Assessment and Proposals for Uranium Production Legacy Sites in Central Asia:

An International Approach

FOREWORD

Uranium mining and milling was an intensive industry in most of the Central Asian countries of the former Soviet Union. It has left a legacy of radioactive residues. Development of most of the uranium deposits in Uzbekistan, Tajikistan, Kyrgyzstan and partially in Kazakhstan was stopped after the collapse of the former Soviet Union. All of these countries found themselves facing the problem of safe management and remediation of many sites affected by the operation of uranium mining and milling facilities. After these countries became independent, the issues of restructuring and decommissioning of the mines and other uranium facilities arose at the same time.

Safe management of uranium mill tailings is one of the important tasks for the past present and future uranium producing Member States of the IAEA. Particularly in Central Asia, their common problem is an immature regulatory infrastructure coupled with a lack of previous experience in safety assessment and remediation planning. National experience in development of environmental monitoring and the analytical capacities of most laboratories, which are in charge of monitoring programs at legacy sites and other areas of concern, are also very limited.

Therefore, the Member States and the IAEA with support from the International Organizations (EC, UNDP, OSCE) embarked on an initiative to develop a common understanding of the risks posed by these sites with the aim to protect their populations and environment.

One of the main objectives of this initiative was to develop a document that provides a technical baseline for a common understanding of regional and site specific issues. The purpose of this document is to do just. It is hoped that this document will serve as a basis for identifying, prioritizing and coordinating the necessary activities to make these sites safe for the population and the environment around them.

The assessment and evaluations presented in this document are based upon the International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (Safety Series No.115), the Safety Guides on Occupational Radiation Protection in the Mining and Processing of Raw Materials (IAEA Safety Standard Series No. RS.-G-1.6), and Management of Radioactive Waste from the Mining and Milling of Ores (IAEA Safety Standards Series No. WS-G-1.2) were utilized.

This report was drafted in two consultants meetings and reviewed in a Technical Meeting during 2009-2010. The IAEA officer responsible for this report is Russel Edge of the Division of Radiation, Transport and Waste Safety.

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EXECUTIVE SUMMARY

Central Asia (CA) is at a strategically important intersection between Europe and Asia situated between the Caspian Sea in the west, China in the east, the southern plains of Russia in the north and bordering with Iran and Afghanistan in the south. For the purposes of this document Central Asia includes the states of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and Mongolia.

This area covers approx.3.5 million sq.km, and the population exceeds 55 million people. Except for Mongolia, the states listed above became independent in 1991 from the former Soviet Union. Two prominent rivers drain the region, again excluding Mongolia, the Amu Darya and Syr Darya, whose upland drainage basins account for 60% of water resources which are essential to the future development of the region. Uzbekistan, located downstream of these drainage basins, depends on the quantity and quality of the water it receives through these rivers

During the Soviet period, the uranium mining operations of the region provided approximately 30% of the uranium production of the Soviet Union but left behind an extensive legacy of uranium mining and processing wastes, which remained abandoned or inadequately contained/secured on the former sites of uranium mining and processing.

As shown in Table 1, about 1 billion tons of waste from mining and processing radioactive ores is stored on these tailings sites and in the mining waste dumps of functioning and abandoned uranium mines in Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan and Uzbekistan. As can be seen from the table, the volume of tailings is larger than the volume of waste rock, since a considerable amount of uranium ore was imported to CA from East European countries such as East Germany, Czech Republic, Bulgaria and Romania for processing.

Table 1. Details of wastes in uranium legacy sites in Central Asia [1] [1]

Country	Tailings sites		Waste dumps of rocks and low-grade ores (million tons)	Total in the country (million tons)	Area of affected land (km^2)
	Number	(million tons)			
Kazakhstan (KAZ)	3	246	37	283	52*
Kyrgyzstan (KIG)	34	77	209	286	6.5
Tajikistan (TAD)	10	55	115	170	3
Uzbekistan (UZ)	1	60	13	73	3
Mongolia (MN)	2	0	6	6	1.5
Central Asia (CA)	50	438	380	818	66

* excluding Semipalatinsk

Many of these uranium legacy sites are located adjacent to tributaries in the upper reaches of the watershed. The presence of these sites, have led to concerns regarding adverse

[1] Assessment of national experts, Regional Conference "Uranium Tailings: Local Problems, Regional Consequences, Global Solution", Bishkek, April 21-24, 2009

environmental impacts and exposure to the populations living nearby and potentially downstream. Previous international assessments (TACIS, INTAS, IAEA, NATO, ENVSEC, etc.) and the results of this assessment show that a number of high risk legacy sites are insufficiently secured, the waste containment structures are often inadequate and frequently damaged and are unstable in the local geological and geotechnical conditions. The legacy waste sites are often visited by the local members of the general public mainly for the purpose of salvaging scrap metal; domestic animals are also frequently graze on these contaminated sites. Contaminated seepage from the sites is often used for irrigation, livestock and sometimes for household purposes. In addition there is evidence that some contaminated material may have been used for domestic construction purposes.

It is important to remember that the radiologic hazards that may exist are chronic long term exposure hazards, not acute hazards. It is also important to acknowledge that the toxic and chemical hazards from the heavy metals associated with these uranium wastes are of equal concern.

Some progress has been made. The Government of Kazakhstan instituted a National Remediation Program and soil covers have been constructed at a number of sites. The ongoing World Bank project for remediation of the Mailuu-Suu legacy site in Kyrgyzstan is another example. However, for most Central Asian states, there appears to be no national strategy that addresses the uranium production legacies.

While it is reasonable to expect that a national program to deal with the legacy sites in Uzbekistan will be developed (with moderate international assistance), the states of Kyrgyzstan and Tajikistan lack the economic strength and capabilities to establish national strategic environmental assessment and management plans. Nonetheless, the uranium legacy sites in Kyrgyzstan and Tajikistan require additional attention as they are located in the upper reaches of the tributaries to the Amu Darya and Syr Darya rivers.

The containment failure at some legacy sites in these countries, in addition to the risks to local population (as described above), may have transboundary implications and quite likely cause international disputes. The area most threatened by the risk of containment failure at legacy waste sites is the densely populated Fergana Valley, the agricultural centre of the region shared by Kyrgyzstan, Tajikistan and Uzbekistan (Figure 1).

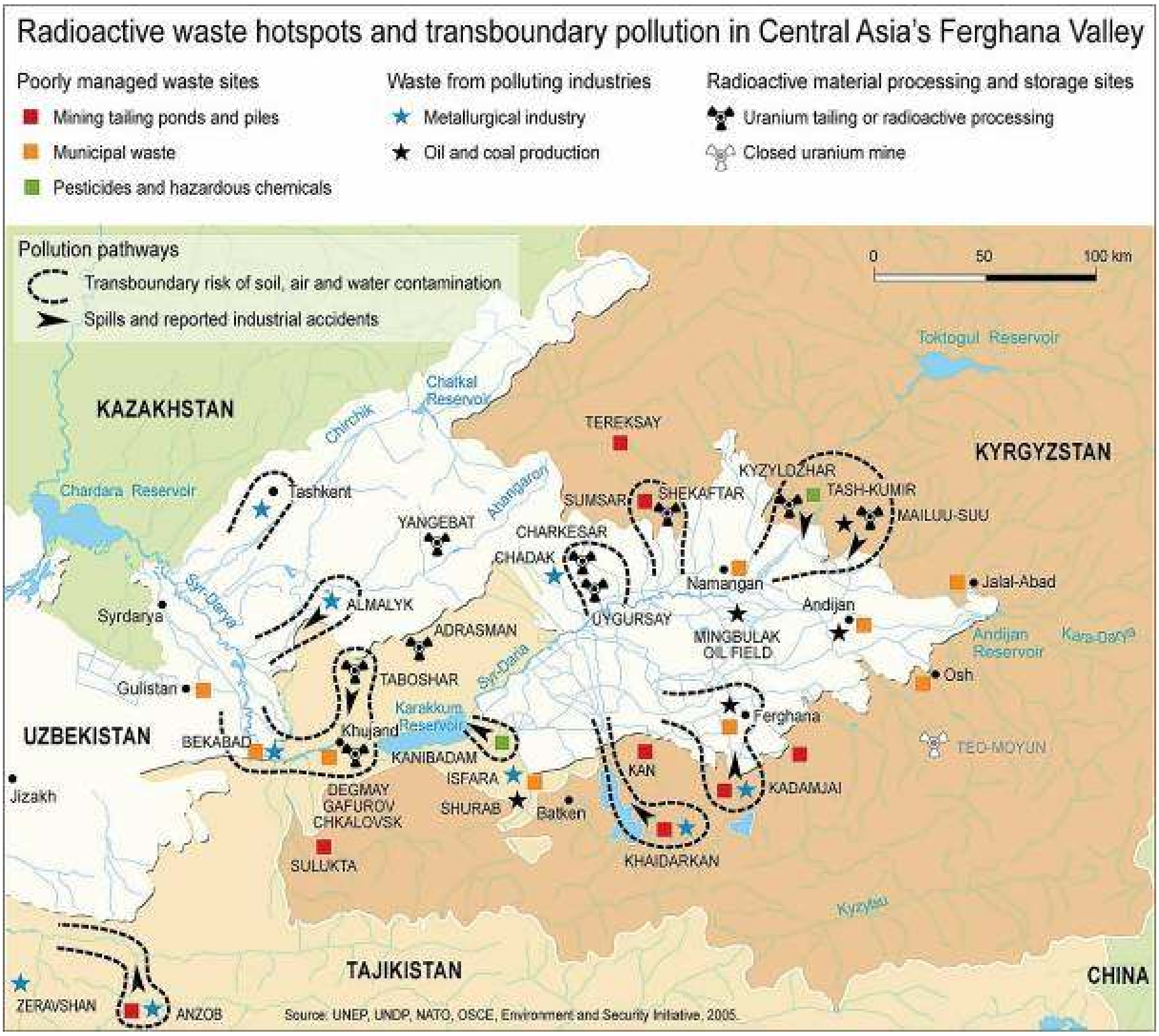

Figure 1. Legacy uranium production sites [2]

International and national interest to secure and contain the uranium production legacy wastes

The international community has a strong interest in the environmentally and socially responsible systematic remediation of these legacy sites – in agreement with international standards, proposals and practice. In order to accomplish this goal the following actions are necessary:

- Harmonization of the national legislation and regulatory framework with the relevant international standards and proposals;
- Preparation of environmental assessments prior to the commencement of remediation of the uranium legacy sites;
- Development of safety assessments to prioritize remedial actions;
- Development of remedial action plans;
- Implementation of remedial actions;
- Post remediation monitoring and maintenance;

- Development and delivery of appropriate educational programs for the regulatory bodies, mining and processing companies, relevant scientific institutions and representatives of the impacted communities; and
- Development of national analytical capabilities.

The goal of the IAEA is to actively contribute to the application of international safety standards and good practices as they related to the remediation of legacy sites in Central Asia. This document builds on the progress the Central Asian states have made since attaining independence while taking into account the common context in the region as well as the specific national context and requirements.

The information contained in this document complements the results obtained under the implementation of the various international projects and assistance programs that addressed the current situation at the most important uranium waste sites (TACIS, INTAS, IAEA, NATO, ENVSEC, etc.). These projects have identified the uranium legacy wastes to be the source of environmental contamination observed locally and in some cases, downstream of the former production sites, and the vulnerability of the sites (tailings storage facilities threatened by landslides from the adjacent mountain slopes, exposed to seasonally high water inflow into the impoundment and located in seismically unstable areas). The historical records confirm the repeated occurrence of downstream contamination with the possibility of cross-boundary contamination; such events have led to localized release of contamination from Min-Kush (1956), Mailuu-Suu (1958), Ak-Tyuz (1964) and in the Sumsar-Shekaftar mining-industrial region (1994).

Thus, the remediation of the uranium legacy sites presents a common interest of the states of Central Asia and many international organizations.

The state of uranium legacy sites in Central Asia has attracted the attention of a number of international organizations. In 2004 the Central Asian Republics of Uzbekistan, Tajikistan, Kyrgyzstan and Kazakhstan approached the IAEA with the request to receive technical assistance and expert advice to deal with the legacy sites of the former uranium industry. In response to this request the IAEA has initiated several projects in Central Asia.

Concurrently with the IAEA projects a number of other institutions were also active in the region. Projects addressing the issues of the legacy sites were run by the European Commission Aid Cooperation (EC-AIDCO), the World Bank (WB), the European Bank for Reconstruction and Development (EBRD), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Organization for Security and Cooperation in Europe (OSCE) and the North Atlantic Treaty Organization (NATO). These organizations addressed the problem of the uranium legacy sites from various perspectives, all of which are complementary to the overall objective of minimization of the health and environmental hazards. There is a need to coordinate and integrate the results of all these projects to optimize the use of resources and strengthen the political impact of these efforts.

The need for integration has been recognized by all organizations working in the region; in 2008, the UNDP in conjunction with the Government of Kyrgyzstan approached several international organizations regarding the solution of the problems presented by the uranium legacies in the region. There was an agreement among the international organizations involved and the representatives of the affected countries that the solution of the problem should be addressed at the regional level, similar to the regional approach previously followed by the IAEA. A regional conference was sponsored by the UNDP in Bishkek, Kyrgyzstan in April 2009, followed by the IAEA conference on “Remediation of Land Contaminated by

Radioactive Material Residues" in Astana, Kazakhstan in May 2009. In follow-up actions, several other international organizations were engaged by the IAEA through a series of meetings beginning in May of 2009 to plan and coordinate further action.

In April 2009, the UNDP office in Bishkek (Kyrgyzstan) held a regional workshop regarding the Central Asian legacy sites which yielded 60 project proposals by institutions from Kazakhstan (2), Kyrgyzstan (33), Tajikistan (15), Uzbekistan (9) and Eurasian Economic Community (EurAsEC) (1). The requested financial volume of these projects amounted to 236 million USD.

The project proposals were aimed at:

- Upgrading of regulatory framework;
- Remediation of legacy sites;
- Monitoring and health care;
- Re-working of tailings at legacy sites; and
- Improvement of socio-economic conditions for the population living in the vicinity of the legacy sites.

To raise the awareness of the international community of the problem of uranium legacy sites in Central Asia an international forum was conducted by the UNDP in Geneva, Switzerland in June 2009 called "Uranium Tailings in Central Asia: Local Problems, Regional Consequences, Global Solution".

Building upon and complementing the previous international assessment and assistance projects, this document focuses on the technical issues with the legacy sites, with the objective of the remediation and mitigation of the hazards associated with them. It provides a brief overview of the uranium legacy sites and proposes several recommended actions at a regional and national level, which are summarized in Tables 2 and 3. They include regional and national projects and are intended to complement the UNDP Framework Document entitled "Uranium Tailings in Central Asia: Local Problems, Regional Consequences, and Global Solution".

Table 2. Transboundary proposals

Proposals	Priority	Costs (million €)	Time frame (years)
1. Regulatory framework Development of guidelines and technical standards for the legacy sites, and of efficient regulatory processes	high	each country: 0.4	2
2. Training and education In the areas of radiation protection, environmental and long-term monitoring, project management, remediation planning, restoration technologies, experience exchange, risk assessment, operation of scientific equipment	high	each country: 0.4	2
3. Internet database for information exchange To include monitoring data, regional knowledge exchange and experiences in project management	high	0.15	1.5
4. Establishment of a regional watershed monitoring network	high	2	3
5. Analytical capacity building Effective laboratory system for site investigation (soil and ground water samples) and river water sampling	high	each country: 0.8	3
6. Environmental impact assessments and safety assessments conducted region wide at priority legacy sites	high	will be determined	2

The regional proposals listed above are intended to provide a platform for the successful remediation of uranium legacy sites in the Central Asian region. This list is based upon the collective opinion of experts within and from out side the region.

A strong regulatory framework in each of the countries of the region is necessary to establish requirements, roles and responsibilities, and ensure adequate protection of the public and the environment. Currently some national legislation exists however the implementing regulations and guidance is missing. In addition there is inadequate support of regulatory infrastructure (equipment, trained personnel, facilities etc.).

Training and education is essential. There is a need to develop a trained workforce to evaluate the need, plan and implement any remedial action, otherwise the majority of the work will be conducted by foreign firms and any economic benefit which may arise from the remediation will minimized. Coordination between ministries, institutions, national and international organizations is essential to optimize the use of the limited resources in the region.

The region could benefit from increased communication and exchange of technical knowledge, information and expertise. The UNDP has assisted Kyrgyzstan in developing a website which contains a great deal of good information. This should be expanded to include other countries in the region. Many of the issues are similar and all could benefit from each others experience.

There is a high degree of concern regarding the downstream impacts to the Fergana Valley from these legacy sites. The establishment of a regional watershed monitoring system would begin to address this issue. This would serve as a trust and confidence building activity as well as establishing a baseline in the event of a catastrophic failure of a waste containment structure upstream. Initially the level of sophistication of this project needs to be consistent with the available infrastructure to support it.

The effectiveness of the analytical capacity of the laboratories needs to be increased. Several international organizations have initiated activities to address this but more needs to be done. Reliable, representative samples are essential for site characterization, modelling input, dose and risk calculation and ultimately they are part of the basis for remediation decision making. Laboratory facilities need to be upgraded not only in terms of equipment and facilities but in terms of training for staff, quality assurance and quality control (QA/QC). Laboratory resources need to be shared within country and within the region. A network of laboratory capability needs to be established which should include the universities which are a potential resource.

Finally, there needs to be some type of coordinating mechanism in the region to address these uranium legacy sites. To optimize the use of resources and to strengthen the political impact there is a need to coordinate and integrate the results of different projects. This will require a framework mechanism and an organization to coordinate it. The United Nations Environment Program (UNEP) proposed such a mechanism in the form of a Strategic Environmental Assessment (SEA) [3, 4] and National Remediation Plan (RP). This mechanism may be an option for Central Asia and could contribute to a consistent approach for the solution of the uranium production legacy problems. The SEA/RP is briefly described later in the document.

