serebrennikov.

Reffering subject matter, this report contains data on the key stages of project implementation under the Contract, such as inception stage reports, field trip reports, and office analysis and sample handling reports.

The project objectives were:

1. Determine the level of contamination of selected demonstration sites within a former air base on Alexandra Island of Franz Josef Land Archipelago by petroleum products, PAHs, POPs and heavy metals, conduct an inventory of contamination sources with the aim of determining their quantity, state of repair and risks of deterioration, and an assessment of associated environmental risks.

2. Pilot utilization of spent oil drums, including drain of liquids, removal of oil leftovers, drum compaction, and transportation from the archipelago for disposal at Archangelsk Oblast disposal sites.

3. Assessment of opportunities and available techniques for the conservation of PCB-containing items as part of technical facilities of airfield services and aircraft defense at a selected site.

4. Clean up of the area from where the drums were removed, using state-of-the-art land oil decontamination methods designed for Arctic regions.

5. Develop guidelines for the remediation of contaminated areas at decommissioned military bases in the Russian Arctic.

6. Collect contamination samples prior to and after taking remediation measures so as to determine the efficiency of decontamination techniques used and to deliver recommendations and methodologies for further clean-up action in contaminated areas.

7. Develop legal and organizational procedures for transferring the rights of governance of the remediated areas from the Ministry of Defense of Russia to Archangelsk Oblast Administration.

The contamination criteria were determined based on the requirements for the quality of soils laid down in the Russian regulatory documents (GOST, SanPiN and RD), as well as the recommendations by Arctic Monitoring and Assessment Programme (AMAP) of the Arctic Council for the key areas of monitoring of persistent organic pollutant levels (POPs).

The contractor was the NPO 'POLAR FOUNDATION' that was responsible for the organization and coordination of the studies involved. The State Institution "State Oceanographic Institute SOI" (management of expeditionary work), Moscow; LLC "I.K.M. Engineering", Saint-Petersburg; North-West Branch of SPA "Typhoon", Saint-Petersburg; and the Northern Territorial Administration for Hydrometeorology and Environmental Monitoring (Northern UGMS), Archangelsk, acted as subcontractors.

Field work was conducted in 2007 at the time of a trip of the Northern Hydro-meteorological Service Administration's Research Vessel "Mikhail Somov" to deliver supplies to polar stations and research projects within the 2007/2008 International Polar Year Program. A second set of samples were taken in 2008 during the feasibility studies for the remediation pilot project on Alexandra Island.

Field and lab studies were conducted in line with the regulatory documents in force that lay down the requirements for monitoring, sampling and analysis procedures.

Study Area Background

Alexandra Island is a part of Franz Josef Land Archipelago (FJL) located in the west of the Russian Arctic, in the north-east of the Barents Sea, within 80^{o}-82^{o}N, and is the northernmost land in Eurasia. There are no indigenous people on the archipelago.

FJL is a complex system of larger (over 1000 km^2) and smaller (10 to 100 km^2 or less) islands, and deep straights (300 to 600 m deep) separating them. Available studies differ in giving the number of the islands: from 152 to 282 – depending on whether or not certain rocks and banks are counted in. The archipelago is 375 km long

alongside the parallel, and 234 km long alongside the meridian. Most of the islands are the remnants of a vast basalt plateau, cut into separate blocks by tectonic fractures, and largely destroyed by glaciations and other denudation processes. Many islands have a plateau-like relief owing to the basalt layers' horizontal orientation . Glaciers take up 85% of the archipelago's total area. The glacier area is in the process of shrinking.

All FJL islands fall in the arctic desert climatic zone. Precipitation is 200-300 to 500-550 mm (in ice dome accumulation areas) per annum. Average January temperature is -24C°, June +2C°, the lowest temperature ever recorded here was -52C°. Wind velocity is up to 40 m/s (Heiss Island, the location of the northernmost meteorological station in the world). Glacier-free soils are rocky with varying degrees of fragmentation, and have virtually no humus layer. The driest areas have thin vegetation of lichens and mosses. Negative landforms have algae for living forms.

From the early 50's to early 90's, the islands were hosts of few military bases and frontier guard sites. Since the early 90's all these sites, save for the Nagurskaya frontier post on Alexandra Island, have been closed. The exceptionally high transportation costs resulted in lack of proper decommission action, and the fact that most equipment and materials were left behind. Dozens of thousands of tons of petrochemicals and lubricants were left on the island in drums and cisterns, including waste oils, a few million drums with oil leftovers, abandoned equipment and machines, houses and service buildings. Many of the items pose high environmental threats.

According to AMAP reports, submitted to the Arctic Council in 1997/1998 and in 2002, the environment of Spitsbergen and Franz Josef Land Archipelago (FJL) has the highest levels of polychlorinated biphenyl (PCB) contamination among all Arctic regions.

The report 'Updating of Environmental "Hot Spots" List in the Russian Part of the Barents Region: Proposal for Environmentally Sound Investment Projects', prepared by NEFCO/AMAP at the request of the Kirkenes Summit of the Barents Euro-Arctic Council in January 2003, called the Franz Josef Land Archipelago a site of special concern and placed it on a list of 'hot spots' and priority projects(Project A 7-2).

FJL Archipelago has several areas of critical environmental concern. These are the islands of Hoffman, Graham-Bell, Alexandra, Heiss, Rudolf and Guker which hosted at different times sites of Roshydromet, Ministry of Defense, and some other institutions', and whereto a large quantity of machinery, building equipment and oil products had been shipped.

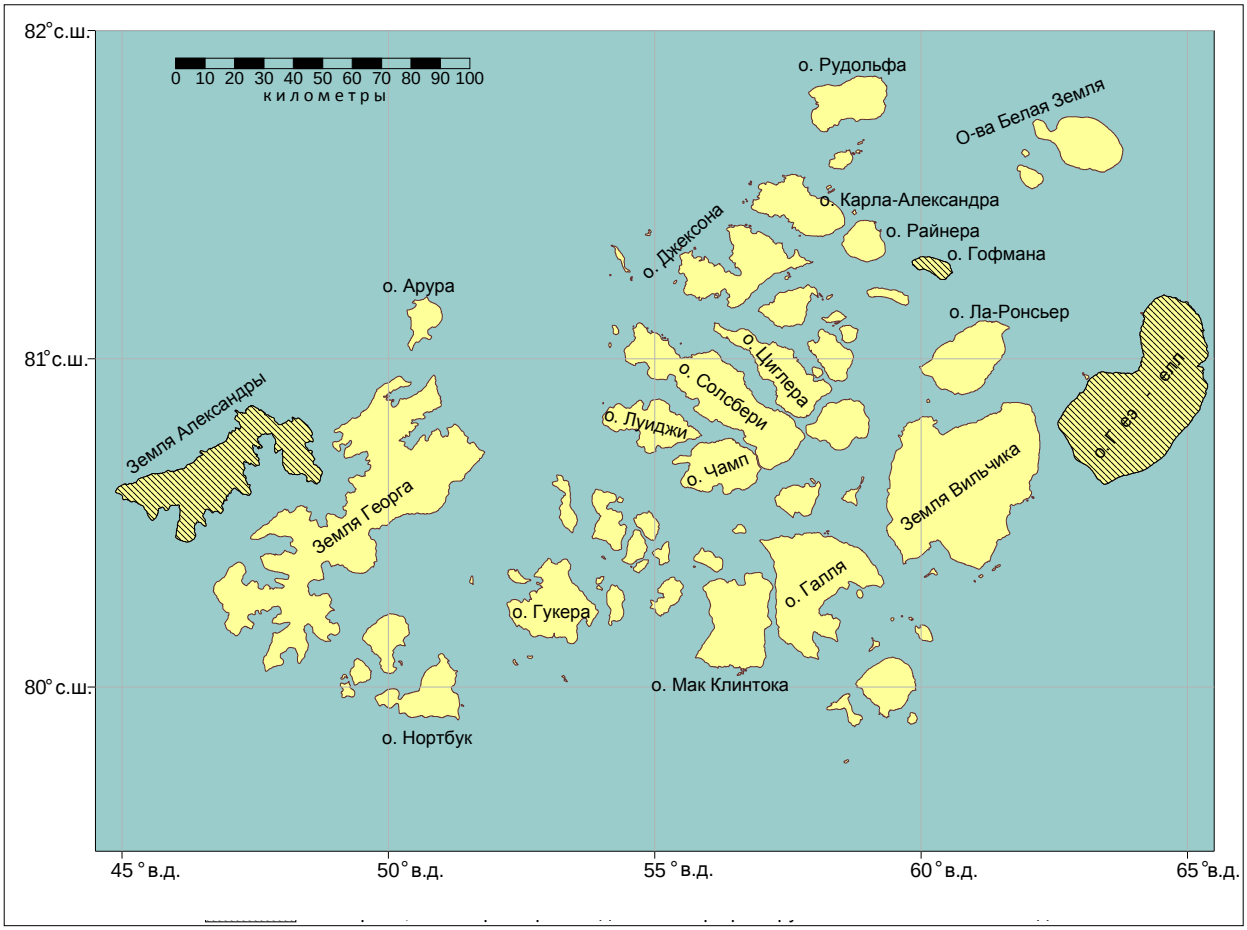


Fig. 1. A map of Franz Josef Land Archipelago

2. ORGANIZATION OF MAPPING AND GEO-ECOLOGICAL STUDIES

2.1. Review of Technogenic Impacts on the Study Area

Airborne and land studies of the decommissioned sites on Alexandra Island were conducted from 15 through 21 September 2007. The research equipment and team were delivered to Franz Josef Land Archipelago by the Research Vessel Mikhail Somov. A MI-8T helicopter of OAO Joint Arkhangelsk Detachment Two based on the research ship Mikhail Somov was used for airborne studies and taking the research team to the mainland.

Airborne and land study areas are presented in Table 2.1-1.

Table 2.1-1. Airborne and land study areas

Area	Land Study Site Number	Study Area, km^2	Description
Alexandra Island	1	0.2	Severnaya Bay Fuels-Lubes Storage
	9	2.9	Locator Station (Air Defense Radar Post, Fuels-Lubes Storage)
	10		Fuels-Lubes Storage, at Nagurskoye settlement
Total:	**3**	**3.1**	

2.2. Chemical-ecological study of the parts of the area with most prominent signs of potential contamination

Site 01. Located on the shore of Severnaya Bay nearby the pier at which the unloading of cargo ships takes place. The area holds a large quantity of cisterns and metal drums. Part of the cisterns are still being used as fuels-lubes storage. The drums are date-marked of 50's and 80's. The 50's drums are empty, while the 80's ones are partly filled with oil products to various degree.

A sketch map of geo-ecological sampling is presented in Fig. 2.2-12 at the end of this chapter.

Fig. 2.2-1 A section of the Severnaya Bay fuel-lubes storage

Site 09. A system of objectsnamed collectively ‘locator station’ due to the fact that remnants of radar installations are the most typical structures here. According to the helicopter crew, an air defense post used to be located here. A hydro-meteorological station was said to have been located nearby, however, no signs of a meteorological gauging site was found. There were some abandoned buildings (one had an inscription saying ‘ДЭС-2’ on the wall), a wooden rack, tanks with an unknown substance and level of filling, and drums. The site is heavily littered by scrap metal and other wastes. Thawed ground had extensive signs of petrochemical contamination.

A sketch map of geo-ecological sampling is presented in Fig. 2.2-10 at the end of this chapter.

Fig. 2.2-2 A section of the locator station site

Site 10. A fuels-lubes storage near Nagurskoye settlement (it is the location of a dump site for drums and other contaminated objects where experiments were conducted

within the demonstration project on the remediation of the environment of a decommissioned military base, see Chapter 6). A sketch map of geo-ecological sampling is presented in Fig. 2.2-11 at the end of this chapter.

Sampling methodology. Soil sampling was carried out in accordance with the relevant regulatory documents in force in the country. Sampling was by the 'envelope' method using the top layer 0 to 10 cm. Five soil samples were taken at each geo-ecological sampling point. A sample was placed in a plastic bag with a zipper. The bag was then labeled using an accepted labeling system. A bagged sample was placed in an 'Isoterm' container. On completing the sampling procedure, a sample ID form was filled out. The filled containers were placed in a freezer to be kept there until delivered to the experimental lab.

During the sampling a GPS navigator was used to determine the geographical coordinates of the sampling points. Wherever possible, the sampling site was photographed. In total, 239 samples and specimens were taken.

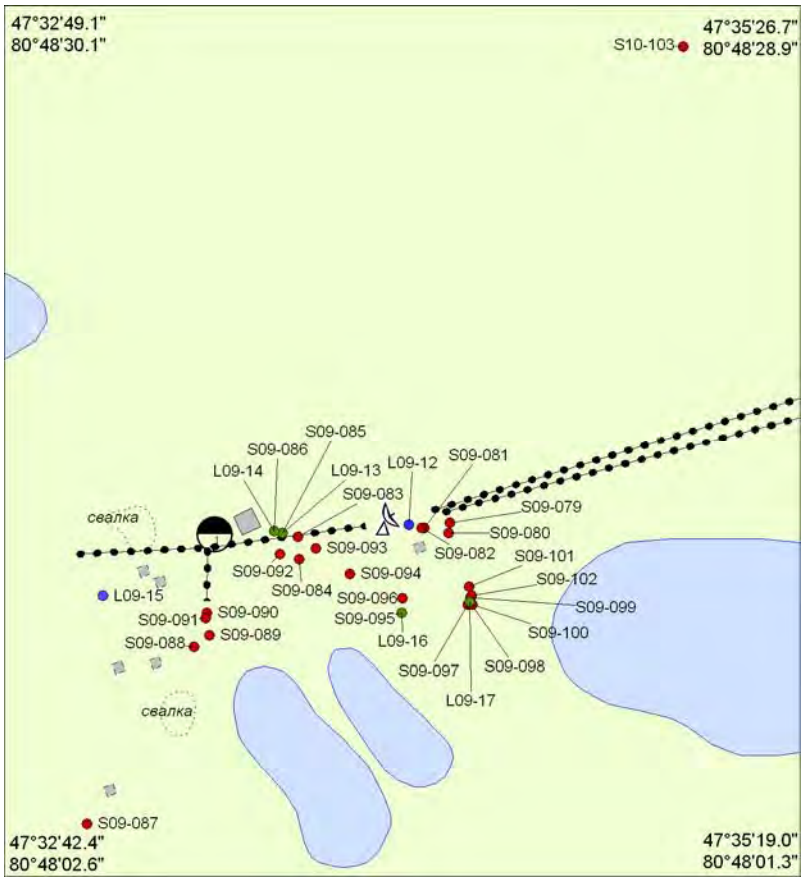


Fig.2.2-10 Sketch map of geo-ecological sampling at Site 9 (Locator Station)) on Alexandra Island (1: 7500)

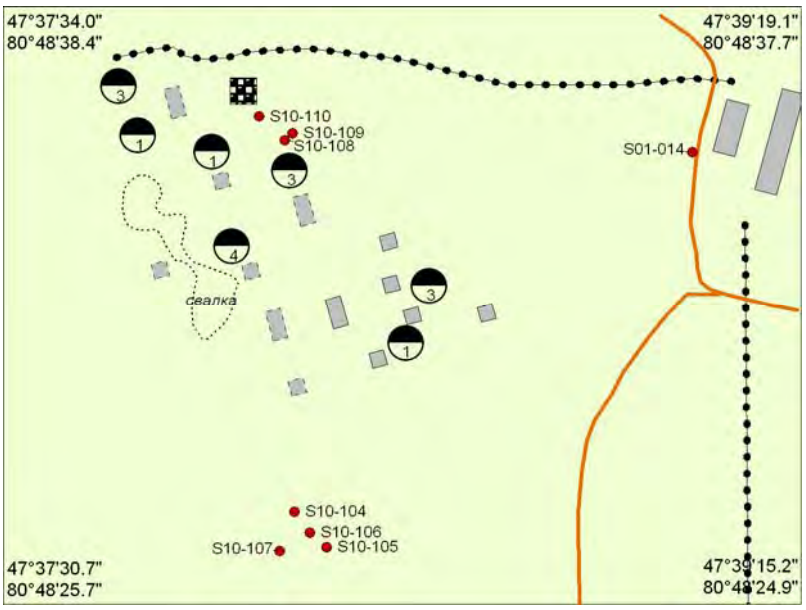


Fig.2.2-11 Sketch map of geo-ecological sampling at Site 10 (Fuels-lubes storage at Nagurskoye Settlement) on Alexandra Island (1: 5000)

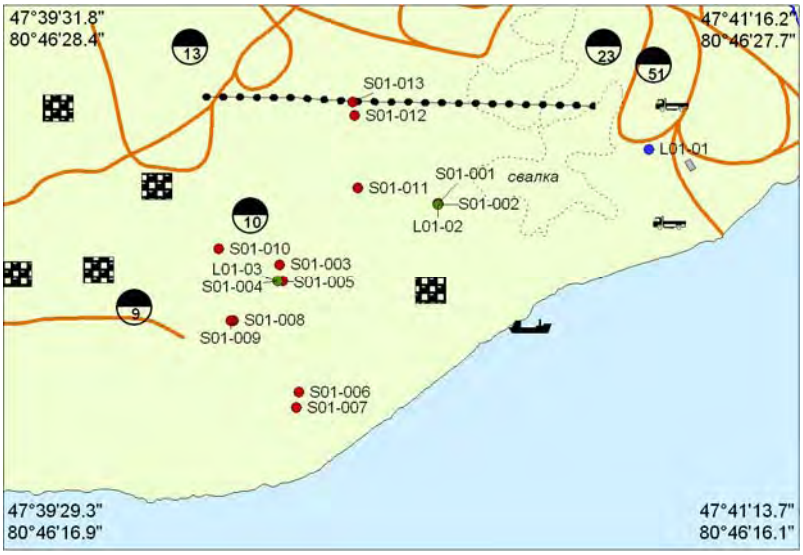
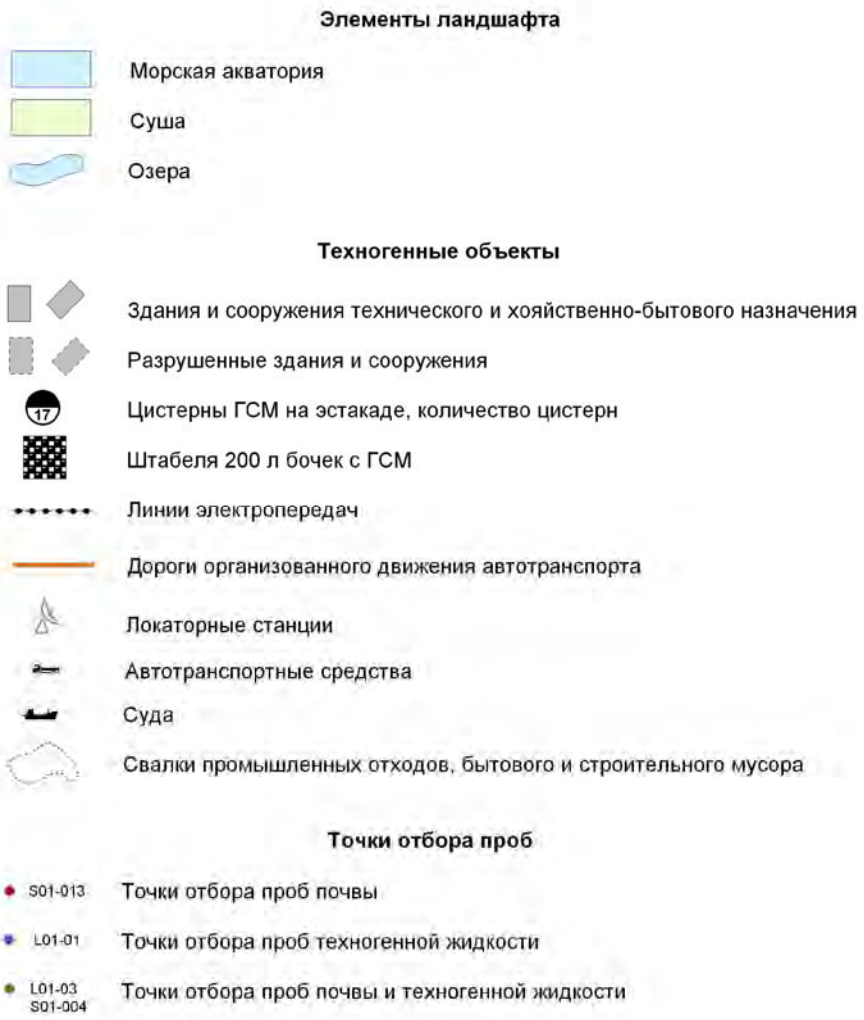


Fig.2.2-12 Sketch map of geo-ecological sampling at Site 1 (Fuels-lubes storage at Severnaya Bay) on Alexandra Island (1: 5000)

Geo-ecological sampling map legend



2.2.2. List of instruments, testing and auxiliary equipment used in the analytical studies

Table 2.2-2. **List of accepted chemical analytical and measurement instruments and certified testing equipment.**

#	Instruments	Date of lest verification or certification	Number of units
Accepted measurement and certified test equipment			
1	Electronic analytic balance Adventurer AR-2140, class 2, 0.1 mg, Ohaus, Switzerland	January 2008	2
2	Electronic rough balance Adventurer, balance error 0.01g ARA-520 Ohaus, Switzerland	January 2008	2
3	Laboratory digital dosing unit Akvastep, 50ml	February 2008	4
4	Adjustable pipettor Termoelectron	November-December 2007	10
5	Atomic absorbtion spectrophotometer Kvent-2 with data processing station based on IBM PC	November 2007	1
6	Atomic absorbtion spectrophotometer (AAS) Kvant-Z-ETA with "cold vapor" GRG-106 device	December 2007	1
7	Atomic absorbtion spectrophotometer (AAS) A-02	December 2007	1
8	Oil products analyzer AN-2	September 2007	1
9	Chromatographic analytical system based on gas liquid chromatographer "Kristal-2000M" with dipole electrical sounding detector, autosampler DAZh and data control and processing station based on hard and software complex Khromatek-Analitik and IBM PC.	November 2007	1
10	Chromatographic analytical system based on gas liquid chromatographer "Kristal-2000M" with flame ionization detector, equilibrium vapor dosing unit and data control and processing station based on hard and software complex Khromatek-Analitik and IBM PC.	November 2007	1
1 1	Chromatographic analytical system based on gradient liquid chromatographer "Stayr Gradient", autosampler Stayer Basik, UV and fluorimetric detector and data control and processing station based on hard and software complex MULTICHROM-AKVILON AND IBM PC.	November 2007	1
12	Flash Point Analyzer in closed cup (Pensky Martens) LAUDA DIN 51758	September 2007	1
13	Flash Point Analyzer in open cup TVOT	October 2007	1
14	Vibration hydrometer VIP-2M	November 2007	1
15	Areometer (range of measurement 1010-950 kg/m3, scale interval 0.5 kg/m3) ANT-1	February 2008	1
16	Areometer (range of measurement 950-890 kg/m3, scale interval 0.5 kg/m3) ANT-1	February 2008	1
17	Areometer (range of measurement 890-830 kg/m3,	February 2008	1

	scale interval 0.5 kg/m3) ANT-1		
1 8	Areometer (range of measurement 830-770 kg/m3, scale interval 0.5 kg/m3) ANT-1	February 2008	1
1 9	Viscometer MAR - TEC VISCOMAR MAR-TEC VISCOMAR	July 2007	1
20	Drying oven SNOL 58/350	February 2008	1
21	Muffle furnace SNOL 7.2/1100	February 2008	1
22	Double chamber programmable furnace PDP-18M	February 2008	1
23	Thermostat to measure oil product density according to GOST 3900-85 VT-p	February 2008	1
Editional equipments which isnot subject to certification			
24	Freeze dryer Alpha-1-4, Martin Christ, Germany		1
25	Sample grinder “PULVERIZETTE”, Fritch, Switzerland		1
26	Analytical mill A-10, IKA, Germany		1
27	Bank of sieves LO 251		1
28	Centrifuge OS-6M		1
29	Automated digital laminar extractor for AN-2		2
30	Ultrasonic Cleaner Branson Ultrasonics 3510-R-MT		1
31	Ultrasonic dispersant UZD-100		
32	System for high-purity water D300, NPKF AKVILON		2
33	Rotary Evaporator RV-05 BASIC, IKA- Werke, Germany		2

3. MAPPING AND GEO-ECOLOGICAL STUDIES

3.1 Human impacts study

Under the Contract, the Contractor:

- Carried out an airborne visual study of the territory taken up by the decommissioned bases of the Ministry of Defense of Russia, with photographing and documenting evidence of human impacts on the local environment.

- Took 88 plan pictures of Alexandra Island.

258 objects were geo-coded on Alexandra Island

- Building , construction for technical

or utility purposes - 55

- Fuels-lubes tank rack - 18 (194 tanks)

- Container, tank -15

- Stack of 200 l fuels-lubes drums	- 42
- Cluster of drums	- 38
- Locator station	- 1
- Motor vehicle	- 12
- Water craft	- 1
- Airplane	- 1
- Access bridge, wood	- 2
- Power line	- 14 sections (5 km)
- Landfill for industrial, domestic and construction waste	- 34 (125.2 thousand m^2)
- Outdoors storage for construction materials and equipment	-5
- Motor road	-16 sections (6.7 km)

Using the list of the geo-coded objects and vector blank maps, electronic vector maps were created for the studied areas of the decommissioned bases of the Ministry of Defense of Russia where adverse human impacts on the environment were found.

3.2 Characteristics of the results of chemical studies

While carrying out studies of soil and water contamination in the study area, a total of 230 soil samples and 9 of utility liquids were taken. The obtained data was enough for assessing the levels of contamination at the study decommissioned bases of the Ministry of Defense of Russia.

Principles of processing and summarizing data

Comparative analysis of the data was performed based on averaging the results of individual samples for each sampling point.

Summarizing data about the distribution of soil contamination over the study area was based on the results obtained on the following sites on Alexandra Island:

- Locator station (site 09);
- Fuels-lubes storage near Nagurskoye settlement (site 10);
- Fuels-lubes storage at Severnaya Bay (site 01);

4. STUDYING THE CURRENT STATE OF AVERSE HUMAN IMPACTS ON THE STUDY AREA

4.1 Human impact study methodology

Airborne study methodology

Airborne studies included visual observations and documenting adverse human impacts using technical means.
The objectives of the visual observations were as follows:

- Study the site for environmental issues (unauthorized waste disposal, clusters of drums with petrochemicals, fuels-lubes tanks on racks, technical or utility buildings and structures);
- Preliminary assessment of total adverse human impacts;
- Referencing key landmarks to the geographical grid for deciphering the photographs.

Taking a visual of the area lasted as long as the flight. The results were entered in a visual study log. The data recorded in the log included the location of objects and items being observed, violations of environmental regulations, and adverse human impacts.

In case an adverse human impact was detected, the airplane took a flyover to allow for taking pictures.

The objectives of photographing were as follows:

- Provide a proof of violations of environmental law on the site;
- Register the geographical location of adverse human impacts;
- Determine the borders of the contaminated area as accurately as possible.

Methodology used for a land study of adverse human impacts

The land study immediately followed the airborne one. The objectives of the land study were as follows:

- Provide a more detailed picture of adverse human impacts;
- Photograph detected adverse human impacts;
- Determine geographical coordinates of the adverse human impacts using GPS technology and reference them to local landmarks;
- Sampling soils and utility liquids.

4.2 Methodologies for processing air visual study and photo data

The processing of air visual study and photo data included:

- Preparation of electronic vector blank maps;
- Preliminary processing of digital pictures of adverse human impacts;
- Deciphering of the pictures;
- Geo-coding of discovered adverse human impacts;
- Statistical processing of geo-coding data; and
- Preparation of 1: 5000 and 1: 1000 maps of study areas with adverse human impacts detected.

4.3 Analysis of the state of the decommissioned bases of the Ministry of Defense of Russia

Alexandra Island is located in the west of FJL Archipelago. The island has an area of 1,039 km^2, with glaciers taking up 74% of its surface. Two glaciers, Kupol Lunny and Kropotkin's Kupol, 323 and 314 m high, respectively, are the highest ones.

The study decommissioned military sites are located in the north of Alexandra Island.

4.3.1. Locator station and fuels-lubes storage at Nagurskoye Settlement

The studied site, covering an area of 2.9 km^2, has an operating frontier post and a closed air defense station.

Human impacts in the area included technical and utility buildings and structures of the closed air defense station, fuels-lubes storages, industrial, utility and construction waste disposal sites, outdoor storages of materials and equipment.

Fuels-lubes storage near the Nagurskoye settlement

The key human impacts around the Nagurskoye settlement are fuels-lubes tanks – cisterns and 200 l drums, and utility and industrial waste disposal sites.

Cisterns

Eight racks with 19 cisterns were geo-coded west of the Nagurskoye settlement. 20 cisterns were found on 2 racks south of the settlement near a local operating airdrome.

200 l drums

200 l drums were found in 2 stacks, with a total count of about 250 drums. Also, 5 clusters of drums were found near the settlement, with a total count of about 450.

Apart from the stacked and clustered drums, the area was littered with metal drums scattered all over the study area near the Nagurskoye settlement. Their total number ranged between (approximately) 1 to 2 thousand.

Disposal sites for industrial, utility and construction waste

A disposal site of industrial and construction waste was found to be a strip 500-600 m wide running north to south, west of Nagurskoye settlement. The total area of 7 sections of the waste disposal site was 28 thousand m^2.

In addition to the said objects, the area near Nagurskoye settlement had the following items geo-coded:

- 16 buildings and structures in various states of repair, taking up a total area of 4.8 thousand m^2;

- 9 motor vehicles;

- 1 airplane at a filling station.

Locator station

The key human impacts included the locator station (elements of the antenna system, parts of power system – converters, capacitors and other electronic components), fuels-lubes cisterns on racks, disposal sites of metal constructions and construction waste.

Locator

Locator station – an antenna system and operations building – is surrounded by a junkyard of metal constructions and other waste with an area of 6.5 thousand m^2. The total area of waste disposal sites around the station is 13.6 thousand m^2.

Cisterns

18 fuels-lubes cisterns on 2 racks. One cistern is next to the wall of the building.

Buildings, structures

The locator station site had 13 buildings in the various state of repair geo-coded, covering an area of 3.9 thousand m^2, one wooden rack.

