Additional information for the materials on the Pri-Irtyshye forests radioactive pollution

1. Background for previously proposed scope of work on forest ecosystems components testing

It seems to be impossible to propose a structure of investigations that would provide exhaustive project information on the potential hazard for the population when there is a lack of information on the locality of the explosion clouds traces as well as representational data on the level of radioactive pollution on the traces.

Nuclear fall-out occurred in a highly uneven manner due to the strong turbulence of a cloud and the atmosphere. Then, influenced by wind, surface drainage, and vertical filtration, the radionuclides passed through the process of redistribution for several decades. The residual volume of radionuclides that have not undergone the decay formed small spots on the terrain, possibly not more than several tens of meters in their size. Even smaller particles of ground, which caked during an explosion and contain non-decayed corpuscles of the charge - plutonium or uranium, represent the most hazards. Such sort of hazardous aggregates are well known under the name of "hot particles" from the Chernobyl catastrophe consequences study. The hot particles were found on the major traces of Semipalatinsk polygon as well.

In the study of such situations, where small fragmentary pollutions of low abnormal and background level are an object of quest, a complete reliability even under the high costs (that don’t however overstep the reasonable limits), is principally impossible. Due to this fact, there are investigations in common practice conducted in several stages, each is basing on the data of the previous research phase.

1. The first stage is collecting materials of previous studies that can help in establishing places and lines of maximum pollution, where the next research stages will be focused. With these materials at hands (there are data of two rounds of investigations; the first one were provided in the previously prepared report, the second one are provided below), if possible, it should be established the prevalent pollution spots size, natural barriers, on which the migrating (soluble and insoluble) radionuclide concentration occurs. Depressed internal-drainage elements of relief, bottom sediments, and places of soil material deposition mobilized through the water or wind erosion serve as such barriers. Peat swamps, rind (for incorporated material), mosses, lichens, and mushrooms (for biological accumulation of radionuclide soluble component) serve as biological barriers.

Investigations of the forest ecosystems' role in primary distribution of radionuclides showed that the forests are pronounced accumulators of technogenic fall-outs. Under the radioecological studies, special attention is paid to the investigation of $^{137}$Cs and $^{90}$Sr behavior peculiarities. At the same time, there is not much information on the investigations of $^{239/240}$Pu accumulation and migration, which is one of the most hazardous and long-living radionuclides. Since the principal source of $^{239/240}$Pu supply into the environment is nuclear weapon tests, research of $^{239/240}$Pu behavior in ecosystems in the radioactive pollution studies of the zones under the nuclear polygon’s direct impact should be made foremost. It is known that up to 99% of incoming into the environment plutonium lies at the surface layers of soil and bottom sediments. As the main part of plutonium (more than 90%) is in soils in insoluble form, redistribution of $^{239/240}$Pu along the land surface is defined basically by the wind transfer. The latter one leads to accumulation of $^{239/240}$Pu nearby any obstacles, including plants. It is noted that the most concentrations of $^{239/240}$Pu were registered in undersized plants (grass, lichens, and mosses). The surface pollution therewith is several orders higher than the accumulation due to the processes of assimilation. In conditions of frequent gale-strength winds in Semipalatinsk region that rise dust clouds, not only undersized plants, but also trees (rind and needles) can be polluted. Using this timber for fuel in private houses can cause significant additional irradiation of the population due to the
inhalation supply of $^{239/240}\text{Pu}$ into the human bodies. But the given aspects is not studied completely yet and require more precise definition and confirmation.

The real reason leading to the radionuclide redistribution mainly in the forest biocenoses, are fires. They not only touch upon sod, but almost completely eliminate the main deponents of radionuclides that are forest litters, mosses, and lichens. In addition to the material losses caused by the forest fires, there is a peril of the secondary pollution of neighboring areas with radionuclides in top-soil and vegetation cover. The investigations show that during a surface fire, $^{137}\text{Cs}$ concentration exceeds background level 25 times. During a crown fire the named value increases up to 100 times. The fact that plutonium isotopes have been revealed in smoke undoubtedly necessitates additional measures to protect respiratory apparatus of both fire liquidators and local population.