Table 3. Proposed remediation related activities by country (the high and medium evaluated risk sites only considered)

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Kyrgyzstan (KIG)	1. Mailuu-Suu	Tailings (TP 3, 2/13 and 8)	high	Feasibility study (FS), design of relocation of TP 2, 3, 8 and 13	0.3	0.5
				Remediation	1.7	1.5
	2. Min-Kush	Min-Kush mill site and adjacent areas	high	Radiological survey of residential areas and safety assessment	0.3	0.5
				Establish surveillance and maintenance program to include radon monitoring, geotechnical monitoring, water quality monitoring program for community	0.3	1
				Selective remediation of the houses in residential area	0.3	1
		Tuyuk-Suu tailings dump	high	Safety assessment	0.1	ongoing
				Establish geotechnical monitoring program as part of long term surveillance and monitoring program	0.2	1
				Emergency response training	0.3	1

				Engineering evaluation and repair of drainage system	0.8	1
				FS: remediation (option 1, stabilization)	0.9	1
				FS: remediation (option 2, tailings relocation)	3.8	1.5
	3. Kadji-Say	Mill site and tailings piles	medium	Evaluation of erosion problem	2	1
				Develop and implement remedy	2	1
				Control site access	2	1
				Establish groundwater monitoring network	0.4	1
	4. Ak-Tyuz	Thorium ore concentrate storage facility and tailings dumps	medium	Radiological survey and safety assessment	0.2	0.5
				Environmental impact assessment (EIA), engineering design	0.4	1
				Remediation of the contaminated lands around facility	2.2	2
	5. Orlovka (Burdinskoe)	Drainage system	medium	Environmental impact assessment	0.1	0.3
				Engineering design and installation	1	1
				Remediation on assessment results	2.7	2

Continuation of Table 3.

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Tajikistan (TAD)	1. Chkalovsk Khujand industrial site	Degmay tailings	high	Environmental impact assessment, design of cover	1.3	1.5
				Remediation (cover the tailings)	15	2
				Establish long term surveillance and maintenance program to include institutional controls, environmental monitoring (radon, groundwater)	0.3	1.5
		Gafurov tailings	medium	Establish long term surveillance and maintenance program to include institutional controls, environmental monitoring (radon, groundwater)	0.2	1
				Risk-communication (public awareness)	0.1	1
		Mine 3	medium	Design mine water management system)	0.2	0.5
				Replace ion-exchange and repair and operate mine water treatment facility	0.5	1
				EIA of all areas of the site, design of cover	2.1	2
				Remediation (cover and stabilisation)	13	3

		Mine waters treatment	high	Provision of alternate water supply to eliminate local consumption of contaminated water	2	1
				Surveillance and monitoring	0.2	1
		Industrial site and tailings cover	high	Repair of existing covers	3	1
				Design of new covers to address acid water drainage	0.3	1
				Remediation (implementation phase)	30	3
				Should include backfilling and plugging mine openings, collection of material along Archie-Say and Utken-Suu river banks transported off-site by mudslides and floods	0.5	1
		Taboshar water treatment system	high	Design of sustainable water supply system	0.2	0.5
				Construction	0.7	0.5
				Risk communication and risk awareness programme	0.1	0.5

Continuation of Table 3.

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Uzbekistan (UZ)	1. Charkesar-2	Uranium production former industrial site	high	Environmental impact assessment	1	1
				FS and cover design	0.3	0.6
				Repair of waste covers where inadequate	2.4	1.5
				Backfilling and closure of mine openings and shafts	0.5	1
				Collection and treatment of contaminated mine discharge	0.7	1
				Establish long-term surveillance and monitoring program	0.3	1
		Residential area	high	Gamma dose survey in residential areas	2	1.5
				Radon monitoring program	0.3	1
				Clean-up of the buildings, including residences where contaminated materials from the legacy site used	0.4	1
	2. Yangiabad		medium	EIA	0.6	1
				FS	0.5	0.7

				Remediation of ore storage yard and waste dumps near residential areas	1	1
				Closure of open mine workings	0.5	1
				Establish long-term monitoring program	0.3	1
Kazakhstan (KAZ)	1. Koshkar-Ata		medium	Evaluation of the remedial actions completed and assessment	0.2	0.5
				Establish long-term monitoring program	0.3	1
	2. Vostochny mine		medium	Evaluation of the remediation done.	0.2	0.5
				Assessment of long-term stabilization actions	0.2	1
				Establish long-term care program.	0.3	1
Mongolia (MNG)	General			Regulation and guidelines development for remediation requirements and long-term monitoring program	0.2	2

*possibly plus operational costs of water treatment and mine water monitoring for many years

Taking into account small variation in climatic, geographic and geotechnical conditions, the technical legacy problems left behind by uranium mining and processing in Central Asia are not very different from other countries. The most important constraints to the development and implementation of an efficient monitoring system and the application of remediation activities can be summarized as follows:

Costs of remediation and limited availability of national funding

None of the Central Asian countries allocated specific funds for mine closure and remediation. Except for Kazakhstan, none of these countries has a systematic national programme for remediation of the legacy sites. The Gross National Product of some Central Asian countries is relatively low, therefore it appears to be quite difficult for the governments to allocate specific funds for remediation programs and an external help for these projects may be required. A combined national/international financing programme would be a feasible approach in these cases, having in mind that priorities for "bankable" projects have to be fully justified.

Inadequate knowledge of the inventory of the legacy components and the risks associated with them

Except for some obvious cases, such as Mailuu-Suu, there is not sufficiently reliable data that would allow for the assessment of the real risks presented by the legacy sites. A reliable database is essential for justification and prioritization of the remediation, especially in case of sites that are less known. The preparation of the effective and efficient remediation plans requires additional data to that available for most of the legacy sites at the current stage.

It is necessary to undertake a consistent and reliable assessment of the uranium production legacy sites and their components, which should include:

- The creation of the inventory of both radioactive and non-radioactive contaminants, followed by their characterization;
- The effluent and influent streams from and to the disposal sites and the emissions to the air;
- Information on the geotechnical stability of the sites, erosion, stability of the current containment, if any, and the design details of the containment;
- Safety assessment methodology and risk assessment should become a common platform in remediation planning.

To develop the understanding of a site an appropriate monitoring and surveillance plan must be developed, including specifications of media to be sampled, monitoring locations, sampling methods, frequency and amount of samples to be taken, and analytical methods to be used for sample analyses. The use of the recently acquired instruments and equipment should be incorporated into these plans.

The decision regarding in-situ stabilization or relocation of residues such as tailings should be based on both the results available to-date and on the new data.

A long-term surveillance and monitoring program is essential to ensuring the effectiveness of any remedial action and continued risk reduction.

Public and social attitude toward the legacy sites

The health and environmental risks presented by the legacy sites are perceived very differently by the various stakeholders. The members of the general public residing in the vicinity of the legacy sites are quite often unaware of potential health hazards.

An example describing the complacency of local population used to the uranium mining and processing operations in their vicinity can be given from the Taboshar site in Tajikistan: A small farm is operating below a large tailings pile at the top of a valley which utilizes water that emanates from periodic seepages from the waste pile. A local shepherd appears to see no problems in grazing his animals directly on the tailings and waste rock piles overgrown with grass. In addition, different materials from the tailings storage facilities are occasionally used for construction purposes by the local population

Institutional controls must be implemented at these sites. **This is the single greatest risk reducing action the governments could take.** For institutional controls to be effective public communication about risks and hazards these sites present is essential. Equally important is the provision of alternate water supplies where local populations are utilizing contaminated water, or alternative livestock grazing areas etc.

Inadequate legislative and regulatory framework for mine closure and environmental remediation

Since independence in 1991, one of the major issues in the Central Asian countries is the lack of adequate technological and regulatory infrastructure. The requirement to assess, monitor and, if justified, remediate the legacy sites should come from a consistent set of legally-enacted health and environmental protection regulations.

A set of legal acts, decrees and regulations, which govern the remediation of sites is partially in place in Kazakhstan and, due to the understanding of the complexity of the remediation issues (prompted by the case of Mailuu Suu), some regulations are also being developed in Kyrgyzstan.

At the current stage a typical regulatory process does not include a requirement for an environmental impact assessment (EIA), at least not to the extent as in other countries where uranium is being mined and processed; not even for situations that may be considered as posing a serious hazard. A consistent set of practical regulations based on an environmental and human health risk assessment approach and using relevant international standards and guidelines is strongly recommended for adoption in the Central Asian countries. This could also facilitate, at least to some degree, the availability of international funding.

The main regulatory requirements to be established:

- Site characterization and safety assessment procedures;
- Organizational structure for site specific monitoring, surveillance programs, information exchange and data reporting;
- Criteria for cost effective remediation strategies;
- Institutional control; and

- Public involvement and risk communication.

Lack of personnel with uranium mining and milling experience or knowledge of remedial works

This problem appears to exist at all levels:

- Government administration that provides the funding,
- Regulators assessing and approving the permit requests, and
- Operators carrying out remediation works.

Personnel responsible for raising international funds and cooperation with the funding agencies, steering the national remediation programme, organizing the projects and controlling their implementation would need on-the-job training, which will need to be supported by experienced international experts.

Shortage of state of the art equipment and machinery

In addition to the need for the instrumentation needed for samples collection, analyses and data interpretation, there is also a lack of modern machinery that will be required for remediation projects. It appears that drilling rigs and sampling devices for investigation of the sites are not easily available. There is also a lack of mining equipment for the construction of covers, such as bulldozers and scrapers capable of working on steep slopes. There are no large size (100+ tonne) haul trucks available for relocation of waste rock or tailings.

The machinery that is available is typically old and relatively small in size, which would hinder the efficient implementation of remediation projects in accordance with international standards. Unless large scale investments can be made into mining machinery, the remediation plans must take into account that the pace of work will most likely to slower than in comparable projects elsewhere.

Finally, of utmost importance in overcoming the constraints to remediation, is the collection and dissemination of up-to-date information on latest technological advances and know-how in this area; preferably disseminating the information directly to the relevant countries.

1. INTRODUCTION

1.1.Territory, population and economic indicators

The legacy of five decades of uranium mining throughout Central Asia (Figure 2) is a source of concern for the population and the governments of the region. The abandoned mining activities have left radiological and chemical hazards (in the form of large volumes of unprotected uranium tailings, waste rock dumps) and physical hazards (unsecured shafts and entrances to the underground mines) in these countries.

Figure 2. Regional map

There are significant national differences. Table 4 gives an overview of relevant country specific data.

During the 1970s and 80s, more than 30% of the uranium production of former USSR came from the Central Asian republics. The extensive uranium production left behind a huge legacy of mining and processing wastes.

In general the areas of former uranium production and waste disposal are vulnerable to wind and water erosion, resulting in the risk of radiation exposure for the population living nearby via both inhalation and ingestion pathways. Furthermore, some of the legacy sites are located in seismically active, landslide – and/or flooding–prone regions posing additional radiological and other threats to the environment and the population in the areas around the sites. At some sites not only mining but also processing of uranium ores took place, which has resulted in additional problems associated with the presence of both organic and inorganic chemicals. The risk is often shared with a neighbouring country, due to the shared Central Asia water basin.

Table 4. Territory, population and economic indicators of the countries of Central Asia [5]

Country (rating based on the human development index (HDI))	**Territory** (km²)	**Population** (million)	**Population density** (people/km^2)	**Gross Domestic Product** (GDP), 2007		**GDP per capita** (2007)		Annual growth rate (%) 1990 - 2007
				(US$ billions)	(PPP in US$ billion)	(US$)	(PPP in US$)	
82 Kazakhstan (**KAZ)**	2 727 300	16.4	6	104.9	168.2	6772	10 863	3.2
115 Mongolia (**MNG**)	1 564 116	2.671	1.7	3.9	8.4	1507	3236	2.2
119 Uzbekistan (**UZ**)	447 400	27.606	61.4	22.3	65.1	830	2425	1,2
120 Kyrgyzstan (**KIG**)	199 900	5.482	27.4	3.7	10.5	715	2652	-0.4
127 Tajikistan (**TAD**)	143 100	7.349	48.6	3.7	11.8	551	3685	-2.2

Note: PPP – Purchasing Power Parity.

Source: Human Development Report 2009: Overcoming barriers: Human mobility and development UNDP 200

1.2.Background and historical development

The Soviet Ministry of Medium Scale Machine Industry was responsible for the uranium industry in the former Soviet Union., including the function of the regulatory body. The regulatory standards ("norms") for exposure and emissions control were prescriptive and applied uniformly across the country, which made their application easy to administer. The applied maximum permissible limits were comparable to the European/US standards of the 1960s and 70s. However, because of the dual responsibility of the Ministry the achievement of production targets usually took precedent over environmental, health and safety standards. Production targets were strictly enforced and production performance supported by a reward system; compliance with the health, safety and environmental standards was obligatory but not enforced to the same degree.

At the time of the uranium production boom in the 60s and 70s there was no requirement to collect and evaluate baseline data and assess the environmental impact prior to the development of new mining and processing sites and consequently, no such data is available for comparison with the present day situation at the legacy sites.

During the Soviet period of Central Asia, a large number of uranium mines operated in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan with no requirement for the planning of remediation or provision of remediation funds. The closure of mines and processing plants took place at various times between 1961 and 1995 but only the waste sites located relatively close to large population centres were remediated to any degree.

Past and current activities

For the development of effective solutions for the uranium legacy sites in the Central Asian republics it is necessary to take into account the history of the uranium industry in the region and the conditions found when the Central Asian republics became independent (1991). At that time the institutions responsible for common economic policies and transfer of goods and services between Central Asian republics ceased to exist, and the uranium industry of the newly independent countries lost their traditional customers due to a stagnant uranium market. There was a general economic downturn as these countries transitioned to a market–oriented economy.

The fate of the legacy sites after independence was considerably different in the individual Central Asian republics. While in Tajikistan and Kyrgyzstan the uranium mining and production ceased entirely, in Uzbekistan and Kazakhstan the production of uranium continued. Due to the low uranium price on the world market, the previously extensive conventional uranium mining operations could only be maintained for a limited time. Most of the conventional mines and processing plants in Central Asia ceased operations by 1995. The decommissioning and closure of the conventional uranium mines in some cases has been carried out with a limited technical or regulatory experience and without adequate funding, in other cases the sites were simply abandoned. A common problem after independence was the lack of qualified specialists and experience in this field.

Tajikistan has closed all its mines. Uzbekistan has 12 uranium mines in operation and is constructing 2 more. Kyrgyzstan closed its mines but has re-opened its mill at Kara-Balta operating on uranium from Kazakhstan. More than 10 mines have been closed in Kazakhstan, but as many are in operation or under exploration/construction. Mongolia has 2 abandoned uranium mines which are likely to be re-opened in the near future by foreign companies or joint ventures with Mongolia.

Along with the closure of the uranium mines and processing plants a large number of operational tailings storage facilities were closed as well. The only large tailings storage facilities which continue operation are the ones at Aksu in Kazakhstan (operated by the Stepnogorsk Mining-Chemical Combine), Kara-Balta in Kyrgyzstan (operated by the private enterprise Kara-Balta Mining-Chemical Combine) and Navoi in Uzbekistan (operated by the enterprise Navoi Mining-Metallurgy Combine).

After 1995 uranium mining focused on in situ leaching (ISL) or open pit mining, wherever the geological conditions were favourable (in Kazakhstan and Uzbekistan). The only conventional uranium mine operating in the region at present is the Vostok/Zvezdnoe mine in Kazakhstan. Most of the uranium production today comes from in-situ leaching and the rate of waste generation is very low compared to other mining techniques.

By summer 2003, the global uranium market started recovering and uranium production in Uzbekistan and Kazakhstan made a strong comeback. Presently, Kazakhstan and Uzbekistan are among largest uranium–producing countries in the world.

Early in 2009 the Navoi Mining-Metallurgy Combine announced plans to develop seven new uranium deposits (out of 27 major uranium ore bodies) in Uzbekistan. At five of the seven targeted ore bodies, in the areas of Sugraly, Northern Kenimeh, Ketmenchi, Meilysai and Tutlinskaya the exploration works are underway.

General issues

There are two important issues that need to be addressed in all Central Asian countries:

- The Central Asian countries appear not to have sufficient resources (such as specialized equipment, trained and experienced personnel, infrastructure, practical regulations applicable in practice) to solve the issues associated with numerous uranium legacy sites.

- The problem is essentially international as political tensions could arise in the event that a leakage or catastrophic failure due to a seismic event at an un-remediated site in one country could result in the radiological and chemical contamination in another country;

Therefore, several common problems need to be addressed:

a) Regulatory framework

There is an urgent need of support and commitment to be supported both internally and externally in such regulatory work as:

- The development consistent regulations and technical standards;

- The development of guidelines for future remediation activities and for long term monitoring;

- The establishment of exposure limits, dose constraints and intervention levels;

- Establishment of training programs particularly in radiation protection aspects of uranium mining, processing and waste management, both for the inspectors of relevant regulatory authorities and for personnel involved in remediation projects;

- Provision of adequate equipment and infrastructure;

- Coordination between various responsible regulatory bodies within country;

- Provision of adequate staffing levels and funding.

b) Site issues

There are several common issues associated with most of the legacy sites, as detailed below:

- Most of the legacy sites are freely accessible to the public, which create exposure pathways
- In many cases the “historical” information on the sites are non-existent making proper safety or comprehensive environmental risk assessments (EIA’s) infeasible. Most sites need EIA’s and feasibility studies which would lead to the development of remediation plans. Cost estimates could be made for these plans and presented to potential donors.
- The geotechnical stability of some tailings storage facilities and physical hazards (shafts, open pits) are likely to represent a hazard that is much more serious than potential radiological issues associated with the material stored at a particular site. This issue is exacerbated by the fact that in some countries these legacy sites are located in the areas of elevated seismic activity.
- Toxicological issues due to the presence of metals are poorly understood at most of these sites.
- Groundwater impacts at many of these sites are yet to be evaluated.
- In many cases where the measurements of the dose rates and, in particular, radioactivity content in soil, air and water have been undertaken, the amount of data available and the above-mentioned lack of quality control do not allow for a comprehensive assessment of radiological hazard represented by many legacy sites.
- Public understanding of these hazards is low.
- There is a lack of comprehensive monitoring programs (air, soil, water) and no reporting requirements.
- Where some remediation has taken place there is no longer term maintenance and monitoring to ensure the integrity of the remedial works.

c) Public communication and information

The development of an effective public information and communication strategy on the issues of uranium production legacy sites is vital for the success of all planned remedial actions. Such strategy should be developed in each individual country, taking into account national. It should include risk and hazard communication and educational programs.

d) Education and training of personnel

The training and education of professionals in all countries is also considered to be essential for the success of remediation projects. The training in the following areas appears to be necessary:

- Project design and management;
- Contracts and procurements;
- Radiation protection;
- Long term monitoring of all media – soil, air and water;

- Environmental and safety assessments, specifically for the tailings of the uranium mining and processing;

- Analytical capabilities including proper equipment, correct operation of analytical equipment, QA/QC programs, trained staff etc.

That list is by no means exhaustive as the specific needs of individual countries will undoubtedly differ.