Apart from the said objects, there were man-made objects posing potential risk to the environment between the locator station and the Nagurskoye settlement. An area of 140 thousand m^2 had:

- 4 waste dumps, with a total area of 59 thousand m^2;

- 1 rack with 8 cisterns;

- 17 buildings of various states of repair, of a total area of 5.1 thousand m^2;

- 1 wooden rack.

1.3 km south of the locator station there were:

- 3 waste dumps of a total area of 16 thousand m^2,

- 8 buildings of various states of repair (total area is 2,4 thousand m^2).

On the whole, the studied area of the locator station was heavily littered by metal drums, scattered all over the place. The approximate number of these was 1.8 to 3.6 thousand.

Figures 4.1-4.6 have the pictures of sections of the locator station site, that of fuels-lubes storage near the Nagurskoye settlement, and human impact objects found there.

Fig. 4.1 The Nagurskoye settlement on Alexandra Island

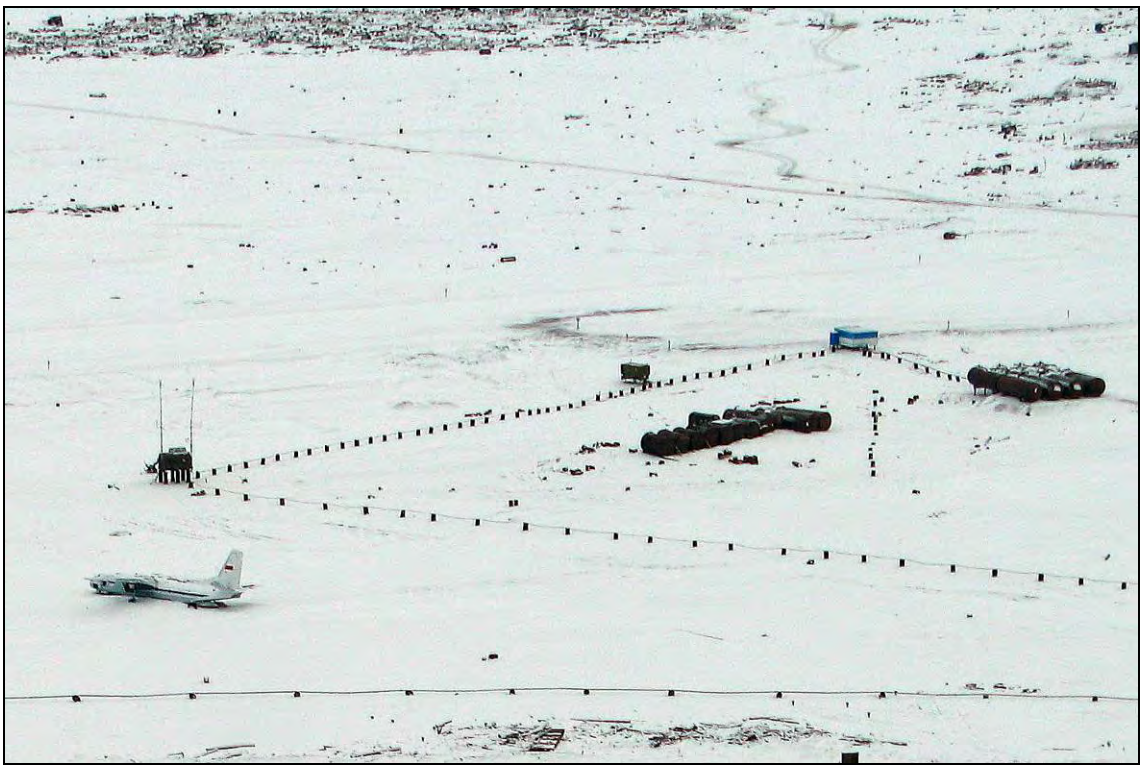


Fig. 4.2 Fuels-lubes storage near the Nagurskoye settlement, industrial, utility and construction waste dump (in the background)

Fig. 4.3 Ruins of buildings, fuels-lubes cisterns on the study area near the Nagurskoye settlement (site 10, Alexandra Island)

Fig. 4.4 Locator station and littered area around it on Alexandra Island

Fig. 4.5 Section of the study area littered by metal drums with fuels-lubes near the locator station

Fig. 4.6 Area affected by heavy machinery movements near the locator station (Alexandra Island)

4.3.2 Fuels-lubes storage at Severnaya Bay

The study area of 332 thousand m^2 on the shore of Severnaya Bay had numerous fuels-lubes containers.

Human impacts in the area included stacks of 200 l drums, cisterns, industrial waste dumps, broken soils cover due to organized and sporadic motor vehicle movements. .

The geo-mapped objects on the study area included:

fuels-lubes cisterns – 142

200 l drums – 31-36 thousand

7 waste dumps, about 1,000 $м^2$.

Total length of motor roads is about 4 km.

Figures 4.7 to 4.10 have pictures of parts of the fuels-lubes storage area at Severnaya Bay, and other human impact objects.

Fig. 4.7 Fuels-lubes storage at Severnaya Bay (site 1, Alexandra Island)

Fig. 4.8 Fuels-lubes drum stacks at Severnaya Bay (site 1, Alexandra Island)

Fig. 4.9 Fuels-lubes cisterns, motor road and waste dump at Severnaya Bay (site 1, Alexandra Island)

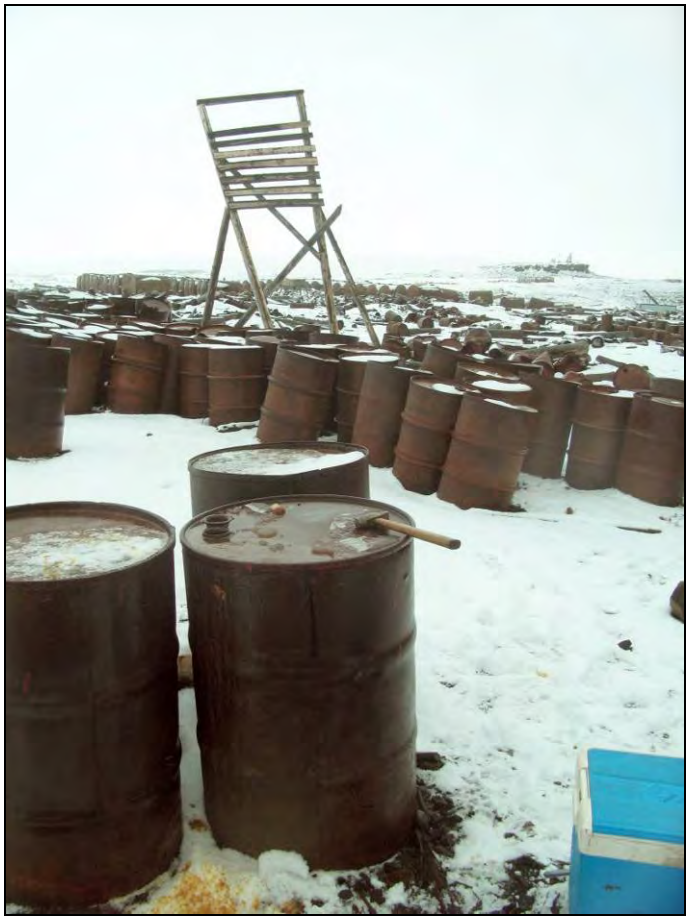


Fig.4.10 200 l fuels-lubes drums at Severnaya Bay (site 1, Alexandra Island)

5. EXISTING CONTAMINATION LEVELS STUDY

5.1. Chemical and environmental characteristics of the contaminantsmonitored in the study

Oil hydrocarbons

Total levels of oil hydrocarbons

According to Russian and international standards, measuring total levels of oil hydrocarbons was done using non-dispersive IR-spectrophotometry that allows monitoring the most characteristic group of compounds of raw oil and products thereof: non- and low-polarity hydrocarbons, non-absorbable on active alumina.

The group includes all alkanes of normal and branched structure, naphthene hydrocarbons and low-polar aromatic hydrocarbons without condensed rings. It is these hydrocarbons that are an inseparable part of the natural geochemical background. Their presence in surface waters at 10 to 50 µg/l can be explained by both entry of petrochemicals from an external source, and the presence of biogenic lipids of hydrobiont or terrigenous genesis.

Higher levels of oil hydrocarbons in surface and ground waters are an indicator of there being a permanent source of pollution nearby.

The toxicity of aliphatic and naphthenic hydrocarbons is relatively low, although their strong tendency towards forming emulsions and surface films, presence of these compounds even in trace amounts in surface, ground waters and soils markedly affects oxygen exchange, which in turn leads to adverse eco-toxicological consequences (loss of great numbers of embryos and young fish, plant growth inhibition, etc.).

Volatile aromatic hydrocarbons (VAH)

Volatile aromatic hydrocarbons (VAH) - benzene, toluene and ortho-, para-, and meta-xylenes – are highly volatile compounds with a relatively high toxicity, irritant action, and strong specific odor, which, combined with their relatively high solubility in water (100-800 mg/l), make them able to give water unpleasant odor and taste, thus rendering it unusable as potable water.

Aromatic hydrocarbons are also the most toxic of all. Owing to high volatility of these compounds, even at low temperatures, their presence in water bodies is only possible if there are closely located objects permanently discharging petrochemicals into the water.

High volatility of this group of compounds poses high toxic threat to personnel and local residents if inhaled.

If there is a buildup of VAHs in areas of oil spills or coal fires, their speed of evaporation vary widely, leading to increased times during which the personnel is exposed to detrimental effects thereof, while one-time levels of VAHs in the ambient air tend to decrease, as well as resulting in ground water contamination by these compounds becoming long-term.

Polycyclic aromatic hydrocarbons (PAH)

The key human sources of PAH include various technology processes, of which more than half of the emissions come from power production (incomplete combustion of various organic fuels – coal, petrochemicals, wood) . A significant contribution to PAH levels comes from by-product-coking and oil refinery industries, as well as motor transport emissions.

It must be noted that the qualitative composition and structure of PAH from natural abiogenous sources is virtually no different from man-made PAH, provided the latter are a product of high- and medium-temperature processes.

To study trace quantities of PAH in environmental objects is important due to their relatively high chemical stability and high toxicity, resulting in their carcinogenic, mutagenic and teratogenic effects, and ability to cause poisoning, and immune system problems as a result of their buildup in the body. With their integrated toxic effect on the body, PAH can be considered as biosphere transforming agents, affecting both current generations of organisms and generations to come.

Of common PAHs, the most carcinogenic ones are benz(a)pyrene and dibenz(a,h)anthracene. It should be emphasized that the products of the degradation of PAH in the environment due to physical-chemical and microbiological factors, can be even stronger carcinogens than the original substances. However, monitoring these substances and PAH metabolites is a complex task, and is virtually non-existent at present.

Organochlorine compounds

Organochlorine compounds (OCC) are xenobiotic, i.e. substances that do not normally occur in nature, and come solely from human operations. OCC are the most dangerous group of persistent organic contaminants, and have low solubility in water (about 0.5 - 0.001 mg/l), high solubility in organic solvents and fats (lipophily), low vapor pressure (10^{-3} - 10^{-5} Pa at 20°C) and extraordinarily high microbiological, chemical and thermal stability.

Persistent organochlorine compounds occurring in the environment are mainly represented by organochlorine pesticides of various origin (hexachlorocyclohexanes, DDT and its isomers, metabolites and by-products, polychlorocyclodienes, polychlorobenzenes, herbicides and defoliants based on 2,4-D acid and polychlorinated phenols), polychlorinated biphenyls (PCB), as well as polychlorodioxines and polychlorobenzofurans that have never been a product of chemical synthesis, and

entered the environment solely as admixtures to other products, or as products of the combustion of garbage, fires at the production sites of clorine-containing plastic products, transformation of wastes in the bleaching of paper or other materials.

Polychlorinated biphenyls

Polychlorinated biphenyls (PCB) include 209 substances (congeners), that are the products of diphenyl (biphenyl) chlorination, differing in the degree of substitution, and the arrangement of substituents relative to each other.

Polychlorinated biphenyls (PCB), a group of persistent organic pollutants (POP), are subject to mandatory monitoring in the developed countries due to a very great danger they pose to the environment and human health. Persistent organic pollutants (POP) are a group of organic compounds that are toxic, stable and able to build up in living tissues, can be transferred over great distances in various environments, thus posing grave danger to human heath and the environment.

It is characteristic of PCB production to prefer to get through diphenil chlorination not individual compounds, but complex mixtures, whose composition depends on the conditions and length of the production process. Such mixtures can contain 20 to 71 weight percent of chlorine, this usually reflected in the trade name of a final product.

Commercial PCB-based products were widely used as dielectrics – converter and capacitor oils, cooling agents in heat exchange systems (coolants), hydraulic fluids, lubricant and sealing oils, as well as additives to pesticides. Insulation materials and plastics used to include PCB as plasticisers. PCB were also widely used as additives to paints, lacquers, adhesives, and color tracing paper.

The contamination of the environment by polychlorinated biphenyls comes from two key sources: emergency spills from closed controlled systems – industrial converters, capacitors, heat exchangers and hydraulic devices, and uncontrolled combustion of industrial and domestic wastes. Over many years of extensive use of PCB in industries in many countries huge amounts of these compounds have been discharged into the environment, and at present the whole biosphere is at risk of potential impacts coming from these xenobiotics. Their physical and chemical properties ensure that PCB survive for a long time (years, even decades) in abiotic environments, and are able to build up in bottom sediments, soils, and fat tissues of living organisms. Along with organochlorine pesticides, PCB are the most common contaminants polluting natural bodies of water. Environmental standards require that PCB levels in clean bodies of fresh water must be under 0.5 ng/l, while in moderately polluted – 50 ng/l.

5.2. Lab chemical analytical studies

Soil contamination studies used approved analytical methods recommended for environmental monitoring purposes and entered in the federal register.

Measuring the physical properties of utility fluids was in accordance with the Russian standards GOST and GOST R and the international standards ASTM and ISO recommended for application (until a corresponding national standard has been adopted).

Determining PCB levels in utility fluids was in line with the international standard ASTM, since no national oil analysis methodology is currently available.

Description of soil analysis methods

Polychlorinated biphenyls(PCB)

The quantitative analysis method for organochlorine compounds was gas chromatography with an electron capture detector (ECD).

For polychlorinated biphenyls, the quantitative analysis method was absolute calibration for target components, using two internal standards – DBOFB and PCB#198, added to the sample prior to sample prep.

The PCB recovery rate was estimated using recovery standard - naphthalene tetrachloride, which was added to the sample directly before analysis. A recovery rate of 50 to 110 percent was considered satisfactory, if running outside the range – new extraction was carried out. The actual range of recovery rates in all samples was 54 to 89 percent.

Polycyclic aromatic hydrocarbons (PAH)

The analysis used a high efficiency liquid chromatography system ‘Stayer Gradient’ with a PAH specific temperature-controlled column ‘Envirosep PP’, autosampler ‘Stayer-Basic’ and a set of detectors for spectrometric and fluorometric measurement of PAH levels. The parameters of the chromatographic system are given in Table 5.2-3, analytical parameters – in Table 5.2-4.

Spectrometric absorption measurements used a wave length of 255 nm for all PAH, less naphthalene, acenaphthene and acenaphthylene, for which a 220 nm wave length was used.

Fluorescent detector is selective and sensitive of compounds, such as anthracene, fluoranthene, benz(v)fluoranthene, benz(k)fluoranthene, benz(a)pyrene, and benz(ghi)perylene. The detector has linear response for these compounds in the range of 0.5 to 100 ng.

Volatile aromatic hydrocarbons (VAH)

Volatile aromatic hydrocarbons (VAH) were detected using gas-liquid capillary chromatography of saturated vapor (Head Space) with flame ionization detection. The quantitative analysis used a chromatograph “Kristall-2000M” with a flame ionization detector and equilibrium vapor dosing unit. Chromatec Analytic 2.0 software was used

to process the chromatographic data. The analytical results were used to calculate a dry soil equivalent. The soil moisture content was determined using a parallel sample.

Oil products (total)

Quantitative measurements used infrared spectrophotometry on a non-dispersive infrared spectrometer AN-2.

Working standard solution was prepared by 10-fold dilution of a standard solution of a 1000 mg/l concentration. The instrument was calibrated using two points: 0 mg/l (pure carbon tetrachloride) and 100 mg/l.

The solution to be analyzed (eluate) was poured in a cell, placed in the instrument, and its concentration measured. The readings of the instrument were used in the calculations. If the concentration was above the upper limit of the range, the solution was diluted by a multiple volume of carbon tetrachloride. The dilution was accounted for in the calculations.

Quality control

Quality control over the data obtained in the studies on the levels of pollutants (OP, LAH, PAH and HM) in soil included procedures for analyzing blank samples, standard solutions, plied-up specimens, similar matrix composition specimens with a known content of target components, as well as calibration control using standard solutions of the compounds being analyzed. Russian-made state standard specimens were used as calibration standards, while calibration control used certified standard solutions made by ULTRA Scientific (USA).

5.3 Soil contamination levels

Estimating the levels of pollution in soils used maximum permissible concentrations (MPC) and approximate permissible concentrations (APC) set by respective Russian normative documents, international criteria for environmental assessment of soil contamination, according to Building Regulations SP 11-102-97 “Engineering and environmental studies in the construction industry”, as well as other normative documents:

- Health Standard 2.1.7.2041-06 Maximum permissible concentrations (MPC) of chemical substances in soils;
- Health Standard 2.1.7.2042-06 Approximate permissible concentrations (APC) of chemical substances in soils;
- International criteria for environmental assessment of soil contamination according to Neue Niederlandische Liste. Altlasten Spektrum 3/95; Annex B to Building Regulations SP 11-102-97.

Of the 49 monitored substances in the study area, the Russian normative documents define MPC and APC (for individual values, or a total in a given group of compounds) for 22 soil quality parameter. The 'Dutch Lists' set out permissible concentrations (PC) and intervention levels (IL) (for an individual value, or a total in a given group of compounds) for 32 compounds.

For multi-element contamination, the soil contamination threat is assessed using the most toxic element of the involved with the highest levels.

Estimating the degree of soil contamination as a threat to human health uses indicators developed in relevant geochemical and geo-hygienic studies of the environment in populated areas with existing sources of pollution. Such indicators include: chemical substance concentration factor (Cc). Cc is a ratio of the actual levels of the substance in the soil (Ci), in mg/kg soil, to the regional background (Cbi):

$$Cc = Ci/ Cbi;$$

and *total contamination factor* (Zc). The total contamination factor equals the sum of the substances' concentration factors, expressed by the formula:

$$Zc = \sum (Cci + \ldots + Ccn) - (n-1),$$

where n is the number of the substances being determined; and Cci is the concentration factor of an i-th contaminant.

International norms-based assessment used a comparison of the resulting values of concentrations with PC and IL.

Since there is still no national normative MPC for petrochemical levels in soils in use in Russia, the Dutch Lists' PC was used instead.

Table 5.3-1 presents characteristics of study soils and external signs of contamination.

Table 5.3-1 Description of soil types in samples taken in study areas on Franz Josef Land islands

Point number	Type of soil	Indicators of contamination
Alexandra Island		
S01-001	rubble-loam	significant inclusions of refuse wood, visual contamination with oil products
S01-002	rubble-clay	weak smell of oil products, visual contamination with oil products
S01-003	rubble-loam	strong smell of oil products; visual contamination with oil products, inclusions of refuse wood
S01-004	rubble-clay	strong smell of oil products, visual contamination with oil products
S01-005	loam	strong smell of oil products, visual contamination with oil products

Point number	Type of soil	Indicators of contamination
Alexandra Island		
S01-006	man-made soil (construction waste)	smell of oil products, visual contamination with oil products
S01-007	rubble-clay	smell of oil products, visual contamination with oil products
S01-008	loam	weak smell of oil products
S01-009	rubble-sand loam	very weak smell of oil products
S01-010	loam	weak smell of oil products
S01-011	loam	strong smell of oil products, visual contamination with oil products
S01-012	Man-made soil (construction waste)	smell of oil products, visual contamination with oil products
S01-013	rubble-clay	not very strong smell of oil products
S09-79	loamy sand	smell is absent
S09-80	loamy sand	weak smell of oil products
S09-81	loamy sand	strong smell of oil products, visual contamination with oil products
S09-82	break stone	not very strong smell of oil products, visual contamination with oil products
S09-83	loamy sand	strong smell of oil products, visual contamination with oil products
S09-84	man-made soil (construction waste)	strong smell of oil products, visual contamination with oil products
S09-85	sand	strong smell of oil products, visual contamination with oil products
S09-86	man-made soil (construction waste)	strong smell of oil products
S09-87	rubble-clay	smell of oil products, visual contamination with oil products
S09-88	rubble-clay	very strong smell of oil products, visual contamination with oil products
S09-89	loam	strong smell of oil products, visual contamination with oil products
S09-90	rubble-loam	strong smell of oil products, visual contamination with oil products
S09-91	sand	very strong smell of oil products, visual contamination with oil products
S09-92	sand	strong smell of oil products, visual contamination with oil products
S09-93	sand	strong smell of oil products, visual contamination with oil products
S09-94	sand	strong smell of oil products, visual contamination with oil products
S09-95	rubble-clay	smell of hot asphalt, visual contamination with oil products
S09-96	rubble-clay	very strong smell of oil products, visual contamination with oil products
S09-97	rubble-sand loam	very strong smell of oil products, visual contamination with oil products
S09-98	rubble-sand loam	smell of oil products, visual contamination with oil products
S09-99	rubble-loam	very strong smell of oil products, visual contamination with oil products
S09-100	rubble-loam	strong smell of oil products, visual contamination with oil products
S09-101	rubble-loam	strong smell of oil products
S09-102	rubble-loam	strong smell of oil products, visual contamination with oil products
S10-103	loamy sand	smell is absent
S01-014	loamy sand	smell is absent
S10-104	loamy sand	weak smell of oil products
S10-105	loamy sand	weak smell of oil products

Point number	Type of soil	Indicators of contamination
Alexandra Island		
S10-106	loamy sand	smell is absent
S10-107	loamy sand	smell of burning
S10-108	clay	smell is absent
S10-109	clay	weak smell of oil products
S10-110	clay	smell is absent
S04-047	loamy sand	smell is absent
S04-048	rubble-clay	very strong smell of oil products, visual contamination with oil products, inclusions of refuse wood
S04-049	clay	weak smell of oil products
S04-050	loamy sand	weak smell of oil products
S04-051	clay	strong smell of oil products, visual contamination with oil products
S04-052	sand	smell is absent
S04-053	Loam	smell is absent
S04-054	sand	weak smell of oil products

5.4. Studied sites on Alexandra Island

5.4.1. Locator Station

Site 9 Alexandra Island (Locator Station): 125 soil samples at 25 points of geo-ecological testing.

Assessment using Russian norms

VAH levels in soils in the study area did not exceed tenths of MPC, and were as follows:

- benzene - 0.003 mg/kg (up to 0.01 MPC),
- toluene - 0.025 mg/kg (up to 0.08 MPC)
- meta- and para-xylenes together - 0.029 mg/kg (up to 0.10 MPC),
- ortho-xylene - 0.025 mg/kg (up to 0.08 MPC),
- isopropylbenzene - 0.007 mg/kg (up to 0.01 MPC).

Benz(a)pyrene was up to 0.1785 mg/kg (up to 8.9 MPC units, point S09-090). The levels of other PAH compounds included in the study are not rated under Russian normative documents.

Total PCB were up to 0.245 mg/kg (up to 4 APC, point S09-082).

Weight concentrations and MPC, APC and PC of pollutants at Site 9 geo-ecological sampling points are given in Table 5.4-2 at the end of this section.

Table 5.4-1 presents an assessment of soil contamination (contamination category) on the site based on the guidelines in SanPiN 2.1.7.1287-03 using MPC (APC), and contamination levels in units of international permissible concentrations.

Table 5.4-1 Assessment of the levels of soil contamination at the radar station area (site 9) according to SanPiN 2.1.7.1287-03 and internatinal standards.

Index	site 9									
	Values, mg/kg	Values in MPC (APC)			Contamination class			Values in PC units		
	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	18134							2.34	**1068.8***	**362.67***
Benzene	0.002	0.00	0.01	0.00	permissible	permissible	permissible	0.00	0.07	0.03
Toluene	0.012	0.00	0.08	0.04	permissible	permissible	permissible	0.00	0.05	0.02
Ethylbenzene	0.004					permissible	permissible	0.00	0.19	0.09
Σ meta- and para-Xylene	0.012	0.00	0.10	0.04	permissible	permissible	permissible	0.00	0.06	0.02
Ortho-Xylene	0.010	0.00	0.08	0.03	permissible	permissible	permissible	0.00	0.05	0.02
Isopropybenzene	0.003	0.00	0.01	0.01	permissible	permissible	permissible			
Benz(a)pyrene	0.0423	0.03	8.93	2.12	permissible	extra-hazardous	hazardous			
Total 10 PAHs	1.7264							0.06	8.11	1.73
Total 7 PSBs	0.051	0.04	4.08	0.85	permissible	hazardous	permissible	0.11	12.23	2.54
Manganese	70.1	0.01	0.12	0.05	permissible	permissible	permissible			
Zinc	58.6	0.06	140.0	28.48	permissible	extra-hazardous	extra-hazardous	0.09	1.66	0.42
Copper	47.4	0.10	36.00	8.35	permissible	extra-hazardous	extra-hazardous	0.36	2.63	1.32
Nickel	6.8	0.03	35.00	8.32	permissible	extra-hazardous	extra-hazardous	0.06	0.45	0.20
Cobalt	4.4							0.06	0.44	0.22
Lead	31.7	0.00	5.05	0.99	permissible	extra-hazardous	permissible	0.00	1.90	0.37
Cadmium	0.16	0.00	1.50	0.70	permissible	extra-hazardous	permissible	0.03	0.94	0.20
Chrome	5.2	0.28	1.65	0.87	permissible	extra-hazardous	permissible	0.02	0.10	0.05
Mercury	<0.003	0.728	0.058	0.00	permissible	permissible	permissible	0.00	2.43	0.19
Zc metals	9.15						permissible			

Note: * - values exceeded the intervention level (IL)

By average levels of volatile aromatic hydrocarbons, total PCB, manganese, lead, cadmium, chromium and mercury, Site 9 soils fall in the **acceptable** pollution category; by average **benz(a)pyrene** – in **hazardous** pollution category; by zinc, copper and nickel – **extremely hazardous** pollution category.

The values of total pollution index, Zc, calculated for an array of metals, varied from 1.99 (**acceptable** pollution category) to 28.62 (**moderately hazardous** pollution category), with a site average of 9.15 – **acceptable** category.

All sampling points (except for S09-101) had NPC and APC exceeded for zinc, copper, nickel, lead, chromium, and cadmium, as well as Kmax (according to MU 2.1.7.730-99), this corresponding to **extremely hazardous** soil pollution category.

On the whole, soil contamination levels in the locator station study area can be assessed as **extremely hazardous.**

Assessment using international norms

An exceedence of permissible concentrations (PC) in the site soils at some sampling points was registered for oil products, total PAH, total PCB, zinc, copper, lead and mercury, including:

- oil products- up to 1068.8 PC;
- total PAH - up to 8.11 PC;
- total PCB – up to 12.23 PC;

It was found that average levels of contaminants for the site as a whole exceeded PC as follows: oil products – 362-fold, total PAH – 1.7-fold, and total PCB – 2.5-fold.

It should be emphasized that soil contamination at the site by oil products **exceeded the intervention level*** both in its average value (3.6-fold) , and in the values at some sampling points(up to 10 IL).

Figures 5.4-1 - 5.4-3 present the spatial distribution of soil contamination on Site 9 by oil products, total PAH, total PCB in PC units.

* According to international soil contamination standards («Dutch Lists», Neue Niederlandische Liste. Altlasten Spektrum 3/95. and «Brandenburg Lists», Brandenburgische Liste. AbschluBentwurf 27.7.1990.) **permissible concentration** (PC) is defined as an approximately determined maximum concentration of a soil contaminant that do not have direct or indirect adverse impacts on the environment and human health.
If found to have contaminant levels in excess of a **intervention level**, soils are considered hazardously contaminated and fall in Toxic Waste Hazard Class 2 or higher. Removal, transportation, stocking and storage of such soils must be done as part of a project developed, approved by regulatory authorities and passed environmental assessment according to the law of the Russian Federation. Storage of the soils is allowed in a special landfill with protection measures taken against the entry of the contaminants in the environment. t.