When evaluating a radiation-absorbed dose on the population, the radionuclides content data in food stuff that composes basket of goods for a territory of a separate administrative unit (oblast) is widely used. In doing so, a contribution of forest-originated food stuff is not practically taken into account or taken in average independently of the environmental conditions around a population area, revealing itself as a modifying factor of dose referent value.

From the investigations made in Russia, Byelorussia and Ukraine it was shown that contribution value into internal irradiation dose caused by food stuff is widely varies from 22% till 66% for the basic group, and for critical groups increase up to 80%. Such significant variation of wild berries, mushrooms, herbs/medicinal plants and hunting animals' meat with similar sizes of forestland area around various populated areas, can be explained from several main reasons:

- Differences in density of soil pollution by radionuclides;
- Differences in environmental conditions of forest growing places that influence the biological and hence exploitation resources of berries and mushrooms as well as migration capability of radionuclides in food chains;
- Differences in traditional food allowance/rations and food preparation methods.

Due to the known economic reasons and lack of information about risk associated with forest food stuff consumption, their contribution into the food ration considerably rises.

To correctly calculate the doses stemming from the forest food stuff consumption, it is necessary to have information on the main artificial dose-forming radionuclides' specific activity ($^{137}\text{Cs}$, $^{90}\text{Sr}$ and $^{239/240}\text{Pu}$) in mushrooms, berries, and game as well as appraise a contribution of each of the listed forest food product into the concrete settlement's population ration.

From the above reasoning, there is a necessity to make precise assessment of forest food stuff contribution into the population's internal irradiation dose. That is necessary to make scientifically grounded decisions to reduce dose stress on the rural population of the suffered areas in regional and national level. These investigations are especially topical in the strip pineries of Pri-Irtyshye.

2. The forest ecosystem components testing as it was proposed before, should be concentrated on the presumptive routs of explosion clouds that can conform to a line passing point by point across the maximum pollution found during the previous works and comply with the cloud movement direction, which was established through the archive materials study. The volume of radiological works can be reduced through the extension of radiometric measurements. But as it was noted above, with supposed low concentrations of cesium and americium (plutonium decay product) and possible availability of natural abnormalities defined by the heightened content of natural radionuclides of the uranium series in sand and gravel, radiometric measurements can register/display their unavailability.

3. The density of testing chosen at the first stage is a decisive for the final results of the works, as the following stages of testing will be focused only on the abnormalities revealed through the radiochemical samples of the given stage. Probably, the only criterion for the testing density selection in the stage is availability of funding, the amount of which will be
defined by the Project investigations as well as degree of reliability and vagueness of outcome.

4. If the final result testifies to the radioactive abnormalities absence, the conclusion will only be rightful in respect to the sampled territory. Extrapolation of the conclusion for other areas of the potential pollution will not be correct. If the result indicates that there exists heightened level of pollution, it will be necessary either to get more precise information about the outcome and make ranking the territories according to the hazard degree in the framework of the Project or make recommendations for the Kazakhstan part to conduct such works.

5. It is expedient to conduct a simulation for a hazard of radionuclide transfer with forest material burning products. Such modeling seems to be oriented on two situations. The first one is associated with mathematical simulation or with an experiment on the burning the forest material collected at the most polluted areas in case if it is found. The second one is connected with modeling or an experiment with a hypothetical situation of minimum hazardous level of pollution. The second situation will provide an opportunity to gain a more precise project conclusion that there are no any pollution levels posing danger to the population since no one of the previous and project investigations such levels of pollution in the project area have not been found. A possibility of such conclusion is based on the assumption that this situation actually represents the facts.

6. To conduct radiological studies in the strip pineries of Semipalatinsk region it is necessary to make it in two stages.