1.3.Structure

This document consists of six sections and one appendix. In Section 2, a methodology of risk (based on the sources of data describing the current status of engineered structures and the environmental situation, as well as the experience of experts) and cost estimation (on the basis of specific costs of comparable projects in the region) are provided. Section 3 is a brief description of the major uranium production legacy sites as currently known from the information provided by the respective country. There is a brief overview of the legislative and decision making structures and proposed measures relating to specific legacy sites. Section 4 consists of proposals for regional cooperative activities and Section 5 briefly describes the necessary organizational work for remediation preparation and coordination. Summary and conclusions reached are presented in Section 6, including proposed remediation related activities country by country. Appendix contains the Risk Evaluation Sheets and an overview of proposed site remediation measures.

2. METHODOLOGY OF RISK AND COST ESTIMATION

2.1.General approach

Decisions regarding remediation of former uranium mining and processing sites in Central Asian countries should be based on the substantiated estimation of the risks represented by these sites. The estimation of these risks should be based on the detailed information describing the current status of engineered structures (i.e. tailings storage facilities), and the environmental situation, such as radiological monitoring data and estimation of potential doses of the members of the general public (calculated using actual exposure pathways and taking into account the diet and other factors characteristic for a specific group of people).

The probability of containment failure of tailings storage facility containing waste from uranium processing is not different from the probability of failure of the facility for conventional mining and processing wastes at the same site. The different level of risk associated with uranium processing wastes is associated with different consequences following a containment failure or a spill of wastes. In the case of uranium processing wastes (and similarly to the waste generated during chemical processing of some other minerals) the spill may represent additional hazard due to the presence of radionuclides and different chemicals in the waste.

The probability of a sudden failure of a tailings storage facility and the likelihood of a subsequent release of contaminants as well as the probability of an uncontrolled seepage depend on the site characteristics, type of the facility and effectiveness of the safety measures that were put in place during construction and operation of a particular facility.

The assessment done in this report is based on the aggregative expert's risk analyses. The methodology is described below. To keep the risk level as low as reasonably achievable, it is a good policy to manage the tailings storage facility in accordance with the internationally recommended standards and guidelines – both during the operational phase and after closure and remediation. The underlying principles and Proposals of the experts is based upon IAEA Safety Guides: WS-G-1.2: "Management of Radioactive Waste from the Mining and Milling of Ores" [6] and SR-27: "Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium" [7] and other IAEA guidance documents (such as RS-G-1.7 [8], RS-G-1.8 [9], SR-35 [10]) and EC documents (RP-112 [11], RP-122 [12], RP-124 [13]).

With regard to site specific risks, due consideration needs to be given to:

- Site conditions (geology, seismicity, climate, upstream and downstream water catchment areas, etc.);
- Extreme events specific to the site (heavy rain, flood, earthquake, etc.);
- Impact of potential dam failure scenarios (slurry flow pathway, downstream land use, water use, etc.);
- Type of storage (engineered features such as tailings embankment, covers material, drainage structures);
- Results of a quality assurance program for the technology and materials used and for the remedial works;

- Results of monitoring and surveillance (erosion, seepage, dam movements, etc.);
- Upgrading of waste management facilities where safety measures are considered to be inadequate (by constructing diversion canals and retention walls to prevent excessive inflow, decreasing the slope angle of the landform containing waste and embankments; or – where the level of risk cannot be sufficiently decreased, consideration of alternatives, such as relocation of the material; and

Long-term potential risk including beyond containment/embankment failure, dusting, excessive seepage, long-term erosion, bio-intrusion, etc.

Limited assessments of most of the uranium legacy sites in Central Asian countries were carried out in 2005-2008, but no comprehensive evaluation has taken place. In most cases information about the sites is limited to qualitative data and statements of local experts. Environmental and radiological data are mostly fragmentary and is not considered sufficient for a comprehensive description of the real situation. The risk estimates presented in this document are based on the expert judgement of international and local experts with long-term experience and expertise, and by comparison with similar sites and projects worldwide by using all currently available data and IAEA guidance.

2.2.Data compilation and data base

In the process of preparation of this document many possible sources of data were identified and were invited to contribute relevant information. The main information sources are:

- The owners of the relevant sites, the appropriate authorities and companies in the countries;
- Existing reports of consultants and different international organisations (i.e. IAEA reports RER/9086 [15] , Final Report TACIS Regional Project No.G 4.2/93 [16], NATO SfP 981742 project report [17], OSCE and EurAsEc project proposals for site remediation and other);
- Planning documents of ongoing remediation projects (Mailuu-Suu, Kara-Balta);
- The Framework Document for Kyrgyzstan, prepared by national experts and compiled by the UNDP;
- Freely accessible Internet resources, including scientific papers and data;
- Archives of the former MINATOM (now ROSATOM) in Moscow (the data from archives in Moscow is not yet available).

Additionally, questionnaires (see Annex) were prepared and sent to relevant countries, including a “risk evaluation sheet” as a tool for the evaluation and justification of single risks.

The questionnaires were filled out with all available data by the responsible organisations in the relevant countries and a respective ranking table for each country, based on their own opinion and experiences, was also prepared.

2.3.Risk estimation

The estimation of risk is based on the experience of experts, combined with the evaluation of the available data and discussions with local specialists. Abandoned uranium mining and processing sites present specific problems and risks, (i.e. stability of dams, slopes and underground openings, heavy metals and other contaminants in mining residues and water) associated with the increased levels of radioactivity.

Radioactivity can be not only the cause of the increase in dose levels and associated health risks, but can also lead to increased concern of the nearby population due to the lack of knowledge and reliable information.

The risks were grouped as follows:

- "Natural" risks (seismicity, occurrence of landslides, storm events);
- Political and economical risks (issues associated with the sites that have transboundary impacts, lack of funds, and vandalism);
- Site specific risks, subdivided into:

⇒ radiological risks;

⇒ non-radiological risks (i.e. heavy metals in water); and

⇒ geotechnical and mining-specific risks (i.e. dam stability, shafts, open workings).

It has become common to use a "Geotechnical, Hydrological, Environmental, and Economic Rating Matrix" (GHEERM) [19] in risk assessments to assist in the complex assessment of technical and economic factors applicable to the decommissioning of a uranium waste management facility. The "GHEERM matrix" has been adjusted to accommodate and compare the critical components of the uranium legacy sites in Central Asian conditions.

Table 5 on the following page describes the numerical rating system that was developed to assess the clean-up options to be considered at "priority" sites. The anticipated performance of each option is "scored" against a standardized set of important technical and economic factors.

Table 5. Rating system based on balance of probabilities

Factor	Rank					Score
Containment integrity: Geotechnical Hydrological, hydrogeological	very poor	poor	moderate	minor	excellent	
Public safety: Access Exposure	very easy very high	easy high	remote moderate	remote with restrictio n restrictio ns minor	total restriction normal	
Receiving environment: Aquatic, terrestrial Atmosphere, radiol.exposure	very high potential impact	high	moderate	minor	insignificant potential impact	
Occupational health ja safety: Conventional Radiological	very high threat	high	moderate	minor	insignificant threat	
Implementation: Time to complete, cost Ability to monitor, future burden Public preference	very high constraints	high	moderate	minor	insignificant constraints	
Risk of failure	very high	high	moderate	minor	insignificant	

Specific information collected during the IAEA projects in the region was used to rank each legacy site.

To ensure that remedial actions are effective in the long term the following factors must be taken into consideration:

- The integrity of the containment structure with respect to geotechnical, hydro-geological and hydrological performance;
- Public safety: the ease of access to the tailings storage facility and potential for the exposure of the local population to radiation via different pathways (the assessment should consider not only the regional established population but also the potential for transient members of the general public to visit the site);
- Protection of the environment: components such as aquatic, terrestrial, atmospheric and radiological performance were selected as representative environmental protection indicators for a tailings storage facility. For the purpose of this assessment the atmospheric score reflects the potential impact from wind blown tailings and radon, while the radiological component primarily takes into account gamma radiation. The potential for spills during tailings relocation are taken into account where appropriate;
- Potential impact on all aspects of occupational health and safety of workers that would be required to implement a particular option (all aspects of industrial hygiene needs be taken into account – such as exposure no noise, heat/cold, different atmospheric contaminants and ionizing radiation;

- Ease of implementation: the assessment takes into account economic and logistical factors such as scheduling, cost, ability to effectively and reliably monitor the decommissioned site, and anticipated public preference considerations. The public preference factor was assessed a score based on a review of the public's response to various decommissioning options that have been discussed during public consultation. A major factor that is included in this section is the "future burden" potential for a particular option. This score reflects the potential for an economic or environmental burden due to a decommissioned site developing problems in the future; and

- The risk of failure.

The "score" for each factor was generated by applying professional judgment regarding the "rank" of each factor against the "balance of probabilities" for each potential response of the option under consideration. This approach allows for a general comparison of all options and sites by comparison between their total scores. The use of scores also allows for the comparison of the sensitivity of the various options.

For the actual estimation of the risks, five levels from "zero" to "extreme" were used. The result of the risk estimation is a single value that summarizes all risks for the entire site. Because of the uncertainties in the assessment procedure (see Chapter 2.1 above), this summary value is not a mathematical sum or weighted average but a result of weighting the different risks in a qualitative way.

The Figure 3 on the following page shows the risk evaluation sheet for the Mailuu-Suu site in Kyrgyzstan as an example. For the Mailuu-Suu site, the summarized risk value is "high" (4) because of the high probability and the high risk potential of natural events and the engineered structures (tailings ponds) which can be affected (see row 4.2).

By using this evaluation method all sites can be ranked and, as a result of the risk estimation each site has been assigned risk value (see Chapter 3 and Annex).

2.4.Examples of risk estimation

Generally, the major issues to be considered in the remediation and closure of tailings and waste-rock management facilities include the long-term: Physical stability of structures, chemical stability of tailings and waste-rock, and subsequent land use.

A difference in approaches for the remediation and closure of tailings ponds and waste dumps from uranium ore mining and processing is due to the additional need to minimize radiation levels to ensure that the exposure levels for the members of the general public at as low as reasonably achievable, taking into account social and economic factors.

In particular, the following issues need to be addressed:

- Minimization of the emanation of radon gas from the waste body;
- Prevention of the exposure to the direct gamma radiation from the surface of the waste;
- Prevention of the wind-blown dispersal of dust containing radionuclides from the surface of the waste; and
- Minimization of discharges of contaminated water from the waste body or from the surface into the groundwater or water streams.

Risk Evaluation Sheet

Country	Kyrgizstan
Name of site/complex:	Mailuu Suu
Name of object	Entire Mining and Milling Complex
No. of data sheet	Ky MS risk

Risk Catalogue		Risk categories (estimation): probability of occurence	risk potential (consequences of occurence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)	remarks
		1 zero 2 low 3 medium 4 high 5 extreme	1 no risk 2 low 3 medium 4 high 5 extreme	Please fill in data sheets for all named single objects and mark the relevant risk parameters!	
Summarization for the entire site (complex)		4	4	TP 3; TP 13+ 2+4+ 1; TP 5+7	
regional, "natural" environmental risks					
0.1	seismic activity, earthquake risk	5	4		
0.2	landslides	5	4		
0.3	extreme precipitation rates, risk of flooding and mudflows	4	4		
0.4	extreme storm events	2	3		
general risks					
1	"political + economical" risks				
1.1	assumed cross border impact, (possible) conflicts with neighbouring countries	4	4	TP 3; TP 13+ 2+4+ 1; TP 5+7	
1.2	increased anxiety of the local population, political pressure	4	3		
1.3	obstacles for development chances in the region, deterrance of investors	4	3		
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	4	3	all objects	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	3		
site specific risks					
2	radiological risks				
2.1	elevated level of gamma radiation in the environment	2	3		
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	3		
	elevated concentrations of radio-nuclides in water	2	2		
	mine water	2	3		
	seepage water	2	3		
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	2	3		
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstreams of rivers)	3	3	TP 3; TP 13+ 2+4+ 1; TP 5+7	only possible after an extreme floodings or river blocking
3	non-radiological risks (toxic/ cancerogenic substances, e.g. U as heavy metal, As)				
3.1	in water				
	pollution of groundwater	2	3		
	pollution of drinking water ressources in the region of the site	2	3		
	pollution of surface water - intake in a river system, damage to ecosystems	2	3		
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	2		higher during remediation works
4	"geotechnical" and mining specific risks				
4.1	danger of dam failures	2	3	TP 13+ 2	
4.2	danger of overflooding of dams or contaminated objects	4	4	TP 3; TP 13+ 2+4+ 1; TP 5+7	TP 3 remediation planned
4.3	danger of surface cracks and strong subsistences in populated areas	2	2		
4.4	danger of rockfalls, sliding of steep slopes	2	3	WD 1+2+6	in remediation

Figure 3. Example of the risk evaluation sheet for Mailuu-Suu

In many cases tailings ponds and waste dumps are part of a former uranium mining and processing sites with features like buildings, open mine workings, shafts, open pits that may pose some additional risks. It is recommended to include all associated structures in a comprehensive environmental impact assessment (EIA) and estimate their respective contributions to the environmental impacts and risks of the entire site. This allows the prioritization of remediation related activities in a manner that optimizes the use of available resources.

2.5.Options of cost estimation

The following technical options are available to meet the criteria described above:

- Fencing and/or guarding of the contaminated areas on a particular site (physical protection and signage);

- Reduction of the steepness of dams and/or slopes to improve the structural stability and safety by cutting and/or filling of material;
- Covering/capping of the surface of tailings and mine waste using suitable earth material or technical barrier, and re-vegetation of the surface;
- Relocation of contaminated material to more appropriate storage, either completely or partially;
- Installation (and repair where necessary) of water management systems (ditches, perimeter channels, dams etc.);
- Installation and maintenance of water treatment systems;
- Demolition of contaminated buildings and installations, and appropriate disposal of scrap and other demolition waste (i.e. in tailings dams before covering);
- Providing engineering barriers (concrete dams, plugs, backfilling) of open mine installations (shafts, tunnels, workings).

For each site and each particular situation the appropriate technical solution should be determined on the basis of a detailed technical planning and design process.

2.6.Basis of cost estimations

The estimation of costs associated with the remediation of Central Asian uranium mining and processing legacy sites is required. Unfortunately, for most of the sites no EIA's or other planning documents are available. In addition, the baseline data for the sites is, in many cases, not sufficient for a justified statement of technical measures as basis for more precise cost estimation.

In order to provide at least an approximate estimate of the costs as basis for a project ranking and decisions on higher political level, the following general assumptions for all sites were made on the basis of experiences with similar projects:

- The surface of tailings ponds has to be covered with a multi-layer or soil/rock cover with an average thickness of 2 m and the surface of waste dumps has to be covered with a one-layer cover with the thickness of 1 m. Typically, it is expected that the cover material will need to be transported a distance of 10 km.
- The surface has to be re-vegetated, and additional engineering measures for water management and erosion protection have to be implemented.
- Mine and seepage water with elevated concentrations of uranium and/or other contaminants has to be treated.
- Open shafts and open mine workings have to be secured (filled).

Cost estimations are made on the basis of specific costs from comparable projects in the region i.e. the "Disaster Hazard Mitigation Project" (Mailuu-Suu site) in Kyrgyzstan and the "Ust-Kamenogorsk Environmental Remediation Project" in Kazakhstan, both financed by the World Bank. Additionally the results were compared with planning costs of other similar projects worldwide (i.e. Wismut-Project, Germany; relocation of AMCO uranium tailings, Zambia; and Lermontov Uranium Mining Remediation project, Russia).

2.7.Costs estimates for specific items

Main cost factor for all projects is the loading, hauling and placing of large volumes of material. In the absence of specific data it would be prudent to assume that the specific costs for these activities are within the same range.

The following specific costs presented in Table 6. below were used for the average cost estimations.

Table 6. General cost factors of different work steps

Work step	Unit	General costs
Earth works		
Excavation of earth material, loading on trucks	EURO/m^3	1
Haulage, distance 10 km	EURO/m^3	4.5
Unloading, compaction	EURO/m^3	1.5
Sub-total transport	**EURO/m^3**	**7**
Re-vegetation, water catchment, erosion protection	EURO/m^2	1.5
Water treatment		
Investment costs (until 10 m^3/h)	EURO/m^3	50 000
Investment costs (more than 10 m^3/h)	EURO/m^3	30 000
Annual treatment costs	EURO/m^3	2
Other costs		
Drilling including equipment for water monitoring	EURO/m	150
Plugging or backfilling of shafts	EURO/shaft	50 000

3. COUNTRY SITUATION

3.1.Kazakhstan

3.1.1. Introduction

Among the Central Asian countries, Kazakhstan has the strongest economy and the fastest growing uranium production. Regarding the potential for further growth it is important to note that approximately 20% of the world uranium reasonably assured resources are located in Kazakhstan. Figure 4 shows the sites of uranium industry and additional data for these sites is provided in Table 7.

Figure 4. Sites of uranium industry in Kazakhstan

The responsibility for the uranium mining lies with the National joint stock company „Kazatomprom“. A review conducted in 1993 has identified 127 uranium mining/processing legacy sites located in three areas:

Northern Kazakhstan

The legacy sites in this area are associated with 12 uranium deposits: These include the Kokshetau area, the group of mines of Kozatchinnoe, Shatskoe, Glubinnoe, Agashskoe, Koksorskoe; and Manybaiskoe mine; and in the Stepnogorsk Hydrometallurgical Plant Processing plant tailings disposal site. The total amount of waste is 81.2 Mt;

Southern/central Kazakhstan

The legacy sites in this area are associated with 4 deposits: Kurday, Vostochniy, Zapadniy in the Zhanbyl region (in Southern Kazakhstan) and Karasaiskiy, Ulken-Akzhal in Central Kazakhstan. The total amount of waste is 117.8 Mt;

Western Kazakhstan

The legacy sites in this area are associated with 2 deposits and the Koshkar Ata tailings site near Aktau. The total amount of waste is 58.9 Mt.