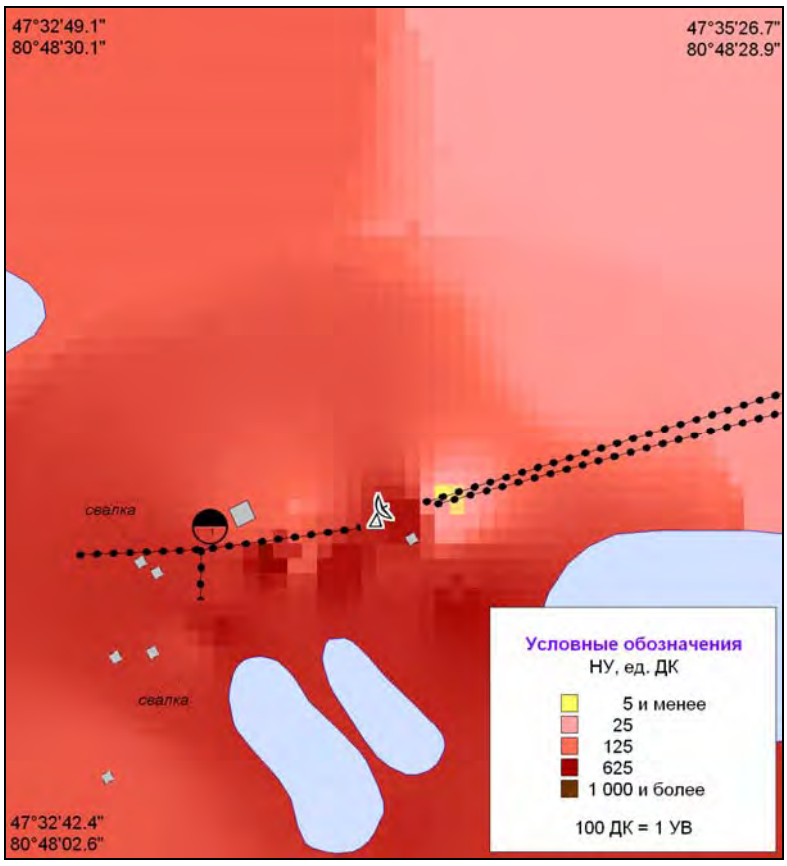
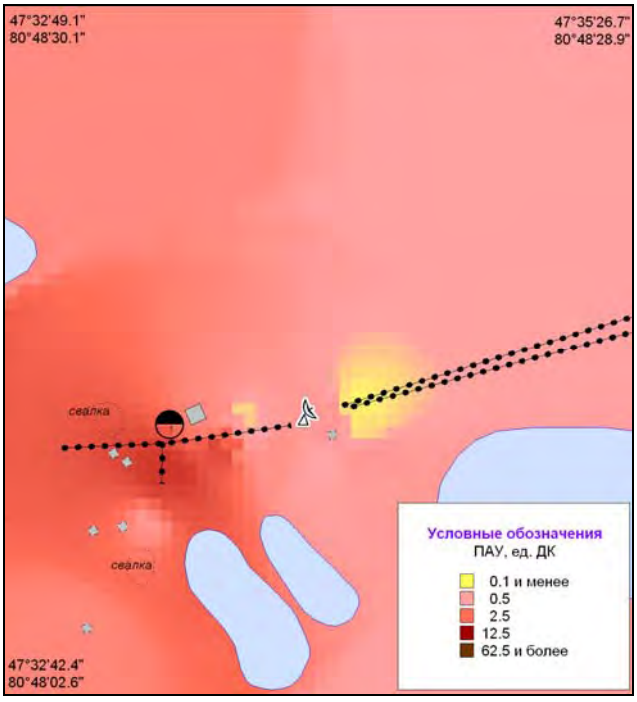
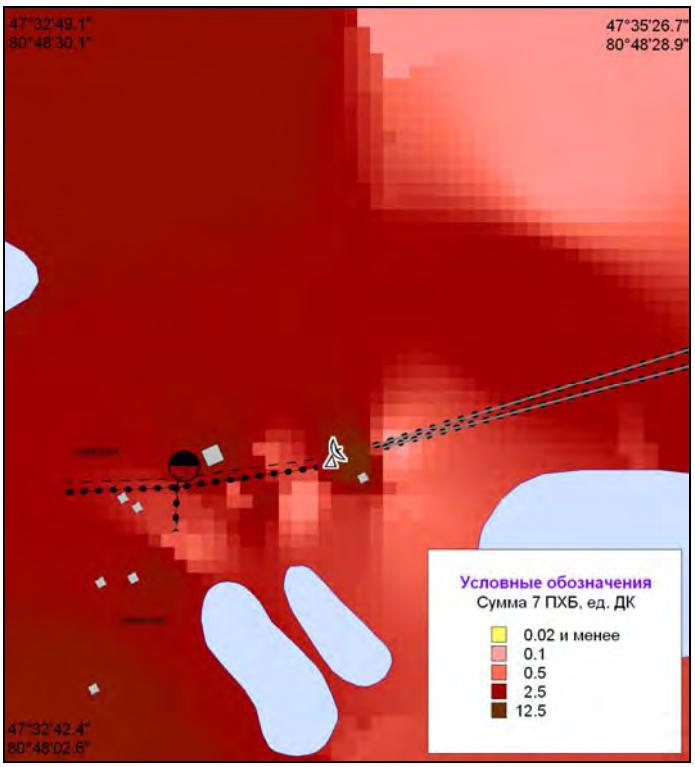


Fig. 5.4-1 Spatial distribution of soil contamination in the locator station area (Site 9) by petroleum hydrocarbons (oil products)



Note: 10 PAH - anthracene, benz(a)anthracene, benz(k)fluoranthene, benz(a)pyrene, chrysene, phenanthrene, fluoranthene, indeno(123cd) pyrene, naphthalene, benz(ghi)perylene

Fig. 5.4-2 Spatial distribution of soil contamination in the locator station area (Site 9) by polycyclic aromatic hydrocarbons



Note: 7 PCBs - #28, #52, #101, #118, #138, #153, #180

Figure. 5.4-3. Spatial distribution of soil contamination in the locator station area (Site 9) by polychlorinated biphenyls

Table 5.4-2. Contamination weight concentration intervals and MPC, APC and PC units in Site 9 soils

Index	Point number											
	S09-079						S09-080					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	117	290	182	2.34*	5.80*	3.64*	2284	3190	2659	45.68*	63.80*	53.18*
Benzene	0.001	0.001	0.001	0.00	0.00	0.00	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.001	0.002	0.002	0.00	0.01	0.01	0.001	0.002	0.002	0.00	0.01	0.01
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	<0.001	<0.001	0.00	0.00	0.00
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	<0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	<0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0041	0.0063	0.0051	0.21	0.32	0.26	0.0005	0.0008	0.0006	0.03	0.04	0.03
Total 10 PAHs	0.1067	0.1768	0.1428	0.11*	0.18*	0.14*	0.2231	0.2858	0.2539	0.22*	0.29*	0.25*
Total 7 PSBs	0.002	0.003	0.002	0.04	0.04	0.04	0.006	0.007	0.006	0.10	0.12	0.11
Manganese	88.0	123.0	110.2	0.06	0.08	0.07	28.5	61.2	43.8	0.02	0.04	0.03
Zinc	24.1	37.2	32.9	0.44	0.68	0.60	37.5	99.6	70.5	0.68	1.81	1.28
Copper	27.5	42.6	34.3	0.83	1.29	1.04	23.8	44	34.1	0.72	1.33	1.03
Nickel	6.2	8.8	7.3	0.31	0.44	0.37	4.0	9.0	6.6	0.20	0.45	0.33
Cobalt	2.2	5.1	3.3	0.11*	0.26*	0.17*	2.3	3.2	2.8	0.12*	0.16*	0.14*
Lead	<0.2	1.2	0.5	0.00	0.04	0.02	24.9	58.5	48.0	0.78	1.83	1.50
Cadmium	0.02	0.27	0.11	0.04	0.54	0.22	0.25	0.46	0.39	0.51	0.91	0.77
Chrome	2.2	5.1	3.5	0.37	0.85	0.58	2.8	7.4	6.0	0.47	1.23	1.00
Mercury	0.003	0.010	0.008	0.00	0.00	0.00	0.069	0.091	0.082	0.03	0.04	0.04

Index	Point number											
	S09-081						S09-082					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	37075	53440	45991	741.50*	068.80	919.82*	6078	10364	8728	121.56*	207.28*	174.56*
Benzene	<0.001	0.001	<0.001	0.00	0.00	0.00	<0.001	<0.001	<0.001	0.00	0.00	0.00
Toluene	0.007	0.010	0.009	0.02	0.03	0.03	0.008	0.011	0.009	0.03	0.04	0.03
Ethylbenzene	0.003	0.005	0.005	0.06*	0.11*	0.09*	0.002	0.004	0.004	0.04*	0.09*	0.07*
Σ meta- and para-Xylene	0.008	0.012	0.011	0.03	0.04	0.03	0.010	0.013	0.011	0.03	0.04	0.04
Ortho-Xylene	0.002	0.004	0.003	0.01	0.01	0.01	0.002	0.002	0.002	0.01	0.01	0.01
Isopropybenzene	0.002	0.004	0.003	0.00	0.01	0.01	0.002	0.003	0.003	0.00	0.01	0.01
Benz(a)pyrene	0.0143	0.0222	0.0178	0.72	1.11	0.89	0.0205	0.0398	0.0322	1.03	1.99	1.61
Total 10 PAHs	0.8861	1.0855	0.9612	0.89*	1.09*	0.96*	0.8343	1.0747	0.9419	0.83*	1.07*	0.94*
Total 7 PSBs	0.182	0.217	0.203	3.03	3.62	3.39	0.186	0.245	0.213	3.10	4.08	3.55
Manganese	42.6	81.2	59.3	0.03	0.05	0.04	31.0	65.3	48.1	0.02	0.04	0.03
Zinc	123.0	175	151.0	2.24	3.18	2.75	124.8	232	202.7	2.27	4.22	3.69
Copper	41.7	52.3	46.0	1.26	1.58	1.39	33.1	64	44.7	1.00	1.94	1.35
Nickel	5.2	7.1	6.1	0.26	0.36	0.31	5.3	10.8	8.3	0.27	0.54	0.41
Cobalt	1.2	3.4	2.0	0.06*	0.17*	0.10*	3.7	5.3	4.2	0.19*	0.27*	0.21
Lead	50.8	93.5	71.5	1.59	2.92	2.23	108.4	161.7	141.9	3.39	5.05	4.43
Cadmium	0.07	0.40	0.23	0.14	0.80	0.47	0.24	0.34	0.29	0.48	0.67	0.57
Chrome	3.8	5.5	4.4	0.63	0.92	0.73	2.2	3.4	2.8	0.37	0.57	0.47
Mercury	0.050	0.180	0.098	0.02	0.09	0.05	0.102	0.135	0.118	0.05	0.06	0.06

Continuation of table 5.4-2

Index	Point number											
	S09-083						S09-084					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	2466	4231	3411	49.32*	84.62*	68.22*	3715	7301	5635	74.30*	146.02*	112.71*
Benzene	0.001	0.002	0.001	0.00	0.01	0.00	<0.001	<0.001	<0.001	0.00	0.00	0.00
Toluene	0.007	0.010	0.008	0.02	0.03	0.03	0.006	0.013	0.011	0.02	0.04	0.04
Ethylbenzene	0.003	0.008	0.006	0.07*	0.15*	0.12*	0.002	0.004	0.003	0.04*	0.07*	0.06*
Σ meta- and para-Xylene	0.011	0.019	0.016	0.04	0.06	0.05	0.007	0.016	0.012	0.02	0.05	0.04
Ortho-Xylene	0.002	0.004	0.003	0.01	0.01	0.01	0.002	0.003	0.003	0.01	0.01	0.01
Isopropybenzene	0.003	0.004	0.004	0.01	0.01	0.01	0.003	0.004	0.004	0.01	0.01	0.01
Benz(a)pyrene	0.0017	0.0028	0.0023	0.09	0.14	0.11	0.0586	0.0755	0.0648	2.93	3.78	3.24
Total 10 PAHs	0.0627	0.0921	0.0785	0.06*	0.09*	0.08*	0.9409	1.2638	1.1600	0.94*	1.26*	1.16*
Total 7 PSBs	0.005	0.006	0.005	0.09	0.10	0.09	0.111	0.132	0.126	1.86	2.21	2.09
Manganese	55.5	106.3	90.0	0.04	0.07	0.06	44.7	86.1	68.0	0.03	0.06	0.05
Zinc	68.3	120.3	89.3	1.24	2.19	1.62	25.6	56.1	42.8	0.47	1.02	0.78
Copper	36.8	79.0	57.0	1.12	2.39	1.73	41.8	68.0	54.5	1.27	2.06	1.65

Index	Point number											
	S09-083						S09-084					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Nickel	4.5	9.9	6.9	0.23	0.50	0.35	3.1	6.3	4.9	0.16	0.32	0.24
Cobalt	2.2	3.0	2.5	0.11*	0.15*	0.13*	1.5	2.0	1.8	0.08*	0.10*	0.09*
Lead	43.7	75.8	63.2	1.37	2.37	1.98	33.1	59.7	47.2	1.03	1.87	1.48
Cadmium	0.03	0.05	0.04	0.07	0.10	0.09	0.05	0.11	0.09	0.10	0.21	0.17
Chrome	3.5	6.0	5.0	0.58	1.00	0.83	3.2	5.6	4.6	0.53	0.93	0.77
Mercury	0.211	0.279	0.236	0.10	0.13	0.11	0.008	0.011	0.009	0.00	0.01	0.00

Index	Point number											
	S09-085						S09-086					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	6365	11222	9287	127.30*	224.44*	185.75*	5891	10359	8671	117.82*	207.18*	173.42*
Benzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	0.001	0.002	0.001	0.00	0.01	0.00
Toluene	0.004	0.008	0.006	0.01	0.03	0.02	0.004	0.008	0.006	0.01	0.03	0.02
Ethylbenzene	0.002	0.003	0.003	0.05*	0.06*	0.06*	0.003	0.008	0.006	0.06*	0.15*	0.12*
Σ meta- and para-Xylene	0.007	0.011	0.009	0.02	0.04	0.03	0.009	0.023	0.016	0.03	0.08	0.05
Ortho-Xylene	0.001	0.002	0.002	0.00	0.01	0.01	0.002	0.003	0.002	0.01	0.01	0.01
Isopropybenzene	0.001	0.002	0.001	0.00	0.00	0.00	0.005	0.007	0.006	0.01	0.01	0.01
Benz(a)pyrene	0.0297	0.0483	0.0416	1.49	2.42	2.08	0.0326	0.0564	0.0478	1.63	2.82	2.39
Total 10 PAHs	1.2895	1.5273	1.4065	1.29*	1.53*	1.41*	1.4289	1.5527	1.5198	1.43*	1.55*	1.52*
Total 7 PSBs	0.095	0.116	0.101	1.58	1.93	1.68	0.114	0.140	0.125	1.89	2.34	2.08
Manganese	83.5	129.0	109.1	0.06	0.09	0.07	86	183.2	131.7	0.06	0.12	0.09
Zinc	36.7	50.2	42.9	0.67	0.91	0.78	13.4	30.2	22.5	0.24	0.55	0.41
Copper	62.8	94.5	74.8	1.90	2.86	2.27	33	56.4	42.5	1.00	1.71	1.29
Nickel	6.4	13.5	9.1	0.32	0.68	0.46	4.6	12.0	8.1	0.23	0.60	0.40
Cobalt	1.2	2.8	1.8	0.06*	0.14*	0.09*	1.5	1.9	1.7	0.08*	0.10*	0.09*
Lead	28.1	42.1	35.7	0.88	1.32	1.11	32.5	75.1	56.3	1.02	2.35	1.76
Cadmium	0.04	0.07	0.05	0.08	0.14	0.10	0.04	0.07	0.06	0.07	0.15	0.12
Chrome	3.3	6.1	4.7	0.55	1.02	0.78	2.5	5.2	4.1	0.42	0.87	0.68
Mercury	<0.003	0.010	0.006	0.00	0.00	0.00	0.007	0.009	0.008	0.00	0.00	0.00

Continuation of table 5.4-2

Index	Point number											
	S09-087						S09-088					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	7642	15577	11364	152.84*	311.54*	227.28*	11558	21590	16835	231.16*	431.80*	336.70*
Benzene	0.001	0.001	0.001	0.00	0.00	0.00	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.004	0.010	0.007	0.01	0.03	0.02	0.006	0.010	0.008	0.02	0.03	0.03
Ethylbenzene	0.003	0.007	0.005	0.05*	0.14*	0.10*	0.002	0.003	0.002	0.04*	0.05*	0.05*
Σ meta- and para-Xylene	0.007	0.012	0.009	0.02	0.04	0.03	0.006	0.010	0.009	0.02	0.03	0.03
Ortho-Xylene	0.002	0.004	0.003	0.01	0.01	0.01	0.002	0.003	0.003	0.01	0.01	0.01

sopropybenz ene	0.003	0.005	0.004	0.01	0.01	0.01	0.005	0.007	0.006	0.01	0.01	0.01
Benz(a)pyren e	0.0416	0.0577	0.0493	2.08	2.89	2.47	0.0268	0.0499	0.0391	1.34	2.50	1.96
Total 10 PAHs	1.3921	1.8673	1.6147	1.39*	1.87*	1.61*	0.9306	1.0591	1.0042	0.93*	1.06*	1.00*
Total 7 PSBs	0.124	0.153	0.140	2.06	2.55	2.34	0.113	0.133	0.122	1.88	2.22	2.03
Manganese	53.0	105.9	83.8	0.04	0.07	0.06	75.1	138.8	111.3	0.05	0.09	0.07
Zinc	12.1	29	21.6	0.06	0.13	0.10	24.0	37.3	32.6	0.44	0.68	0.59
Copper	35.3	76.7	64.7	0.27	0.58	0.49	46.7	78.2	62.3	1.42	2.37	1.89
Nickel	6.2	15.1	10.0	0.08	0.19	0.12	6.3	15.9	10.6	0.32	0.80	0.53
Cobalt	1.3	1.3	1.3	0.07*	0.07*	0.07*	1.2	1.8	1.5	0.06*	0.09	0.08*
Lead	17.9	26.2	23.2	0.56	0.82	0.73	29.7	68.9	55.6	0.93	2.15	1.74
Cadmium	0.03	0.06	0.05	0.01	0.03	0.02	0.07	0.08	0.08	0.15	0.17	0.16
Chrome	3.1	5.4	4.3	0.52	0.90	0.72	1.7	2.0	1.8	0.28	0.33	0.30
Mercury	0.007	0.009	0.008	0.00	0.00	0.00	0.008	0.011	0.010	0.00	0.01	0.00

Index	Point number											
	S09-089						S09-090					
	Values, mg/kg			lues in MPC (APC), *PC un			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	21595	35563	28678	431.90*	711.26*	573.55*	12450	26388	19410	249.00*	527.76*	388.21*
Benzene	0.001	0.002	0.001	0.00	0.01	0.00	0.001	0.002	0.002	0.00	0.01	0.01
Toluene	0.011	0.025	0.019	0.04	0.08	0.06	0.008	0.016	0.013	0.03	0.05	0.04
Ethy benzene	0.003	0.008	0.007	0.07*	0.16*	0.13*	0.004	0.007	0.005	0.08*	0.14*	0.11*
Σ meta- and para-Xylene	0.010	0.024	0.018	0.03	0.08	0.06	0.011	0.023	0.017	0.04	0.08	0.06
Ortho-Xylene	0.015	0.018	0.016	0.05	0.06	0.05	0.013	0.018	0.016	0.04	0.06	0.05
sopropybenzene	0.003	0.004	0.003	0.01	0.01	0.01	0.002	0.003	0.002	0.00	0.01	0.00
Benz(a)pyrene	0.0487	0.1039	0.0802	2.44	5.20	4.01	0.1263	0.1785	0.1509	6.32	8.93	7.55
Total 10 PAHs	3.9643	6.3869	5.1382	3.96*	6.39*	5.14*	6.5934	8.1066	7.4825	6.59*	8.11*	7.48*
Total 7 PSBs	0.009	0.011	0.010	0.15	0.19	0.17	0.029	0.036	0.032	0.48	0.60	0.53
Manganese	18.4	51.6	36.6	0.01	0.03	0.02	43.3	103.2	75.1	0.03	0.07	0.05
Zinc	34.9	68.9	51.9	0.16	0.31	0.24	40.8	79.5	58.6	0.19	0.36	0.27
Copper	12.9	32.4	25.0	0.10	0.25	0.19	30.0	59.4	48.0	0.23	0.45	0.36
Nickel	2.1	4.7	3.3	0.03	0.06	0.04	4.2	9.7	7.4	0.05	0.12	0.09
Cobalt	5.9	7.9	7.0	0.30*	0.40*	0.35*	5.9	8.2	7.1	0.30*	0.41*	0.36*
Lead	17.9	39.1	30.2	0.56	1.22	0.94	15.7	40.2	30.2	0.49	1.26	0.95
Cadmium	0.10	0.22	0.17	0.05	0.11	0.09	0.14	0.24	0.19	0.07	0.12	0.10
Chrome	3.2	7.3	5.9	0.53	1.22	0.98	3.9	6.2	5.2	0.65	1.03	0.86
Mercury	0.026	0.033	0.029	0.01	0.02	0.01	0.024	0.033	0.028	0.01	0.02	0.01

Continuation of table 5.4-2

Index	Point number											
	S09-091						S09-092					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	15838	28701	22560	316.76*	574.02*	451.19*	32206	45597	38451	644.12*	911.94*	769.02*
Benzene	0.002	0.002	0.002	0.01	0.01	0.01	0.001	0.002	0.002	0.00	0.01	0.01
Toluene	0.010	0.025	0.019	0.03	0.08	0.06	0.013	0.023	0.020	0.04	0.08	0.07
Ethylbenzene	0.004	0.009	0.007	0.08*	0.18*	0.13*	0.004	0.009	0.007	0.07*	0.17*	0.13*
Σ meta- and	0.008	0.014	0.011	0.03	0.05	0.04	0.013	0.024	0.019	0.04	0.08	0.06

Index	Point number											
	S09-091						S09-092					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
para-Xylene												
Ortho-Xylene	0.015	0.021	0.018	0.05	0.07	0.06	0.014	0.019	0.016	0.05	0.06	0.05
Isopropybenzene	0.003	0.004	0.003	0.01	0.01	0.01	0.003	0.004	0.004	0.01	0.01	0.01
Benz(a)pyrene	0.0837	0.1289	0.1129	4.19	6.45	5.65	0.0784	0.1015	0.0932	3.92	5.08	4.66
Total 10 PAHs	5.3412	7.3136	6.5006	5.34*	7.31*	6.50*	5.5863	6.8165	6.2303	5.59*	6.82*	6.23*
Total 7 PSBs	0.011	0.012	0.011	0.18	0.21	0.19	0.009	0.012	0.011	0.16	0.20	0.18
Manganese	30.8	57.9	42.5	0.02	0.04	0.03	46.7	69.6	61.7	0.03	0.05	0.04
Zinc	17.9	30.6	24.1	0.33	0.56	0.44	17.1	26.4	22.4	0.31	0.48	0.41
Copper	32.6	79.2	60.8	0.99	2.40	1.84	28.5	66	46.2	0.86	2.00	1.40
Nickel	4.1	9.8	7.0	0.21	0.49	0.35	2.1	4.4	3.2	0.11	0.22	0.16
Cobalt	6.6	8.8	7.3	0.33*	0.44*	0.37*	6.7	7.9	7.2	0.34*	0.40*	0.36*
Lead	14.8	21.6	17.9	0.46	0.68	0.56	18.2	43.6	36.4	0.57	1.36	1.14
Cadmium	0.06	0.13	0.09	0.11	0.26	0.18	0.09	0.15	0.13	0.19	0.31	0.26
Chrome	7.0	9.8	8.6	1.17	1.63	1.43	5.5	9.8	8.0	0.92	1.63	1.34
Mercury	0.021	0.029	0.023	0.01	0.01	0.01	0.021	0.028	0.024	0.01	0.01	0.01

Index	Point number											
	S09-093						S09-094					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	10640	18070	14040	212.80*	361.40*	280.80*	18505	36750	27765	370.10*	735.00*	555.30*
Benzene	0.001	0.002	0.002	0.00	0.01	0.00	0.002	0.003	0.002	0.01	0.01	0.01
Toluene	0.011	0.016	0.013	0.04	0.05	0.04	0.014	0.024	0.018	0.05	0.08	0.06
Ethylbenzene	0.004	0.007	0.005	0.08*	0.15*	0.11*	0.003	0.006	0.005	0.06*	0.13*	0.09*
Σ meta- and para-Xylene	0.014	0.018	0.016	0.05	0.06	0.05	0.007	0.017	0.012	0.02	0.06	0.04
Ortho-Xylene	0.012	0.015	0.013	0.04	0.05	0.04	0.010	0.020	0.015	0.03	0.07	0.05
Isopropybenzene	0.002	0.003	0.002	0.00	0.01	0.00	0.001	0.002	0.002	0.00	0.00	0.00
Benz(a)pyrene	0.0031	0.0051	0.0042	0.16	0.26	0.21	0.0434	0.0704	0.0565	2.17	3.52	2.82
Total 10 PAHs	0.4575	0.6478	0.5343	0.46*	0.65*	0.53*	0.9636	1.3204	1.1331	0.96*	1.32*	1.13*
Total 7 PSBs	0.023	0.028	0.026	0.39	0.47	0.43	0.006	0.007	0.006	0.09	0.11	0.10
Manganese	35.5	91.4	63.2	0.02	0.06	0.04	53.1	86.8	70.8	0.04	0.06	0.05
Zinc	21.7	50	36.9	0.39	0.91	0.67	58.3	73.4	65.6	1.06	1.33	1.19
Copper	25.7	53.1	39.4	0.78	1.61	1.19	44.5	57	50.0	1.35	1.73	1.52
Nickel	3.1	7.4	5.1	0.16	0.37	0.26	5.1	7.4	6.2	0.26	0.37	0.31
Cobalt	5.0	6.4	5.7	0.25*	0.32*	0.28*	4.0	5.4	4.8	0.20*	0.27*	0.24*
Lead	12.9	26.1	20.8	0.40	0.82	0.65	8.9	15.4	11.2	0.28	0.48	0.35
Cadmium	0.10	0.15	0.13	0.21	0.29	0.25	0.05	0.16	0.10	0.10	0.32	0.20
Chrome	5.5	8.4	6.9	0.92	1.40	1.15	3.2	5.8	4.5	0.53	0.97	0.76
Mercury	0.020	0.028	0.023	0.01	0.01	0.01	0.005	0.016	0.011	0.00	0.01	0.01

Continuation of table 5.4-2

Index	Point number											
	S09-095						S09-096					
	Values, mg/kg			alues in MPC (APC), *F units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	13645	30115	22773	272.90*	602.30*	455.46*	12929	26130	19645	258.58*	522.60*	392.91*
Benzene	0.002	0.003	0.003	0.01	0.01	0.01	0.002	0.003	0.002	0.01	0.01	0.01
Toluene	0.009	0.020	0.014	0.03	0.07	0.05	0.013	0.018	0.015	0.04	0.06	0.05
Ethylbenzene	0.003	0.006	0.005	0.06*	0.12*	0.09*	0.002	0.003	0.003	0.05*	0.06*	0.05*
Σ meta- and para-Xylene	0.011	0.019	0.015	0.04	0.06	0.05	0.009	0.019	0.014	0.03	0.06	0.05
Ortho-Xylene	0.015	0.022	0.019	0.05	0.07	0.06	0.014	0.017	0.016	0.05	0.06	0.05
Isopropybenzene	0.001	0.003	0.002	0.00	0.01	0.00	0.002	0.003	0.003	0.00	0.01	0.01
Benz(a)pyrene	0.0060	0.0078	0.0067	0.30	0.39	0.34	0.0041	0.0083	0.0061	0.21	0.42	0.31
Total 10 PAHs	0.5599	0.6904	0.6192	0.56*	0.69*	0.62*	0.4021	0.6232	0.5573	0.40*	0.62*	0.56*
Total 7 PSBs	0.026	0.034	0.030	0.44	0.56	0.49	0.030	0.037	0.033	0.51	0.62	0.55
Manganese	54.5	111.8	80.9	0.04	0.07	0.05	46.1	90.1	66.0	0.03	0.06	0.04
Zinc	45.7	57.4	53.0	0.21	0.26	0.24	51.2	74.1	58.8	0.23	0.34	0.27
Copper	23.5	45.2	33.7	0.18	0.34	0.26	31.8	75.2	55.1	0.24	0.57	0.42
Nickel	4.2	8.6	6.5	0.05	0.11	0.08	6.3	9.3	7.5	0.08	0.12	0.09
Cobalt	4.5	5.3	4.8	0.23*	0.27*	0.24*	3.9	5	4.5	0.20*	0.25*	0.22*
Lead	6.7	11.2	9.4	0.21	0.35	0.29	6.2	8.2	7.4	0.19	0.26	0.23
Cadmium	0.08	0.12	0.10	0.04	0.06	0.05	0.04	0.10	0.08	0.02	0.05	0.04
Chrome	4.5	7.2	5.9	0.75	1.20	0.98	3.8	5.7	4.7	0.63	0.95	0.78
Mercury	0.009	0.012	0.011	0.00	0.01	0.01	0.010	0.013	0.011	0.00	0.01	0.01

Index	Point number											
	S09-097						S09-098					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	21484	47331	36944	429.68*	946.62*	738.88*	16985	29510	22825	339.70*	590.20*	456.50*
Benzene	0.002	0.003	0.003	0.01	0.01	0.01	0.002	0.003	0.002	0.01	0.01	0.01
Toluene	0.013	0.021	0.017	0.04	0.07	0.06	0.016	0.018	0.017	0.05	0.06	0.06
Ethylbenzene	0.004	0.007	0.005	0.07*	0.14*	0.11*	0.005	0.008	0.007	0.11*	0.16*	0.13*
Σ meta- and para-Xylene	0.013	0.020	0.017	0.04	0.07	0.06	0.020	0.029	0.024	0.07	0.10	0.08
Ortho-Xylene	0.019	0.025	0.021	0.06	0.08	0.07	0.011	0.017	0.014	0.04	0.06	0.05
Isopropybenzene	0.002	0.003	0.003	0.00	0.01	0.00	0.001	0.004	0.003	0.00	0.01	0.01
Benz(a)pyrene	0.0042	0.0089	0.0071	0.21	0.45	0.35	0.0024	0.0046	0.0034	0.12	0.23	0.17
Total 10 PAHs	0.5403	0.6799	0.6119	0.54*	0.68*	0.61*	0.4963	0.7706	0.6683	0.50*	0.77*	0.67*
Total 7 PSBs	0.024	0.029	0.027	0.40	0.48	0.44	0.007	0.008	0.007	0.11	0.14	0.12
Manganese	36.9	63.2	53.0	0.02	0.04	0.04	55.3	153.7	103.3	0.04	0.10	0.07
Zinc	75.3	116.8	91.5	1.37	2.12	1.66	51.9	100.2	72.9	0.94	1.82	1.33
Copper	18.8	47.9	36.2	0.57	1.45	1.10	52.5	86.8	66.3	1.59	2.63	2.01
Nickel	3.0	6.3	5.1	0.15	0.32	0.25	6.3	13.7	10.4	0.32	0.69	0.52
Cobalt	5.4	6.9	6.1	0.27*	0.35*	0.31*	4.5	5.6	5.3	0.23*	0.28*	0.26*
Lead	6.9	13.4	10.6	0.22	0.42	0.33	5.7	12.1	9.4	0.18	0.38	0.29
Cadmium	0.11	0.16	0.13	0.22	0.32	0.25	0.10	0.18	0.14	0.20	0.36	0.27
Chrome	4.1	6.8	5.6	0.68	1.13	0.93	3.3	4.8	4.1	0.55	0.80	0.69

Index	Point number											
	S09-097						S09-098					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Mercury	0.013	0.014	0.013	0.01	0.01	0.01	0.009	0.011	0.010	0.00	0.01	0.00