At the first stage it is necessary to implement reconnaissance work in order to determine the forestlands current location, and compare it with the available data on the radioactive fall-out traces and known areas of radioactive pollution. Then, it is necessary to select potential zones of future detailed investigations. The next step is a field trip to sample a small number of soil samples (about 10) for the assessment of existence and level of the radioactive pollution of the areas for further investigations. Cost of works will comprise about US$ 2,000.

The second stage lies in the implementation of the previously proposed works. (Cost of them comprises about US$30,000). This amount does not include expenses for experimental works in radionuclide migration with burning products. It is possible to presume that the mentioned works will remove the issue of the radioactive pollution of the Priirtyshye forests.

7. At the same time, it is necessary to more clearly define a task of the given Project component: whether the assumed measure of reliability is sufficient or it is needed to considerably approach it to the exhaustive one. In the second case, it is necessary to reserve some amount of money equivalent to the ones, which were recommended for the first two stages.

8. The organizations carried out previous investigations, in particular ИРБЭ and JSC "Volkovgeologia", should be offered for the implementation of the studies. It will significantly increase the level of precision for the polluted areas identification and measure of investigation reliability.

Additional information about the radiological investigations in the Project area

The radiological studies in the Republic of Kazakhstan were launched by the JSC Volkovgeologia’s Department (Expedition) #39 (in the scale 1:1 000 000) in 1991 as a part of the all-Union program on hydrological lytho-chemical survey on the small rivers water flow. They were allowed to solve tasks for ecogeochemical assessment of the pollution degree of the large areas and regions of the former USSR by radionuclides, pesticides, and some toxic elements. The complex of filed, experimental and methodical, analytical and office studies resulted in the data, which characterized a distribution of the contents of major radioactive
elements pollution degree of natural and technogenic nature in the studied environments (surface water, bottom sediments).

Below, the maps (1:1 000 000 scale) of total beta-activity and $^{137}$Cs distribution on the territory of Beskaragay rayon in the areas of prospective investigations according to the results of an inquiry.

Map of the total beta-activity distribution in the bottom sediments of the small rivers water flow

**Legend:**
Points of radiological litho-geochemical sampling
Border of Polygon (SNTA)
Border of rayons (administrative areas)
Specific beta-activity in the bottom sediments, Bk/kg

An area where heightened level of beta-radiation was fixed showed in red on the total beta-activity distribution map. The provided data testify on the existence of the area's radioactive pollution at the very place where the works are intended to be conducted.

On the map of $^{137}$Cs distribution, one can suppose that there is a superposition of several radioactive cloud traces. This location of the trace differs from the one that took place in 1949 (red ellipses). It testifies that the given territory underwent the radioactive pollution several times and the radionuclides are only distributed in the given place. Besides, the pattern of pollution indicates that even on the line of a trace one can found both polluted and clean areas.
To make a detailed elaboration of the radioactive pollution distribution, ИРБЭ and JSC “Volkovgeologia” conducted radiological investigations in scale 1:200 000 in 2004 in the area that was outlined by a blue rectangle. In the area under investigation, there are open and forest areas. The laboratory analyses have not been finished yet, but it is possible to conclude that in some points of investigations, $^{137}\text{Cs}$ content reaches 50 Bk/kg that exceeds the background level of global fall-outs and testify to existence of the zone of radioactive pollution. The obtained by ИРБЭ data can be a basis for a site selection and further investigations that were proposed before.

A certain difficulty in deciding on a particular research area represents availability of the modern cartographic materials/maps. The latest upgrading the topographic maps for the given region have been made more than 20 years ago. Forest fires taken place during the period has considerably changed the situation. Therefore it is desirable that selecting the strip pinery areas in the assumed radioactive fall-out trace limits to be based on the 2003 airborne survey made on this territory, and deciphering materials or basing on the satellite-borne photography. In the selected forest areas, burnt woods and others, it is necessary to select several soil samples and analyze them in a laboratory for $^{137}\text{Cs}$ content and other radionuclides, if needed. Corroborating of the area radioactive pollution will be an ample basis to conduct further investigations in the planned volume.

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February 1, 2005