Table 7. Sites of uranium industry in Kazakhstan

No *	City/Name	Object	Number of objects	Status	Remediation Activities
1	Akdal mine (ISL)	mines	1	in operation	no information
2	Inkay project (ISL)	mines	1	in operation	no information
3	Kandjugan mine (ISL)	mines	1	in operation	no information
4	Munkuduk project (ISL)	mines	1	in operation	no information
5	Muyunkum mine (ISL)	mines	1	in operation	no information
6	Uvanas mine (ISL)	mines	1	in operation	no information
7	North-Karamurun mine (ISL)	mines	1	in operation	no information
8	South-Karamurun mine (ISL)	mines	1	in operation	no information
9	Zarechnoye project (ISL)	mines	1	in operation	no information
10	Tasmurun	mines	1	standby	no information
11	Taibagar	mines	1	standby	no information
12	Tomaskoye	mines	1	closed	no information
13	Aktau/Melovoye	mines	2	closed	later
14	Zaozerniy/Zaozernoye, Mine No.8	mines	1	closed	completed
15	Tastykolskoje/ Rudnik No.9	mines	1	closed	completed
16	Aksu/Manybaiskoje	mines	1	closed	completed
16'	Shatskoe	mines	1	closed	completed
17	Kokshetau/Ishimskoje	mines	1	closed	completed
20	Kokshetau/Vostok	mines	2	in operation	later
21	Kokshetau/ Balkashinskoje	mines	1	closed	completed
21′	Shokpak/Shokpak, Kamyshovoje	mines	2	closed standby	completed
22	Saumalkol/Grachevskoje/ Rudnik No.12	mines	1	closed	completed

22′	Kokshetau/Kosachinoje		1	standby	completed
23	Muzbel/Kurdai	mines	1	closed	completed
24	Aktau/ Koshkar-Ata	mill tailings	1	closed	Partly completed, international expertise required
25	Tselinny/Stepnogorsk	mill tailings	1	suspended	later
	Tselinny/Stepnogorsk	mine	3	in operation	
	Tselinny/Stepnogorsk-Zaozerniy	mine waste	2	in operation	
26	Botaburum/Vostochniy	mines	2	closed	completed
	Botaburum/Vostochniy	waste rock	2	closed	
27	Kysylsay/Zapadniy	mines	7	closed	completed
28	Shalgiya/Djideli	mines	1	closed	completed
29	Shalgiya/Kostobe	mines	1	closed	completed
30	Balkashinskoe	mines	1	closed	completed

*The number is related to the map above

Most of the mines listed above ceased operation in 1995. The inventory of the legacies comprises (approximately): 368 M m^3 mine waste piles; 13 M m^3 low grade ore piles, 869 K m^3 ore stockpiles, 4.9 M t of metal scrap and building debris and 865 ha of contaminated areas.

The Government of Kazakhstan adopted a legislative framework to deal with the legacy sites and established the State Program for "Remediation of (the sites left behind by) Uranium Mining Enterprises and Mitigation of the Consequences of Mining of the Uranium Deposits defined for the period 2001-2010". The responsibility for the implementation of the program was given to the SE Uranlikvidrudnik established in 1999.

This Programme was approved by State Decree No. 1006 of the Republic of Kazakhstan in 2001 and is financed annually from the country's budget (more than 3 million US dollars per annum).

The program is designed to be carried out in 2 stages; the first stage has been completed in 2006 and has included 6 sites in Northern and 2 sites in Southern Kazakhstan. During period 2007-2009 most of these legacy sites were remediated.

By 2007, the remediation was completed at the mine sites No. 12, 3, 1, Kozachinnoye, 8, 9, and 14; and Kurday as well as for the parts of the Vostochnyj mine (where mining continues in other parts of the mine). The remediation included (a) sealing and cementation of the shafts and raises, (b) removal of the contaminated soil, (c) collection of the scrap metal, disposal of the contaminated and recycling of the non-contaminated scrap metal, (d) decommissioning, dismantling, demolition and/or decontamination of related buildings and structures, (e) disposal of the contaminated debris into waste piles, (f) grading of the surface and concentration of the waste into rock and mixed waste rock/debris piles, (g) covering of the piles with a soil cover up to 1 m thick, (h) fencing of the area if located within 5 km of a settlement. Some visual results of the site remediation are shown on Figure 5.

Figure 5. Covering of a stabilized waste rock pile at the mine site No. 9 in N. Kazakhstan

The completed works included the decommissioning and sealing of 43 shafts and 22 ventilation shafts and raises, remediation of approximately 75 M m^3 of waste piles, 30 M m^3 of mixed waste piles, 6.7 Mm^3 of low grade ore piles and approximately 400 ha of contaminated soil. By the end of 2007 approximately 20% of the legacy sites had been remediated.

The safe flooding control of the mines and handling of the contaminated mine water proved to be a challenge and the issue of water treatment will have to be addressed in the next phase of the remedial program. Figure 6 shows an example of a mine wall collapse into an open pit mine which resulted in flooding the pit. The solution for this type of problem has not yet been found and it is expected that future remediation planning will address this issue. On of the greatest future challenges in Kazakhstan will be the remediation of the tailings impoundments of the former Stepnogorsk Hydrometallurgical Plant. There are 46.8 Mt of the tailings deposited in three compartments of a tailings impoundment, which extends over 734 ha. The present state of the compartments is as follows: compartment No.1 is filled, compartment No.2 is operational and receives tailings from the plant and compartment No.3 is left to evaporate. Presently, approximately 1.5 Mt of tailings are being discharged into the impoundment annually. In all 3 compartments the tailings surface is unconsolidated below the surface crust.

The recommendation regarding this site is to commence the monitoring of the tailings dust for alpha activity and to ensure continued groundwater monitoring to evaluate the impacts of the seepage from the unlined tailings ponds.

Figure 6. Collapse of the mine No.3 after ground water rebound in northern Kazakhstan

The current (2009) remedial work is focusing on the stabilization of the tailings at Stepnogorsk and on the commencement of remediation at the Koshkar-Ata site on the Caspian Sea, near Aktau in western Kazakhstan. At the Koshkar-Ata site, the operations of the former Caspian Hydrometallurgical Plant left behind approximately 52 Mt of mine waste spread over an area of 66 km^2 and a uranium tailings pond extending over an area of 77 km^2. Typically, about a half of the tailings pond area is covered by water (with the extent of the coverage dependent on the season), while the other half of the tailings pond is dry and is likely to be a source of radon and airborne dust. The gamma-dose rates over the tailings vary from 10 μSv/h to several Sv/h. Measurements by SE “Uranliquidrudnik” show that in the southern parts of the tailings pond the gamma dose rates exceed 10 μSv/h.

The explanation for the high dose rate is that in the southern part of the tailings pond an area covering more than 15.8 km2 may have been used for dumping of radioactive sources; Approximately 140 Kt of radioactive waste unrelated to uranium processing were disposed here. Unfortunately, this same part of the tailings pond is also a popular scavenging ground for scrap metals. Thus the remediation goals for the site are the prevention of the generation of airborne dust and of unauthorized collection of scrap metals from the tailings (Figure 7).

The present remedial plans for the southern part of the Koshkar-Ata tailings deposit contain the placement of a concrete cover over the tailings, which subsequently will be covered with waste rock from the adjacent pile. The planned remedial solution deviates considerably from the practice of tailings remediation. It is the recommendation of the experts involved with this assessment that an international review of the overall remediation plans for the Koshkar-Ata site be conducted.

Scrap metal (decommissioned equipment of the former Caspian Hydrometallurgical Plant) is located in the close vicinity of the tailings pond. Although the storage yard is surrounded by a concrete wall a timely resolution of the fate of the collected scrap metal is strongly advised.

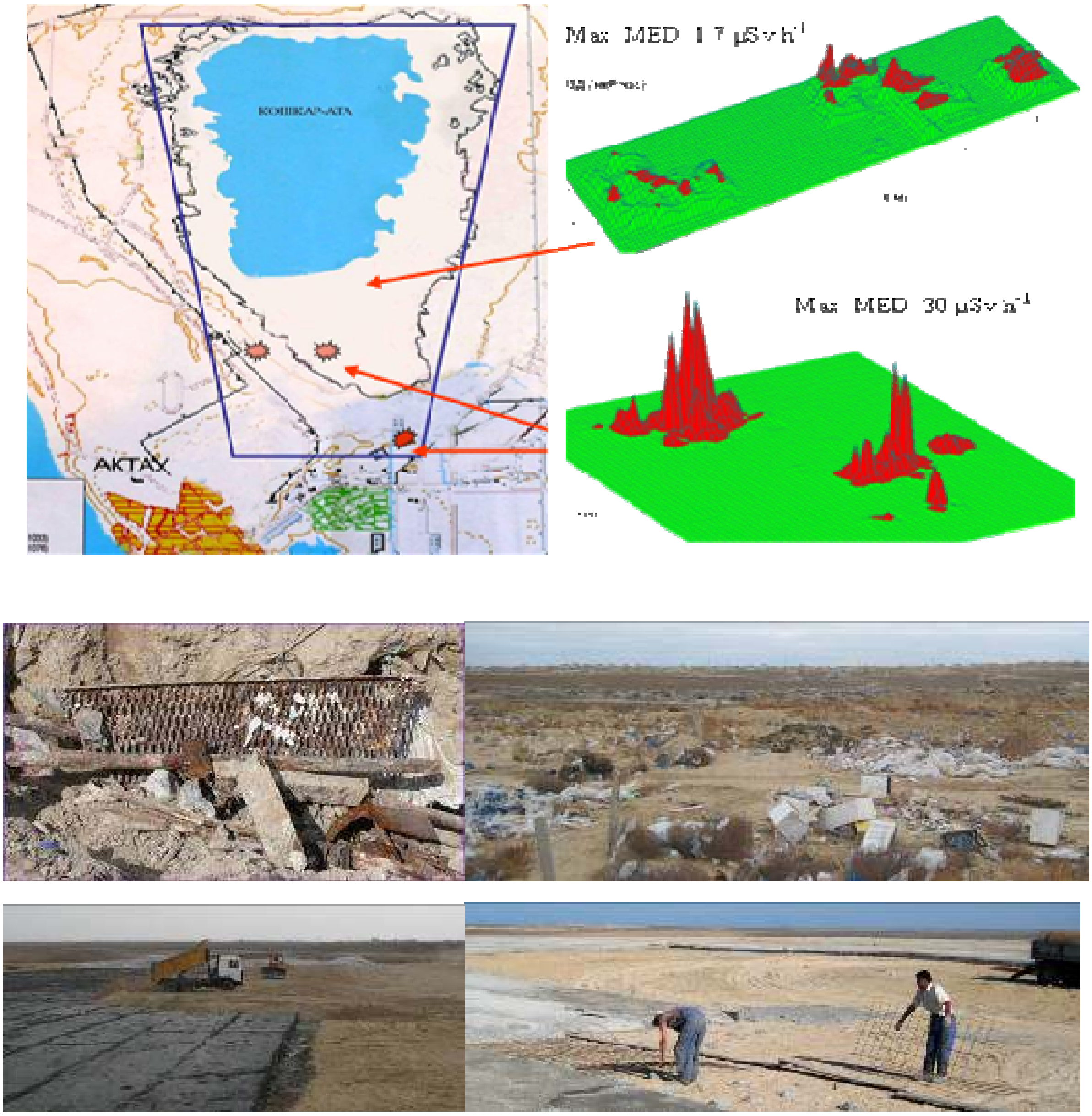

Figure 7. General view on the Koshkar-Ata uranium residue tailings bear Aktau city (western Kazakhstan) with still recently allocated radioactive waste storage facilities derived from the Caspian Hydrometallurgical Plant before and after partial remediation done in 2009.

The development and establishment of the efficient site specific monitoring and surveillance programmes around the uranium legacy sites and efficient institutional control at the remediated sites are appears to be problematic. To evaluate further actions needed, to develop and launch site specific monitoring programs, and to establishing the effective management system for remediated legacy sites the Government of Kazakhstan Republic requested international support (see project proposal RK 2 in the UNDP Framework Document proposal, 1.4 million USD, 1 year duration).

3.1.2. Legislative and regulatory framework

In 1997 Kazakhstan signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [14], which allows for the modification of the national waste management concepts (developed in 1992) in accordance with internationally accepted practice. Permits and licenses issued to the specialized government and private companies in regards to the radioactive waste and residues from uranium mining and processing became a part of normal practice in the country.

Four ministries are involved in the licensing process:

- Ministry of Energy and mineral resources [safety analyses, through the Kazakhstan Atomic Energy Committee – KAEC],
- Ministry of Health (radiation safety),
- Ministry of Environmental Protection (ecological audits),
- Ministry of Emergency Management (accident management).

Responsibility for licensing in the sphere of radioactive waste management lies with the Kazakhstan Atomic Energy Committee KAEC.

Major problem is the large amounts of wastes from the mining of uranium ore and its processing, which cannot be associated with a specific owner. The remediation of these sites (dumps and settling ponds) therefore, appears to be a financial problem for the Kazakhstan Government.

The newly amended (2008) Environmental Code [20] provides a good legal framework for environmentally responsible management of uranium resources and legacy sites. Nevertheless, the interpretation, implementation and enforcement of the Environmental Code is not yet noticeable at the working level of the uranium producing companies and regulating authorities.

Although considerable work for remediation of the legacy sites has been done within the "Program of Conservation of Uranium Production Enterprises and Liquidation of Consequences of Mining of Uranium Deposits for 2001-2010" a post-remedial monitoring, maintenance and stewardship program for the legacy sites are still required to maintain the results of remediation in the long term. The responsibility for monitoring and necessary maintenance of the remediated sites, repair of the damaged covers, prevention of geotechnical and/or mechanical instabilities, uncontrolled mine and waste pile seepages has not been satisfactory resolved. There also exists a potential problem of the ongoing environmental contamination by operating uranium companies, which requires a strengthening of the site specific monitoring systems that are still typically not sufficient to produce reliable environmental information at uranium legacy sites and has significant gaps in monitoring coverage (air, soil, water).

The standing Water Code, adopted in 2003, which defines the framework for management of water resources should be more effectively applied to waste water discharges and ground water contamination from the uranium sites. The present practice of discharging of contaminated mine waters and seepages after a very basic treatment, such as removal of the particulates, is likely to leave a long-term effect on the water quality. Because the Water Code is based on a river basin management approach it is recommended that the relevant River Water Councils shall be involved in the development of a water and ground water monitoring system suitable for the uranium sites from the early stages. The current monitoring network at the sites appears to be unsuitable to link contamination levels with emission patterns and thus identify activities that may result in breaches of the environmental quality standards under normal operating conditions.

On the whole, a suitably developed normative base exists in the country. The main documents regulating the population's safety and environmental protection against radioactive contamination in Kazakhstan are:

- Law of the RK "On radiation safety of the population";
- Law of the RK "On the sanitary-epidemiological well-being of the population";
- Law of the RK "On atomic energy use";
- Law of the RK "On subsurface entities and subsurface management"; and
- Ecological Code of the RK.

The radiation safety is ensured by adhering to the requirement of 99 functioning normative acts and sanitary rules such as:

- Sanitary rules and norms "Sanitary-hygienic requirements to ensure radiation safety";
- Sanitary rules for the liquidation, conservation and remediation of the former mining and milling enterprises mining and site processing of radioactive ores (SR LCP-98) [21]; and
- Sanitary rules for handling radioactive waste (SRHRW-97) [22].

However, most of these documents are not directly relevant for uranium production legacy sites management; with some documents based on relatively old principles, which were in use in 1990's (for instance SR LCP-98). These documents need to be reviewed and amended in accordance with international accepted requirements.

3.1.3. Decision making structure

This report only includes an assessment and proposals for those sites which have not been fully or partially remediated. It also addresses the need to improve overall uranium residue management system and site specific monitoring programs.

Proposed supporting measures

➢ There is a need of general support in the development of regulations and guidelines for future remediation activities and for long-term monitoring (site specific and regional), with specific focus on uranium residues and legacy site management (similar as to other Central Asian countries).

➢ The government representatives expressed an interest in an independent assessment of the adequacy of remediation measures that have already been undertaken. The assessment of the effectiveness of the site specific measures already implemented within framework of the State Remediation Programme (2001-2010) which would help to identify the optimal programmes and mechanisms for long-term institutional control and stewardship actions under responsibility of SE "Uranliquidrudnik"

➢ Safety assessment methodology needs to be applied for the remaining legacy sites, with special focus on the failure of engineering constructions that have occurred due to inadequate design of the protection facilities (for example, a collapse of the mine and its inundation by ground water.

- A web-based information system seems to be of interest to initiate basic knowledge exchange such as the methods and analytical guidelines, data quality assessment and data exchange, consulting of users in the safety assessment tools application, methods for the selection of engineering barriers (tailings covers, water treatment, drainage and dust control, etc).

- Special attention should be paid to the utilizing existing expertise in safety assessment and adequate long-term remediation strategy development for Koshkar-Ata and Stepnogorsk tailings dumps.

- Basic educational programs including actions for improved risk communication and risk awareness of the public to gain support of the remedial measures and long-term institutional control should be developed.

3.2.Kyrgyzstan

3.2.1. Introduction

The history of the uranium industry in Kyrgyzstan has many similarities with the other republics in Central Asia. Huge amounts of waste rock and other uranium residues have been accumulated near mining and processing sites such as Mailuu-Suu, Shekaftar, Min-Kush, Kadji-Say, Ak-Tyuz, Kann and others. According to an approximate assessment by the Ministry of Emergency Situations of the Kyrgyz Republic, within the country there are 35 tailings dumps and 25 sites where waste rock piles. Among these, 30 tailings dumps contain the residues from uranium production from the past and there are also five storage facilities containing NORM (Naturally Occurring Radioactive Material) residues from production of non-ferrous metals. Figure 8 shows the sites associated with the uranium industry and details for all these sites are provided in Table 8.

Figure 8. Sites of the uranium industry facilities of the Kyrgyz Republic

Since March 1999, according to the Government Degree No.161, the above mentioned uranium tailings dumps and other waste rock piles containing radionuclides of uranium and thorium series are under the management of a special department which is a part of the Ministry of Emergency Situations of the Kyrgyz Republic. This department is responsible for the establishment of surveillance and monitoring services at the sites where the former uranium facilities were located, and also for the maintenance of protective fences and management of the remediation programmes. Before 1999, when the governmental programme for remediation of the uranium tailings dumps was established, no monitoring and no remediation works were carried out at the legacy sites.

To establish the remediation priorities, the data from several international reports were analysed. The results show that the main component of aggregated risk, which was taken into consideration was the geotechnical instability of the tailings and waste piles in mountainous areas, which may potentially have a significant impact on the engineered features of the tailings dumps and the surrounding environment. Based on such criteria the Mailuu-Suu and Min-Kush uranium legacy sites are considered to be a first priority for remediation. Other former uranium facilities should be considered for remediation as well.