Continuation of table 5.4-2

Index	Point number											
	S09-099						S09-100					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	14696	22369	19385	293.92*	447.38*	387.71*	17746	32222	27419	354.92*	544.44*	548.38*
Benzene	0.002	0.003	0.002	0.01	0.01	0.01	0.002	0.002	0.002	0.01	0.01	0.01
Toluene	0.014	0.021	0.019	0.05	0.07	0.06	0.002	0.021	0.012	0.01	0.07	0.04
Ethylbenzene	0.005	0.007	0.006	0.11*	0.14*	0.13*	0.002	0.006	0.005	0.04*	0.13*	0.09*
Σ meta- and para-Xylene	0.007	0.014	0.011	0.02	0.05	0.04	0.002	0.016	0.009	0.01	0.05	0.03
Ortho-Xylene	0.016	0.022	0.019	0.05	0.07	0.06	0.002	0.016	0.009	0.01	0.05	0.03
Isopropybenzene	0.003	0.004	0.004	0.01	0.01	0.01	0.002	0.004	0.003	0.00	0.01	0.01
Benz(a)pyrene	0.0593	0.0948	0.0795	2.97	4.74	3.97	0.0519	0.0755	0.0668	2.60	3.78	3.34
Total 10 PAHs	1.0686	1.2343	1.1630	1.07*	1.23*	1.16*	0.7754	1.1092	0.9523	0.78*	1.11*	0.95*
Total 7 PSBs	0.007	0.009	0.008	0.12	0.14	0.13	0.006	0.008	0.007	0.11	0.13	0.12
Manganese	31.6	88.1	61.7	0.02	0.06	0.04	19.3	40.9	29.5	0.01	0.03	0.02
Zinc	20.5	32.1	27.4	0.09	0.15	0.12	32.8	64.2	48.7	0.15	0.29	0.22
Copper	19.7	44.2	30.7	0.15	0.33	0.23	31.4	63.2	49.0	0.24	0.48	0.37
Nickel	4.8	8.4	6.4	0.06	0.11	0.08	6.1	10.1	7.5	0.08	0.13	0.09
Cobalt	4.3	6.1	5.0	0.22*	0.31*	0.25*	5.6	7.7	6.9	0.28*	0.39*	0.34*
Lead	5.0	12.0	9.3	0.16	0.38	0.29	2.9	7.3	5.6	0.09	0.23	0.17
Cadmium	0.15	0.23	0.18	0.07	0.12	0.09	0.07	0.18	0.14	0.03	0.09	0.07
Chrome	4.1	9.5	7.0	0.68	1.58	1.17	5.3	6.8	6.0	0.88	1.13	1.00
Mercury	0.007	0.008	0.007	0.00	0.00	0.00	0.005	0.007	0.006	0.00	0.00	0.00

Index	Point number											
	S09-101						S09-102					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	13709	33646	25503	274.18*	672.92*	510.05*	10290	16162	13951	205.80*	323.24*	279.02*
Benzene	0.002	0.003	0.002	0.01	0.01	0.01	0.002	0.002	0.002	0.01	0.01	0.01
Toluene	0.012	0.023	0.017	0.04	0.08	0.06	0.005	0.008	0.007	0.02	0.03	0.02
Ethylbenzene	0.004	0.010	0.007	0.08*	0.19*	0.14*	0.003	0.005	0.004	0.06*	0.11*	0.08*
Σ meta- and para-Xylene	0.015	0.023	0.020	0.05	0.08	0.07	0.009	0.015	0.012	0.03	0.05	0.04
Ortho-Xylene	0.012	0.019	0.016	0.04	0.06	0.05	0.006	0.014	0.011	0.02	0.05	0.04
Isopropybenzene	0.003	0.004	0.003	0.01	0.01	0.01	0.001	0.002	0.002	0.00	0.00	0.00
Benz(a)pyrene	0.0373	0.0641	0.0510	1.87	3.21	2.55	0.0287	0.0431	0.0361	1.44	2.16	1.81
Total 10 PAHs	0.7825	1.0741	0.9609	0.78*	1.07*	0.96*	0.8781	1.0481	0.9616	0.88*	1.05*	0.96*
Total 7 PSBs	0.007	0.008	0.008	0.12	0.14	0.13	0.007	0.008	0.008	0.12	0.14	0.13

Index	Point number											
	S09-101						S09-102					
	Values, mg/kg			Values in MPC (APC) *PC units			Values, mg/kg			Values in MPC (APC) *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Manganese	17.4	48.1	31.0	0.01	0.03	0.02	40.7	109.2	77.1	0.03	0.07	0.05
Zinc	36.7	62.8	52.0	0.17	0.29	0.24	37.8	97.6	72.4	0.17	0.44	0.33
Copper	15.9	35.9	25.8	0.12	0.27	0.20	32.6	87.3	61.7	0.25	0.66	0.47
Nickel	2.5	5.8	4.4	0.03	0.07	0.06	4.6	8.9	7.4	0.06	0.11	0.09
Cobalt	4.5	6.2	5.2	0.23*	0.31*	0.26*	4.3	5.4	4.8	0.22*	0.27*	0.24*
Lead	7.7	16.1	12.0	0.24	0.50	0.37	7.1	14.5	11.9	0.22	0.45	0.37
Cadmium	0.12	0.25	0.21	0.06	0.13	0.10	0.14	0.22	0.19	0.07	0.11	0.09
Chrome	6.5	9.9	8.4	1.08	1.65	1.40	2.3	3.9	3.2	0.38	0.65	0.53
Mercury	0.007	0.009	0.008	0.00	0.00	0.00	0.005	0.006	0.005	0.00	0.00	0.00

Continuation of table 5.4-2

Index	Point number					
	S10-103					
	Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.
Oil products	953	1880	1231	19.06*	37.60*	24.62*
Benzene	<0.001	0.001	<0.001	0.00	0.00	0.00
Toluene	0.001	0.002	0.002	0.00	0.01	0.01
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.002	0.003	0.002	0.01	0.01	0.01
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0018	0.0033	0.0025	0.09	0.17	0.13
Total 10 PAHs	0.4718	0.6604	0.5632	0.47*	0.66*	0.56*
Total 7 PSBs	0.004	0.004	0.004	0.06	0.07	0.07
Manganese	26.2	58.8	44.7	0.02	0.04	0.03
Zinc	12.9	26	21.2	0.23	0.47	0.38
Copper	20.7	57.9	43.2	0.63	1.75	1.31
Nickel	3.3	7.2	5.8	0.17	0.36	0.29
Cobalt	4.0	5.5	4.5	0.20*	0.28*	0.23*
Lead	18.3	34.7	27.9	0.57	1.08	0.87
Cadmium	0.61	0.75	0.69	1.22	1.50	1.38
Chrome	4.8	7.5	6.0	0.80	1.25	1.00
Mercury	0.528	0.728	0.662	0.25	0.35	0.32

5.4.2. Fuels-lubes storage in the Nagurskoye settlement

Site 10 Alexandra Island (Nagurskoye settlement fuels-lubes storage) had 40 soil samples collected at 8 sampling points.

Assessment using Russian norms

VAH levels on Site 10 were :

- benzene - 0.011 mg/kg (up to 0.04 MPC units),
- toluene - 0.061 mg/kg (up to 0.20 MPC units)

- meta- and para-xylenes- 0.012 mg/kg (up to 0.04 MPC units),
- ortho-xylene - 0.013 mg/kg (up to 0.04 MPC units),
- isopropylbenzene - 0.004 mg/kg (up to 0.01 MPC units).

Benz(a)pyrene was as high as0.0328 mg/kg (up to 1.64 MPC, point S10-109). The rest of the PAH compounds involved in the study are not regulated by Russian normative documents.

Weight concentrations and MPC, APC and PC of pollutants at Site 10 geo-ecological sampling points are given in Table 5.4-4 at the end of this section.

Table 5.4-3 presents an assessment of soil contamination (contamination category) on the site based on the guidelines in SanPiN 2.1.7.1287-03 using MPC (APC), and contamination levels in units of internationally recognized permissible concentrations.

Table 5.4-3 Assessment of soil contamination in the area of Nagurskoye settlement fuels-lubes storage, (Site 10), according to SanPiN 2.1.7.1287-03 and international norms

Index	площадка 10									
	Values, mg/kg	Values in MPC (APC)			Contamination class			Values in PC units		
	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	9105							4.86	**863.20***	**204.59***
Benzene	0.002	0.00	0.04	0.01	permissible	permissible	permissible	0.00	0.22	0.04
Toluene	0.012	0.00	0.20	0.04	permissible	permissible	permissible	0.00	0.12	0.03
Ethylbenzene	0.002					permissible	permissible	0.00	0.19	0.05
Σ meta- and para-Xylene	0.006	0.01	0.04	0.02	permissible	permissible	permissible	0.00	0.02	0.01
Ortho-Xylene	0.003	0.00	0.04	0.01	permissible	permissible	permissible	0.00	0.03	0.01
Isopropybenzene	0.001	0.00	0.01	0.00	permissible	permissible	permissible			
Benz(a)pyrene	0.0120	0.04	1.64	0.60	permissible	hazardous	permissible			
Total 10 PAHs	0.5622							0.25	1.10	0.56
Total 7 PSBs	0.021	0.02	1.27	0.38	permissible	permissible	permissible	0.05	3.82	1.15
Manganese	75.1	0.02	0.08	0.05	permissible	permissible	permissible			
Zinc	26.1	0.06	1.06	0.38	permissible	extra-hazardous	permissible	0.06	0.39	0.19
Copper	78.4	0.31	3.82	1.71	permissible	extra-hazardous	extra-hazardous	0.67	3.97	2.32
Nickel	10.9	0.06	0.84	0.38	permissible	permissible	permissible	0.12	0.75	0.33
Cobalt	4.0							0.10	0.29	0.20
Lead	86.3	0.07	9.22	2.70	permissible	extra-hazardous	extra-hazardous	0.03	3.47	1.11
Cadmium	0.47	0.10	1.98	0.62	permissibl	extra-	permissible	0.13	1.24	0.54

Index	площадка 10									
	Values, mg/kg	Values in MPC (APC)			Contamination class			Values in PC units		
	aver.	min	max	aver.	min	max	aver.	min	max	aver.
					e	hazardous				
Chrome	3.8	0.28	1.13	0.59	permissible	extra-hazardous	permissible	0.02	0.07	0.04
Mercury	0.279	0.01	0.35	0.13	permissible	permissible	permissible	0.07	2.18	0.75
Zc	22.62						moderately hazardous			

Note: * - values exceed the intervention level(UV)

By average levels of volatile aromatic hydrocarbons, benz(a)pyrene, total PCB, manganese, zinc, nickel, cadmium, chromium and mercury, Site 10 soils fall in **acceptable** pollution category; by average **copper and lead** – in **extremely hazardous** pollution category.

The values of total pollution index, Zc, calculated for an array of metals, varied from 11.05 (**acceptable** pollution category) to 47.13 (**hazardous** pollution category), with a site average of 22.6 – **moderately hazardous** category.

All sampling points (except for S09-101) had NPC and APC exceeded for zinc, copper, lead, chromium, and cadmium, as well as Kmax (according to MU 2.1.7.730-99), this corresponding to **extremely hazardous** soil pollution category.

On the whole, soil contamination levels in the Nagurskoye settlement fuels-lubes storage study area can be assessed as **extremely hazardous.**

Assessment using international norms

An exceedence of permissible concentrations (PC) in the site soils at some sampling points was registered for oil products, total PAH, total PCB, copper, lead, cadmium, and mercury, including:

- oil products – up to 863 PC;
- total PAHs – up to 1.10 PC;
- total PCBs – up to 3.82 PC;
- copper – up to 3.97 PC;
- lead – up to 3.47PC;
- cadmium – up to 1.24 PC;
- mercury – up to 2.18 PC.

It was found that average levels of contaminants for the site as a whole exceeded PC as follows: oil products – 205-fold, total PCB – 1.2-fold, copper – 2.3-fold, lead – 1.1-fold.

It should be emphasized that soil contamination at the site by oil products **exceeded the intervention level** both in its average value (2-fold) , and in the values at some sampling points(up to 8.6 IL).

Figures 5.4-4 - 5.4-6 present the spatial distribution of soil contamination on Site 10 by oil products, total PAH, total PCB in PC units, as well as heavy metal contamination in Zc units.

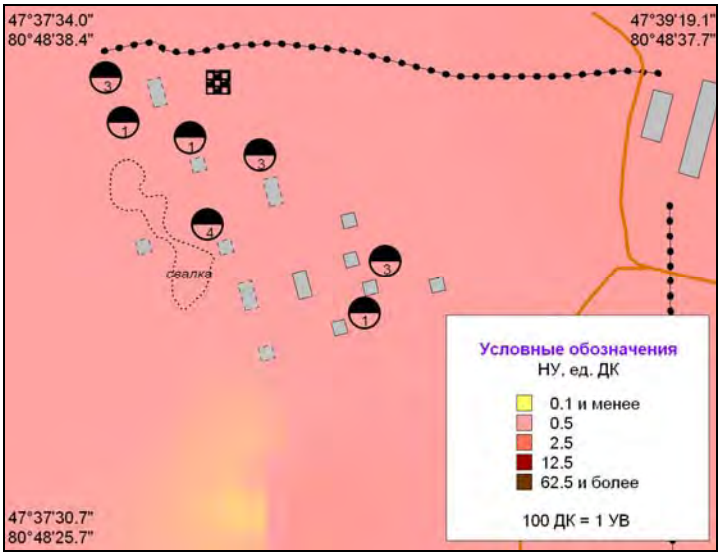
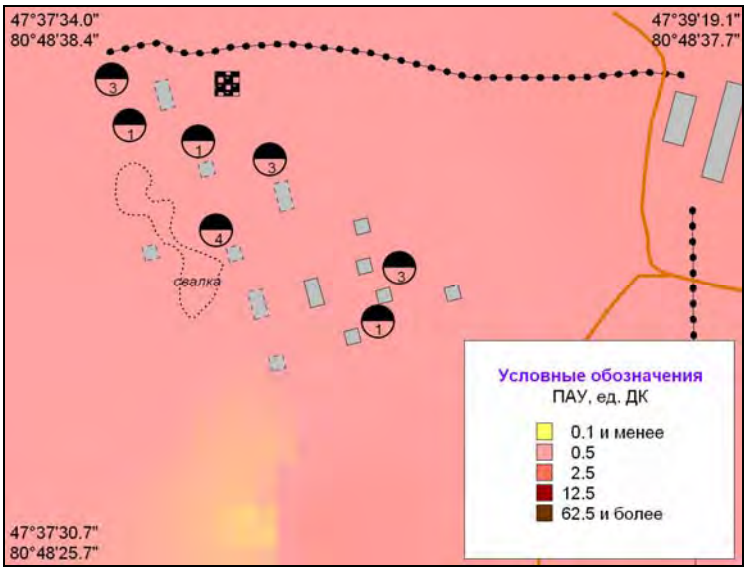
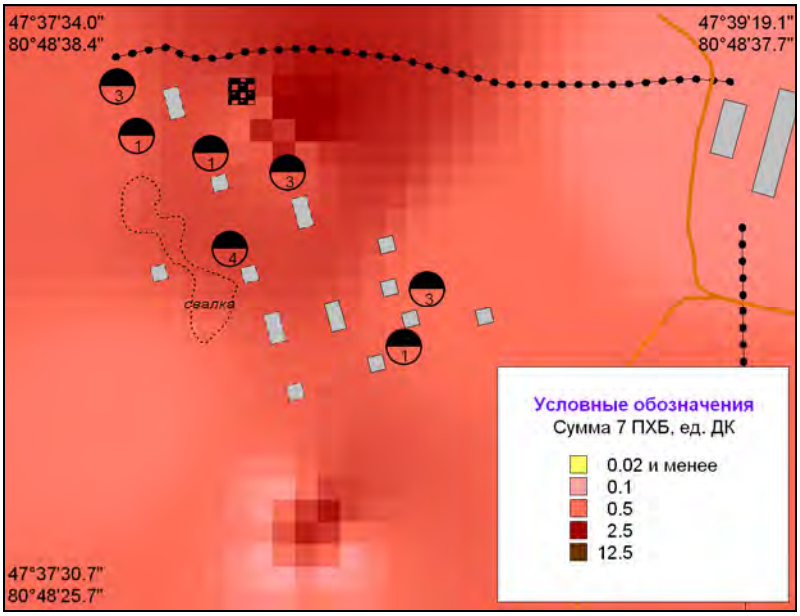


Fig. 5.4-4 Spatial distribution of soil contamination in the Nagurskoye settlement fuels-lubes storage area (Site 10) by petroleum hydrocarbons (oil products)



Note: 10 PAHs - anthracene, benz(a)anthracene, benz(k)fluoranthene, benz(a)pyrene, chrysene, phenanthrene, fluoranthene, indeno(123cd) pyrene, naphthalene, benz(ghi)perylene)

Fig. 5.4-5 Spatial distribution of soil contamination in the Nagurskoye settlement fuels-lubes storage area (Site 10) by polycyclic aromatic hydrocarbons



Note: 7 PCBs- #28, #52, #101, #118, #138, #153, #180

Fig. 5.4-6 Spatial distribution of soil contamination in the Nagurskoye settlement fuels-lubes storage area (Site 10) by polychlorinated biphenyls

Table 5.4-4. Contamination weight concentration intervals and MPC, APC and PC units in Site 10 soils

Index	Point number											
	S01-014						S10-104					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	3124	5250	4025	62.48*	105*	80.49*	8240	15240	12339	164.80*	304.80*	246.78*
Benzene	<0.001	0.001	0.001	0.00	0.00	0.00	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.001	0.002	0.001	0.00	0.01	0.00	0.006	0.009	0.008	0.02	0.03	0.03
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	0.005	0.008	0.007	0.11*	0.16*	0.13*
Σ meta- and para-Xylene	0.001	0.002	0.002	0.00	0.01	0.01	0.006	0.008	0.007	0.02	0.03	0.02
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	0.002	0.003	0.002	0.01	0.01	0.01
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	0.003	0.004	0.003	0.01	0.01	0.01
Benz(a)pyrene	0.0092	0.0157	0.0117	0.46	0.79	0.59	0.0038	0.0057	0.0047	0.19	0.29	0.23
Total 10 PAHs	0.5709	0.8800	0.7336	0.57*	0.88*	0.73*	0.3313	0.4580	0.3952	0.33*	0.46*	0.40*
Total 7 PSBs	0.006	0.006	0.006	0.09	0.11	0.10	0.003	0.003	0.003	0.05	0.05	0.05
Manganese	71.5	137.0	111.1	0.05	0.09	0.07	79.4	93.0	85.2	0.05	0.06	0.06
Zinc	53.1	58.3	55.7	0.97	1.06	1.01	25.3	34.2	29.5	0.46	0.62	0.54
Copper	53.2	68.1	62.6	1.61	2.06	1.90	81.5	94.6	86.8	2.47	2.87	2.63
Nickel	10.9	16.8	13.4	0.55	0.84	0.67	7.5	11.2	9.4	0.38	0.56	0.47

Cobalt	3.1	6.2	4.7	0.16*	0.31*	0.23*	3.7	5.2	4.3	0.19*	0.26*	0.21*
Lead	11.1	18.3	14.6	0.35	0.57	0.46	18.4	26.4	22.6	0.58	0.83	0.71
Cadmium	0.07	0.30	0.18	0.14	0.60	0.37	0.10	0.60	0.34	0.20	1.20	0.68
Chrome	3.4	5.3	4.4	0.57	0.88	0.73	3.1	4.3	3.7	0.52	0.72	0.62
Mercury	0.050	0.200	0.116	0.02	0.10	0.06	0.200	0.600	0.360	0.10	0.29	0.17

Index	Point number											
	S10-105						S10-106					
	Values, mg/kg			Values in MPC (APC), *PC units			Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	746	1378	1009	14.92*	27.56*	20.18*	243	416	314	4.86*	8.32*	6.28*
Benzene	<0.001	0.001	<0.001	0.00	0.00	0.00	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.002	0.002	0.002	0.01	0.01	0.01	0.002	0.005	0.004	0.01	0.02	0.01
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.002	0.002	0.002	0.01	0.01	0.01	0.002	0.004	0.003	0.01	0.01	0.01
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	0.010	0.013	0.011	0.03	0.04	0.04
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0198	0.0318	0.0259	0.99	1.59	1.30	0.0062	0.0113	0.0096	0.31	0.57	0.48
Total 10 PAHs	0.6818	1.0996	0.9124	0.68*	1.10*	0.91*	0.6048	0.6596	0.6272	0.60*	0.66*	0.63*
Total 7 PSBs	0.002	0.003	0.003	0.04	0.05	0.05	0.052	0.063	0.057	0.87	1.05	0.95
Manganese	76.4	83.1	79.6	0.05	0.06	0.05	50	108.8	80.8	0.03	0.07	0.05
Zinc	17.2	26.7	22.7	0.31	0.49	0.41	8.2	15.9	11.1	0.15	0.29	0.20
Copper	87.2	113	101.7	2.64	3.42	3.08	24.2	53.6	39.6	0.73	1.62	1.20
Nickel	10.2	15.1	12.4	0.51	0.76	0.62	4.2	8.2	5.7	0.21	0.41	0.29
Cobalt	3.3	4.5	4.0	0.17*	0.23*	0.20*	4.3	5.7	4.9	0.22*	0.29*	0.25*
Lead	6.5	10.2	8.2	0.20	0.32	0.26	8.8	15.9	12.1	0.28	0.50	0.38
Cadmium	0.30	0.70	0.46	0.60	1.40	0.92	0.44	0.99	0.72	0.89	1.98	1.43
Chrome	2.4	3.9	3.0	0.40	0.65	0.51	2.1	3.0	2.6	0.35	0.50	0.43
Mercury	0.1	0.3	0.220	0.05	0.14	0.10	0.428	0.654	0.534	0.20	0.31	0.25

Index	Point number											
	S10-107						S10-108					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	261	673	488	5.22*	13.46*	9.76*	8461	16385	11992	169.22*	327.70*	239.84*
Benzene	0.001	0.002	0.001	0.00	0.01	0.00	0.009	0.011	0.010	0.03	0.04	0.03
Toluene	<0.001	<0.001	<0.001	0.00	0.00	0.00	0.054	0.061	0.058	0.18	0.20	0.19
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.004	0.006	0.005	0.01	0.02	0.02	0.008	0.012	0.011	0.03	0.04	0.03
Ortho-Xylene	0.002	0.002	0.002	0.01	0.01	0.01	0.002	0.004	0.003	0.01	0.01	0.01
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0007	0.0010	0.0009	0.04	0.05	0.04	0.0159	0.0195	0.0179	0.80	0.98	0.90
Total 10 PAHs	0.2469	0.3301	0.2964	0.25*	0.33*	0.30*	0.4642	0.6964	0.5904	0.46*	0.70*	0.59*
Total 7 PSBs	0.001	0.001	0.001	0.02	0.02	0.02	0.014	0.017	0.016	0.24	0.29	0.26
Manganese	41.3	64.2	54.7	0.03	0.04	0.04	62.3	92.1	76.7	0.04	0.06	0.05
Zinc	13.2	26.7	20.4	0.24	0.49	0.37	37.5	54.3	46.3	0.17	0.25	0.21

Index	Point number											
	S10-107						S10-108					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Copper	73.4	126	97.1	2.22	3.82	2.94	68.1	113	90.1	0.52	0.86	0.68
Nickel	5.6	14.7	9.1	0.28	0.74	0.46	12.1	18.4	15.1	0.15	0.23	0.19
Cobalt	1.9	3.5	2.6	0.10*	0.18*	0.13*	3.3	4.6	4.0	0.17*	0.23*	0.20*
Lead	2.2	5.1	3.3	0.07	0.16	0.10	108	210.0	158.0	3.38	6.56	4.94
Cadmium	0.40	0.70	0.52	0.80	1.40	1.04	0.20	0.40	0.26	0.10	0.20	0.13
Chrome	1.8	4.7	3.3	0.30	0.78	0.56	3.2	6.8	4.4	0.53	1.13	0.73
Mercury	0.1	0.5	0.200	0.05	0.24	0.10	0.1	0.3	0.180	0.05	0.14	0.09

Index	Point number											
	S10-109						S10-110					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	13280	43160	31124	265.60 *	863.20 *	622.48 *	6431	21060	14342	128.62 *	421.20 *	286.84 *
Benzene	0.001	0.002	0.001	0.00	0.01	0.00	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.011	0.014	0.012	0.04	0.05	0.04	0.006	0.008	0.007	0.02	0.03	0.02
Ethylbenzene	0.006	0.010	0.008	0.13*	0.19*	0.15*	0.003	0.003	0.003	0.05*	0.07*	0.06*
Σ meta- and para-Xylene	0.009	0.012	0.011	0.03	0.04	0.04	0.004	0.006	0.005	0.01	0.02	0.02
Ortho-Xylene	0.004	0.007	0.005	0.01	0.02	0.02	0.002	0.002	0.002	0.01	0.01	0.01
Isopropybenzene	0.002	0.004	0.003	0.00	0.01	0.01	0.002	0.002	0.002	0.00	0.00	0.00
Benz(a)pyrene	0.0174	0.0328	0.0268	0.87	1.64	1.34	0.0054	0.0100	0.0076	0.27	0.50	0.38
Total 10 PAHs	0.4842	0.6132	0.5645	0.48*	0.61*	0.56*	0.4994	0.5839	0.5484	0.50*	0.58*	0.55*
Total 7 PSBs	0.062	0.076	0.068	1.04	1.27	1.14	0.012	0.014	0.013	0.20	0.23	0.21
Manganese	74.5	124.0	90.7	0.05	0.08	0.06	61.8	107.0	88.6	0.04	0.07	0.06
Zinc	24.6	52.1	40.8	0.11	0.24	0.19	12.3	22.8	16.9	0.06	0.10	0.08
Copper	92.8	143	112.5	0.70	1.08	0.85	41	68.2	55.9	0.31	0.52	0.42
Nickel	17.1	26.2	22.1	0.21	0.33	0.28	4.4	10.5	7.7	0.06	0.13	0.10
Cobalt	3.2	5.4	4.4	0.16*	0.27*	0.22*	2.9	4	3.6	0.15	0.20*	0.18*
Lead	214	295.0	255.6	6.69	9.22	7.99	131	258.0	202.2	4.09	8.06	6.32
Cadmium	0.30	0.60	0.46	0.15	0.30	0.23	0.25	0.33	0.29	0.13	0.17	0.15
Chrome	4.3	5.7	5.0	0.72	0.95	0.83	1.7	3.2	2.7	0.01	0.01	0.01
Mercury	0.02	0.07	0.050	0.01	0.03	0.02	0.02	0.027	0.023	0.01	0.01	0.01

5.4.3. Fuels-lubes storage in Severnaya Bay

Site 01 Alexandra Island (Severnaya Bay fuels-lubes storage) had 65 soil samples collected at 13 geo-ecological sampling points.

Assessment using Russian norms

VAH levels in soils in the study area did not exceed tenths of MPC, being as follows:

- benzene - 0.002 mg/kg (up to 0.01 MPC);
- toluene - 0.003 mg/kg (up to 0.01 MPC);

- sum of meta- and para-xylenes - 0.004 mg/kg (up to 0.01 MPC);
- ortho-xylene – all values were below the analysis technique's threshold;
- isopropylbenzene – all values were below the analysis technique's threshold.

Benz(a)pyrene was as high as0.2374 mg/kg (up to 11.87 MPC, point S01-003). The levels of the rest of the PAH compounds involved in the study are not regulated by Russian normative documents.

Total PCB was as high as 0.005 mg/kg (up to 0.5 APC, point S01-013).

Weight concentrations and MPC, APC and PC of pollutants at the Site 1 geo-ecological sampling points are given in Table 5.4-6 at the end of this section.

Table 5.4-5 presents an assessment of soil contamination (contamination category) on the site based on the guidelines in SanPiN 2.1.7.1287-03 using MPC (APC), and contamination levels in units of internationally recognized permissible concentrations.

Table 5.4-5 Assessment of soil contamination in the area of Severnaya Bay fuels-lubes storage (Site 1) according to SanPiN 2.1.7.1287-03 and international norms

Index	Site 1									
	Values, mg/kg	Values in MPC (APC)			Contamination class			Values in PC units		
	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	33344							46.72	**2627.6***	**666.88***
Benzene	0.001	0.00	0.01	0.00	permissible	permissible	permissible	0.00	0.04	0.02
Toluene	0.001	0.00	0.01	0.00	permissible	permissible	permissible	0.00	0.01	0.00
Ethylbenzene	<0.001					permissible	permissible	0.00	0.00	0.00
∑ meta- and para-Xylene	0.002	0.00	0.01	0.01	permissible	permissible	permissible	0.00	0.01	0.00
Ortho-Xylene	<0.001	0.00	0.00	0.00	permissible	permissible	permissible	0.00	0.00	0.00
Isopropybenzene	<0.001	0.00	0.00	0.00	permissible	permissible	permissible			
Benz(a)pyrene	0.0827	0.23	11.87	4.14	permissible	extra-hazardous	hazardous			
Total 10 PAHs	8.7778							0.16	25.03	8.78
Total 7 PSBs	0.019	0.10	0.52	0.32	permissible	permissible	permissible	0.31	1.57	0.97
Manganese	107.1	0.02	0.16	0.07	permissible	permissible	permissible			
Zinc	89.1	0.12	2.74	0.68	permissible	extra-hazardous	extra-hazardous	0.19	1.25	0.64
Copper	85.5	0.26	4.52	1.10	permissible	extra-hazardous	extra-hazardous	0.95	4.47	2.38
Nickel	22.6	0.10	1.49	0.44	permissible	extra-hazardous	permissible	0.22	1.47	0.65
Cobalt	5.7							0.16	0.46	0.28

Index	Site 1									
	Values, mg/kg	Values in MPC (APC)			Contamination class			Values in PC units		
	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Lead	57.7	0.55	3.40	1.80	permissible	extra-hazardous	extra-hazardous	0.21	1.28	0.68
Cadmium	0.07	0.01	0.22	0.06	permissible	permissible	permissible	0.03	0.16	0.08
Chrome	6.6	0.53	1.87	1.10	permissible	extra-hazardous	extra-hazardous	0.03	0.11	0.07
Mercury	0.033	0.00	0.03	0.02	permissible	permissible	permissible	0.03	0.20	0.11
Zc metals	19.94						moderately hazardous			

Note: * - values exceeded the intervention level (IL)

By average levels of volatile aromatic hydrocarbons, total PCB, manganese, nickel, cadmium, and mercury, Site 1 soils fall in **acceptable** pollution category; by average **benz(a)pyrene** – in **hazardous** pollution category; by average **zinc, copper and lead** – **extremely hazardous** pollution category.

The values of total pollution index, Zc, calculated for an array of metals, varied from 8.93 (**acceptable** pollution category) to 38.2 (**hazardous** pollution category), with a site average of 19.9 – **moderately hazardous** category.

All sampling points had NPC and APC exceeded for zinc, copper, nickel, lead, and chromium, as well as Kmax (according to MU 2.1.7.730-99), this corresponding to **extremely hazardous** soil pollution category.

On the whole, soil contamination levels in the Severnaya Bay fuels-lubes storage study area can be assessed as **extremely hazardous.**

Assessment using international norms

An exceedence of permissible concentrations (PC) in the site soils at some sampling points was registered for oil products, total PAH, total PCB, zinc, copper, nickel, lead, including:

- oil products - up to 2628 PC units;
- total PAHs - up to 25 PC units;
- total PCBs – up to 1.6 PC units;
- zinc - up to 1.3 PC units;
- copper - up to 4.5 PC units;
- nickel – up to 1.5 PC units;
- lead - up to 1.3 PC units.

It was found that average levels of contaminants for the site as a whole exceeded PC as follows: oil products – 667-fold, total PCB – 8.8-fold, copper – 2.4-fold.

It should be emphasized that soil contamination at the site by oil products **exceeded the intervention level** both in its average value (6.7-fold) , and in the values at some sampling points(up to 26.3 IL).

Figures 5.4-7 - 5.4-9 present the spatial distribution of soil contamination on Site 1 by oil products, total PAH, total PCB in PC units, as well as heavy metal contamination in Zc units.

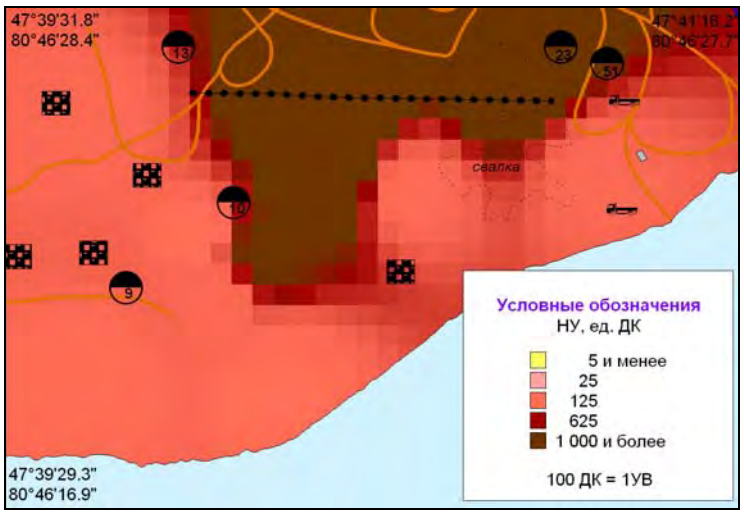
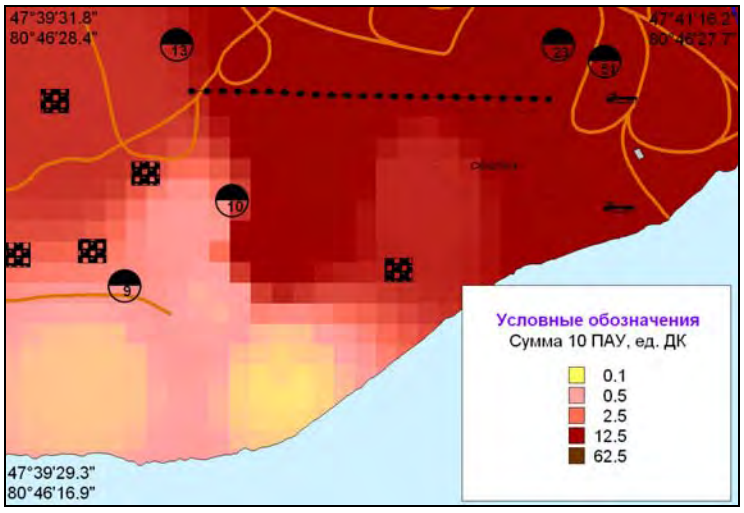
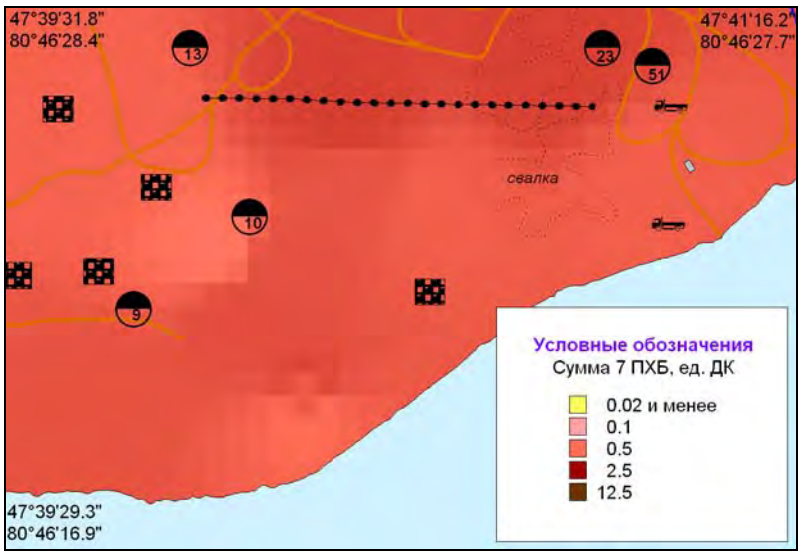


Fig. 5.4-7 Spatial distribution of soil contamination in the Severnaya Bay fuels-lubes storage area (Site 1) by petroleum hydrocarbons (oil products)



Note: 10 PAHs - anthracene, benz(a)anthracene, benz(k)fluoranthene, benz(a)pyrene, chrysene, phenanthrene, fluoranthene, indeno(123cd) pyrene, naphthalene, benz(ghi)perylene

Fig. 5.4-8 Spatial distribution of soil contamination in the Severnaya Bay fuels-lubes storage area (Site 1) by polycyclic aromatic hydrocarbons



Note: 7 PCBs - #28, #52, #101, #118, #138, #153, #180

Fig. 5.4-9 Spatial distribution of soil contamination in the Severnaya Bay fuels-lubes storage area (Site 1) by polychlorinated biphenyls

Table 5.4-6. Contamination weight concentration intervals and MPC, APC and PC units in Site 1 soils

Index	Point number											
	S01-001						S01-002					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	4341	10881	7984	86.82*	217.62*	159.68*	3603	7393	6104	72.06*	147.86*	122.08*
Benzene	<0.001	0.002	0.002	0.00	0.01	0.00	<0.001	0.002	<0.001	0.00	0.01	0.00
Toluene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.002	<0.001	0.00	0.01	0.00
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	<0.001	0.002	0.001	0.00	0.01	0.00	0.001	0.002	0.002	0.00	0.01	0.00
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0917	0.1448	0.1227	4.59	7.24	6.13	0.0092	0.0202	0.0147	0.46	1.01	0.74
Total 10 PAHs	4.8782	0.2057	7.6604	14.88*	20.21*	17.66*	0.2010	0.3002	0.2540	0.20*	0.30*	0.25*
Total 7 PSBs	0.021	0.025	0.024	0.35	0.42	0.39	0.008	0.009	0.009	0.13	0.15	0.14
Manganese	37.4	86.0	62.8	0.02	0.06	0.04	104.3	245.8	161.8	0.07	0.16	0.11
Zinc	26.0	66.8	50.4	0.12	0.30	0.23	46.5	92.7	71.5	0.21	0.42	0.33
Copper	45.9	79.9	58.2	0.35	0.61	0.44	50.6	133	92.6	0.38	1.01	0.70
Nickel	8.7	18.2	14.2	0.11	0.23	0.18	8.1	18.4	13.6	0.10	0.23	0.17
Cobalt	5.9	7.3	6.5	0.30*	0.37*	0.32*	4.7	6.2	5.4	0.24*	0.31*	0.27*
Lead	23.6	46.0	38.1	0.74	1.44	1.19	47	91.4	74.6	1.47	2.86	2.33
Cadmium	0.07	0.13	0.10	0.04	0.06	0.05	0.03	0.07	0.06	0.02	0.04	0.03
Chrome	3.8	8.3	6.8	0.63	1.38	1.13	5.1	8.7	7.4	0.85	1.45	1.23
Mercury	0.021	0.024	0.022	0.01	0.01	0.01	0.031	0.041	0.036	0.01	0.02	0.02

Index	Point number											
	S01-003						S01-004					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	24801	51359	38351	496.02 *	027.18 *	767.03 *	80038	13138 0	10517 9	00.76*	2627.6 *	2103.58 *
Benzene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Toluene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.002	0.001	0.00	0.01	0.00
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	<0.001	0.001	0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.1187	0.2374	0.1885	5.94	11.87	9.42	0.1424	0.2303	0.1883	7.12	11.52	9.42
Total 10 PAHs	0.5043	5.0338	3.3354	20.50*	25.03*	23.34*	7.7242	1.5322	0.0771	17.72*	21.53*	20.08*
Total 7 PSBs	0.023	0.029	0.026	0.39	0.48	0.44	0.025	0.030	0.028	0.42	0.50	0.46
Manganese	69.5	124.9	95.0	0.05	0.08	0.06	54.9	108.9	81.8	0.04	0.07	0.05
Zinc	74.7	161.5	122.8	0.34	0.73	0.56	50.1	89.9	74.3	0.23	0.41	0.34
Copper	52.5	78.1	62.9	0.40	0.59	0.48	34.3	61.5	46.4	0.26	0.47	0.35
Nickel	22.8	39	30.5	0.29	0.49	0.38	14	22.4	17.9	0.18	0.28	0.22
Cobalt	5.7	8.4	7.0	0.29*	0.42*	0.35*	6.2	8.6	7.6	0.31*	0.43*	0.38*
Lead	37.2	57.3	47.3	1.16	1.79	1.48	38.5	61.8	51.1	1.20	1.93	1.60
Cadmium	0.06	0.09	0.08	0.03	0.05	0.04	0.08	0.13	0.10	0.04	0.06	0.05
Chrome	3.8	5.8	5.1	0.63	0.97	0.85	7.4	11.2	9.3	1.23	1.87	1.56
Mercury	0.020	0.027	0.022	0.01	0.01	0.01	0.025	0.032	0.028	0.01	0.02	0.01

Index	Point number											
	S01-005						S01-006					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	2336	7134	5201	46.72*	142.68 *	104.02 *	5141	11417	7130	102.82 *	228.34 *	142.60 *
Benzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Toluene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.001	0.002	0.001	0.00	0.01	0.00	0.002	0.004	0.003	0.01	0.01	0.01
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0086	0.0148	0.0116	0.43	0.74	0.58	0.0118	0.0252	0.0197	0.59	1.26	0.99
Total 10 PAHs	0.1630	0.2140	0.1846	0.16*	0.21*	0.18*	0.3111	0.3736	0.3484	0.31*	0.37*	0.35*
Total 7 PSBs	0.006	0.008	0.007	0.10	0.13	0.12	0.022	0.026	0.024	0.37	0.44	0.40
Manganese	128	146.0	137.4	0.09	0.10	0.09	69.9	172.1	121.0	0.05	0.11	0.08
Zinc	98.0	110	104.2	0.45	0.50	0.47	93.5	150.8	119.0	1.70	2.74	2.16
Copper	100	112	105.6	0.76	0.85	0.80	56.1	149.2	108.5	1.70	4.52	3.29
Nickel	25.1	29.3	27.0	0.31	0.37	0.34	18.4	29.8	24.9	0.92	1.49	1.25
Cobalt	3.1	3.7	3.4	0.16*	0.19*	0.17*	3.6	4.7	4.1	0.18*	0.24*	0.21*
Lead	60.7	62.8	61.8	1.90	1.96	1.93	47.6	108.7	81.9	1.49	3.40	2.56
Cadmium	0.03	0.06	0.05	0.02	0.03	0.02	0.03	0.07	0.05	0.06	0.13	0.10

Index	Point number											
	S01-005						S01-006					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Chrome	5.1	6.1	5.6	0.85	1.02	0.93	3.5	6.4	5.0	0.58	1.07	0.83
Mercury	0.01	0.03	0.018	0.00	0.01	0.01	0.039	0.054	0.044	0.02	0.03	0.02

Index	Point number											
	S01-007						S01-008					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	3670	7448	6136	73.4*	148.96*	122.73*	7655	12430	9687	153.1*	248.6*	193.74*
Benzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	0.001	0.00	0.00	0.00
Toluene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.001	0.002	0.002	0.00	0.01	0.01	<0.001	0.002	0.001	0.00	0.01	0.00
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0045	0.0100	0.0074	0.23	0.50	0.37	0.0108	0.0162	0.0132	0.54	0.81	0.66
Total 10 PAHs	0.1909	0.2603	0.2170	0.19*	0.26*	0.22*	0.3193	0.3719	0.3500	0.32*	0.37*	0.35*
Total 7 PSBs	0.008	0.012	0.010	0.14	0.20	0.16	0.019	0.023	0.021	0.31	0.38	0.35
Manganese	121	185.7	153.8	0.08	0.12	0.10	38.7	92.2	68.6	0.03	0.06	0.05
Zinc	53.5	113.4	84.5	0.24	0.52	0.38	39.8	87.3	68.3	0.18	0.40	0.31
Copper	50	102.5	76.0	0.38	0.78	0.58	103.2	160.9	131.1	0.78	1.22	0.99
Nickel	17.4	30.1	22.1	0.22	0.38	0.28	22	33.9	28.7	0.28	0.42	0.36
Cobalt	3.9	5.3	4.7	0.20*	0.27*	0.23*	4.4	5.4	4.9	0.22*	0.27*	0.25*
Lead	55.5	86.8	71.9	1.73	2.71	2.25	49.3	74.0	58.4	1.54	2.31	1.83
Cadmium	0.04	0.06	0.05	0.02	0.03	0.02	0.03	0.06	0.05	0.01	0.03	0.02
Chrome	3.2	7.9	5.9	0.53	1.32	0.99	5.5	8.1	7.3	0.92	1.35	1.22
Mercury	0.037	0.051	0.041	0.02	0.02	0.02	0.038	0.048	0.042	0.02	0.02	0.02

Index	Point number											
	S01-009						S01-0010					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	3908	5806	4861	78.16*	116.12*	97.22*	5128	8266	6431	102.56*	165.32*	128.62*
Benzene	<0.001	0.001	<0.001	0.00	0.00	0.00	<0.001	0.002	0.001	0.00	0.01	0.00
Toluene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.002	0.004	0.003	0.01	0.01	0.01	0.001	0.003	0.002	0.00	0.01	0.01
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0162	0.0208	0.0190	0.81	1.04	0.95	0.0479	0.0691	0.0571	2.40	3.46	2.86
Total 10 PAHs	0.4662	0.5865	0.5043	0.47*	0.59*	0.50*	0.7352	0.8501	0.7925	0.74*	0.85*	0.79*
Total 7 PSBs	0.020	0.023	0.022	0.33	0.39	0.37	0.008	0.010	0.009	0.13	0.17	0.15

Manganese	44.8	81.0	65.6	0.03	0.05	0.04	98.2	199.6	165.8	0.07	0.13	0.11
Zinc	54.0	113.4	93.8	0.98	2.06	1.71	67.3	174.4	126.3	0.31	0.79	0.57
Copper	48.3	122.5	87.8	1.46	3.71	2.66	68.4	152.6	112.3	0.52	1.16	0.85
Nickel	12.8	21.4	17.4	0.64	1.07	0.87	23.3	51.4	36.9	0.29	0.64	0.46
Cobalt	3.8	4.6	4.1	0.19*	0.23*	0.21*	3.7	5.2	4.3	0.19*	0.26*	0.22*
Lead	43.5	97.1	76.5	1.36	3.03	2.39	60.3	104.2	86.0	1.88	3.26	2.69
Cadmium	0.06	0.08	0.07	0.11	0.16	0.13	0.05	0.06	0.06	0.03	0.03	0.03
Chrome	3.8	8.6	6.7	0.63	1.43	1.12	3.6	5.4	4.5	0.60	0.90	0.74
Mercury	0.041	0.057	0.051	0.02	0.03	0.02	0.034	0.047	0.042	0.02	0.02	0.02

Index	Point number											
	S01-011						S01-012					
	Values, mg/kg			alues in MPC (APC), *PC units			Values, mg/kg			/alues in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.	min	max	aver.	min	max	aver.
Oil products	60290	92160	77301	1205.8*	1843.2*	546.02*	63967	91377	81093	1279.34*	1827.54*	21.86*
Benzene	0.001	0.002	0.001	0.00	0.01	0.00	0.001	0.002	0.002	0.00	0.01	0.00
Toluene	0.001	0.002	0.002	0.00	0.01	0.01	0.001	0.003	0.002	0.00	0.01	0.01
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*	<0.001	0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	<0.001	0.002	0.001	0.00	0.01	0.00	<0.001	0.002	0.002	0.00	0.01	0.00
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00	<0.001	0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.0796	0.1401	0.1137	3.98	7.01	5.69	0.1202	0.1619	0.1420	6.01	8.10	7.10
Total 10 PAHs	5.3553	9.1155	7.4634	15.36*	19.12*	17.46*	5.1351	6.8888	6.1523	15.14*	16.89*	16.15*
Total 7 PSBs	0.017	0.020	0.019	0.29	0.34	0.32	0.023	0.026	0.024	0.38	0.43	0.41
Manganese	95.3	100.2	97.6	0.06	0.07	0.07	72.4	131.3	104.0	0.05	0.09	0.07
Zinc	97.1	101.2	98.7	0.44	0.46	0.45	41.5	62.7	51.6	0.75	1.14	0.94
Copper	83.4	87.3	86.0	0.63	0.66	0.65	41.6	77.7	60.1	1.26	2.35	1.82
Nickel	21.9	25.9	23.9	0.27	0.32	0.30	7.8	18.3	14.0	0.39	0.92	0.70
Cobalt	5.2	7.2	6.4	0.26*	0.36*	0.32*	6.7	9.2	7.8	0.34*	0.46*	0.39*
Lead	28.2	34.3	31.7	0.88	1.07	0.99	33.6	51.9	44.1	1.05	1.62	1.38
Cadmium	0.02	0.08	0.06	0.01	0.04	0.03	0.06	0.11	0.10	0.13	0.22	0.19
Chrome	5.1	6.3	5.7	0.85	1.05	0.95	4.8	9.2	8.0	0.80	1.53	1.34
Mercury	0.010	0.060	0.024	0.00	0.03	0.01	0.028	0.039	0.034	0.01	0.02	0.02

Index	Point number					
	S01-013					
	Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.
Oil products	43862	109924	78015	877.24*	2198.48*	1560.31*
Benzene	0.001	0.001	0.001	0.00	0.00	0.00
Toluene	0.001	0.003	0.002	0.00	0.01	0.01
Ethylbenzene	<0.001	<0.001	<0.001	0.00*	0.00*	0.00*
Σ meta- and para-Xylene	0.001	0.003	0.002	0.00	0.01	0.01
Ortho-Xylene	<0.001	<0.001	<0.001	0.00	0.00	0.00
Isopropybenzene	<0.001	<0.001	<0.001	0.00	0.00	0.00
Benz(a)pyrene	0.1164	0.2146	0.1775	5.82	10.73	8.88
Total 10 PAHs	15.8753	17.6033	16.7727	15.88*	17.60*	16.77*
Total 7 PSBs	0.026	0.031	0.029	0.43	0.52	0.48
Manganese	59.9	100.0	77.3	0.31	0.53	0.42

Index	Point number S01-013					
	Values, mg/kg			Values in MPC (APC), *PC units		
	min	max	aver.	min	max	aver.
Zinc	67.1	116.6	92.4	0.42	0.90	0.64
Copper	55.1	119	84.2	0.15	0.42	0.28
Nickel	12.2	33.9	22.5	0.35	0.97	0.64
Cobalt	6.6	8.3	7.7	0.33*	0.42*	0.38*
Lead	17.5	35.3	27.3	0.55	1.10	0.85
Cadmium	0.06	0.08	0.07	0.03	0.04	0.04
Chrome	5.3	10.4	8.2	0.88	1.73	1.36
Mercury	0.026	0.034	0.030	0.01	0.02	0.01

5.4.4.Comparative analysis of contamination levels at the study sites on Alexandra Island

A comparison of soil contamination levels on the studied sites allows making the following conclusions:

- Regarding **petroleum hydrocarbons**, the most contaminated by these are the soils in the area of the Severnaya Bay fuels-lubes storage (Site 1) where average PH levels are **6.7 times** the **intervention level** set down in international standards.

- The Site 1 soils are also the most contaminated by **polycyclic aromatic hydrocarbons.** Average PAH levels (for a sum of PAH compounds) exceeded the internationally recognized PC by a factor of **8.8**, while with regard to **benz(a)pyrene** the site soils fall in **hazardous pollution category**, according to SanPiN 2.1.7.1287-03.

- The highest levels of **polychlorinated biphenyls** were registered in the soil in the area of the locator station (Site 9). While on none of the study sites average PCB levels were as high as **MPC or PC**, which corresponds to **acceptable pollution category** as per SanPiN 2.1.7.1287-03, the fact there were found spots with relatively high local contamination levels additional research is required to identify possible sources.

On the whole, soil contamination levels can assessed as follows:

- Locator station area (Site9) – **extremely hazardous**;

- Nagurskoye settlement fules-lubes storage (Site 10) - **extremely hazardous**;

- Severnaya Bay fuels-lubes storage (Site 1) - **extremely hazardous**.

Figure 5.4-10 presents a comparative review of average levels of contaminants in the study site soils on Alexandra Island.

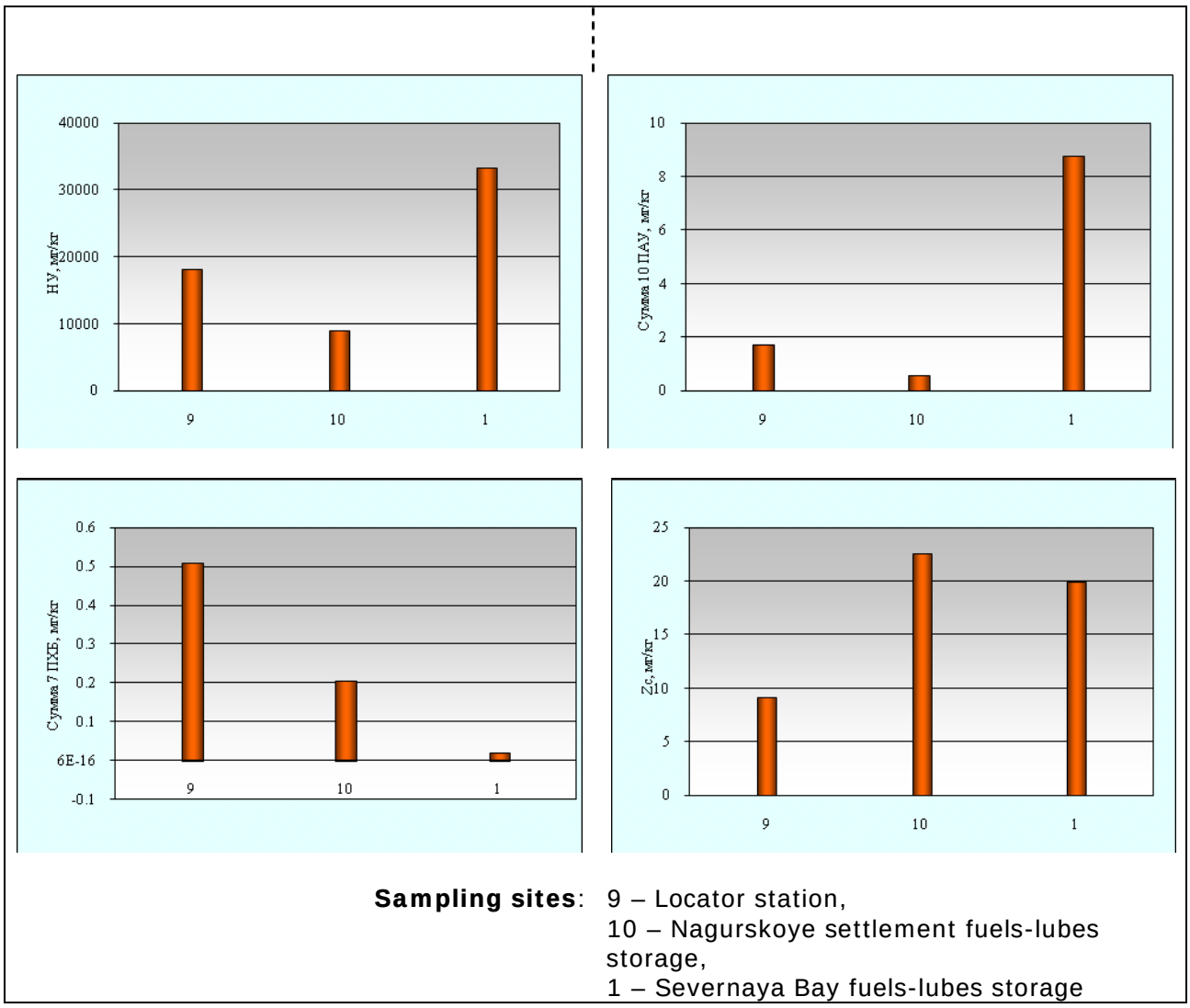


Fig. 5.4-10 Averages of total contamination factor Zc, and average PH, PAH and PCB concentrations on the study sites on Alexandra Island

5.5. Utility fluids analysis results

The purpose of the study of utility fluids from the containers on Alexandra Island and Graham-Bell was to identify any unaccounted for stock of organic products based on polychlorinated biphenyls such as sovols, sovtols and hexanols. The study included inspecting the storage area, packing, labeling, visual characteristics of the fluids, identifying petroleum products based on physical and chemical analysis in accordance with the relevant standards (GOST) and technical guidelines, as well as the levels of polychlorinated biphenylsin the samples. For the purposes of the study, oil products unambiguously identified as petrol, kerosene or diesel were not sampled.

The results of visual inspection of the utility fluid storage sites, containers, labeling and organoleptic properties are presented in Table 5.5-1.

Table 5.5-1. Characteristics of utility fluid samples collected on Alexandra Island study sites

№ of sample	Location	Type of tank	Presence of the stamp and label	Visual characteristics of the specimen
L01-01	Dump of drums and operative fuel and labricants storage fascility on the coston	200 l iron drum	Stamp of 1981	Thick light brown liquid with oil odor
L01-02	Dump of drums and operative fuel and labricants storage fascility on the coston	200 l iron drum	-	Thick light brown liquid with oil odor
L01-03	Dump of drums and operative fuel and labricants storage fascility on the coston	200 l iron drum	-	Thick light brown liquid with oil odor
L09-12	Radar station	Radar transformer station	-	Yellow- brown liquid with oil odor
L09-13	Radar station	200 l metallic drum	Label «1-БК»	Brown liquid with oil odor
L09-14	Radar station	200 l metallic drum	Stamp 1981	Brown liquid with oil odor
L09-15	Radar station	200 l metallic drum	-	Brown liquid with oil odor
L09-16	Radar station	200 l metallic drum	-	Brown liquid with oil odor
L09-17	Radar station	200 l metallic drum	-	Brown liquid with oil odor

Fig. 5.5-1. Taking a sample of an utility fluid from the transformer of the locator on Site 9 (locator station), Alexandra Island

Fig. 5.5-2. Labels on the parts of the locator from which a sample of utility fluid a sample was taken on Site 9 (locator station), Alexandra Island

Fig. 5.5-3 Labeling of the drum from which a utility fluid sample was taken on Site 9 (locator station), Alexandra Island

Fig. 5.5-4 Sampling utility fluids on Site 1 (Severnaya Bay fuels-lubes storage), Alexandra Island

Fig. 5.5-5 Sampling utility fluids on Site 2 (aviation base), Graham-Bell Island

Fig. 5.5-6 Sampling utility fluids on Site 3 (runway), Graham-Bell Island

The results of a physical and chemical analysis of utility fluids (tables 5.5-2 – 5.5-8) suggested that the sample **L01-03** was that of motor car lubricating oil for carburetor engines, M-6_3/$10G_1$, sample **L09-12** – low-pour-point oil MGE-10A (MG-15-B by GOST 17479.3-85), **L09-15** – transmission oil TCp-10, **L01-02** – damping fluid AJ-12T, **L01-01, L09-13, L09-14, L09-16 and L09-17** – turboprop oil MN-7,5u.