Table 8. Sites of uranium industry in the Kyrgyz Republic

No.*	City/Name	Object	Number of objects	Status	Remediation activities
1	Mailuu-Suu	mines	23	closed	planned
1	Mailuu-Suu	waste pile rock	13	partially remediated and cultivated	realized
1	Mailuu-Suu	mill tailings	23	partially remediated and recultivated	realized
2	Min-Kush	mines	4	closed	ongoing
2	Min-Kush	waste pile rock	4	closed	planned
2	Min-Kush/Tuyuk-Suu	mill tailings	1	closed	planned
2	Min-Kush/Taldy-Bulak	mill tailings	1	closed	planned
2	Min-Kush/"D"	mill tailings	1	closed	planned
2	Min-Kush/"K"	mill tailings	1	closed	planned
3	Kara-Balta	processing plant	1	in operation, uranium from Kazakhstan	
3	Kara-Balta	mill tailings	1	in operation	planned
4	Kadji-Say	mines	1	closed	
4	Kadji-Say	processing plant	1	closed	planned
4	Kadji-Say	mill tailings	1	in operation	reclamation ongoing
5	Shekaftar	mines	3	closed	planned
5	Shekaftar	waste rock piles	8	closed	planned
6	Ak-Tyuz	mill tailings	4	in operation	planned
7	Kann	mill tailings	2	in operation	planned
8	Sumsar	mill tailings	3	not recultivated	planned
9	Orlovka/Buurdin	mill tailings	1	covered partly	planned
10	Kyzyl-Djar	waste rock	1	covered	planned

*The number is related to the map above

As the result of mining and processing of uranium ores and rare earth elements a large volume of radioactive and chemically toxically residues has been generated on the territory of the republic. According to the State inventory assessment there are 92 facilities, with a total volume of 254 million m³ of residues, which formally nominated as a waste.

It should be noted that at the time this work was done radiological experience in the country was very weak. Analytical laboratories that would be potentially involved in the radiation safety programme, had been mainly located within the mining and chemical combines that had little experience with environmental impact assessment. Most of their experience had dealt mainly with uranium extraction and processing technologies (for instance Kara-Balta MCP). The institutions of the Academy of Sciences of the Kyrgyz Republic, such as the Institute of Physics and Institute for Water Problems, have been mainly involved in research programmes, which were not oriented towards risk assessment and regular monitoring. The best-studied areas in terms of environmental pollution are the tailings dumps around Kara-Balta MCP, which are still in operation. The Chui Ecological Laboratory is now responsible for routine monitoring programme at this site as well for other uranium legacy sites (as a partner of the Agency for Environment Protections and Ministry of Emergency of the Kyrgyz Republic).

Since 2006 the Soil-Biological Institute of Kyrgyz Academy of Science and Analytical Laboratories of the Sanitary-Epidemiological Service of the Republic have also been involved in environment monitoring and radioecological research programs.

At the current stage, the country appears to lack the necessary regulatory provisions and resources and monitoring programs. This results in lack of site specific information and monitoring data. The lack of reliable monitoring data and detailed assessments appear to be the reasons that the uranium legacy sites have not been adequately assessed in regards to their radiological and ecological risks (financial resources aside). As an example, the first priority for remediation was given to the Mailuu-Suu site (where large amounts of uranium residues have been accumulated) – mainly because of the fact that the national experts and NGOs considered geotechnical stability of some tailings dumps at the site (possibly resulting in serious radiological contamination of the Fergana Valley) as the main hazard.

The actual radiological danger at Mailuu-Suu is most probably overestimated and little is known about the toxicological hazards. At the moment several large international projects funded by the World Bank and other funding agencies are under way. Therefore the future actions and possible ranking of other remediation measures, which are needed in the country, should be based on the comparable multi-attributive assessment of all uranium legacy sites. This needs to be carried out using internationally-accepted practice for selection of the priority measures and determination of the radiological risks taking into consideration ecological, economic and political factors.

3.2.2. Legislative and regulatory framework

In the Kyrgyz Republic (similar to other Central Asian countries) the management of uranium residues is not covered by regulations that address other types of waste (radioactive and industrial). Therefore, the current practice is to use basic legislative and regulatory provisions, which are in many cases not applicable to uranium mining and processing facilities and specific regulations are yet to be developed.

A basic law of the Kyrgyz Republic, which currently regulates handling of radiation sources (in that case uranium residues and naturally occurring radioactive materials are considering as radiation sources) is the Law "On Radiation Safety of the Population of the Kyrgyz Republic". The law details the legal framework in the sphere of radiation safety of population and environment protection from the sources of ionized radiation. There is another Law "On Tailings and Rock Dumps" which is document regarding uranium tailings and rock dumps management but needs specific requirements added and integrated into other laws.

At the current stage the regulatory responsibilities for the operating uranium industry are different from those for uranium legacy sites, while the question of the regulatory authority remains unclear. There appears to be a need to consolidate the uranium waste issues into one coordinating regulatory body, which would have the task to organize and coordinate the input of all relevant "specialist" governmental bodies; so that the project proponents would have to deal with one regulatory body only ("one stop shopping" for permits). From a practical point of view it would be desirable to combine the organizational consolidation of the regulatory authority with the consolidation of the licensing and permitting procedures, which appear to be inconsistent.

Standards of Radiation Safety NRS-99 [23], as well as sanitary regulations related to radioactive waste management (SPORO-2002)[24], which had previously been drawn up for the Russian Federation, are currently in force in the Kyrgyz Republic. Maximum permissible doses for workers and people directly involved in radioactive waste management have been established, but there are no special regulations for engineering measures and remediation of facilities.

The guidelines for the remediation of former uranium facilities are given in the "Sanitary rules for the liquidation, conservation and re-profiling of enterprises mining and processing radioactive ores" (SR LCR-91). This document is relatively old and it would be advisable to review and amend it.

3.2.3. Decision making structure

At present several key governmental bodies are involved into the decision making process in regards to the uranium legacy sites safe management and remediation planning. The key agencies are Ministry of Emergency Situations and the State Agency for Nature Protection and Forestry Management, which are responsible for decision making process and the waste management policy for the former uranium industry.

Ministry of Emergency Situations of the Kyrgyz Republic has special department for "Tailings Dump Monitoring", which is responsible for carrying out surveillance programs and for the control of the geotechnical stability of the tailings storage facilities (covers and slopes, dykes and other constructions); as well as for the prevention and minimization of possible risks related to potential emergencies at the legacy sites.

The State Agency for Nature Protection and Forestry Management of the Government of the Kyrgyz Republic has a special department, which acts as a regulatory body and is responsible for the nuclear and radiation safety, including uranium residues. This department also acts as a state inspectorate.

The Ministry of Health of the Kyrgyz Republic is also involved in the control of the monitoring of residential areas in the vicinity of former uranium facilities in the Kyrgyz Republic. The Department of State Sanitary Epidemiological Control (DSSEC), which belongs to this ministry, focuses its activity on the quality of drinking water (gross alpha activity), indoor and outdoor ambient Rn-222 concentration in settlements near the former uranium facilities, as well as on undertaking the monitoring for compliance with radiation and hygiene regulations applicable for residential areas.

However, due to various reasons, the country does not possess sufficient funds to remediate the uranium production legacy sites. Therefore the above-mentioned agencies and their institutions have mostly worked with international assistance. In the process of implementation of several IAEA technical cooperation projects both national and international experts have agreed that the system of waste management and other relevant activities in regards to environmental monitoring program implementation and remediation planning, coordination and decision making structure have to be improved.

One of a serious current constraints is that there is not a central organization or institution in the republic, which has the responsibility to collect and adequately analyze all available information about the hazards at the uranium production legacy sites and provide site characterization and site specific safety assessment for the prioritization and management of the uranium residues.

At the "International Forum on Uranium Tailings Issues in Central Asia" held in Geneva on 29 June 2009, Kyrgyz Prime Minister Mr. Igor Chudinov asked the international community for help with the management of the abandoned uranium mill tailings dumps located in the country. The scale of the problem would make it impossible to ensure a solution using the country's own resources. However to use such assistance, the Kyrgyz Republic appears to need to improve coordination and management structure of the ongoing and potential remediation project activities. To implement this task the country will require qualified personal and also a special government body to coordinate remediation activities.

Expert’s assistance in creation of the national network for centers of excellence and to help country create effective decision making structure as a basis for efficient utilization of the national and international funds available for problem solution might be one of the country specific tasks for further international cooperation.

3.2.4. Site description, risk estimation and proposed measures

Introduction

According to the information from the Ministry of Emergency Situations of the Kyrgyz Republic, a result of the long-term activity of uranium mines and processing enterprises in Kyrgyzstan is, that over 132 million m^3 of waste were accumulated. The uranium production residues and related radioactive wastes accumulated at the different sites over the country (see Figure 9) are associated with a number of potential risks (radiological, ecological, engineering, social, political) in Kyrgyzstan itself and its neighbouring countries.

The main uranium ore mining and processing facilities in Kyrgyzstan are listed above in the Table 8 and include such enterprises as Mailuu-Suu, Shekaftar, Kyzyl-Djar; and also tailings sites near Min-Kush and Kadji-Say villages. The tailings and waste heaps around Kara-Balta mining combine contain residues generated in past, which are expected to be managed by the combine that is still in operation. The enterprises of the Kyrgyz Mining and Smelting and Chemical-Metallurgical Plants in Ak-Tyuz and Orlovka villages generated other radioactive wastes, which are not related to mining and processing of uranium.

Most of the legacy sites are located in the catchments areas of the Syr Darya and Chu rivers, and therefore have transboundary significance, potentially resulting in serious social and political concerns. Therefore risks associated with these legacy sites need to be assessed to avoid inadequate risk perception, economical losses and possible disputes between neighbouring countries.

Mailuu-Suu uranium mining and milling site

Short site description

The Mailuu-Suu uranium deposit was exploited between 1946 and 1967 during which the Western Mining Chemical Combine in Mailuu-Suu (Figure 9) produced 10 000 t U_3O_8 and left behind mining and milling waste deposited in 23 tailings and 13 mine waste piles on the territory of the former enterprise, some of which are within the town's boundaries [25].

The majority of the tailings dumps are located along the Mailuu-Suu river and its tributary, the Yampa Say (Figure 4.7). After closure of production in 1966-67 the waste piles were abandoned in accordance with former Soviet standards. The staff of the industrial complex continued supervision and maintenance of the tailings piles until 1991. After 1991, the monitoring activities became sporadic.

The remediation priority of the Mailuu-Suu site is justified by the large volume of tailings on the site and the possibility of extensive landslides, possible flooding and ultimate structural failure, loss of containment and uncontrolled release of tailings from some of the impoundments. The overall hazard is heightened by the possibility of seismic events.

Presently, several internationally funded remediation projects are ongoing at Mailuu-Suu of which the World Bank project is the most prominent. One of the most significant achievements in the recent years is the mitigation of several landslide prone spots close to the tailings piles of Mailuu Suu (Figure 9).

During last three years, comprehensive EIA and FS were prepared in the framework of the World Bank project [26], considering remediation strategy for tailings ponds (TP) 1, 2, 3, 5 and 6 and also for interim measures to reduce potential hazards associated with the tailings pond 13. The most important sub-project is the relocation of the tailings pond 3 to a safer location. The future of tailings pond 6 will be decided in a project that is expected to commence in spring 2010.

The current budget of the World Bank for Mailuu-Suu is limited and not all remaining safety issues are covered by these funds. It is suggested that in the future, the focus should be on justification of further measures for the TP 2 and TP 13 tailings complex and the TP 8, which may be subject to risk from flooding or fluvial erosion of Mailuu-Suu by the Aylampa river.

The study of the potential radiological consequences of the tailings materials being flooded due to possible landslide event (EC TACIS project implemented by the Belgian Nuclear Research Center SCK-CEN) [27] has concluded that there is no significant radiological danger for the population of Mailuu-Suu and also for people living downstream of the river, since radionuclide concentrations in the water are expected to be relatively low. The average gamma-radiation exposure dose rates over the surface of the covered tailings piles are up to 1 μSv/h. Typical background levels are 0.20-0.30 μSv/h. At places where the cover is breached, the gamma-radiation exposure dose rate can reach 15 μSv/h and high radon
is breached, the gamma-radiation exposure dose rate can reach 15 μSv/h and high radon

exhalation rates are expected. The average annual gamma exposure dose rate was estimated to be 0.17-0.36 mSv/a.

Figure 9. Mailuu-Suu uranium production legacy site and potential main hazards such as landslides

Figure 10. Aerial photo of Aylampa Say tailings complex (left picture) and photo of erosion processes caused by the river (right picture)

Therefore, the main problem of the Mailu-Suu site is high potential hazards of the geotechnical instability of the site which may be a cause of high risks of non-radiological origin (toxicological or ecological).

Risk estimation and proposed measures

Based on previous data and taking into account non-radiological considerations, the aggregated risk estimation resulted in the category of "high risk". The main factor is the lack of stability of some of the tailings structures and the danger of spreading of contaminated material along the river system. The following measures were proposed by the World Bank project to reduce the above-mentioned risks:

- Relocation of TP 3 to the storage facility on TP 6;
- Technical planning (FS and design) for the securing of TP 2/13 and 8, preferably by relocation to safer locations;
- Relocation of TP 2 and 13 to TP 5, relocation of TP 8 to TP 6.

Min-Kush mining and milling site

The mining and milling site is located in the mountainous terrain of the Min-Kush area. The tailings are deposited in four impoundments at four sites: Tuyuk-Suu, Taldy-Bulak, "K" and "D". The mill operated from 1955 till 1960 and generated approximately 1.9 million m^3 tailings. The tailings impoundments, Tuyuk-Suu (approximately 2 km from Min-Kush), Taldy-Bulak (approximately 9 km from Min-Kush) are near the river Tuyuk-Suu; the tailings impoundment "Dalnee" ("D") and tailings dump "Kakk" ("K") are located in a high mountain basin (approximately 11 km from Min-Kush). The regular supervision and maintenance of the impoundments ceased in 1991. In the register of the Ministry of Ecology and Emergency Situations of the Kyrgyz Republic, the Min-Kush legacy site (Figure 11) is considered as a one of priority for assessment and remediation measures that will be needed.

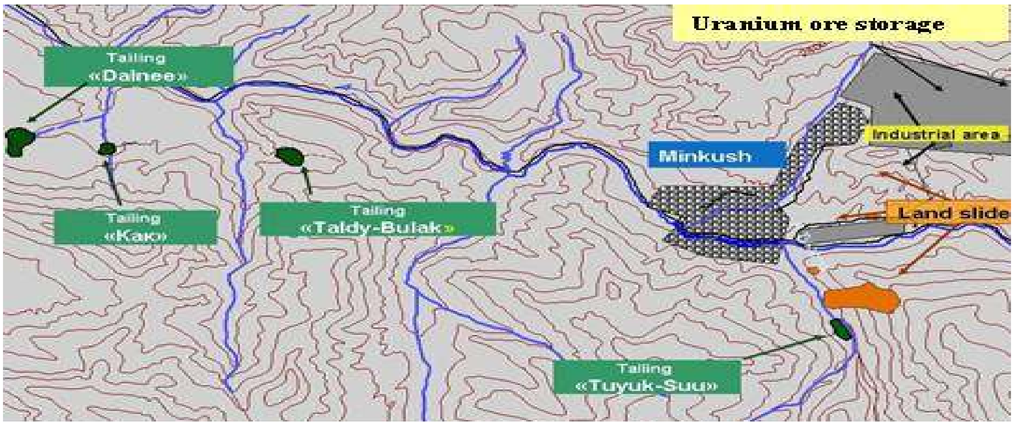

Figure 11. Tailings ponds at the area of Min-ush legacy site and schematic view on the Tuyuk-Suu tailings pond and potential landslide hazard upstream of the Min-kush settlement

The key problems that need to be addressed at the Min-Kush legacy site are:

- Perform an assessment and to provide measures to stabilize the adjacent landslide, which can potentially block the river and result in the flooding of the tailings dump;
- Conduct surveys, safety assessment and clean-up of the residential buildings in the Min-Kush settlement, where residues from the uranium site have been used for the construction.

Tuyuk-Suu tailings dump

Tuyuk-Suu is located in the river valley with the same name. The total volume of the deposited uranium tailings is 450 m^3 covering an area of 3.2 ha. A reinforced concrete by-pass channel was constructed to control the river flows. Presently, a part of the reinforced concrete structures of the by-pass channel has been destroyed by torrential floods, the surface of tailings piles has settled unevenly, and local blockages formed, which prevent channeling of surface water.

The protective cover, fences and warning signs have also been destroyed in some locations of the tailings facility. The further destruction of the tailings dump and, in particular, of the by-pass channel may lead to erosion of the tailings material.

In accordance with the results of a qualitative analysis of the risks related to the Tuyuk-Suu tailings, there appears to be an increased risk for the northern dam in a case when a by-pass channel is destroyed in the event of an earthquake, thus resulting in the reduction of dam stability. As a result of a landslide, the river downstream of the uranium tailings may be blocked and tailings may be flooded. Currently, as a preventive measure, the geotechnical stability of the landslide body is under surveillance to ensure early warning of a potential incident.

As a preventive mitigation measure, the landslide stabilization and restoration of the water by-pass system appear to be the most appropriate mitigation measures.

Min-Kush settlement residential area

The residential buildings in some locations of Min-Kush are located directly on the former mining and processing site resulting in a potential exposure scenario in the residential areas, due to dust dispersion and possible access of the local people to the site. The total area that is considered contaminated area is about 61 thousand m^2. The average gamma-radiation dose rate is from 0.30 to 1.0 μSv h^{-1}, in some locations – from 1.0 to 5.0 μSv h^{-1}. The former industrial site has no fence or other access control. Therefore, people living at the vicinity have visited the former uranium facilities, collecting contaminated residues (metals, building materials and other remained wastes) for domestic purposes.

According to the NATO "RESCA" (2009) project report [17] there are several buildings, where spent filters from the former uranium mill ventilation facilities and uranium ore residues (rock and coal) were used for insulation of the houses, resulting in a significant increase of the gamma-dose rate. The photo on Figure 12 illustrates the situation where extremely high gamma dose rate up to 47 μSv h^{-1} was measured where the material was used.

To further investigate this problem, the IAEA has initiated a project called "Assessment of the Radiation Situation and Public Exposure at the Former Uranium Mining Sites of Min-Kush". It is currently being implemented by the Department of State Sanitary Epidemiological Services (Ministry of Health of the Kyrgyz Republic). It is expected that in framework of this project, the houses and adjacent areas will be carefully investigated by the local radiation safety experts. Gamma and Rn-222 measurement services for all residential buildings in the vicinity of the legacy site and radiation safety assessment will be carried out.

The remediation of the ore storage areas and mining disposal areas is recommended and a suitable design for planned works will need to be prepared. However the first priority action is to reduce radiation exposure at some residential areas in the vicinity of the former mill site.