Table 5.5-2 Correspondence of the properties of the fluid L01-03 to Technical Standards (TU)

Vehicle motor oil for carbureted engines M-63/10G1			
Parameter to be determined, unit of measurement	**Normative document for testing**	**Norms for M-63/10G1 according to GOST 10541-78**	**Actual values of the parameters according to the test results**
			L01-03
Density at 20°C, g/cm³	GOST 3900-85	не более 0.900	0.900
Viscosity at 100°C, mm²/s	GOST 33-2000	not less than 10.0 ± 0.5	9.95
Flash point in open cup, °C	GOST 4333-87	не ниже 210	240

Table 5.5-3 Conformance of liquid L09-12 to specifications

Low pour point hydraulic oil MGE-10A(MG-15-V according to GOST 17479.3-85)			
Parameter to be determined, unit of measurement	Normative document for testing	Norms for MG-15-V according to GOST 10541-78	Actual values of the parameters according to the test results
			L09-12
Appearance	-	Light brown transparent liquid	Light brown transparent liquid
Density at 20°C, g/cm³	GOST 3900-85	not more than 0.860	0.851
Viscosity at 100°C, mm²/s	GOST 33-2000	not less than 10.0	13.61
Flash point in open cup, °C	GOST 4333-87	not lower than 96	124

Table 5.5-4 Conformance of liquid L09-15 to specifications

Transmission oil TSp-10			
Parameter to be determined, unit of measurement	Normative document for testing	Norms for TSp-10 according to GOST 10541-78	Actual values of the parameters according to the test results
			L09-15
Density at 20°C, g/cm³	GOST 3900-85	not more than 0.915	0.913
Viscosity at 100°C, mm²/s	GOST 33-2000	not less than 10.0	10.36
Flash point in open cup, °C	GOST 4333-87	not lower than 128	228

Table 5.5-5. Conformance of liquid L02-04 to specifications

Shock-absorber fluid AZh-12T								
Parameter to be determined, unit of measurement	Normative document for testing	Normative for AZh-12 accordong to GOST 23008-78	Normative for MGP-12 according to Specification 38.301-29-40-97	Normative for ГРЖ-12 according to Specification 0253- 048-05767 -924-96	Actual values of the parameters according to the test results			
					L01- 02	L02-08	L02-09	L03-10

Density at 20°C, g/cm^{33}	GOST 3900-85	-	not more than 0.917	not more than 0.917	0.900	0.880	0.887	0.895
Viscosity at 100°C, mm^2/s	GOST 33-2000	not less than 3.6	not lower than 3.8	not less than 3.9	8.87	5.51	4.13	8.94
Flash point in open cup, °C	GOST 4333-87	not lower than 165	не ниже 140	not lower than 140	226	210	178	232

Table 5.5-6. Conformance of liquids L01-01, L02-07, L03-11, L09-13, L09-14, L09-16 and L09-17 to specifications

Oil for turboprop engines MN-7,5u								
Parameter to be determined, unit of measurement	**Normative document for testing**	**Normative for MH-7,5u accordong to specification 38.101722-85**	**Actual values of the parameters according to the test results**					
			L01-01	**L02-07**	**L03-11**	**L09-13**	**L09-14**	**L09-16**	**L09-17**
Density at 20°C, g/cm^{33}	GOST 3900-85	not more than 0.900	0.899	0.884	0.893	0.882	0.882	0.893	0.893
Viscosity at 100°C, mm^2/s	GOST 33-2000	not less than 7.5	9.23	9.25	9.03	9.26	9.13	9.33	9.17
Flash point in open cup, °C	GOST 4333-87	not lower than 150	227	210	228	213	222	226	228

A summary of the results of identifying utility fluids by physical and chemical properties is given in Table 5.5-7.

Table 5.5-7 The results of identifying utility fluids sampled on Alexandra Island

Site #	**1**			**9**	
Point #	**L01-001**	**L01-002**	**L01-003**	**L09-012**	**L09-013**
Results of identification	vehicle motor oil M-63/10G1	vehicle motor oil M-8G1	vehicle motor oil M-63/10G1 or motor oil for automotive diesel engines M-16IKhP-3 (M-16-$_{2}$)	low pour point hydraulic oil MGE-10A	vehicle motor oil M-63/10G$_{1}$

Site #	9			
Point #	L09-014	L09-015	L09-016	L09-017
Results of identification	vehicle motor oil M-63/10G$_1$	vehicle motor oil M-63/10G1 or transmission oil TSp-10 motor oil for automotive diesel engines M-16IKhP-3 (M-16-V$_2$)	vehicle motor oil M-63/10G$_1$	vehicle motor oil M-63/10G$_1$

Table 5.5-8 Содержание полихлорированных бифенилов в образцах технических жидкостей, отобранных на острове Земля Александры

Site #	1			9	
Point #	L01-01	L01-02	L01-03	L09-012	L09-013
PCB, mkg/kg					
#28	15.61	12.48	10.27	4.66	17.54
#31	<0.5	<0.5	<0.5	<0.5	<0.5
#52	12.42	38.56	55.64	12.40	27.81
#99	4.72	1.66	3.21	2.43	12.54
#101	22.06	17.65	10.28	1.10	8.17
#105	2.24	3.95	5.28	6.76	<0.5
#118	20.68	18.05	7.34	0.46	12.47
#128	<0.5	<0.5	<0.5	31.95	<0.5
#138	21.45	14.74	31.73	30.10	35.28
#153	5.74	50.62	4.27	130.06	9.67
#156	2.49	4.53	<0.5	10.04	1.62
#170	11.45	9.41	3.45	0.96	6.65
#180	24.69	<0.5	19.43	11.61	20.67
#183	<0.5	<0.5	<0.5	75.93	<0.5
#187	33.45	<0.5	10.82	7.43	<0.5
Sun PCBs	147.54	171.65	161.72	325.88	152.42

Site #	9			
Points #	**L09-014**	**L09-015**	**L09-016**	**L09-017**
PCB, mkg/kg				
#28	13.45	12.87	16.66	9.17
#31	<0.5	<0.5	<0.5	<0.5
#52	20.54	15.37	45.92	40.82
#99	3.78	6.27	10.46	7.16
#101	6.24	21.73	6.13	4.26
#105	<0.5	1.22	<0.5	1.47
#118	2.53	15.13	8.15	5.36
#128	<0.5	<0.5	<0.5	<0.5
#138	15.64	11.37	10.88	8.31
#153	37.82	43.25	77.49	13.59
#156	3.53	<0.5	<0.5	<0.5
#170	1.16	6.75	6.23	2.04
#180	<0.5	11.75	<0.5	28.24
#183	<0.5	<0.5	<0.5	<0.5
#187	25.36	<0.5	<0.5	<0.5
Sum PCBs	130.05	145.71	167.55	120.42

The results confirmed that none of the studied fluids was a product based on organochlorine compounds, since the total PCB content in all the samples did not exceed a few hundred micrograms per kilogram of the product. This level of organic chlorine content in oils is permissible and can result from contamination during production, filling, transportation or long-term storage. PCB congeners differ in the studied samples, but there is a marked prevalence of the 'Dutch Seven' regular major congeners (#28, #52, #101, #118, #138, #153, #180), however, considerable differences in their relative contribution to the total PCB content also suggest a multitude of sources from where the contamination of the study fluids came, including extraction from painted surfaces of containers and hoses. Even an emergency spill of these petroleum products cannot cause a hazardous soil contamination by organochlorine compounds.

An analysis of the results did not reveal a match between the qualitative PCB composition in the contaminated soils with that in the studied utility fluids stored on the same site. This goes to prove that there are a number of sources of soil contamination, both local (flaking of PCB-containing paint off drums and containers as a result of corrosion) and global, like long-range atmospheric transfer deposits.

5.6. The results of the study of soil contamination levels on Alexandra Island

A reconnaissance study of parts of decommissioned bases of the Ministry of Defense of Russia on Alexandra Island of Franz Josef Land Archipelago provided irrefutable evidence of a significant level of contamination and degradation of soils in the study areas.

On Alexandra Island, of 3.1 km^2 of the study area, 2.55 km^2 (82%) are heavily littered and have a broken soil and vegetation top layer as a result of unorganized transportation.

The most of the area included in the study is littered by metal drums as densely as 10 to 30 drums per hectare. The total number of fuels-lubes storage drums in the area is 15 to 25 thousand.

The studied areas had numerous remnants of utility and housing buildings and constructions, metal junkyards, abandoned vehicles, locator stations, containers, fuels-lubes cistern racks, and even airplanes. These included the following identified and geo-coded items:

- Buildings and structures – 55;
- Vehicles– 12;
- Airplane – 1;
- Containers and cisterns – 194;
- Locator station - 1;
- Outdoor storages for equipment and materials– 5;
- Waste dumps– 34, with a total area of 125.2 thousand m^2.

In addition, these areas had 30 to 35 thousand drums with fuels-lubes products in racks and clusters. .

It should be noted that the reconnaissance study was conducted in the fall, with snow cover starting to form, and therefore, even on the studied sites, the size of actual human impact affected areas is likely to be much larger, and even by a multiple larger

that the presented in this report, if one takes into account the size of the unstudied parts of the islands.

This conclusion is equally applicable to the quantity of geo-coded objects.

A study of soil quality drawing on Rospotrebnadzor SanPiN 2.1.7.1287-03, GN 2.1.7.2041-06, ПТ 2.1.7.2042-06 normative documents suggested that the degree of soil contamination on all geo-ecologocal sampling sites of Alexandra Island involved in the study could be assessed as **hazardous and extremely hazardous**.

An assessment based on international standards (Dutch Lists) showed that the sampling sites had petroleum product contamination 2 to 6 times the intervention level, while average total polycyclic aromatic hydrocarbon levels were 2 to 8 times the permissible concentrations.

The highest levels of **polychlorinated biphenyls** were registered in the locator station soils. While on none of the study sites average PCB levels were as high as **MPC or PC**, which corresponds to **acceptable pollution category** as per SanPiN 2.1.7.1287-03, the fact that there were found spots with relatively high local contamination levels calls for additional research to identify possible sources, especially in view of the fact that none of the sampled utility fluids was an organochlorine-based product.

6. ENVIRONMENTAL REMEDIATION ACTIVITIES ON DECOMMISSIONED NAGURSKAYA MILITARY BASE

The decommissioned Nagurskaya military base on Alexandra Island was the site of a demonstration project on collection and utilization of empty and partly filled fuels-lubes drums, as well as cleaning the top soil layer of spilled petrochemicals using decomposing biological products.

For the demonstration project, three testing grounds were chosen, however, since it turned out to be impossible to do the cleaning on Test Ground 1 (empty fuel-lube drums are still the property of the frontier outpost), it was only done on test grounds 2 and 3.

Geographically, test grounds 2 and 3 lie within Site 10.

A detailed description of collection and cleaning activities is given in the demonstration project field report, the sections below discuss main work stages, conclusions, and the results of chemical analysis of soils for petroleum hydrocarbons.

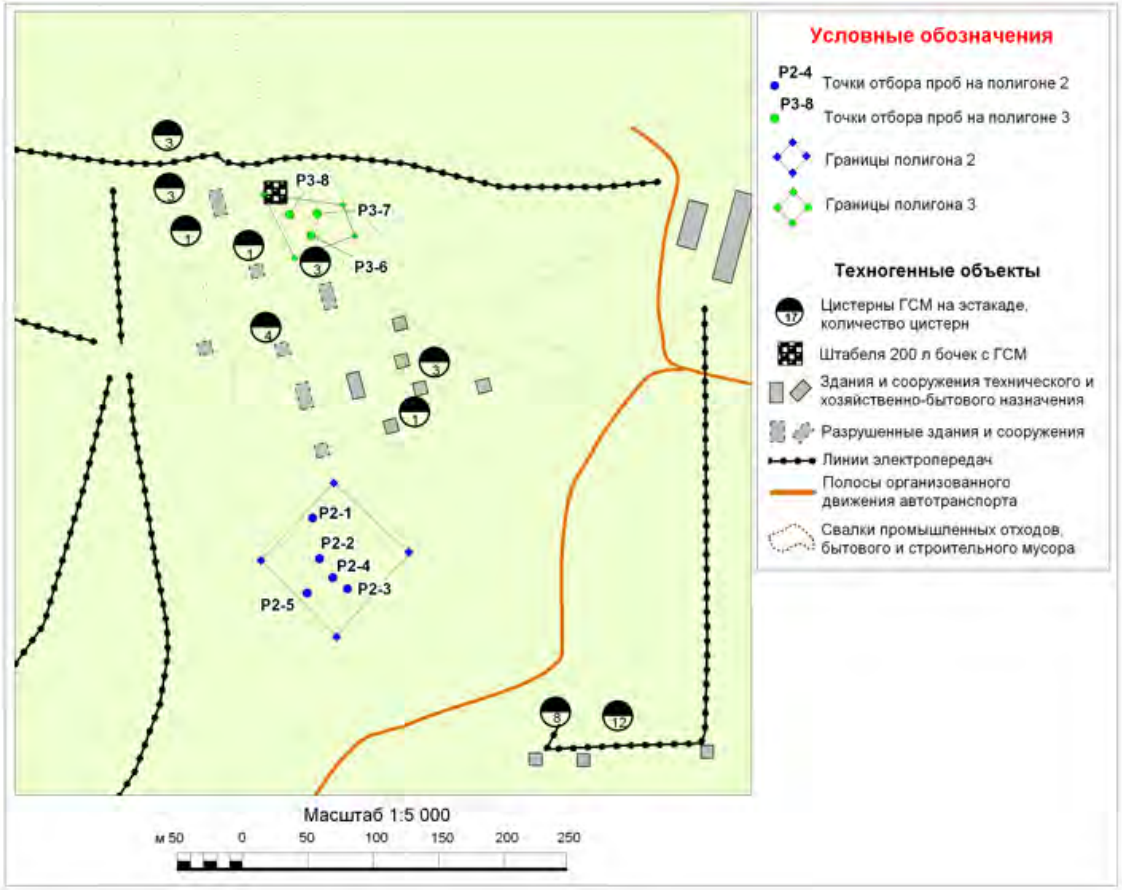


Fig.6-1. A map of test grounds on Site 10 (Nagurskoye settlement fuels-lubes storage) on Alexandra Island (1: 5000)

6.1. Work plan

According to the Project Terms of Reference (ToR), the key objectives of the works were as follows:

- clean-up of a demonstration site within the decommissioned Nagurskaya military base; and

- demonstration activities on the remediation of the polluted area.

The work plan included the following steps:

- Clean the demonstration site of scrap metal;
- Collect empty and partly-filled drums of oil products on one or several sites (total area not to exceed 1 ha);
- Transfer remnants to cisterns available on site;
- Wash the emptied drums by a special detergent that can be regenerated;
- Compacting empty drums;
- Stacking compacted drums, delivery to the Mikhail Somov research ship, and hand over to metal scrap utilization companies;
- Tilling the cleaned-up areas by a cultivator;
- Using two types of biological products to decompose organic contaminants on the cleaned-up sites.

6.2. Logistics

To implement the demonstration project, the following equipment and preparations were procured:

a) a diesel mini-tractor KMZ-0124 with a cart (for transporting drums and extracting the frozen-in ones);

b) “KÄRCHER” washer and water purifying system;

c) 12 tons hydraulic press, by «Tochnaya mehanika» plant;

d) ‘Vepr’ gasoline engine generator with HONDA engines (one- and three-phase), 5 kW and 7 kW; respectively (to supply power to the press and washer);

e) walk-behind tractor-cultivator SunGarden, model T/35;

f) three diesel pumps Grundfos JP;

g) biological products: ‘Devouroil’ and ‘Petro Treat’;

i) GPS-navigator GARMIN Etrex Legend.

j) fertilizer ‘NITROAMOFOSKA’, 24 kg (purchased in Archangelsk);

k) fish tank pump OXYBOOST APR-300 (to activate the biological product Devouroil);

l) ‘breathing’ polyethylene, two rolls (for covering plots treated by the biological products).

6.3. Project progress in 2007

The clean-up operations (not counting in the time for loading, unloading and commissioning the equipment) took place from 18 to 20 September.

After choosing a site to be Test Ground 2 and deploying part of the equipment (mini-tractor with a cart, gas-fueled generators, and pumps), the team got down to work on cleaning up the area and preparing the soil for treatment by the biological products.

Fig. 6.3.1. Test Ground 2 before clean-up operations

Soil tilling was carried out on day 1 only. The cultivator was down after 6 hours of work due to numerous heavy stones and virtually no humus layer on the ground. Apparently, using a tiller is quite unjustifiable in the present conditions of pollution and the quality of the surface of the ground, since it is the thin, top layer that holds most contaminants.

Pumping the remnants of oil products from drums to cisterns left behind on the decommissioned military base presented no difficulty. The gas-fueled generator placed near a cistern had a pump connected to it, and the oil product remnantsnd water-oil emulsion leftovers were pumped into the cisterns using hoses. Most of the drums on both test grounds were empty.

Fig. 6.3.2. Tilling soil on Test Ground 2, the structure of soil is well presented

Fig. 6.3.3. Transfer of oil product leftovers to cisterns

The empty drums (as well as the ones emptied by pumping) were delivered, by the mini-tractor and a truck provided by the command of the Nagurskaya frontier outpost, to the work site where the pumped dry ones were washed, and then both types, empty and washed clean, were compacted.

Fig. 6.3.4. “KÄRCHER” washer and water purifying system assembled

Fig. 6.3.5. Drum washing

While washing the drums the team ran into some problems. Firstly, the washer nozzle is not designed for working with containers with a narrow opening. Secondly, temperatures on FJL do not match operating temperatures of washers of this type (according to the user's manual the "KÄRCHER" washer can be used at a minimum ambient temperature of +4C°). The team was forced to drain the equipment of water after work. The results of the operations suggested that drum washing needs to be done indoors, in heated conditions, and the drums ought to be cut open to make access to their inner surface easier.

The press manufactured at the Tochnaya Mechanika plant generates a pressing power of 12 tons, and compacts modern design drums to a sheet 17 cm thick in 24 seconds. There are very few modern design drums on FJL on decommissioned military bases or other abandoned man-made sites. Most of the drums (over 80 per cent) here are military type containers for fuels-lubes produced in the USSR after the World War II till the early 80's. Made of steel, the drums have 2 mm thick walls, and, on top of that, three strengthening ribs. The press leaves no visual marks of compacting on such drums.

Fig. 6.3.6. Compacting modern design drums

Fig. 6.3.7. The drum has had no visual changes after using the press (the dent on the top was there before the press was used on it)

Due to the fact that compacting went well with modern design containers only, all collected drums and other wastes (mostly, scrap metal) from two pilot grounds (2 and 3) were stockpiled in one place (beyond the north boundary of Pilot Ground 3, at an existing waste storage site).

All in all, from the two pilot grounds, 218 drums were removed, along with other junk (tractor track shoes, rundown engines, and other scrap). Pilot Ground 2 had 77 drums removed, including 24 washed and 6 compacted. Pilot Ground 3 had 141 drums removed, of which 7 were washed and 5 compacted. Only drums with oil product remains were washed, while empty dry ones were stockpiled at once. Compacted drums were packed and delivered to the Mikhail Somov research ship. These as well as a few whole drums were transported to Archangelsk. The delivered drums were stockpiled on a storage site of Roshydromet's North Administration. The plan is to use the whole drums for testing equipment designed to compact this type of drums. The compacted drums were consigned to JSC Archangelsk Metal Group as scrap metal.

The soil at both pilot grounds was sampled for petroleum hydrocarbons. Since Pilot Grounds 2 and 3 were small in area (0.53 и 0.14 ha, respectively), uniform sampling was used as much as possible, instead of the 'envelope' technique. The results of the soil analysis are presented in Table 6-1. The analysis was made in the labs of the MA NPO Typhoon, North-West Branch, Saint-Petersburg. The analytical methodologies are discussed in chapter 5.2 – Petroleum products (total).

Table 6-1. The results of the soil analysis

Total PH levels in soil samples, in mg/kg and MPC							
Pilot Ground 2					Pilot Ground 3		
P 2-1	P 2-2	P 2-3	P 2-4	P 2-5	P 3-6	P 3-7	P 3-8
брак	12375	1009	314	488	11992	31126	14342
	248	20	6	10	240	623	287

Fig. 6.3.8. Removing metal scrap from Pilot Ground 3

PH levels in the soil of several dozens of MPC, especially in such a rocky one as on FJL, leaves no doubt that large amounts of petrol products have been spilled onto the ground. It is inaccurate to term this kind of contamination as 'PH levels'. The measured amount is simply heavy fractions of petroleum products that have not undergone decomposition or weathering. These residues are not part of the soil structure, but come as localized inclusions.

Following the cleaning the area of drums and other waste and limited tilling (until the cultivator broke down), biological products 'Devouroil' and 'Petro-Treat' were applied on a section of Pilot Ground 2. 'Devouroil' was applied in the liquid form as a suspension, while 'Petro-Treat' in the dry form. Before application, the 'Devouroil' was kept in water in a warm room for three days and aerated using a fish tank pump. A NITROAMOFOSKA fertilizer was applied to the section treated with the Devouroil product.

Fig. 6.3.9. Application of 'Devouroil' biological product

Fig. 6.3.10. Application of ‘Petro-Treat’ biological product

Some of the areas treated with the biological products were then covered by ‘breathing’ polyethylene.

Below are the coordinates of pilot grounds 2 and 3 (those of Pilot Ground 1 are not given, since no work was done there), sampling points, as well as the coordinates of the sections treated by the biological products.

Coordinates of the site # 2:

N 80^{o} 48.466’; E 47^{o} 37.857’

N 80^{o} 48.505’; E 47^{o} 37.735’ (motable sign: 21.10.2004)

N 80^{o} 48.522’; E 47^{o} 37.805’

N 80^{o} 48.490’; E 47^{o} 37.640’

Coordinates of sampling points on the site # 2

Sample P2-1, p. 44, N 80^{o} 48.508’; E 47^{o} 37.747’

Sample P2-2, p. 45, N 80^{o} 48.491’; E 47^{o} 37.760’

Sample P2-3, p. 46, N 80° 48.478’; E 47° 37.828’

Sample P2-4, p. 47, N 80° 48.483’; E 47° 37.792’

Sample P2-5, p. 65, N 80° 48.477’; E 47° 37.724’

Coordinates of the site # 3

N 80° 48. 643’; E 47° 37.657’

N 80° 48.616’; E 47° 37.730’

N 80° 48.637’; E 47° 37.863’

N 80° 48.624’; E 47° 37.889’

Coordinates of sampling points on the site # 3

Sample P3-6, p. 58, N 80° 48.625’; E 47° 37.777’

Sample P3-7, p. 59, N 80° 48.634’; E 47° 37.795’

Sample P3-8, p. 60, N 80° 48.634’; E 47° 37.722’

Coordinates of the site treatet by “Devoroil”

N 80° 48.486’; E 47° 37.763’

N 80° 48.485’; E 47° 37.757’

N 80° 48.495’; E 47° 37.695’

N 80° 48.498’; E 47° 37.706’

Coordinates of the site treatet by «Petro-Treat»

N 80° 48.504’; E 47° 37.733’

N 80° 48.508’; E 47° 37.734’

N 80° 48.500’; E 47° 37.843’

N 80° 48.496’; E 47° 37.826’

Fig. 6.3.11. A section on Pilot Ground 2 treated by biological product ‘Devouroil’ and covered by breathing polyethylene.

6.4. 2008 Monitor Survey

Soil sampling on the pilot clean-up areas was conducted in October 2008, during an expedition to carry out additional studies of the project site on Alexandra Island.

Sampling was carried out in line with the GOST standard (GOST 17.4.3.01-83 Environmental protection. Soils. General soil sampling requirements), and other regulatory documents.

Sampling was by the 'envelope' method using the top layer 0 to 10 cm. A sample was placed in a plastic bag with a zipper. The bag was then labeled using the accepted labeling system. A bagged sample was placed in an 'Isoterm' container. On completing the sampling procedure, a sample ID form was filled out. The filled container was placed in a freezer to be kept there until delivered to the experimental lab.

During sampling, a GPS navigator was used to determine the sampling point coordinates (table). The sampling point coordinates were as follows:

# of point	# of site	N	E
P2-1	1	80^0 48.508´	47^0 37.747´
P2-2		80^0 48.491´	47^0 37.760´
P2-3		80^0 48.478´	47^0 37.828´
P2-4		80^0 48.483´	47^0 37.792´
P2-5		80^0 48.477´	47^0 37.724´
P3-6	2	80^0 48.625´	47^0 37.777´
P3-7		80^0 48.634´	47^0 37.795´
P3-8		80^0 48.634´	47^0 37.722´

The analysis of the samples was done in the N.N. Zubov GU GOIN Laboratory, see Annex 2 for the lab's licenses and accreditation certificates. The sample analysis report is given in Annex 1.

The results of the sampling and sample analysis in 2007 and 2008 are presented below.

Table 6-2. SUMMARY TABLE OF PETROLEUM HYDROCARBON LEVELS (IN MG/KG) IN PILOT GROUND SOILS IN 2007 AND 2008

YEAR	P2-1	P2-2	P2-3	P2-4	P2-5	P3-6	P3-7	P3-8
2007	no data	12340	1010	310	490	11990	31120	14340
2008	2800	200	75	800	125	6000	3200	9200

As can be seen from Table 6-2, practically all the samples in 2008 (except for P2-4) had a significantly lower levels of petroleum hydrocarbons. However, it is not quite correct to use this evidence to draw definitive and valid conclusions, for a few reasons.

Firstly, as pointed out elsewhere, soils in the study area on Alexandra Island is a mixture of fragments of different size, mainly of basalt origin, sand and a very small amount of organic deposits. Therefore, contaminating oil does not become a structural element of the soil, but comes as blots or inclusions on various mineral deposits. Hence measured levels of petroleum hydrocarbons only indicate the fact that at this point a given amount of petrochemicals was spilled. Another sampling point, located nearby, can have petroleum hydrocarbon levels to differ by 1 to 2 orders from the first one (for example, the distance between points P2-2 and P2-4 is under 50 m). To get truly representative data, more advanced soil sampling techniques are required to allow estimating average levels of petroleum hydrocarbons in the contaminated soils.

Secondly, the accuracy of the coordinates determined by a GPS-navigator is within 10 meters, thus the dispersion of the sampling points in 2007 and 2008 can be as much as 20 meters. Providing landmarks for the sampling points was found ineffective, since the ground there is a mixture of rocks frozen together, and in between the sampling sessions of 2007 and 2008 the study area was crossed by heavy machinery of the frontier guard forces of Federal Security Service of the Russian Federation.

To get a more objective comparative picture, it is better to compare contamination level averages for all samples collected on the pilot grounds. Average levels for pointsP2-1 through P2-5, Pilot Ground 2, and points P3-6 through P3-8, Pilot Ground 3, are presented in Table 6-3.

Таблица 6-3. AVERAGE PETROLEUM HYDROCARBON LEVELS (MG/KG) IN PILOT GROUND SOILS IN 2007 AND 2008

Year	Site # 2	Site # 3
2007	3540	19150
2008	800	6130

It is clear from the table that petroleum hydrocarbon levels in 2008 were 4.5 times as low as in 2007on Pilot Ground 2, and 3 times as low on Pilot Ground 3.

Apparently, the 1.5 times larger reduction of contamination levels on Pilot Ground 2 had been caused by the application of biological products. On the other hand, with the given data representativeness a difference of 150 percent is by far too small.

The results of the experiments on cleaning up soils by means of biological products allow drawing the following main conclusions:

- Biological products for bringing down soil contamination levels ought to be applied in areas of increased localized contamination by petroleum hydrocarbons, provided maximum effects of the application can be ensured, i.e. such areas should

have natural or man-made boundaries that would prevent the biological products from being carried away with runoff water, along with biogenic substances they contain.

- Wherever feasible, biological products should be applied early into the warm season to ensure their longest possible effects.

- To increase the efficiency of the biological products, covers of various kind should be used, such as special films or stationary polycarbonate greenhouses to achieve maximum soil warm-up.

- It is feasible to set up relatively small clean-up sites where biological treatment of contaminated soils collected and delivered to the sites from elsewhere, in line with the operations above.

- The biological basis for such products must be petroleum hydrocarbon biodegrading microorganisms grown from strains of bacteria occurring naturally in Arctic soils.

7. Legal and organizational procedures for taking cleaned-up areas from under the control of Ministry of Defense of Russia

The Russian Federation legislation pertaining to legal relations in land uses and land protection, in particular the Federal Law of RF 136-FZ of 2001 'Land Code of the Russian Federation' (Article 93), defines 'defense and national security lands' as lands being in use for the purpose of enabling the Armed Forces of the Russian Federation, other troops, military units, and bodies, organizations, companies, institutions that perform functions of the armed protection of integrity and inviolability of the territory of the Russian Federation, protection and guarding of the frontier of the Russian Federation, information security, other types of security in closed administrative-territorial units, and the rights thereon have been vested in the parties of land relations on the basis of provisions of this Code and other federal laws.

As they perform their functions to protect and ensure the integrity and inviolability of the territory of the Russian Federation, lands under their jurisdiction can be used for building up, preparing and maintaining the necessary level of readiness (including for placement of military organizations, institutions and other objects, military units, fleet forces etc.). The lands are federal property. They cannot be privatized by citizens or legal persons, as well as cannot be the object of legal transactions under civil procedure laws. This legal provision is also entrenched in the Federal Law 61-FZ of 1996 'On Defense' (Article 1 Paragraph 10). Allotment of land strips, dimensions of the lands, usage procedures, as well as procedure to change the status of the lands (i.e. transferring from one category to another) regarding federal property ones are set out in the Russian Federation legislation and administered by the Government of the Russian Federation.

Ministry of Defense of Russia implements the above provisions of the RF land legislation through a package of institutional legal acts of the Ministry of Defense, of which one of the key ones is the Minister of Defense's Order 75 of 1977 'Regulation on housing and maintenance service and quarters allowance in the Soviet Army and Naval Forces' (as amended on 26 June 2000).

The Order sets out mechanisms and procedures for: applying for allotting lands to Ministry of Defense of Russia (as well as excluding them from the 'defense and security' land category and assigning them to the balance sheet of bodies of the federal executive power of the Russian Federation), inventorying lands and monitoring their uses, as well as establishes a list of Ministry of Defense's officials in charge of the above requirements. In particular, the Order sets out the following:

- assignment of lands to be used for the needs of Ministry of Defense is effected by allotment;

- the allotment of lands is based on regulatory acts endorsed by the Government of the Russian Federation.

Lands for the needs of Ministry of Defense of Russia are allotted for perpetual land use (with the operating management authority over them). Once the need is over, the lands are to be returned by withdrawing from the 'defense and security' land category in accordance with the land legislation of RF, and be further used in line with the RF Government's decisions.

According to the Minister of Defense of the Russian Federation's Directive 205/2/129 of 15 May 2007 the decision on applying for the change of the purpose of lands allotted to the Armed Forces of the Russian Federation, and using other property items of the Armed Forces of the Russian Federation, is to be taken exclusively by the Minister of Defense of the Russian Federation.

As lands are allotted to Ministry of Defense of Russia, buildings, houses, forests and water bodies located on them can be allotted too.

It is the responsibility of direct land users and housing and maintenance service bodies to properly use the allotted lands, protect soils and waters from industrial pollution, weed infestation, as well as protect land from water and wind erosion, and waterlogging.

In view of the world military and political situation in the early 60's, to guard the interests of the Soviet Union in the Arctic region, it was decided to build up military presence in the Arctic.

To make it happen, on the basis of respective applications filed by Ministry of Defense, and the decisions of Archangelsk Oblast executive committee, the allotment of the following lands was granted for military bases on Graham-Bell and Alexandra islands of the Franz Josef Land Archipelago:

Graham-Bell Island, Kholmisty Settlement	- military base – **30.0** ha;
Alexandra Island, Primetny	- technical purposes – **10.0** ha;
Alexandra Island, 505 «Nagurskaya »	- military base - **20.0** ha.

In addition, 3 years later, the Council of Ministers of RSFSR granted allotment of additional, listed below, lands for the needs of Ministry of Defense:

Graham-Bell Island, Kholmisty	- military base - **20.0** ha.

Settlement	
Alexandra Island, Nagurskaya*	- military base - **23.0** ha;

**** For reference only:***

Lands allotted to the Frontier Forces of FSB RF have the 'defense and security lands' status, are federal property, and provided on the terms of perpetual land use.

Therefore, the status of the Ministry of Defense's land on Franz Josef Land Archipelago and allotted to FF FSB of Russia in Archangelsk Oblast has not changed. This land, allotted earlier to Ministry of Defense for operating management, has also been allotted to FF FSB of Russia in Archangelsk Oblast for the same purpose. The allotment was based on decisions of the RF Government, Director of FSB, and Minister of Defense of Russia.

The remaining 4 lands of Ministry of Defense are federal property and fall in the 'defense and security lands' category. According to Article 2 of the Federal Law 53-FZ of 2006, management of lands (that are federal property) should follow the registration of ownership rights on the lands with the authorities. Lack of ownership rights on the lands with no state property thereof delimited is not an obstacle for managing them.

Five lands in total were allotted, with a total area of **103.0** ha.

The lands were used by Ministry of Defense in accordance with objectives set before the early 90's.

An early 90's reform of the Armed Forces resulted in decreased military presence in the Arctic. While required by the procedures, it turned out impossible to evacuate items of property, decommissioned weaponry and military machinery, as well as waste of various hazard classes, due to high evacuation costs, lack of ice class ships and mooring facilities on the islands. The remaining barracks and quarters had reached the end of service life and were decommissioned, too.

In 2001, as a result of the changed administrative and territorial division of the Russian Federation, Federal Law 136-FZ 'Land Code of the Russian Federation' was passed. Very inadequate funding did not allow Ministry of Defense to finance re-registration of entitling documents on the said lands. At present, the bodies of Ministry of Defense responsible for taking stock of its lands have got only 1 land use act for 1 of the 5 lands above, namely a 30 ha land on Graham-Bell Island, Kholmisty Settlement, under a military base.

Due to lack of use to put these lands to, the Russian Federation Government decided to involve them in economic life of the country. To this end, the RF Government's directive 571-p of 23 April 1994 endorsed a proposition by Ministry for Natural Resources(Minpriroda) and Ministry for Nationalities of Russia about the creation of a

federal protected area ‘Franz Josef Land’ under Minpriroda, with a total area of 4,200 thousand ha (the reserve lands on Franz Josef Land Archipelago and the adjacent sea). To implement the directive, the Ministry for Natural Resources prepared and enforced a regulatory act (Order 152 of 19 May 1994), setting out required activities on these lands along the following lines:

1. Create a federal protected area ‘Franz Josef Land’ in Archangelsk Oblast, with a total area of 4,200 thousand ha, using Archangelsk Oblast reserve lands and adjacent sea area.

2. Assign the federal protected area ‘Franz Josef Land’ under jurisdiction of the Archangelsk Oblast Committee for Environmental Protection and Natural Resources.

3. Archangelsk Oblast Committee for Environmental Protection and Natural Resources:

- demarcate the boundaries of the protected area ‘Franz Josef Land’ in cooperation with Archangelsk Oblast Administration;
- take all required organizational and technical measures related to the creation of the protected area;
- bring to the knowledge of all stakeholders in Archangelsk Oblast, as well as Murmansk Oblast Committee for Ecology and Natural Resources, of all restrictions in using the territory of Franz Josef Land Archipelago imposed by the protected area statute;
- in cooperation with Murmansk Oblast Committee for Ecology and Natural Resources, make adjustments to the routes of ships of all types to be in line with the protected area ‘Franz Josef Land’ statute.

4. Main Administration for Funding and Logistics: allocate budget funding in the year 1994 as required by Archangelsk Oblast Committee for Environmental Protection and Natural Resources for taking the measures to ensure the functioning of the protected area.

5. Main Natural Reserve Administration: exercise supervision over the creation and functioning of the ‘Franz Josef Land’ protected area.

In accordance with the Federal Law 33-FZ 'On protected areas' of 14 March 1995, federal protected areas, including the federal protected area ‘Franz Josef Land’, are under jurisdiction of federal government bodies and are federal property.

Therefore, withdrawal the Ministry of Defense of Russia’s lands on Franz Josef Land Archipelago from the category of ‘defense and security’ lands does no entail change of their legal status to ‘lands of Russian Federation subjects’ and need to transfer ownership of them to Archangelsk Oblast as a subject of the Russian Federation.

Article 22, paragraph 2, of Federal Law 33-FZ of 1995 stipulates that declaring an area a protected one is allowed '… without exempting the lands from users, or owners.'

Until the present time, the Russian Federation Government (or other federal authorities implementing governmental policy in these matters), as the owner of the lands, has not issued legal acts to define the necessity to withdraw specific lands under jurisdiction of Ministry of Defense of Russia located within Franz Josef Land Archipelago from the 'defense and security lands' category (while keeping their federal land status).

However, in accordance with the current environmental legislation of the Russian Federation the Ministry of Defense's lands on Franz Josef Land Archipelago need action to clean them up and mitigate damage as a result of human impacts.

In 2008 Ministry of Defense conducted pre-project studies on Alexandra Island to develop a clean-up project for the areas. Project development is scheduled for 2009-2010. Regarding other sites, there is no specific plan or deadlines yet. Also, it is still unclear, who and within what period is going to do the clean-up work itself. Taking into account complexity and large amount of work involved, a project of this kind will most likely take a long time and considerable funding, and to make more accurate estimates additional studies are needed.

In taking further decisions about transferring these lands to civil use, as long as administrative procedures are concerned, one should be guided by the current regulatory acts, in particular Directive of the Government of the Russian Federation 623 of 24 June 1998 'On releasing defense materials'.

The following main stages of withdrawing areas under decommissioned military bases from under jurisdiction of Ministry of Defense:

- follow the procedure to change the holder of entitling documents re the Ministry of Defense's lands on the archipelago;

- asset holder: conduct an inventory of immovable military base assets on these lands;

- conduct a study on assessing previous damage done to the archipelago's environment during the functioning of the Ministry of Defense sites;

- carry out work to mitigate environmental damage and remediate the lands in accordance with the legislation and standards in effect;

- Ministry of Defense: take a decision on sending a request to the Federal State Property Agency for changing the use status of the federal lands and withdrawing them from the 'defense and security lands' category;

- forward to the federal executive bodies concerned a list of immovable military base assets (if the owner has them) subject to release, and get a decision of the Federal State Property Agency to agree for or deny the release of the assets.

It is advisable, for addressing practical issues involved in transferring the lands and assets, to set up a task force to include representatives of Ministry of Defense, Minpriroda, Archangelsk Oblast Administration and Archangelsk Administration BG FSB RF.

The structure and composition of the documents on the decommissioned military bases and sites being handed over by Ministry of Defense to civil use are to be defined in coordination with federal regulatory bodies concerned that are involved in the management of respective natural resources.

The task force is to organize and coordinate work on transferring lands to civil use. Upon completion of the force's work, all materials on handing over decommissioned military bases and sites to civil use, including acts, photocopies of the documents proving the right of use of the lands, environmental status documents, calculations, maps and suggestions for further uses of the areas, are to be put together in a land management file and submitted to the Federal State Property Agency.

In accordance with the land, forest, water and other legislation currently in force, as well as the act and other materials submitted by the task force, the Federal Agency shall define further uses of the areas subject to transfer to civil use, draw up a draft decision of the RF Government on this matter and forward it, along with all the required materials,to the Federal Agency for State Registration, Cadaster and Cartography. The latter shall agree, according to established procedure, the draft decision on the transfer of the said areas with concerned ministries and institutions, and submit it to the Government of the Russian Federation for consideration and final decision.

During the process of handing over the lands by the Armed Forces of the Russian Federation to civil use, meeting the environmental regulations shall be in accordance with the law of the Russian Federation and that of the subjects of the Russian Federation.

8. CONCLUSIONS

The reconnaissance study of the current environmental status of the decommissioned site of Ministry of Defense of Russia on Alexandra Island provided clear evidence of a considerable level of contamination and soil layer degradation in the study area.

On the study area of 3.1 km^2, 2.55 km^2 (82%) are littered heavily and have a damaged top soil layer by heavy vehicles that used to cross the area.

Most of the study area is littered by iron drums as densely as 10 to 30 drums per hectare. The total part of the land with this kind of contamination on the island is 3.1 km^2.

The study area has numerous remnants of buildings and structures of housing and utility purpose, landfills for scrap, domestic and industrial waste, abandoned vehicles, locator stations, reservoirs, racks with fuels-lubes cisterns, and even an airplane. The number of such identified and geo-coded items is over 1,000.

The study area has 30 to 35 thousand drums with fuels-lubes or their remnants in stacks or clusters.

The damage resulted from former human activities is mainly of four types:

Type one – organized (stockpiled) and non-organized clusters of drums and cisterns (empty and with petroleum product leftovers) on the shore, near the Nagurskaya frontier outpost, in the vicinity of the abandoned military base, as well as along a road from the shore (anchorage) to the Nagurskaya frontier outpost.

Type two – abandoned military, transport and other machinery within the decommissioned military base site. Some of the abandoned machines still have utility fluids containing heavy metals.

Type three – rundown pipelines from the shore (anchorage) to the Nagurskaya frontier outpost and the decommissioned military base.

Type four – the ruins of the buildings on the old Nagurskaya frontier outpost, the decommissioned military site, construction and utility waste.

A study of soil quality based on Rospotrebnadzor's regulatory documents allows assessing the level of soil contamination on all geo-ecological study sites on Alexandra Island as ***extremely hazardous.***

An assessment using international contamination standards showed that the sampling sites had petroleum hydrocarbon contamination 2 to 6 times as high as the 'intervention level', while average total polycyclic aromatic hydrocarbon levels were 2 to 8 times the maximum permissible concentrations.

The highest levels of **polychlorinated biphenyls** were registered in the locator station soils. While on none of the study sites average PCB levels were as high as **MPC or PC**, which corresponds to **acceptable pollution category** as per SanPiN 2.1.7.1287-03, the fact that there were found spots with relatively high local contamination levels calls for additional research to identify possible sources, especially in view of the fact that none of the sampled utility fluids was an organochlorine-based product.

The results of the demonstration project on cleaning up an area of drums with fuels-lubes leftovers showed the following:

- To compact the drums, equipment with a tonnage of at least 24 tons must be used;
- To clean drums of fuels-lubes leftovers, it is necessary to either combust the leftovers in a high-temperature combustion unit to prevent air pollution, or wash the drums indoors, in specially designed heated conditions; and the drums need to be cut open before washing;
- Soil cultivation on Alexandra Island is a big challenge due to numerous rocks and lack of top soil as such. Remediation measures can help bring the ground to the state close to that of the areas that have not been affected by human presence;
- The geographical and weather conditions in the region suggest that project activities ought to be carried out in the warmest time of the year, July till the first decade of September.

The experience of the project implementation shows that full-scale remediation projects on decommissioned Ministry of Defense's sites in the Arctic region require special or even unique techniques, especially with regard to hazardous and extremely hazardous waste treatment followed by remediation of affected lands. Therefore, alongside with the development of remediation projects for such areas, it is advisable to implement projects on testing various waste management and contaminated soil treatment techniques. In particular, there is need to improve the technique for processing empty fuels-lubes drums to a point where their complete and safe utilization is possible.

The results of the soil treatment experiments using biological products allowed drawing the following conclusions:

- Application of biological products in cleaning up Alexandra Island lands should, apparently, be limited in scale.
- Using biological products for bringing down soil contamination must be in areas of increased localized petroleum hydrocarbon soil contamination, provided effective use of the products can be ensured, i.e. such areas must be enclosed by natural objects or man-made walls, to prevent runoff water washing away the biological products and biogenic substances they contain.

- If possible, application of biological products should be done early into the warn season to ensure the longest effects.

- The effects of the biological products can be enhanced by using covers, such as special films or stationary polycarbonate greenhouses, to help warm up the ground as much as possible.

- It is feasible to set up relatively small clean-up sites where biological treatment of contaminated soils collected and delivered to the sites from elsewhere, in line with the operations above.

- Preferably, specialized biological products best adapted to the Arctic conditions should be used. The biological basis for such products must be petroleum hydrocarbon biodegrading microorganisms grown from strains of bacteria occurring naturally in Arctic soils.

In conclusion, it should be noted that the pilot project on studying and cleaning up Ministry of Defense's decommissioned site on Alexandra Island resulted in obtaining a large amount of unique information, and in testing techniques that can be used in planning and taking further measures to clean up this site and similar ones. Organizational, logistical and technological issues involved in clean-up work on the archipelago in the future will require close cooperation of the project team with Ministry of Defense, Frontier Guards, Ministry for Economic Development, Roshydromet, Ministry of Natural Resources and Ecology of the Russian Federation and other stakeholder organizations, as well as using international experiences and expertise to ensure that state-of–the-art technology is used in utilizing hazardous waste and remediating contaminated lands.

ANNEXES

ANNEX 1. Methodological guidelineson remediation of contaminated areaswithin decommissioned military sitesin the Russian Arctic

TABLE OF CONTENTS

1. GENERAL PROVISIONS

1.1. These methodological guidelines (hereinafter, Guidelines) are developed in accordance with the environmental legislation requirements, RF Government resolutions, environmental protection regulatory documents(defining a system of standardsand limitationsfor the use of nature, and requirementsfor the protection of the environment and human health in the course of ongoing economic activities), requirementsfor the development of project documentsin the environmental protection domain.

1.2. The Guidelinesare aimed to ensure safety of natural ecosystemsand the general public in the short and long term while implementing projectson contaminated area clean-up (CAC) by drawing up research evidence-based projectionsof likely changesin the environment in variousscenariosof using alternative technology and techniques; and conducting pre-project studies. These Guidelinesprovide reference for impact

assessment, emergency risk estimation, selection of environmentally safe technology and monitoring systems.

1.3. In choosing environmentally safe technology and CAC techniquesan environmental and economic balance must be achieved, taking into account possible risksinvolved in processing key typesof contamination, stockpiling, waste neutralization and processing.

1.4. Pre-investment and project design and cost estimate documentation asfar asenvironmental protection isconcerned isto be developed at the customer'srequest by research and design organizationslicensed for thiskind of activity, in accordance with the legislation, national standards and regulatory documents.

1.4.1. Project documentation must include cost estimatesfor the logisticsof environmental measuresaimed at remediation of adverse impacts, conducting additional research required for adjusting project documentsto accommodate practical experiences; a local monitoring (supervision) programme, and the establishment of a sanitary buffer zone (SBZ).

2. ECOSYSTEM IMPACT ASSESSMENT IN CONTAMINATED AREA CLEAN-UP

2.1. At the stage of the development of pre-investment and pre-project documentation, it isrequired to collect and review the information sufficient for taking an integrated approach to environmental risksassociated with the activitiesbeing planned and related environmental impacts/8 - 13, 71 - 74/, thisrequiring that the baseline data should contain preliminary indicationsof the level of potential risksexisting at the site to be cleaned up, aswell aspossible risksof contamination in the course of CAC, and the pathsthat the existing and potential contaminantswill follow asthey affect each component of the ecosystemsinvolved.

2.2. Assessment of risksinvolved in CAC isdone based on relevant standard and methodology documents, available information on the clean-up site, specialist reviews, research resultsof specialized institutions. Analysisof technology- and toxicology-related risksallowsassessing impactson the environment and general public in economic and managerial areas, and, based on the assessment, develop an optimal set of environmental measures.

2.3. The level of technology-related risksinvolved in environmental measurestaken in the Arctic region must be brought down aslow aspossible, bearing in mind the low self-rehabilitation capability of polar ecosystems.

2.4. The level of ecological (toxicological, social) risksposed by CAC action and emergenciesisdetermined based on a preliminary analysisof statistical data on probabilistic environmental contamination, calculationsof the area under systematic or emergency-related risks, taking into account spatial and temporal distribution of

impact subjects(man, animals, vegetation, geo-biocenoses) around the source of potential hazard, aswell asthe frequency of unwanted events.

3. ENVIRONMENTAL REQUIREMENTS FOR DESIGN, EQUIPMENT AND TECHNIQUES USED IN CLEAN-UP OPERATIONS ON CONTAMINATED AREAS

3.1. Environmental justification of CAC operationsisto be prepared at the stage of choosing a work site and drawing up the project, and involvesusing data from pre-investment and pre-project documentation, research organizationsand institutions; statistical reportsand environmental monitoring in the study area; environmental data on similar objects, aswell asmapsof the state of the environment (soils, geo-botanical, animals, ground water vulnerability, etc.); databases, including industrial waste ones.

3.1.1. The sitesfor implementing key technologic CAC stagesmust be chosen drawing on the resultsof sustainability and technological vulnerability analysisof the local environment, and that of existing loadson the biogeocenoses.

3.1.2. Picking up CAC operations sites must take account of spatial distribution of identified contamination over the total area of the site to be cleaned up, in order to minimize possible anthropogenic risks, aswell asof the complex Arctic climatic conditions, such aspermafrost, the shortnessof the warm time of the year, the large proportion of glacier-covered areas, and the extremely low self-regeneration ability of polar ecological systems.

3.1.3. While planning the CAC operations, nature use conditionsare to be agreed between the stakeholders, and environmental requirementsand limitationsare to be imposed on human activitiesin the area. The formatsof agreeing the conditionsand issuing permissionsto use natural resourcesor some of these (emissions, wastewater discharges, special water uses, disposal of industrial wastes, etc.) are presented in the relevant regulatory documents/9 - 11/.

3.1.4. In caseswhen CAC iscarried out in protected natural areas, natural reservesor recreation zones, it isrequired to develop a special project, to get a positive review on it from a state environmental assessment authority, and permission of relevant government authoritiesin coordination with the competent environmental protection agency of the Russian Federation.

3.1.5. CAC site selection acts, along with mapsand termsof land resource uses, must be included in the CAC project.

3.1.6. ItsEnvironmental Protection chapter must contain a schematic map of engineering arrangementsindicating the placement of utility networks, technology and auxiliary equipment, a waste collection and disposal system, storagesfor fuels-lubesand other materials, utility premisesand domestic waste storage sites.

3.1.7. The CAC project must include measureson waterproofing the siteswhere tanksfor storing hazardousmaterials, production and domestic wastes, wastewater will be located, aswell asutility sites. The project must also contain measuresand technical facilitiesallowing for the localization and removal of spillsof hydrocarbonsand other technical fluidsposing potential threatsto the environment.

3.2. The environmental assessment of the CAC project must include materialspresenting the following indicatorsof how natural resourcesare planned to be used.

3.2.1. The area'snature featuresand itscurrent status.

3.2.2. Qualitative and quantitative characteristicsof the ecosystems, and their current status.

3.2.3. The composition, quality and toxicity of wastesbeing processed, and materialsin use.

3.2.4. The human impact intensity zoning of the clean-up area.

3.2.5. The vulnerability of componentsof the environment to impacts, under normal conditionsor in emergencies.

3.2.6. Assessment of projected environmental changesand those of the conditionsin the clean-up area.

3.2.7. Description of environmental measures, their reliability, amplenessand feasibility in environmental and economic terms.

3.2.8. Environmental monitoring and protection methodologies, and those for utility and natural heritage sites.

3.3. CAC-related impactsare assessed using official polluted emission or discharge standard ratescalculated in accordance with relevant regulatory documents /22/.

3.4. The protection of ambient air during the CAC project must be ensured by using standardsin force on maximum permissible ratesfor emitting contaminantsinto the atmosphere.

3.4.1. The maximum permissible emissions(MPE) must be determined for each source of emissionsseparately. Calculating MPE must be in line with the environmental regulations/41, 42/.

3.4.2. While using diesel engines, the content of carbon oxidesand hydrocarbonsin the exhaust gasesmay not exceed standardsvalueslaid down in the GOST standardssystem /53/.

3.5. To prevent contamination of bodiesof water, the CAC project must include water protection measuresand a water use permit /26 - 30/. The project must also provide for recycling treated waste water for technical needs.

3.6. The choosing of waste neutralization and disposal methodologiesmust be based on waste toxicity class, climatic conditionsand the available opportunitiesfor using specific waste treatment technologiesin the Arctic regions.

3.7. Determining industrial waste toxicity classmust be performed in accordance with methodical recommendations/40/.

3.8. The construction of waste disposal sitesmust be preceded by a feasibility study taking account of hydro-geological conditions, filtering capacity of the soils, the location of CAC action, waste toxicity classand the composition of materialsbeing used.

4. MEASURES TO PROTECT NEAR-GROUND ATMOSPHERE, WATER RESOURCES AND BIOCENOSES

4.1. Technologiesand environmental measuresinvolved in a CAC project must take into account maximum permissible loadson the near-ground atmosphere, hydrosphere and biotopes /8 - 13, 16 - 32/. The proposed techniques, technology processesand materialsmust be supported by an engineering design and application certificates. They must involve reliable and efficient measuresfor preventing contamination of the environment by polluted emissions, discharges, wastes; neutralization and utilization of wastes, resource saving, low-waste or no-waste technologies, wise use and reproduction of natural resourceswith due respect to the complex Arctic conditions.

4.2. Key air protection measures, while planning a CAC project, are:

4.2.1. Selecting operating mode for the equipment and technologies, so asto meet the applicable maximum permissible emission rates(MPE), and keeping air pollution levelsbelow MPC.

4.2.2. Using a system of taking stock of and monitoring polluting emissions, in termsof composition and quantities, including summation of effects.

4.2.3. Reduced operating modesfor the equipment (60%, 40%, or 20%) at timesof unfavorable meteorological conditions(no wind, ground inversions, high wind speed, etc.), helping to regulate (bring down) emissionsinto the atmosphere, and ensuring reducing levelsof contaminantsin the ground atmospheric layer and making smaller the zone of hazardouscontamination.

4.2.4. Regulation of fuel systemsof diesel enginesused in equipment and motor vehiclesto bring down gaspollution within the clean-up area.

4.2.5. Piping exhaust gasesof diesel enginesthrough a hydraulic lock or smoke stacks, which height isto be calculated using relevant regulations/54, 55/, to ensure bringing the levelsof gaspollution down to sanitary and hygienic normsby dispersion.

4.2.6. Carrying out waste combustion under favorable weather conditions(wind away from populated areas, absence of no-wind, ground inversions, dangerouswind speeds, etc.).

4.2.7. Using special installationsfor combusting wastesensuring safe levelsof contaminantsproduced in the processof combustion.

4.2.8. Using special high-temperature combustion technologies while dealing with very hazardouswastes.

4.2.9. Using MPC standardsfor re-agentsused in technical fluidsand capable of phase change, evaporation (volatility); excluding highly volatile compounds from the uses.

4.2.10. Placement of stationary sourcesof hazardousemissions(boiler rooms, internal combustion engines, waste combustion installations, and other equipment) taking account of the dominant wind direction in the CAC area, to meet sanitary standardsin the operational and residential areas/55/.

4.3. Key measureson the protection of water resourcesand their wise usesinclude:

4.3.1. Organization of the taking stock of the intake of fresh water in accordance with the official water use form and other regulatory documents/38/.

4.3.2. Use of technology processesto actively reduce filtration capacity of the soilswhile cleaning up polluted areas.

4.3.3. Recycling wastewater for technology needsthrough water treatment.

4.4. Measuresto protect biocenosesare asfollows:

4.4.1. Using proper techniquesand machinery in planning technology sitesdesigned to prevent (bring down) the technogenesisof the landscapesand the changing of water regimeswithin the water clean-up area.

4.4.2. Using technologiesfree of potentially hazardoussubstances.

4.4.3. Localization and elimination of emergency or processspillsof hydrocarbons, technical fluidsand liquid wastesusing sorbentswith subsequent utilization.

5. ENVIRONMENTAL MEASURES AS PART OF COLLECTTION, STORAGE, TREATMENT AND NEUTRALIZATION OF WASTES

5.1. To meet environmental requirements/1, 2, 38/ for protecting natural environments(plants, soils, ground waters) from contamination at the time of

conducting a CAC project, there must be put in place a system for collecting, storing and neutralizing the technology-related and domestic wastesproduced in the course of the project.

5.2. The system for collection, transportation, storage and neutralization of wastesmust include:

5.2.1. Setting up a makeshift storage site for fuels-lubesleftovers, found in the clean-up area. The old drumsand cisternslocated in the area can be used asstorage containers, provided their state of repair permitsit. The containersare to be bermed to prevent contamination of adjacent areasin case of an emergency spill of petrochemicals.

5.2.2. Creating work sitesor buildingsfor draining drumswith fuels-lubesfollowed by cleaning them. The cleaning isto be either by washing using special detergentsand a wash water recycling and treatment system, or by burning the fuels-lubesleftoversout in an incinerator.

5.2.3. Creating work sitesfor compacting metal scrap collected on the area.

5.2.4. Creating work sitesfor collecting, sorting and utilizing construction and domestic waste collected on the clean-up area. Waste utilization can be through crushing inert componentsof the waste into small fragmentsto be later stockpiled on special storage sites, or to be used asfilling material in road construction. The rest of the waste isto be combusted in incinerators, with the exception of the componentscontaining highly hazardouscontaminants.

5.2.5. Putting in place closed type metal containersfor collecting in them toxic wastesto be later transported to a landfill for industrial wastes.

5.2.6. Setting up a processof collecting wastescontaining heavy metalsfor taking to specialized landfills, or for applying special reagentsto convert heavy metal saltsinto insoluble forms, harmlessto the environment.

6. LAND PROTECTION AND REMEDIATION MEASURES

6.1. In setting up work sitesfor collecting, processing and makeshift storing wastes, the project team must meet the requirementslaid down in relevant regulatory documents/19, 48, 49, 51, 52, 59, 60, 73/.

6.2. Creating temporary transport linksmust make the best use of the existing road networks, taking into account local weather conditionsand the availability of culvertsto let excesswater through. While building makeshift roads, inert fractionsof waste put through treatment processescan be used.

6.3. Motor vehiclesand special transport must make use of roadsconstructed for the project purposes, ensuring traffic safety, and no harm to vegetation and soils.

6.4. Once the CAC activitiesare over, work isto be conducted on demounting the equipment, dismantling the waterproof coversof the work sites, and concrete foundations, cleaning up the area of scrap, and construction wastes, removing the contaminated soil layer, and remediating adjacent landscapes.

6.5. The work on remediating the clean-up area must continue non-stop till completion. Should weather conditionsprevent to have the work completed in one go, the deadline can be put off till later, but the completion date may not exceed one year after CAC activitieswere finished.

6.6. Land remediation (landscape planning, transportation and putting on the fertile layer, if it had been removed /19, 27, 59/) isto be performed immediately after CAC activities.

6.7. Fertility restoration activitieson the reclaimed landsare the responsibility of land usersto whom the landsare being returned.

6.7.1. The biological stage of land remediation, in case it isfeasible in view of the weather conditionsin the region, include agrotechnical and vegetation reclamation action. The biological stage isto be carried out by the main land user following the technical remediation and itsacceptance by the decision of a special commission, issued asan acceptance act. Biological remediation isperformed within a special project which must set out an action plan for the remediation, a list of required equipment, materials, including planting stock, and costsinvolved /61/.

7. MONITORING THE STATE OF ENVIRONMENT AND MEASURES TO PROTECT IT WHILE CLEANING UP CONTAMINATED AREAS

7.1. Monitoring over the quality of ambient air, surface and ground waters, soils, and vegetation during CAC, must be conducted in accordance with an action plan included in the CAC project that definesthe selection and location of sampling points, periodicity of observations, listsof control ingredientsand parameters.

7.2. To measure the parametersof contamination of the environment being monitored, instrumentstested in accordance with the standardsGOST 8.001-80 or certified by a representative office of the national meteorological agency /50, 63/.

7.3. Monitoring the environment while handling wastesthat contain highly hazardouscontaminantsmust embrace the work area, the buffer zone, and the emergency discharge pollution dispersion zone, defined within the project.

7.3.1. Premises, facilities, installations, work sites, workshopswhere there can be emission of dust, gases, vaporsor aerosolsmust have in-situ air monitoring using automatic gasanalyzersor other standard methods. The resultsof the analysesare to be entered to a monitoring log /16, 64/.

7.3.2. Ait monitoring in a populated area falling within the possible impact zone of sourcesof polluting emissionswithin the CAC project, must be in line with regulatory requirementsand rules.

7.3.3. Main control ingredientson the clean-up area shall be hydrocarbons, hydrogen sulfide, sulfur dioxide, carbon monoxide, nitrogen oxides, and dust. On a selective basis, there should also be monitoring for aromatic hydrocarbons, toxic metal vapors, radioactivity.

7.3.4. Assessing contamination levelsin the ground layer of the atmosphere must be performed for each control substance separately and taking account of biological summation (hydrogen sulfide and sulfur dioxide, sulfur dioxide and nitrogen oxides, etc.).

7.3.5. Maximum, one-time, maximum permissible concentrations, and twenty minute average interval onesare to be used asair quality control criteria /65/.

7.4. CAC-related emissionsare to be monitored in accordance with regulatory requirements. The required number of measurementson an emission source isdefined based on itscapacity and emission level stability /42, 54, 55/.

7.5. The project documentation for water usersmust set out proceduresfor monitoring of the use and protection of water, which isto include:

7.5.1. Taking stock of the volumesof intake, used and return water, and itsmeeting the quality normsand use limitsin force.

7.5.2. Determining the composition of wastewater and itsmeeting the quality requirementsfor dischargesinto bodiesof water, sewage systems, underground horizonsor on the ground.

7.5.3. Determining the composition and propertiesof the water in water reservoirsand water coursesat the pointsof water intakes, and at background or control crosssectionsof water body under monitoring.

7.6. Areas, located near bodiesof water must have monitoring over the state of surface watersusing the existing water monitoring network. Asand when required, additional water monitoring postscan be set up (water level, flow rate, water quality). Quality monitoring stationsare to be set up the entry point of a water course in the clean-up area impact zone, aswell asthe exit. On a water reservoir, water quality monitoring stationsare to be set up off the shore on the side of a likely source of pollution /57/.

7.7. Soil quality in the CAC area ismonitored for contamination by pollutantsresulted from waste handling, soil salination and degradation, and for the state of the vegetation and microbiota.

7.8. Asthe landsare remediated, the processesof putting on fertile soilsand restoring vegetation on reclaimed land are to be monitored.