Figure 12. Min-kush legacy site and adjacent residential areas (left), where local citizens used contaminated residues from the legacy site for domestic purposes and insullations of the houses (right) (photos taken from NATO “RESCA Report, 2009)[17]

Additional investigation of the site is also planned by the IAEA project RER3010 supporting of preparation for remediation of uranium production legacy sites. This work will consist of some site characterization and safety assessment activities as a basis for further remediation planning. Where the living conditions are found to be unacceptable, additional measures to be taken include remediation if possible.

Other tailings sites

The tailings piles “Dalnee” (D) and “Kakk” (K) are located near each other, at a distance of 11 km from the village of Min-Kush. The total volume of the tailings is 306 thousand m^3 spread over an area of 13.1 ha. Presently, at the surface of tailings dumps there are several low areas, where flood waters have accumulated. The surface of the “Kakk” tailings dump is partly overgrown by grass and the area is used as a pasture. The dose rate of gamma-radiation at the surface of tailings dumps is at average 0.30-0.60 $\mu Sv\ h^{-1}$, although in some locations it reaches 5.0 $\mu Sv\ h^{-1}$. At the tailings pile “Dalnee”, the dose rate of gamma-radiation can reach 12.0 $\mu Sv\ h^{-1}$ in some locations.

To secure these tailings dumps, it will be necessary to construct a water diversion system and repair the protective covers. However they can not be considered as a priority for the immediate actions, because the residential areas are rather far from the sites.

Proposed measures

The situation at the Min-Kush site is a high priority for a detailed assessment, because of potential exposure which is associated both with geotechnical instability of the tailings dumps situated upstream of Tuyuk-Suu river and with radiological risks for the local citizens living in the vicinity of the former mill site in contaminated houses (where tailings materials and contaminated material from the mill were used for home construction and insulation). The high risk was assigned to this site because monitoring data is very limited and there is no detailed site characterization or resulting risk assessment.

Preliminary (immediate) measures:

- to survey of the residential areas, assessing safety of the living conditions and investigation other type of potential hazards at the Min-Kush settlement associated with former uranium production facilities;
- to provide qualified safety assessment for identification of the optimal strategy for intervention or remediation;
- to carry out an assessment of geotechnical stability of the landslide below Tuyuk-Suu tailings, to install geotechnical markers and train staff of the Kyrgyz Ministry of Emergency Situations in all important aspects of the geotechnical monitoring;
- to investigate conditions of the water by-pass system and prepare engineering design options in regard to the prevention of flooding and erosion of the tailings dump;
- to carry out site characterization, feasibility studies and environmental impact assessments as a basis for justification and prioritization of the optimal set of measures that will be needed in the remediation; and
- to establish a regular surveillance program for the all tailings dumps and contaminated areas at the Min-Kush site.

Potential remediation options to be considered:

- survey, assessment and clean-up of the residential houses adjacent to the mining and processing sites;
- to establish monitoring network (geotechnical markers, drainage water seepages, water discharges and water contamination, aerosol dispersion, radon track detectors, etc.);
- repair of water catchments by-pass system;
- reinforcement of the dam of Tuyuk-Suu tailings, depending on the results of engineering assessment and technical inspections (if necessary);
- survey and repair of engineered tailings containment structures or relocation of the tailings to a safer location.

The establishment of a long term surveillance and maintenance programme is essential for the protection of human health and the environment. Institutional control actions to restrict site access and better risk communication are strongly recommended.

Kadji-Say

Short site description

The former uranium facility was in operation from 1952 till 1966, using acid extraction procedures to obtain uranium from the ash residues of the brown coal mined locally. The heating station continued in operation until 1991. The coal was burned in a heat and power generation plant providing the ash for uranium extraction. The tailings were deposited near the power plant and industrial complex on the mountain terraces approximately 2.5 km from the lake Issyk-Kul, which is the receptor area of primary concern. Approximately 150,000 m^3 of uranium tailings and other industrial wastes are located in an area of approximately 1.1 ha.

From 1966 to 1991 the supervision and maintenance of the tailings was conducted by the staff of the industrial complex.

In 1992, to prevent contamination of lake Issyk-Kul the Ministry of Emergency Situations ordered the construction of a protective dam below the main tailings pile. Prior to this, large quantities of tailings had already been already displaced.

On the request of Kyrgyz Government, the restoration works were financed by USA Government (US$ 400 000) through the International Science and Technology Centre (ISTC) in Moscow. The remediation plan was to consolidate waste in a minimum number of locations and then place covers over the sites to reduce radon and gamma emissions, as well as provide erosion protection and containment.

The new cover was built in 2006 as a multi-layer soil design, which incorporated soil and clay over coarse rock and sand fill, with a sand final cover. The average thickness of the cover is about 6 meters of the local soils. However prior to the spring of 2007 the erosion protection (for slope stabilization) have not been completed. As shown on Figure 13, the cover at the tailings site was partly destroyed. This cover was restored at the end of 2007. However, the current state of the final cover on the slope of the tailings pile can not be considered as satisfactory. Therefore the installation of some erosion protection which may prevent such events in the future are still needed.

Figure. 13. The cover of the ash tailings (left photo) at the Kadji-Say facility were built in 2005 (the photo taken in June 2006). The same cover damaged by erosion, (see right photo, in April 2007), [15] (RER9086 Final Report in draft).

Presently, there are no regular inspections of the site, the access is not controlled and the site fencing is not maintained. The system of water diversion canals on the slopes above the pile has also been destroyed.

According to the recent studies carried out by the IAEA the gamma dose rates are between 0.20 and 0.40 $\mu Sv\ h^{-1}$ on the covered tailings pile. However, at the locations where the cover is absent, the gamma radiation is relatively high (6.0-15.0 $\mu Sv\ h^{-1}$). Similar high gamma-dose rates were found in some places where the cover was removed due salvaging of scrap metals by the local population.

The outdoor radon concentration at the ground surface of the legacy site (only limited data is available) is comparable with local natural background. Radon-222 exhalation rates measured on the top of the new cover of the ash tailings piles is 0.1–0.4 Bq m^{-2} s^{-1}, while radon exhalation at the tailings surface with no cover was measured in range from 6 to 20 Bq m^{-2} s^{-1}.

The radon levels measured in the dwellings and social buildings (municipality office and hospital) in a Kadji-Say village were between 140 and 260 Bq m^{-3}. Slightly elevated outdoor and indoor radon concentration in the residential area most probably indicates that local citizens used coal and other residues materials from the legacy site. In fact the radiological conditions at the village Kadji-Say may be considered as safe if the local population are informed of the hazards related to the uranium production legacy site and will not have access to the former uranium facility.

In spite of the fact that this site is situated relatively far from the Kadji-Say residential areas, the local citizens have visited the site in search of scrap metals and other materials that could be used for domestic purposes. Therefore this site will need to be fenced or some type of institutional controls implemented, at least until such time when tailings piles will be properly covered and contaminated buildings will be demolished.

Because the Issyk-Kul lakeside recreational area is located close to the uranium legacy site, it poses a socially and politically sensitive situation. The long-term risk assessment of the site stability and its potential impacts to the environment (especially due to the proximity of the Issyk-Kul lake) have not yet been carried out, which may be a cause of what appears to be an inadequate risk perception by the local public.

Risk estimation and proposed measures

Taking into account social and political factors a "medium risk" category for the site can be established. Main factors are the stability and lack of complete cover of the tailings pile, which contradicts the goal to develop the nearby area as a recreational region.

The following measures are proposed:

- the adequate measures to prevent future possible erosion of the existing and new cover need to be found;
- the legacy site needs to be fenced to prevent access of the local population. The remaining buildings need to be demolished. The materials that will be generated in the demolition process could be categorized and used as cover material, for road construction or disposed in the tailings pond;
- the groundwater monitoring network needs to be restored at the tailings site areas and downstream of the site towards the lake. The groundwater monitoring program should be established as a part site specific long-term surveillance and monitoring programs.

This site can be included as priority 2 in the list of the site priority ranking.

Ak-Tyuz mining and milling site

<u>Short site description</u>

In the Ak-Tyuz district, on either side of the upper part of the river Kichi Kemin, there are four tailings dumps from polymetalic ore processing. The tailings dumps area occupies a total area of about 56 hectares containing mainly thorium, cadmium, lead, molybdenum, zinc, beryllium and other residue minerals. The industrial area was in operation during period from 1942 until 1993.

The tailings deposits are located in a very rugged mountainous terrain in steeply sloping canyon areas often in elevated positions above the Kichi Kemin river. During operations the tailings impoundments were serviced by roads, tailings delivery pipelines, return water collection, settling and conveyance systems.

Consistent with the pronounced topography, the river and the adjacent area is subject to extreme surface water run-off conditions, primarily during the spring. Consequently, the potential for severe erosion is high, and significant damage is evident throughout the sites. It was reported that large scale flash run-off events are common in the spring.

n addition the area is reported to have a “moderate” seismic risk.

The tailings locations range from 1km to 8 km from the settlement of Ak-Tyuz. All tailings ponds are downstream of the community with the closest tailings area being within 1 km of houses. The residents of Ak-Tyuz move actively throughout the valley. People walking through the sites and grazing livestock are a common sight.

Figure 14. Ak-Tyuz residue tailings No.1 (left) and tailings pond No. 2 for the rare earth, which is still in operation (right)

The technical documentation and reliable environment contamination monitoring data available for the Ak-Tyuz tailings dump is very limited.

Presently, the former mining and processing facilities include the large open pit, the mill and several tailings dumps. Tailings ponds No.2 and No.4 are the property of the Russian company "GEORESERV" and are still in operation for the mining and extraction of rare earth elements. The safe management of the tailings ponds 1 and 3 are the responsibility of the Ministry of Emergency Situations of the Kyrgyz Republic (Figure 14).

In the vicinity of the tailings pond No.1 (residues of rare earth) and tailings pond No.3 (thorium ore concentrates) there are several locations with very high gamma dose rates up to1 mSv/h. This area is freely accessible to the local population and animals. These locations have to be considered in further site characterization and safety assessment.

There is no regular site specific monitoring and surveillance program established at these sites. Any management infrastructure that may have been in place to protect the population from the hazards of the tailings impoundments is no longer functional. Inspection, monitoring and maintenance programs only occur on an ad-hoc basis. The information about actual risks, which may be associated with instability of dams or remained contamination during ore processing activities in past is very limited. Therefore a formal risk assessment of the site has not been completed. Some expert assessments (given a limited set of information) are offered below.

Risk estimation and proposed measures

Using the risk matrix a "high potential risk" is established. Main factors are the instability of the dams of TP 2, 3 and 4 and the radiological risks for the local population coming from the scattered radioactive material in the vicinity of the tailings pond No.1.

The following measures are proposed:

- evaluation of current remediation activities with the safety assessment for further priority actions required, including site characterization as a basis for safety assessment in regards of dam stability and potential impact on the environment of the tailings 1 and 3.
- Because tailings 2 and 4 are in operation of the private Russian company, the responsibilities for safety assessment and remediation action plan are likely to be this

company's responsibility. The Regulatory Body of the Kyrgyz Republic should provide regulatory oversight and require institutional controls at the site.

- Preventing access to the tailings ponds.
- Strategy for remediation measures may be justified pending results of the assessment.

Orlovka (Burdinskoye tailings pond)

Short site description

The Burdinskoe tailings dump in Orlovka village is situated in the Kemin district of Chui region. From 1954 a factory processed lead ore from the Burdinskoe Mine and beginning in 1969 there was a chemical-metallurgical plant in Kashka village, which extracted rare-earth metals from ore concentrates supplied by the Ak-Tyuz dressing plant, operated here.

The waste contains lead, zinc, cadmium, zirconium, thorium and traces of rare-earth elements that could contaminate the Berkut river (a tributary of the Chui river) in the event of instability of the tailings dam i.e. as result of an earthquake. The cover of the contaminated material is inadequate.

The water catchment system of the tailings pond is partially out of order and surface water infiltrates the tailings body and the dam and, therefore, impacts the integrity and stability of the dam. This is evidenced by the observation of cracks in the face of the dam.

Risk estimation and proposed measures

The aggregated risk scoring between "high" and "medium" can be assumed as the result of the risk estimation (very limited information of the dam), based on a visual inspections. There is a need for immediate actions to prevent further destabilization of the dam. This site is included in the list of the sites for which further assessment is required.

Kara-Balta tailings pond

Short site description

The tailings dump in Kara-Balta, which has been in use from 1955 until the present, is located near the town of Kara-Balta (1.5 km) which has a population of more than 50 000. The company KGRK, the owner of the TP-complex has been in private hands («URANPLATINUM», Russia) since 2008. The total amount of contaminated material deposited there is about 37 million m³ whereas the designed capacity of the tailings dump is almost twice as much, 63.5 million m³. The tailings dump is being rehabilitated in accordance with former Soviet standards, which may not conform to international standards and good practices.

The Kara-Balta Combine is a private property. This facility is still in operation and its management is responsible for all safety and necessary remediation measures. Therefore, this site cannot be classified as a uranium legacy one at the current stage and may require further consideration in the future.

Shekaftar uranium mining site

Short site description

The Shekaftar site is located in Ala-Bukynsky district of Jalal-Abad Province and was operating from 1946 to 1957. There are 8 tailings piles areas that contain about 700 000 m^3 of low grade ores and residue materials. Houses with gardens are located in the vicinity of the tailings and none of the dumps have been remediated. Average gamma dose rate on the surface of the disposal areas is between 0.6 and 1.5 µSv/h. The dumps are located on the banks of the Sumsar river and have been intensively eroded by the river. The absence of vegetation on the surface makes the area more susceptible to wind and surface erosion of the material and its subsequent migration to the area of Shekaftar settlement and the adjacent Ferghana Valley. Figure 15 shows an aerial photo of the Shekaftar and the tailings piles.

Figure 15. Shekaftar village and some of the tailings piles at the vicinity

Risk estimation and proposed measures

The "medium risk" can be assumed as the result of expert's opinion. Main factors are the risks of increased exposure of the population due to the free access to the dumps (radon, gamma radiation and direct ingestion of contaminated material), due to the lack of cover and absence of assess control. The uncontrolled transport of contaminated material by fluvial erosion should be avoided in all cases. The options for remediation are not yet clear, as they will depend on the screening site assessment that is yet to be undertaken. The main focus should be the state of the cover and material dispersion control measures.

3.2.5. Proposal and risk related ranking

The Table 9 is a cross-reference between proposals in this document and references in the Framework Document of the UNDP prepared for Geneva Conference in July 2009 [29].

Table 9. Proposed list for priority actions

Site	Risk estimation	Measure	Costs (million €)	Time frame (years)	Reference (project -number of the UNDP FD)
1.Mailuu-Suu	high	FS, design	0.3	0.5	KR 5.4; 5.6; RU 2.1; 2.2; 3.1
		Remediation	1.7	1.5	
2. Min-Kush	high	urgent, assessment	0.1	ongoing	EurAsEC 1; KR 2.1; 2.4;
		EIA, engineering	0.8	1	
		Remediation (option 1)	0.9	1	
		Remediation (option 2)	3.8	1.5	
3. Kadji-Say	medium	FS and design	0.1	0.5	EurAsEC 1; KR 2.2;
		remediation	0.8	1	
4. Ak-Tyuz	medium	urgent	0.2	0.5	KR 2.5; 4.3; 4.4
		EIA, engineering	0.4	1	
		remediation	2.2	2	
5. Orlovka (Burdinskoye TP)	medium	urgent	0.1	0.3	KR 2.3; 2.6; 4.2; 4.3; 4.5
		EIA, engineering	1	1	
		remediation	2.7	2	
6. Kara-Balta	medium	remediation	23	5	KR 1.7; 3.8; 3.9; 4.1; 5.3
7. Shekaftar	medium	EIA, engineering	0.2	0.5	
		remediation	0.5	1	

Conclusions

Based on the description above the priority for immediate measures can be given to Mailuu-Suu and Min-Kush uranium production legacy sites.

1. At Mailuu-Suu, the World-Bank project activities to be completed and long-term institutional control to be established. It can be recommended to evaluate the results of the already ongoing activities recommended for the tailings ponds mentioned above. The future Action Plan to be developed depending on the project evaluation and long-term risk assessment, and institutional controls are to be discussed and established.

2. At the Min-Kush site two specific tasks:

2.1. Tuyk-Suu tailings pond stabilization with Option 1 (landslide stabilization and water by-pass system repairs or a new construction) and Option 2 (removal of the tailings to the safer location).

2.2. Urgent measures needed to identify houses, where contaminated materials from the mill and mining site were used and further clean-up of the identified “hot spots”.

3. At Kadji-Say site, the tailings cover should be completed and measures to prevent erosion to be taken. Assessment of possible further actions is also needed.

4. The actions to be recommended for **Ak Tuyz** and **Orlovka** sites have to be justified based on more detailed assessments, using additional expertise.

As a general measure, a regular monitoring and surveillance programs need to be established at all sites. Better public communication is needed and institutional control measures need to be discussed and established.

3.3.Mongolia

3.3.1. Introduction

Mongolia is rich in mineral resources that are being increasingly exploited by a variety of national, joint venture and foreign companies, including the exploration and ongoing development of new and existing uranium deposits.

As reported by the IAEA, uranium exploration within Mongolia commenced immediately after the end of the Second World War. Preliminary geological investigations were carried out by joint Mongolian-Russian geological organizations. Uranium occurrences associated with lignite deposits comprised the results of pre-1966 investigations. Subsequent exploration activities were more systematic, resulting in the identification of four uranium-bearing provinces, which included the Mongol-Priargun, Gobi-Tamsag, Hentei-Daur and northern Mongolia districts.

Uranium production in Mongolia commenced in 1989 following the start-up of the Dornod open pit mine in 1988, located 120 km north of the Choibalsan city in Dornod Province (north-eastern Mongolia). Exploration activities continued in the district through 1990. Development of the required infrastructure, a town site, railway, power lines, support facilities, underground shafts and drifts for exploration drilling and coring of the discovered deposits, and leach processing studies, were completed.

The Dornod mines and associated support infrastructure were developed as a "sub-Combine" (called ERDES) to the Priargunsky Mining and Chemical Enterprise, a division of the (then Soviet) Ministry of Atomic Energy (MINATOM). Priargunsky is located at Krasnokamensk, Russia, approximately 400 km north of Dornod.

Between 1988 and 1995, uranium ore was shipped via a dedicated rail line to the hydrometallurgical plant at Krasnokamensk for processing, packaging and shipment. In March 1995 shipping of ore was stopped, although mining activities continued into late 1996. Production of uranium during this time had been approximately 550 tonnes of U_3O_8.