8. REMOVAL AND ELIMINATION TECHNIQUES FOR MAIN CONTAMINANTS ON DECOMISSIONED MILITARY SITES IN THE ARCTIC

The key contaminantspresent on decommissioned military sitesin the Arctic fall into several large groups. The first and normally the most significant issolid waste including abandoned buildings, metal scrap, including left behind machines, construction waste, domestic and industrial waste. The second one isthe leftoversof petroleum productsin variouscontainers, and soilsand bodiesof water contaminated by petroleum products. Apart from the mentioned key contaminantsthere can be more specific typesof contamination, including, inter alia, hazardous, and thusrequiring special treatment techniquesand methodologies. The techniquesfor treating key typesof waste and contaminantsare discussed below.

8.1 Solid waste treatment techniques

Solid waste, which includesconstruction waste materials, resins, wood, man-made materials(polyethylene, metal, glass, etc.) can be neutralized and processed using the traditional techniques– storage at special sites, combustion, composting, integrated waste treatment that includesthe separation of a part of it for composting and putting the rest to combustion.

Waste isstored at special storage sites, storage grounds, where it iscompacted and buried underground, with layersof earth and other inert materialsput on top. However, rising costsof burial, and complexitiesof obtaining land for and arranging storage sitesdrive toward moving from underground disposal to industrial waste treatment, aswell asrecycling some componentsextracted from the waste.

Waste combustion. The thermal waste treatment method allowsbringing down the resulting amount of waste, using the produced heat for heating, and decreasing contamination of soilsand water. However, apart from the benefits, combustion destroysany valuable componentsin the waste, and leadsto significant contamination of large areasby the productsof incomplete burning of petroleum products, which include, inter alia, carcinogens, such asdioxins, benzapyrenes, etc., and also produce large enough amountsof ashesand slag waste to be in turn disposed of underground at landfills. The combustion of solid waste and petroleum productscollected from the land must be done in special high temperature incineratorsthat have a low level of hazardousand detrimental wastesin the combustion products.

Integrated waste treatment startswith sorting, followed by compacting scrap, crushing glassand ceramicsfractions, fermenting bio-degradable wastes, etc. Eliminating the numeroussitesof dumped fuels-lubesdrumsmust involve drum and cistern compacting using a pressand transporting the compacted scrap to utilization or disposal sites.

8.2 Methodologiesfor cleaning up soilscontaminated by petroleum products

According to the Temporary Industrial Waste Classifier and the methodological industrial waste toxicity determination guidelines(Ministry of Health of the USSR, GK NT SSSR, 1987), soilscontaminated by petroleum productsbelong to Hazard ClassIII.

8.2.1 Localization techniquesfor petroleum product contamination

Mechanical techniquesinvolve putting up earth wallsaround the contaminated site to prevent the petroleum productsfrom spreading (Table 2.2.1).

Physical and chemical techniquesinclude:

- screening the surface of the spilled petroleum product;
- putting the spilled petroleum product into a jellylike or solid state;
- treating the soil to protect it from contamination by petroleum products.

8.2.2 Spilled petroleum product collection techniques

The techniquesallowing to collect spillsof petroleum productsare divided into mechanical and physical-chemical.

The mechanical techniqueswhich are applicable when petroleum productscome in liquid (unbound) form, collection isdone using 'mud' pumps(sludge collectors) that allow collecting petroleum productsof any viscosity and even if they contain particlesof solid matter (e.g. soil). Russian-made vacuum-type collectors can be used, VAU-1, or VAU-2, with a capacity of 200-300 l. Collecting petroleum productsusing collectorshasthe following advantages:

- petroleum productsare collected in the shortest possible time;
- the highest efficiency among all other collecting techniques, for a spill of any size;
- possibility to collect petroleum productsin hard accessareas(spillswithin the limitsof a base, fuel storage sites, grown over lands);
- the technique allowsfor the recycling of the spilled petroleum product.

Physical and chemical techniquesinvolve collecting petroleum productsin jellylike or solid form, after the spill hasbeen contained. The collection isdone by sorption using sorbents– sand, sawdust, or peat. The technique isefficient when dealing with smaller spillson the ground. When a spill islarge, common earth moving machinery isused (an excavator) to collect the spilled petroleum productstogether with the soil into trucksand carry it to a makeshift storage site (the soil playsthe role of a material to bind petroleum products).

8.2.3 Techniquesto bring down the levelsof petroleum productsin the soil to a residual level

Clean-up of heavily contaminated soilscan be carried out by removing the polluted soil layer to be then transported to disposal sites. However, petroleum product mud burial sitestend to exist for decadeswhich resultsin a buildup of toxic contaminantsand, possibly, entry of petrochemicalsinto ground waters. In addition, even if storage sitesare well equipped and waterproof, the technique involvesusing large piecesof land for these purposesand affectsthe soil structure.

Physical and chemical techniquesinclude thermal, chemical, extraction, and soil drainage.

Thermal technique. The combustion method involvesburning of petroleum product contaminated soil on site, or removed soil in special furnacesat 1000-1200ºC. Middle-level contaminated soil isprocessat 700-800ºC, while heavily contaminated in a boiling bed furnace at 900ºC. On-site clean-up usesheating up or 'direct burnout'.

Chemical technique isbased on converting toxic hydrocarbonsinto non-toxic compounds, or putting toxic matter into jellylike or solid state.

The Kursk Environmental Safety Institute specialistshave developed the Econaft product for chemical neutralization of toxic fuels-lubeswaste. The method isbased on the property of mineral sorbents' oxides(quick lime CaO) to increase their effective surface 15-30 timesasa result of slaking, and turn into a bulky bounding substance with a high sorption capacity for high-molecular compounds, raw oil, in particular.

Treating fuels-lubeswaste (including soilscontaminated therewith) by the Econaft product resultsin the absorption of petrochemicalsand a dry, storage resistant substance comprising miniscule granulesthat are oil product micro-particlescontained in lime capsules, and spread evenly in the product. The technique isrecommended for oil spill clean-up operationson utility landsonly.

Oil product extraction technique: The method isbased on extracting petroleum hydrocarbonsfrom contaminated soil by selective solvents(extraction fluids). Common extraction fluidsare hot water, water steam, detergents. Key stagesin using the technique include:

- contaminated soil homogenization and fragmentation;
- mixing the soil with an extraction fluid under special conditions;
- drying of the suspension produced in the processof extraction.

The extraction isperformed in special modular installations. To assist cleaning up soilswith thistechnique, some environmental friendly and inexpensive detergent agents(DA) have been developed. For example,

Uniflok, a polymer with modifying additives.

A variation of the extraction technique issoil draining, that is, cleaning by meansof draining systems.

Biological techniquesare based on environmental biotechnology products. To date Russian industry hasdeveloped a large number of biological oil degradation products: 'Putidoil', 'Devoroil', 'Oleverin'.

8.3 Techniquesto fight raw oil and petroleum product spillsin water areas

The key methodsto eliminate spillsof raw oil or petroleum productsinclude the containment and collection of oil spills; spraying of dispersants; protection of the shoreline, or it self-purification. There are many methodologieson fighting oil spillsdescribed in the literature on the subject, however, the probability of new spillson the sitesin question isvery low, so there isno point dwell much on these methodologieshere, provided the aftermath of past spillsthere hasbeen eliminated in due course.

8.4 Reclamation of affected lands

Land reclamation in the Arctic isvery challenging a task, thusthe best approach would be mechanical clean-up of contaminated soilsto the highest possible degree, followed by the restoration of the natural landscape.

8.5 Cleansing of reservoirsof petroleum productsleftovers

The processof cleansing reservoirsof leftoversof oil productsinclude the following actions:

- heating up the leftoversin the reservoirsusing a heating system;
- removal of the oil product leftovers;
- preliminary degassing in case the reservoir still containsa petroleum product residue with a flashing point below 60°C;
- washing the inner surfacesof the reservoir;
- removal of the product of the cleansing process;
- final treatment of the bottom surface.

To heat up the reservoir hot water at 80-85°C ispoured into it to a level enough to cover the petroleum product residues(or inject live steam). To intensify the heating, live steam traveling in steam pipes(hoses), 50-63 mm in diameter, isinjected directly into the oil product. Steam can be supplied through any available inlet (hatches, holes, sockets) using flexible hosesor jointed pipe. The temperature of the working

steam must not exceed 80% of the self-ignition temperature of the petroleum product, and pressure in the main pipe must be max. 3 kgf/cm^2. To speed up the heating process, it isrecommended to perform the heating of the product with mixing by the pump, using the pattern 'reservoir-pump-reservoir'.

In circulated heating, which isused if a circulating heating system (pipeswith nozzles, heat exchanger, circulation pump) isavailable, hot oil product of temperature 45°C or above ispoured on the oil product residue. The circulation isperformed according to the pattern 'reservoir-pump-heat exchanger-reservoir'. The circulation lastsfor 10 to 15 hours, depending on the amount of the oil product residue.

In a hydraulic monitor method, the oil product isthinned down and washed away from the bottom of the reservoir using a jet of hot water. Water at 75-80°C ispumped to rinsers(hydraulic monitors) at the pressure of 10-12 kgf/cm2. The rinsersare introduced into the reservoir through hatches(at the top or bottom of the reservoir), fixed on feeding brackets, and lowered on safety linesto a height of 3 to 4 m from the bottom of the reservoir. The duration of thinning down the residue of oil productsdependson itsquantity, properties, and lastson average 2 to 8 hoursof non-stop operation of the rinsers. The thinned down mass(water + oil product) ispumped out into a make-up tank or cascaded settling tank.

Degassing a reservoir: Reservoir cleansing practicesinclude the following methodsof degassing and phlegmatization of the free volume of a reservoir to ensure explosion safety:

Bringing down the concentration of oil product vaporsby replacing the free space in the reservoir by

- clean air;
- filling the reservoir with water ;
- bringing down the levelsof oxygen in the reservoir by filling it (phlegmatization) by inert gases.

Decreasing the levelsof petroleum product vaporsin the reservoir isachieved by uncontrolled ventilation, forced ventilation or steam curing of the reservoir.

The water degassing method for reservoirswith residuesof petroleum productsisused only in selected cases: for underground or buried reservoirs, the reason being large quantitiesof water needed for the operation, and the need to purify the water of oil productsafterwards.

Natural ventilation isthe most efficient when used for high vertical reservoirs. It isperformed at wind velocity of at least 1 m/s. Top hatchesare opened and deflectorsare put in place, to intensify the process. The heavier (than the air)

gasmixture flowsout into the atmosphere from the reservoir, while the lighter gas, air, entersit through the top hatches.

Forced ventilation of the inner vapor-air space of the reservoir isconducted using steam-ejectors, intrinsically safe ventilatorswith explosion-proof electric motors. The reservoir must have an air exchange rate of at least three volumesper hour, to avoid the formation of stagnant zones.

When removing residuesof thick oil products, the reservoirsare steam cured first, at 80-90°C, which isthe most efficient for smaller reservoirsup to 1000 m^3. The time the operation should take isdetermined by analyzing samplesof the vapor-air mixture taken at 0.1 m above the bottom of the reservoirs.

Phlegmatization of a reservoir isfilling it with inert gases, such asliquefied nitrogen, compressed nitrogen, or cooled down exhaust fumesfrom engines, boiler plants, or power gas.

Washing of reservoirs: The washing useshot water pumped through rinsers, and detergents. For detergents, can be used water (hot water) and water mixed with ID (industrial detergents). The ID type and quantity are determined depending on the petroleum product being removed, and the design of the reservoir. Common ID: ML-51, ML-52, ML-72, Labomid-203M (Temp-300), etc.

Washing reservoirsisa two stage process:

- primary rinsing after heat up and pumping out the tankage;
- finishing flushing after the tankage hasbeen removed and the reservoir cured by steam.

The system of FLM preparation, storage, regeneration, and collection of cleanup productsincludes:

- cascaded settling tank,
- system of pipesfor pumping FLM to the reservoir and pumping out the cleanup products;
- heat exchanger;
- FLM pumps;
- device for collecting cleanup productsand extracting residual oil productsfrom it.

The tankage removal system includesa pneumatic conveyor and a hydraulic one. A pipeline D = 100 mm islaid (light aluminum pipesor a portable pipeline) from the reservoir to a vacuum plant. An inlet spout isattached to the bottom of the

reservoir. The sedimentsare forced toward the inlet spout of the vacuum plant by water guns.

The troubleshooting of steam heater pipesisperformed by connecting saturated steam section by section and pipe blowout. Clean condensate coming out of the pipesindicatesthe correct functioning of the heater. No condensate or contaminated one coming out from outlet pipesindicatesa fault – a crevice, or a leak in pipe connections, through which oil product got inside the pipes. Faultscan be also detected by visual inspection of the pipes.

Finishing processing of the reservoir surfaces: The processconsistsof the following operations:

- treatment of contaminated surfacesof the reservoir, steam heater pipes, and inlet distributive pipe junction by a solvent;
- finishing flushing;
- removal of residuesof the flushing and finishing the surfacesto the required degree of cleanliness.

Common solventsto use are kerosene, gasoil, diesel oil with a vapor flash point of above 60°C.

Regeneration of the cleanup products. The composition of the cleanup product.

Depending on the technology operation, there may be the following productsof the cleanup process:

- a mixture of heated up and thinned down residue with commercial fuel, water-oil emulsion, the result of flushing the residue with hot water pumped through the rinsers;
- wash water containing emulsified oil productsat 600 - 1500 mg/l;
- wash water containing dissolved gasoline at 110-340 mg/l;
- FLM containing 25 - 100 g/l of emulsified petroleum products;
- solid productsof cleaning (SPC) – silt, rust, sand, etc. containing high-molecular hydrocarbons(paraffin, asphalt-concrete, tarry substances, etc.).
- The thinned down residue along with commercial fuel ispumped to the company'sreservoirs(make-up or specially allocated one) and after settling the product can be used for itsprimary purpose. If needed, thermo-settling at 55-60°C isused.

The fluid massconsisting of water (80 %) and petroleum product (20 %) ispumped into a make-up tank or settling reservoir where it isseparated into two phases– supernatant (top layer) petroleum product and water. The supernatant petroleum product ispumped to a collecting tank and subjected to thermo-settling at 65-70°C. The settling time is10 to 12 hours.

The settled product isanalyzed for water content and solid particles. Depending on the result, the product isclassed asa spent oil productsmix (SOPM) or isto be utilized through added to fuel oil (commercial) insofar asitsquality permits.

Environmental protection: The reservoir clean-up procedure must use multistage water treatment systemsbased on combined operations(flotation, settling), design solutionsthat prevent direct contact between oil productsand the ambient air and soils; using closed design containersfor collected oil products; a circulating wash water supply system; monitoring the quality of treatment (regeneration) of petroleum productsbeing extracted; and monitoring of the equipment involved in the processfor being fault-free.

In addition, there should be put in place a system for draining oil product contaminated watersinto the sewersand to the waste water treatment plant. There also must be arrangementsfor collecting polluted cleaning materials(sawdust, rags, etc.) for recycling or disposal in line with established procedure.

8.6. General recommendations

The listed above techniquesfor removal and elimination of key contaminantshave been developed for use primarily at middle latitudeswhere it iswarm at least several monthsa year. Most sitesin the Arctic have a very short period of temperaturesabove zero, and have permafrost, therefore, each site must use methodologiesbest suited and efficient under the conditionsat hand at the site. Most of the sitesrequire erecting makeshift production buildingswith temperaturesabove zero in the work rooms, since outdoor operationsare heavily hampered by the harsh weather conditions. Using biological productsfor clean-up operationsin the Arctic isconfined to special pilot groundsor reactors, where temperaturesrequired to make sure the biological productsand natural microorganismsinvolved take effective action can be obtained. It isdesirable that biological productsbased on strainsof microorganismsoccurring naturally in the region and capable of degrading oil be primarily used. Operationson most of the sitescan be performed in the warm time of the year only, but some work on collecting, sorting and processing wastes, provided facilitiesfor doing the work indoorsare in place. In handling wastesthat contain highly hazardouscontaminantsit isrequired to use special methodologiesthat allow turning these contaminantsinto safe or practically safe forms, since transporting these typesof waste in the Arctic conditionsiseither very difficult or impracticable. Preference should be given to clean-up and stockpiling techniquesthat involve minimum transportation effort, since transport costsare exorbitant, in view of great distancesto cover to reach most of the sites.

9. LIST OF MAIN REGULATORY AND METHODOLOGY DOCUMENTS

1. RF. Supreme Council of the RF. Law "On environmental protection". - M., 1991.

2. RF. Supreme Council of the RF. Law "On mineral resources". - M., 1992.

3. Law the USSR "On the protection of atmospheric air" Collection of legal, regulatory and methodological documentsfor environmental assessment of air protection projects. - L.: Gidrometeoizdat, 1986.

4. RSFSR. Supreme Council of the RSFSR. RSFSR Land Code. - M., 1991.

5. Resolution CM RF, 1993, N 1229.

6. Resolution RF Government, 03.11.94, N 1207.

7. The main provisionsof the national strategy of the Russian Federation in environmental protection and sustainable development (Endorsed by RF President Decree of 04.02.94, N 236.) - M., 1994.

8. The environmental statusassessment criteria for identifying environmental emergency or environmental disaster zones. - M.: Ministry for ecology and natural resourcesof the Russian Federation, 1992.

9. The regulation on environmental assessment in the RF. Ministry for ecology and natural resourcesof the Russian Federation. (Endorsed by Minpriroda of Russia'sOrder of 18.07.94, N 222.) - M., 1994.

10. The guidelinesfor environmental assessment of economic or other activity in pre-project and project documentation. Minpriroda RF. - M., 1994.

11. Temporary methodological guidelinesfor environmental assessment in the chapter 'Environmental impact assessment in layout schemesof feasibility studies(TEC) and projectson mineral deposit development and developing oil and gasindustry units'. - Ufa, 1992.

12. The guidelinesfor environmental assessment of pre-project and project documentation. Minpriroda RF. - M., 1993.

13. Statute on national nature reservesin RSFSR. (Resolution of Government of the RF of 18.12.91 N 48.)

14. The project development guide (work project) "Environmental protection", to SNIP 1.02.01-85. - M.: Gosstroi SSSR, CNIIproekt, 1988.

15. Rybalskii N.G. et al.. Ecology and safety: Reference book. - Volume 2. - P. 1 - 3. - M.: VNIIPI, 1993.

16. GOST 12.1.005-88. Labor safety standardization system. Workspace ambient air general sanitary and hygienic requirements. - M., 1991.

17. The surface water protection guidelines. - M., 1991.

18. GOST 17.1.1.01-77. Nature Protection. Hydrosphere. The use and protection of water. Key termsand definitions. (Asamended 01.87)

19. GOST 17.4.3.02-85. Nature Protection. Soils. Fertile soil layer protection requirementsin earthwork. - M., 1985.

20. Methodological recommendationson proceduresfor agreement of termsand conditions, and issuance of nature use permits. - M.: VNIC "Ekologiya", 1990.

21. RSFSR. Supreme Council of the RSFSR. Law RSFSR on the general public'ssanitary and epidemiological welfare. - M., 1990.

22. The criteria that the air protection state inspection authoritiescan use to suspend, restrict or ban the activitiesof industrial or other installations, workshops, production units, institutionsor organizations. - L.: Gidrometeoizdat, 1987.

23. The methodological guidelineson the calculation of contaminantsemitted to the atmosphere with combustion gasesof heating and heating-industrial boiler plants. - M.: K.D. Panfilov Academy of Public Utilities, 1990. - S.-Petersburg: A.I. Voeikov GGO, 1995.

24. Temporary recommendationson the calculation of emissionsfrom stationary diesel plants. (Endorsed by CNIDI 20.11.87 and A.I. Voeikov GGO 30.07.87). - L., 1988.

25. Temporary guidelineson developing extremely high air contamination by highly toxic substanceszonesrelocation projects. - L.: A.I. Voikov GGO, NPO "Taifun", 1988.

26. The Water Code of the RSFSR. (Endorsed by Law RSFSR of 30.06.72)

27. GOST 17.5.3.04-83. Nature Protection. Lands. Land Reclamation General Requirements.

28. GOST 17.1.1.02-77. Nature Protection. Hydrosphere. Water Body Classification. (Asamended 04.88)

29. GOST 17.1.1.03-86. Nature Protection. Hydrosphere. Water Use Classification.

30. GOST 17.1.3.05-82. Nature Protection. Hydrosphere. General requirementsfor the protection of ground and surface water against raw oil and petroleum product contamination.

31.Maslov B.S., Minaev I.V., Guber K.V. Land reclamation reference book. - M.: Rosagropromizdat, 1989.

32. Guidelineson submitting justification materialsfor establishing MPC in water bodies. (Endorsed by Ministry of Health USSR of 16.08.82 N 2614-82.) - M. Minzdrav SSSR, 1982.

33. SNIP 2.01.28-85. Toxic industrial waste neutralization and disposal sites. Design guidelines.

34. The limit quantity of toxic waste to build up within company'sown storage facilities. - M.: Minzdrav SSSR, 1985.

35. The limit quantity of toxic industrial waste allowed to be disposed of at solid domestic waste collectors(landfills) (regulatory document). - M.: Minzdrav SSSR, 1985.

36. Toxic industrial waste stockpiling, transporting, neutralizing and burial procedures(sanitary regulations) - M.: Minzdrav SSSR, 1985.

37. SNIP and N 42-128-4690-88. Sanitary rulesfor land management and populated areas. - M.: Minzdrav SSSR, 1988.

38. Surface water pollution prevention sanitary rulesand norms. - M.: Minzdrav SSSR, 1988.

39. The generalized list of maximum permissible concentrations(MPC) approximately safe impact levels(ASIL) of noxioussubstancesfor fishery water. - M.: Minrybhoz SSSR, 1990.

40. The provisional toxic industrial waste classifier and industrial waste toxicity determination methodological recommendations. - M.: Minzdrav SSSR, GKNT SSSR, 1987.

41. OND-86. The calculation method for noxiousambient air pollutantsemitted by industries. - L.: Gidrometeoizdat, 1987.

42. GOST 17.2.3.02-78. Nature Protection. Atmosphere. The noxioussubstance permissible levelsdetermination rulesfor industrial emissions.

43. The maximum permissible discharge (MPD) calculation method for wastewatersdischarged into bodiesof water. (Effective duration isextended by Minpriroda RF letter of 15.04.93 N 07-37/65-1177.) - Kharkov: VNIIVO, 1990.

44. The standardization instructionsfor polluting emissions(discharges) into the atmosphere and bodiesof water. - M.: National Nature Protection Committee, 1989.

45. The provisional rulesfor protecting the environment from industrial and consumption waste in the Russian Federation. - M.: Ministry for environmental protection and natural resourcesof the Russian Federation, 1994.

46. GOST 17.4.3.05-86. Nature Protection. Soils. Requirementsfor wastewater and depositstherein in irrigation and fertilization.

47. GOST 12.1.036-81. Labor safety standard system. Noise. Permissible levelsin housesand public buildings.

48. Serebryakova S.A., Mazurov L.N. Soil contamination analytical monitoring general provisions. - M., 1991.

49. GOST 17.4.3.03-85. Nature Protection. Soils. General requirementsfor contaminant detection methods.

50. GOST 8.001-80. GSI. The arrangementsand proceduresfor State-controlled measuring instrument testing.

51. GOST 17.4.3.04-85. Nature Protection. Soils. General requirementsfor monitoring and protection against pollution.

52. GOST 17.5.1.01-83. Nature Protection. Lands. Land reclamation. Terminology and definitions.

53. GOST 17.2.2.05-86. Nature Protection. Atmosphere. Standardsand measurementsmethodsfor noxioussubstancesin exhaust fumesof tractor and harvester diesel engines.

54. The collection of methodsfor determining contaminant levelsin industrial emissions. - L.: Gidrometeoizdat, 1986.

55. The collection of methodsfor calculating polluting emissionsfrom variousindustries. - L.: Gidrometeoizdat, 1987.

56. The statute on water protection zones(strips) of rivers, lakesand reservoirsin the RSFSR. (Endorsed by Resolution of Council of MinistersRSFSR of 17.03.89 N 91.) - M.: Council of Ministers RSFSR, 1989.

57. The regulation on designing and using sanitary protection zonesof water sourcesand water supply systemsfor domestic and drinking uses. (Endorsed by the Ministry of Health USSR of 18.12.82 N 2640-82.) - M.: Minzdrav SSSR, 1982.

58. GOST 17.1.3.06-82. Nature Protection. Hydrosphere. Groundwater protection general requirements.

59. GOST 17.5.3.05-85. Nature Protection. Lands. The requirementsfor establishing standardson removing fertile soil layer in earthworks.

60. The recommendationsfor removing the fertile soil layer in mining, construction and other works. - M.: Kolos, 1983.

61. GOST 17.5.3.04-83. Nature Protection. Lands. Land reclamation general requirements. (Asamended on 01.11.86.)

62. GOST 17.5.3.05-84. Nature Protection. Land reclamation. Earthing general requirements.

63. Law RF "Ensuring measurement uniformity". - M., 1993.

64. The standard instruction on organizing an industrial emission monitoring system in industries. - L.: Goskomgidromet SSSR, 1985.

65. GOST 17.2.3.01-86. (ST SEV 1925-79). Nature Protection. Atmosphere. Populated area air quality monitoring rules.

66. The provisional instruction on environmental justification of economic activitiesin pre-project and project materials. - M., 1992.

67. GOST 17.0.0.04-90. Nature Protection. Industrial enterprise environmental certificate. General provisions.

68. How to fill in an environmental certificate: methodological recommendations. - M.: Goskompriroda SSSR, 1990.

69. On endorsing procedure for determining the fee and itslimitsfor polluting the environment, waste disposal, other impacts. Resolution of Government RF of 28.08.92 N 632. - M., 1992.

70. GOST 17.4.2.02-83. Nature Protection. Soils. The list of criteria of the suitability of a damaged soil layer for earthing.

71. On utilization, neutralization, and burial of toxic industrial waste. Resolution CM USSR, 1984, N 394.

72. The handbook on the assessment of risksassociated with possible emergenciesin the production, storage, using and transporting of large amountsof inflammable, explosion hazard and toxic substances. (Inter-departmental NMC ‘Risk informatics’ of 31.01.92 N 10-8-7.) - M., 1992.

73. Procedure for determining damagesfrom land contamination by chemical substances. Soil protection department, Minpriroda RF. (Endorsed by Ministry of Justice letter)

74. The provisional procedure for the estimation and indemnification of damagesto the environment asa result of an emergency. (Endorsed by Minpriroda RF of 27.06.94 N 200.).

ANNEX 2 Map of Airborne and Land Study Areas on Alexandra Island

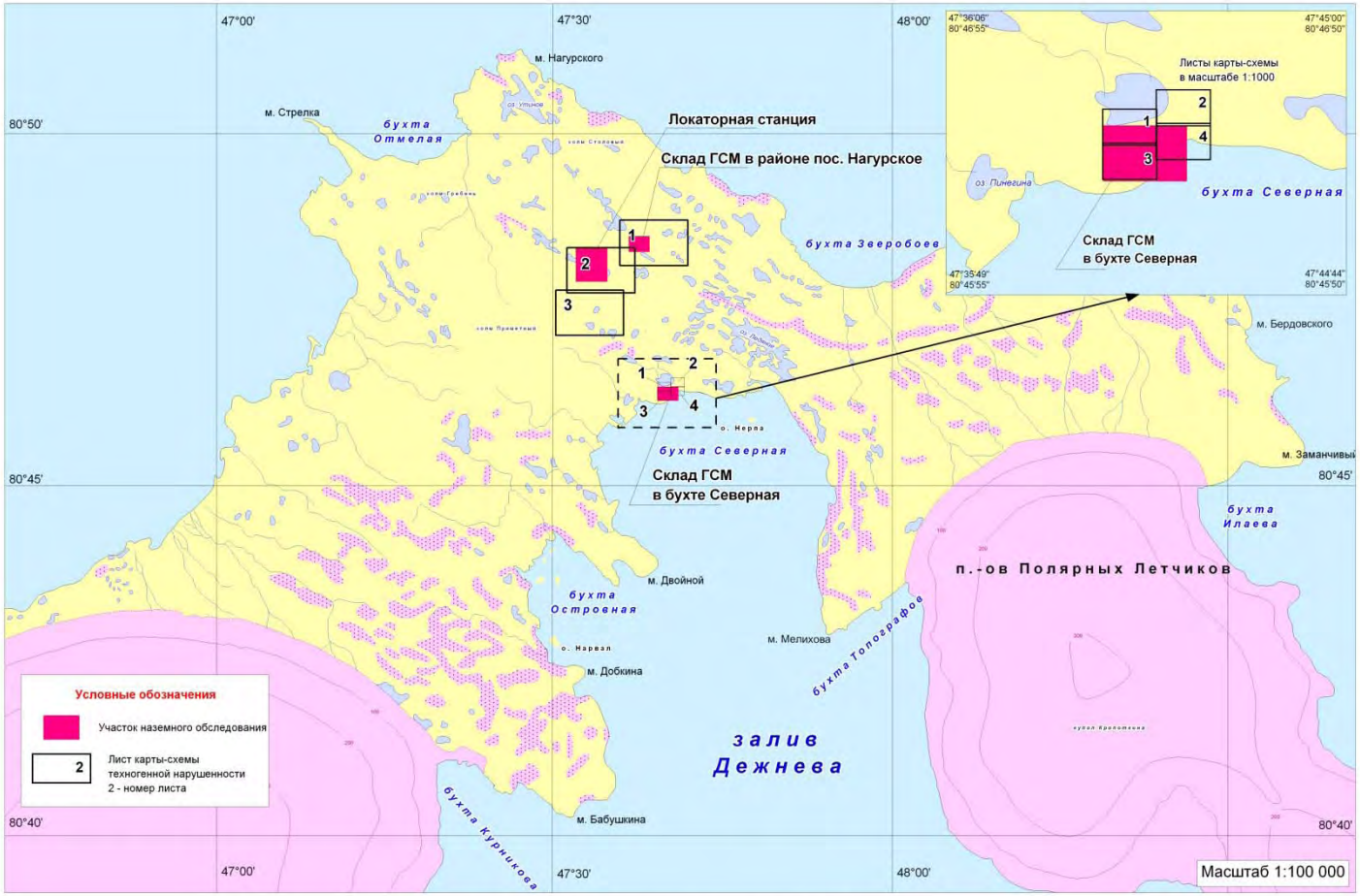


Схема расположения участков авиационного и наземного обследования на о. Земля Александры