Following the democratic revolution in Mongolia (1996) bidding took place for previous mineral leases, including uranium. Western Prospector (WP) and Kahn Resources (shared with Russian and Mongolian interests), both Canadian based mineral exploration and development companies were successful in obtaining mineral exploration rights in the Dornod/Mardai area.

Relevant residues of the first mining period are only a small waste and remnant ore dump covering less than 3 ha and only 3-4 metres high (Saddle Hill project of WP) and an open pit with appending waste dumps on the Dornod site of Kahn Resources Co., Ltd.

Both objects are very far from inhabited areas and the private companies holding the respective mining licences are fully responsible for all safety aspects of these sites.

Presently, a large number of further activities for geological investigations and the exploitation of uranium deposits are under way in Mongolia mainly by Canadian, French, Russian and Chinese companies. Centres of these activities are the southern provinces (Gobi region) with a couple of proposed ISL projects. It can be predicted that Mongolia will be one of the main producers of uranium in the next several decades. Figure 16 shows the sites of uranium industry in Mongolia, which are detailed in Table 10.

Figure 16. Sites of uranium industry in Mongolia

Table 10. Sites of uranium industry in Mongolia

No. *	City / Name	Object	Number of objects	Status	Remediation activities
1	Hairhan deposit	planned mines		standby, no tailings	planned
2	Haraat deposit	planned mines		standby, no tailings	realised
3	Gurvanbulag Central deposit	planned mines	1	construction halted	later
4	Choibalsan/ Dornod-Uran	mines	2	standby, no tailings because ore is processed in Russia	ongoing

*The number is related to the map above

3.3.2. Legislative and regulatory framework

Mongolia is a non-nuclear country, since there are no nuclear power plants and research reactors. The application of nuclear energy is limited. Currently, radiation sources and radioactive substances are used in the following social and economical sectors of the country:

- Industry, geology and mining;
- Science and education; and
- Natural environment.

The purpose of the state policy of Mongolia on exploitation of radioactive minerals and nuclear energy is to explore for radioactive minerals resources, to become one of the leading country on exploitation, processing and exporting of these minerals for peaceful purposes and, subsequently, the extensive utilization of nuclear energy in economy and social sector and producing power through the introduction of technology friendly to human health and environment.

As nuclear energy is the sector of high technology and developing dynamically in the world recently, exploitation of radioactive minerals and nuclear power is an important factor to ensure sustainable development and national security of Mongolia, to improve living standard of its people by producing low cost electricity and heat.

There are no nuclear power plants and no research reactors in Mongolia. Radioactive wastes are generating from industry, research and medicine.

The following laws and regulations are enforced:

- Nuclear Energy Law has been enacted 16 July 2009 and come into force on 15 August 2009. Functions and powers of Regulatory Authority have been described in the Law;
- Radiation Safety Standard (1983);
- Basic Regulation on Radiation Sanitation (1983);
- Transport Regulation for Radioactive Sources (1987) based on IAEA regulation 1985;
- Regulation on Safe Transport for Radioactive Material (1987).

Draft regulations, standards and specific codes of practice (Radioactive Waste Management Regulation, Regulation Radiation Safety for Mining and Milling Radioactive Ores) are expected to be prepared in the near future.

3.3.3. Decision making structure

Mongolia has a single Regulatory Authority - the Nuclear Energy Agency (NEA) was established by the Governmental Resolution in 2008 under the competence of the Prime Minister. It can authorize (license) and inspect regulated activities and enforce the legislation. The legislation provides adequate regulatory power to the Regulatory Authority.

The NEA has prepared Radiation Safety Regulation for radioactive waste with high content of natural occurring radionuclides from gas-oil production and it is in the stage of revision prior to the approval.

The Nuclear Energy Commission (NEC) of the Government of Mongolia was established in 1962. NEC is responsible for development of national policy for the activities relating to development of nuclear research and technology, use of radiation sources and to ensure radiation protection. The Prime Minister of the Government of Mongolia is a chairman of the Nuclear Energy Commission.

Radioactive waste management

Isotope Centre is a radioactive waste management and transportation service unit of Mongolia, which belongs to the Nuclear Energy Agency

At present, the generation of unsealed radioactive waste material is not considered to be a problem, but the situation could change with the development of new phosphate, oil, gas and uranium industries.

Mongolia has no disposal facilities. It is understood that the NEA has long-term plan to convert the storage facility into a disposal facility.

Inspection

System of notification, authorization, inspection and enforcement for radiation protection and the safety of radiation sources is generally in place within the Nuclear and Radiation Regulatory Authority (NRRA) of the NEA. There are also some difficulties in arranging regular and enforceable inspections in countryside hospitals, which are far away from Ulaanbaatar and the lack of a suitable inspection budget.

3.3.4. Proposed measures

As the IAEA experts' visits in Mongolia showed, two abandoned uranium mining sites exists near Dornod. Two foreign companies are preparing these sites for further mining activities and have included all remediation works for the sites into relevant plans. A risk based evaluation is likely to be necessary in case of commencement of uranium mining activities in the future.

Proposed supporting activities are:

- Training and education of professionals for environmental (including radiation protection, environmental monitoring, long-term monitoring, remediation planning and restoration technologies).
- Environmental and safety assessment for tailings of the uranium mining. Radiation protection aspects of uranium mining
- The support in the development of regulations and guidelines for remediation activities and waste management (support for implementation of regulations, standards and specific codes to finalize of revision).
- Training of the regulatory inspectors and other relevant officers. Workshops for radiation users may be in the form of national training courses in a language understood by the participants and organized with the assistance of the IAEA.
- Development of the NORM programme.

- Build in public information components to all activities above (comment from OSCE).

Required support for waste management is to develop a National Radioactive Waste Management Programme addressing waste from mining and mineral processing in general with the assistance expert from the IAEA.

3.4.Tajikistan

3.4.1. Introduction

The uranium mining was carried out in the north-eastern part of the country. The Plant No.6 known as Mining and Chemical Plant of Leninabad, now the State Enterprise "Vostokredmet", was established in 1945. The aim of this plant was the processing of uranium ores from: Taboshar and Adrasman (Tajikistan), Mailuu-Suu (Kyrgyzstan), Uigursai (Uzbekistan) and other mine sites.

One of the tailings sites - the pilot plant No.4 which operated from 1945 to 1955, is located close to the town Gafurov. Initially the tailings were thought to be remediated, but survey data showed this tailings site was hazardous in terms of radon exhalation. In 1991 the tailings were covered by an additional layer of soil that reduced the radon emanation considerably. The tailings occupy 4 hectares and contain 0.4 million tons of wastes. The exposure dose rate at the tailings surface is 0.2 µSv/h. The tailings are located near settlements and access for the local population (in spite of fencing) appears to be open.

The major tailings sites are in the vicinity of the Hydrometallurgical Plant No.4 which commenced operation in 1949 (town Chkalovsk). The capacity of this plant was 2000 tons uranium per year and raw materials from the former USSR were processed at this location. In the period 1995-1999, due to decreasing quantities of raw materials, the plant was closed.

Operation of the plant resulted in two tailings sites:

- Tailings No.1-9 located in the industrial zone of Chkalovsk, volume 3.03 million tons, area 18 hectares, gamma dose rate at surface 0.40-0.45 µSv/h.
- Degmay tailings storage facility is located 1.5 km from Guisyon village and 5 km from the Syr Darya river. The quantity of wastes in the tailings is 36 million tons, the area covers 90 hectares, gamma dose rate at surface vary from 2.5-3.0 µSv/h up to 20 µSv/h. The tailings pond was filled up to about 82-90%.

The tailings are uncovered, therefore, exposed to wind erosion; precipitation infiltrates into the ground water and then to the Syr Darya river.

The following tailings are located in the vicinity of Taboshar town, where mining works were carried out from 1945 to 1965. There were two hydrometallurgical plants and a factory for low grade ore in operation. As a result of their activity the following tailings were generated:

- tailings I-II, III, IV with total areas of 54 ha and the quantity of residues of about 7.62 million tons;
- tailings of the hydrometallurgical plant with area of 2.86 ha and quantity of wastes of 1.17 million ton;
- wastes from barren ore processing, with an area of 3.35 ha and amount of residue materials of about 2.3 million tons.

All these tailings have exposure dose rates ranging from 0.4-0.6 µSv/h at the surface to 3.0–3.5 µSv/h. The tailings piles are not covered and exposed to wind erosion.

During period from 1945 to 1972 uranium ore was also mined and processed at Adrasman. Here, a hydrometallurgical plant was in operation, which resulted in the generation of 6 tailings sites. In 1992-1994 the materials of these tailings were relocated to tailings No.2 and covered by soil. The tailings area is 2.5 ha and the amount of residues is 0.4 million tons.

Figure 17 and Table 11 show the sites of uranium industry in the northern Tajikistan.

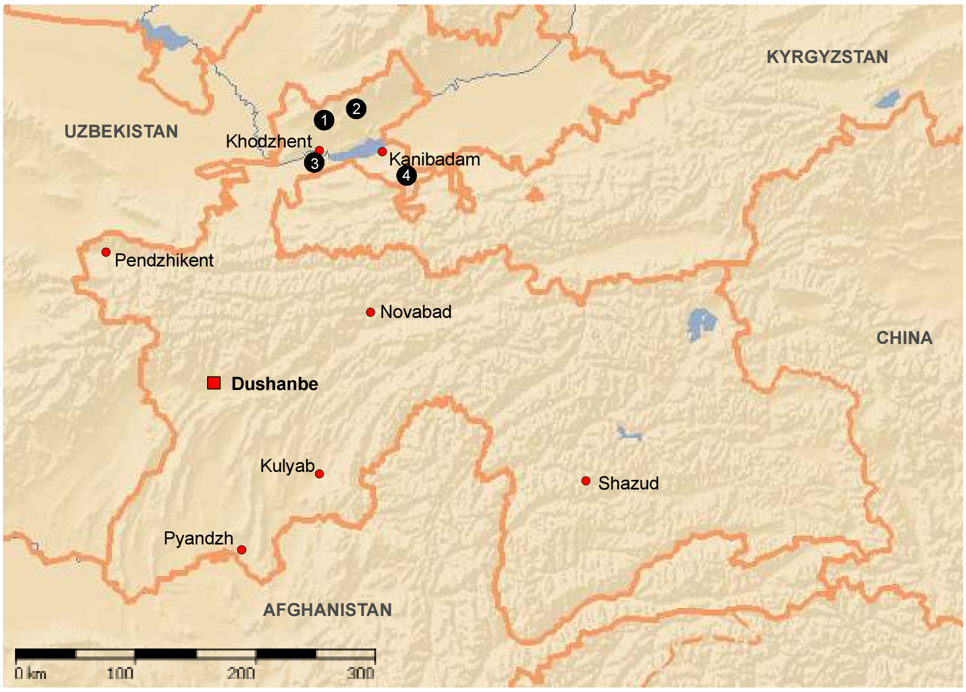

Figure 17. Sites of the former uranium industry in the northern Tajikistan

Table 11. Sites of uranium industry in Tajikistan

No. *	City / Name	Object	Number of objects	Status	Remediation activities
1	Taboshar	mines	5	partially remediated	to be determined
	Taboshar/FBO	mine waste	1	closed	to be determined
	Taboshar	mills	2	closed	to be determined
	Taboshar /N 1 I-II	mill tailings	1	closed	to be determined
	Taboshar/N 1 III	mill tailings	1	closed	to be determined
	Taboshar/N 1 IV	mill tailings	1	closed	to be determined

	Taboshar//N 3	mill tailings	1	closed	to be determined
2	Adrasman/Adrasman	mines	1	closed	to be determined
	Adrasman/N 2	mill tailings	1	closed	to be determined
	Chauly	mines	1	closed	no information
	Kattasay	mines	1	closed	no information
	Alatanga	mines	1	closed	no information
3	Khujand/Chkalovsk	mills	2	closed	to be determined
	Degmay	mill tailings	1	closed	to be determined
	Gafurov	mill tailings	1	closed	to be determined
	Chkalovsk/tailings 1-9	mill tailings	1	closed	to be determined
	Khujand	mine water discharge	4	closed	to be determined
4	Isfara mine	mine	1	closed	no information

* The number is related to the map above

3.4.2. Legislative and regulatory framework

In Tajikistan, there is still no developed specific legislation and regulations regarding management of the former uranium industry, which would be in compliance with the international norms (i.e. Basic Safety Standards of the IAEA). Where the radiation protection legislation does exist, there appear to be no adequate mechanisms for its application. At the working level, the old Soviet "sanitary" rules, which are likely to be inadequate, are still used.

During the last 6–7 years a number of laws and regulatory norms have been developed, which are intended to form the regulatory base for radioactive waste management, as well as for the regulation of handling of ionizing radiation sources. These normative acts are as follows:

- The Law "On Radiation Safety" (Law No.42 as of 01.08.2003);
- The Law "On the Use of Atomic Energy" (Law No.69 as of 09.12.2004);
- The Law "On Licensing of Certain Kinds of Activity" (Law No.37 as of 17.05.2004 with amendments No.277 as of 13.06.2007);

- Provision “On State Regulation of Radiation Safety” approved by the Government Resolution No.482 as of 03.12.2004;
- Provision “On Specifics of Licensing of Certain Kinds of Activity” approved by the Government Resolution No.377 as of 01.09.2005;
- Provision “On Interagency Council on Ensuring of Radiation Safety”;
- Provision “On Inspector of Radiation Safety Science Academy “.

Currently Tajikistan has some other documents concerning regulation of radiation safety, which have recently been approved or are in the process of approval, including:

- Sanitary Regulations “Norms of Radiation Safety” (SR-2.6.1.−001−06);
- "Main Sanitary Regulations Ensuring Radiation Safety";
- Sanitary Regulations “Handling Radioactive Wastes”;
- "State Register and Control Procedure of Radioactive Substances and Radioactive Wastes";
- "Requirements for ensuring radiation safety during collection and utilisation of metal scrap";
- "Handling of Minerals and Raw Materials with High Concentration of Natural Radionuclides";
- Provision “On the order of expertise of documents, justifying provision of nuclear and radiation safety, sources of radiation and quality of proposed activity”;
- Procedure of arrangement and performance of inspection by the Agency on Nuclear and Radiation Security at facilities which are handling radioactive substances and sources of ionizing radiation;
- "Rules for radiation security during transportation of radioactive substances and radioactive wastes".

At the same time, the legal and regulatory framework of the Republic of Tajikistan in the sphere of managing the waste of former uranium industries has not yet been fully developed and needs to be improved and harmonized with international safety standards. For example, additional guidelines are needed in regard to: occupational and public dose criteria, exclusion, exemption and clearance; licensing requirements, regulator/operator responsibilities. The improvement of regulation is underway through a bilateral agreement with the Norwegian Radiation Protection Authority (NRPA). The IAEA will also continue to support the further development of the regulatory infrastructure through its Technical Cooperation Projects.

3.4.3. Decision making structure

All storage facilities of waste from uranium ore mining and processing in the country are on the balance-sheet of the SE “Vostokredmet”. The “Vostokredmet”, under the Ministry of Energy and Industry of the Republic of Tajikistan, handles the tailings’ remediation projects and activities and also has an Analytical Laboratory equipped with instruments to provide adequate surveillance and monitoring.

The Nuclear Radiation Safety Agency (NRSA), as a body of the Academy of Sciences of the Republic, has been appointed as the state regulatory body for ensuring radiation safety. It provides a unified state policy, coordinates the work of other authorized bodies, deals with licensing, sets norms and rules concerning radiation safety and oversees adherence to these norms and rules. The agency is also authorized to coordinate and develop cooperation with the IAEA. The regional branch of the NRSA in the northern Tajikistan (Sogd' oblast) is responsible for specific regulatory provisions and supervision of the uranium production legacy site.

Baseline environment monitoring programme implementation is the responsibility of the Committee on the Environment Protection, which includes an Inspection Department and regional departments for environmental protection in its structure. However this Committee does not cover the issues related to radioactive contamination, or other program elements related to the environment monitoring in the vicinity of uranium production facilities.

The Committee of Emergency Situations and Civil Defense is responsible for the prevention and elimination natural and anthropogenic extreme situations. The Geological Service maintains records of areas under tailings and dumps which are the products of mining industries.

The Interagency Council of radiation safety headed by the Deputy Prime Minister of the Republic of Tajikistan allows collective discussion of issues and coordination of the appropriate responsible bodies – ministries, agencies and local executive bodies in the radiation safety area.

3.4.4. Site description, risk estimation and proposed measures

Introduction

The mining and processing of uranium in Tajikistan in the past has resulted in the generation of more than 170 million tons of waste rock and tailings piles containing hundreds of TBq of radionuclides. A considerable proportion of uranium ore processed in the country was imported from the neighbouring states and from Eastern European countries. The processing was at the former Leninabad Mine-Chemical Combine (predecessor of SE "Vostokredmet") and at the hydro-metallurgical plants operating directly at the mining sites, such as Adrasman and Taboshar. The critical issue concerning these sites is that they are often in the immediate vicinity of residential areas (Chkalovsk, Taboshar, and Khujand) or in the water catchment ares of the internationally important Syr Darya river flowing through the Fergana Valley [30].

The brief inspections of the legacy sites have revealed that the present state of the waste containment as well as the environmental situation in total is unsatisfactory. Dumps and tailings usually do not have a protective cover and their surfaces are exposed to erosion. Furthermore all sites are freely accessible to the local population, and all sites are located in a seismically active area.

Degmay tailings pond

<u>Short site description</u>

Degmay tailings disposal was in operation during the period from 1963 to 1993. It is located in the Gafurov region on the Degmay hill, 1.5 km away from the nearest settlement (Guisyon) and approximately 10 km from the city of Khujand. This facility is the largest single uranium mill tailings site in Central Asia; it extends over 90 ha and holds about 36 million tons of wastes.

Figure 18 shows a photo of the surface of Degmay tailings pond and aerial photos of the main dam of Degmay tailings pond.

Figure 18. Degmay tailings in the surroundings of Khujand and Chkalovsk where:

a) - general view on the surface of the tailings;

b) - general view on the location at Khujand

The surface of tailings is not covered, thus allowing a significant and constant radon exhalation from the tailings. Exhalation of radon-222 into the atmosphere is sufficiently increased in parts of the tailings pond containing significant cracks, some reaching to a depth of over two meters and having a width of 20 to 40 cm. The outdoor radon concentration in the air over the tailings surface during the summer time (under windy conditions) was observed to be in the range from several hundred up to 1000 Bq $m^{-3.}$ In June 2006 exhalation of Rn-222 was found by direct measurements at different places to vary from 10 to 60 Bq m^{-2} s^{-1}, which is significantly higher that the recommended safety level in case of covered surface of the tailings in Tajikistan (1 Bq $m^{-2}s^{-1}$) [15].

Depending on the meteorological conditions and different atmospheric parameters, the air containing high concentrations of radon and daughter decay products could spread over a distance of a few kilometres from Degmay tailings.

The surface of the tailings is completely dry and is covered with cracks and clefts. The tailings pond is only partially fenced and therefore freely accessible for the local population. According to the data obtained during the IAEA expert mission of 2006, the high gamma dose rates measured on the tailings surface (4.5-20 μSv/h) were significantly higher than the reasonable safety levels allowed for an area accessible to the general public.

The generation of the airborne dust from the surface of the tailings is a major concern, as the average wind velocity in the area exceeds 10 m/s. There has been no appreciable groundwater monitoring carried out around Degmay during in more than 10 years. (for hydraulics or chemistry). Most of the wells are unserviceable for observation of the contamination movement and will require reconstruction or replacement.

The nearest settlement is a village about 1500 meters away from the tailings dam. The drinking water supply used by the villagers comes from wells. Water from these wells is also used for irrigation purposes. Under these circumstances it would be prudent to evaluate and predict the possible contamination of the ground water in the vicinity of the Degmay tailings pond.

The main dam of the tailings pond has no geotechnical monitoring installations and therefore neither data nor calculations of the stability conditions are available.

Risk estimation and proposed measures

The conclusion of the risk estimation is “high risk”. Main factors are the dust and radon releases from the uncovered tailings dump and also access to the site available to the general public. In addition, a potential radiological risk for the local population is the contamination of the groundwater, which may be used for drinking and irrigation.

The following measures are proposed:

Preliminary (immediate) measures:

- to clarify current status of the Degmay tailings facility. If this tailings storage facility will be operational in the future, the operator should provide adequate safety assessment and provide assurances to the government and/or regulatory body that safe operation and closure of the facility will be carried out. This would include all potential exposure pathways (especially groundwater). Special attention should be paid to the dam stability.
- temporary fencing or guarding of the area (preventing public and animal access);
- the groundwater monitoring network to be restored, monitoring program to be developed and regular monitoring /reporting established.
- the regular monitoring of airborne dust, Rn-222 and other radiological and toxicological parameters relevant to the site is to be regularly carried out by “Vostokredmet”;
- the environmental impact assessment is to be undertaken and cover for the TSF to be designed.

Proposed remediation measures:

- covering of the tailings surface (taking into account restoration of the water drainage system)
- phyto-stabilization measures to be discussed and applied (if appropriate) to prevent wind erosion
- groundwater monitoring network (observational wells) to be restored where it existed previously and developed in other areas
- long-term monitoring program to be developed

- public communication and institutional control are needed.

Taboshar uranium mining and milling site

Short site description

The uranium mines in the Taboshar area are the oldest uranium mines on the territory of the former USSR. The mines were discovered in 1936 and small-scale extraction of ores followed until the large-scale production was carried out between 1949 and 1965. After the closure of operations, an area of over 400 ha containing different types of mining waste was left abandoned. Part of this legacy is the site of the low-grade ore sorting facility.

The township of Taboshar with the population of about 12 000 people is located a few kilometres away from the disposal sites. This legacy site includes abandoned open mines, inundated uranium pit and rock waste piles (Figure 19), demolished buildings and three tailings dumps with about 10 million tones of acidic waste and uranium ore extracts. The photos of the "barren ore" tailings pile – Yellow hill "are shown in Figure 20.

Figure 19. Waste rock piles and former Uranium pit material near former Radium open cast mine covered with water. Contents of dissolved uranium in the water of pit 40-50 Bq l^{-1}. [15]

The residues at the site of the sorting plant contain more than two million tons of low grade ore. The pile is not covered and has been exposed to wind and water erosion for the past 40 years. Local residents have access to the pile ("Yellow Hill") and allegedly, the material was used repeatedly for construction purposes.

Figure 20. The "Yellow hill" tailings pile of the factory of "barren ore" (FBO) created during the 1960s is one of the sites where remediation measures are required

The low-grade uranium ore pile received special attention because of the potential for environmental impact (Figure 20). The contaminants from this pile are released by erosion and natural leaching processes and subsequently carried by small creeks downstream to the Say Creek reaching residential area (Figure 20, right). The eroded material deposited below the pile has a gamma dose rate in the range from 2.2 to 2.7 $\mu Sv \cdot h^{-1}$. Compared to this, the gamma dose rate measured on the surface of the pile is not particularly high; the dose rate is in the range of 1-1.5 $\mu Sv \cdot h^{-1}$. The low dose rate on the pile is probably due to the thin crust, which has developed over most of the surface.

The radon exhalation in the same area appears to be elevated. The gamma dose rate measured near the "Yellow hill" is 0.4-0.7 $\mu Sv \cdot h^{-1}$ and reaches up to 3.0-4.0 $\mu Sv \cdot h^{-1}$ in the places where uranium waste rock was dumped.

The tailings from the hydrometallurgical plant are located in the upper area of the Utken-Suu river. Besides erosion into the creeks, these tailings are also subject to mudslides. For example, following heavy rains during 1998-2000 mud slides occurred in the tailings pond No.1, which resulted in significant amounts of tailings being released into the valley of Sarym-Sakhly Say creek.

Tailings material of reddish sand appearance was re-deposited along the valley over a distance of 3 km toward the Utken-Suu river, which is the downstream water resource for the local residents. The re-deposited material on the flood plane has a gamma dose rate up to 2.5Sv/h. The re-deposited material is distributed over a relatively large area on the bank of the river. The contaminated sediments along the shore of the river appear to have an attraction for local residents, for the purpose of recreation and thus, may result in avoidable exposure. This applies particularly to children playing with sand on the riverside. These sites require remediation (Figure 21).

Figure 21. The red-yellow materials from the tailings 1 of the Taboshar hydrometallurgical plant have been spilled to the distance up to 3 km resulting by water and mudflows along the Sarym-Sahly Say and Archa-Say creeks.

In 2005, with the financial aid and assistance of an OSCE programme in Tajikistan, the upper springs were cleaned, a mudslide trap was re-established and a cut-off drain was constructed to minimize the consequences of possible mudflow above the spring in the future. The "tongue" of tailings 1 was covered by soil, thus partly reducing the risk of repeated mudflows, at least for some time. However, the tailings material has been partially dispersed far away from the original tailings dump site by the creek flow. It is suggested that this material needs to be collected from the riverside, particularly from the areas available for public access (Figure 21).

A special problem of the Taboshar tailings is the seepage of residual acid solutions from the tailings dumps I-II. The seepage at the bottom of tailings has high levels of sulphate (9200-9600 mg/l) and carbonates (1800 mg/l of HCO_3) and also carries dissolved uranium. The gross alpha activity in several samples taken by IAEA experts from the seepage waters discharging into the Creek was in the range from 1200 to1500 Bq l^{-1}; the contribution of uranium ($^{238}U+^{234}U$) to the gross alpha activity was in the range 1110-1450 Bq l^{-1} (converted into weight concentrations this represents 50-70 mg l^{-1}). Due to the arid climate the seepage water evaporates on the banks of the creek creating a yellowish precipitate, which crystallizes as sulphate and carbonate complexes with high uranium content. These yellow crystals of uranium sulphate complexes have an alpha activity of 12-15 kBq kg^{-1}. The photos show the uranium salt deposits for the spring period; after the accumulation during the previous dry season the salts were washed out to the creek (upper line) and the situation in the summer dry period is shown on Figure 22.

Figure 22. Drainage water salt deposits (with high contents of uranium in the sodium and sulphates crystals) near the tailings dumps of I-II. The view of the drainage water residue in the spring period (April 2007, upper photo) and during the dry season (August 2007) with low groundwater table (data from IAEA RER0986)

The risk of exposure of the local population appears to be increased due to the fact that local residents regularly lead their cows and sheep to contaminated watering places.

An urgent remedial measure in Taboshar should be the treatment of the overflowing mine water discharging directly into Taboshar. Because of the lack of other water sources the local population uses this water. The analysis of the water samples taken during the IAEA expert mission in spring 2007 shows that the water is highly contaminated (Figure 23). Therefore, an important element of any monitoring program to be carried out at the Taboshar site would be measurements of contamination in surface and mine waters.

Figure 23. Assessment of the water bodies pollution at the Taboshar town and nearby areas. Data on radionuclide concentration in the water of Utken-Suu river (1) corresponds to the sampling point located upstream of Taboshar and for Utken-Suu river (2) downstream of the uranium legacy site [15]

Water body	$^{234+238}$**U**, Bq l^{-1}	^{226}**Ra**,Bq l^{-1}
Former uranium pit	47-60	0.05
Mine waters	37-40	0.06-0.16
Sarym-Sahly-Say	26.7	0.02
Utken-Suu river (1)	0.65	0.03
Utken-Suu river (2)	0.73	0.03
Creek in Taboshar	1.86	0.02

Risk estimation and proposed measures

Because or the direct exposure from the tailings pile and due to potential consumption of contaminated water the radiation doses for people living in the vicinity of the site the site may be relatively high. The radiological assessment carried out in the IAEA draft report RER/9086 [15] shows that radiation exposure for residents of Taboshar, who regularly visiting tailings sites and use water for drinking and irrigation may reach up to 7,3 mSv/year, which is much higher than the internationally accepted exposure limit of 1 mSv/year. Therefore, the risk factor for the Taboshar site is “high risk”. The main factor in this assessment is the risk of associated with significantly elevated radiation exposure for the local members of the public through all exposure pathways (groundwater, radon, dust, direct radiation). There is an immediate need for actions to reduce the "high" risk level.

The following measures are proposed:

Preliminary (immediate) measures

- Prevention of the use of mine water by local population and to provide institutional controls with an intention to prevent access of the local people to the tailings site. This may involve the provision of an alternative water supply.
- Installation of a groundwater monitoring network downstream of the acid drainages.
- Comprehensive safety assessment to justify remedial action planning on the basis of an integrated model for the entire site (including all tailings, dumps and the abandoned mine).
- Enhanced cooperation and coordination between all funding Agencies and institutions involved in the assessment and preparation of the remediation plan for the site.
- A risk and public communication program.

Remediation measures

- Temporary fencing or guarding of the area of the "Yellow hill" (preventing of access by people and animals);
- Evaluation of an existing design for remediation prepared in the framework of the OSCE and EuroAsEc projects [18];
- Collection of the tailings material from the tailings 1 pond that was dispersed along Archy-Say and Utken-Suu rivers;
- Water treatment (possible location of a clean water supply);
- Covering (or repair of existing covers) of the surface of all tailings ponds including water catchment and drainage control measures;
- Demolition of contaminated buildings and structures;
- Plugging and backfilling of mine openings.

All items above should include a public consultation/information component. Regular site specific monitoring program should be developed, including surveillance and technical inspections

Khujand, mine No.3

Short site description

The waste rock piles of the former uranium mine No.3 are located 4-5 km from the residential part of the city of Khujand along the slope and foothills of Mogoltau Mountains. The uranium mining in this area was carried out from 1976 to 1985. The total area taken up by the waste rock piles is about 6 ha and the piles contain about 350 000 tonnes of waste rock.

The waste rock piles have a soil cover with the thickness of 0.5 - 0.7 m. The gamma-dose rate on the surface of the waste rock piles is in the range of 0.3-0.6 μSv/h, indicating that the cover is adequate and functional. The mine No.3 is mostly fenced, but free access is still possible at several locations where there is no physical protection. The warning signs describing the radioactive hazard have been stolen or destroyed and at the time of the site visit several persons and animals were seen at the tailings pond [15].

The mine waters discharge from the gallery and contain radionuclides of the uranium and thorium series in increased concentrations. Due to this fact, a mine water treatment facility including sedimentation ponds and ion exchange columns was installed at this site at the end of 1990's. The facility was operational, both in terms of environmental protection and extraction of uranium from the mine water (containing 30-36 mg/l of uranium); but in recent years the treatment facility has been closed [15].

At the moment remediation of the piles is not necessary, the surveillance inspections and regular monitoring of the radionuclides and chemical pollution in the water flowing to the Syr-Darya riverside are need to be re-established. Aerial photos of mine No.3 are shown in Figure 24.

Figure 24. The old mine No.3 at the vicinity of Khujand town (upper aerial photo) and mine waters inlet and water treatment facilities for the mine waters on the right bank Syr Dariya river, to be restored

Risk estimation and proposed measures

The "medium risk" can be established for this site. The main factor is the risk of increased radiation exposure of the local population due to the contact with contaminated mine water and contamination of Syr Darya River with toxic metals in a mine waters.

The following measures are proposed:

- EIA, especially analyses of mine water, assessment of existing covers at the waste rock piles;
- to restore ion exchange column for mine water treatment and continue uranium extraction from the mine water, as commercially beneficial and environmentally acceptable measure;
- monitoring and other actions, depending on the safety assessment and action planning that will be carried out in the future.

Adrasman site

<u>Short site description</u>

A uranium extraction plant operated in the town of Adrasman in the past. As a result, the tailings were generated and current dump contains approximately 800 000 tons of this material. The tailings are located on the outskirts of the town and covered with 40-60 cm of waste rock and soil, the material being obtained from local sources. This relatively recent remediation was carried out by SE “Vostokredmet”. According to the data of “Vostokredmet”, the gamma dose rate on the top of the tailings cover is in range 0.5-0.6 μSv/h [15].

However, a two meter deep ravine has developed on the side of the tailings dump due to water erosion. The tailings dump is not fenced off and people have unrestricted access to the site, which they frequently visit (this includes children living in the nearby settlement).

Currently, the tailings material is covered by the local soils, however as a result of water erosion, the tailings materials are dispersing down slope reaching the area used for agriculture by the Adrasman residents. In the beginning of 2007 the tailings No.2 (in the Adrasman village) was made into a safe condition in respect of the “ravines”, at the expense of «Vostokredmet»; an off-take dam was created in order to prevent the erosion of the dam in future.

Reportedly, the seepage water is coming out of the tailings dump during the rain season but, unfortunately, no quantitative data of the seepage is available. The seepage water is used by the local population for irrigating the outlying vegetable gardens and the contamination level of this water is unknown. An aerial photo of Adrasman is shown in Figure 25.

Figure 25. Aerial photo of Adrasman

Risk estimation and proposed measures

The “medium risk” is assigned for this site. Main factor is the risk of increased radiation exposureof the local population through use of contaminated groundwater, exposure to radon, and direct gamma radiation.

The following measures are proposed:

- assessment of the site;
- groundwater monitoring;
- covering or repair of the existing cover.

Chkalovsk, tailings 1- 9

Short site description

Chkalovsk is a suburb of the city of Khujand (formerly Leninabad – the centre of the Sogd oblast of Tajikistan) which is the location for several mining industries including “Vostokredmet" (former Leninabad Mining Chemical Complex, which was previously involved in the mining and processing of uranium ores).

Residues from the extraction process and acid residues following neutralization were transported and deposited in the nearest tailings disposal site. Pumping was conducted through an existing coal slurry pipeline. The site was reported as extending over 18 ha; containing 3.03 million tones of residues that had been covered with a soil layer 0.5 to 1 m thick.

The surface of the tailings was covered with grasses which are attractive to flocks of sheep as grazing. There is free access to the surface of the tailings for the population. The area around this tailings site is cultivated with orchards for apples and stone fruit (plums. apricots etc.).

Risk estimation and proposed measures

The “low risk” is assigned to this site. There is a risk of increased radiation exposure of the public via direct contact with the tailings material after local damage of the existing cover and contaminated ground water.

The following measures are proposed:

- to restrict access for local residents to the site;
- EIA, especially consideration of possible groundwater contamination by all sources in this region (tailings, mill, other contaminated areas);
- Repair of the existing cover (if necessary);
- Regional groundwater monitoring in the downstream of the contaminated objects;
- Measures against groundwater contamination (if necessary).

Gafurov tailings

<u>Short site description</u>

The Gafurov tailings site is located in the city of Gafurov. It was in operation during period 1945-1950, at the same time as the so-called Experimental Hydrometallurgical Plant.

This facility is located some 10 km away from Degmay, extends over 5 ha, is approximately 13 meter high and contains some 400 000 tons of residues including tailings, waste rock, scrap metal, and decommissioned machines. The cover is reportedly sedimentary material comprising gravel and cobble-sized stones and sand in a silt-clay matrix, and is between 1 and 2 meters thick. The heap was constructed on the natural land surface without any special site preparation.

The site is located adjacent to a main road with blocks of apartments less than 50 m away and a railway station within 150 m. There were no signs of abnormal erosion or human or animal intrusion on the surface of the heap. It was reported that there is only a visual monitoring programme in place and thus there is no evaluation of possible contamination plumes or ground water impacts.

The site is located adjacent to a main road with blocks of apartments less than 50 m away and a railway station within 150 m (Figure 26).

Figure 26. Gafurov tailings site. Photo from the top (left) and Google satellite images (right)

Currently, these abandoned tailings have the status of a inactive mine. Surveillance of the surface and periodic sequential sampling of radon releases and gamma dose rate are conducted by “Vostokredmet”.

Due to effective ground coverage the condition of the tailings is considered satisfactory, meaning that they have no apparent significant impact on the surrounding human population. However, these tailings are located near a residential area and therefore it is necessary to conduct regular observations regarding the exhalation of radon and the content of radon decay products in air. Simple observations are needed at the surface of tailings with selected atmospheric air pump sampling to evaluate possible contamination with the radon decay products.

Risk estimation and proposed measures

The "low risk" is assigned to this site. There is a risk of increased radiation exposure of the local population via direct contact with the tailings material after possible local damage of the existing cover and contaminated ground water.

The following measures are proposed:

- EIA including public participation, especially consideration of possible groundwater contamination by all sources in this region (tailings, mill, other contaminated areas);
- conducting an assessment and repair of the existing cover and drainage system (if necessary);
- establishment of the groundwater monitoring network and measures against groundwater contamination (if necessary).

3.4.5. Project and risk related ranking

Table 12. lists all above described sites, with references to the Framework Document of the UNDP prepared for Geneva Conference in July 2009 [29].

Table 12. Project list

Site	**Risk estimation**	**Measure**	**Costs** Mio. €	**Time frame** years	**Reference to** Project -number of UNDP FD
1. Degmay	high	preliminary	0.2	0.5	RT 3.2; 3.3; 5.2; RU 3.1
		EIA, project design	1.3	1.5	
		remediation	15	2	
2. Taboshar	high	preliminary	0.2	0.5	EurAsEC 1; RT 2.2; 2.5; 3.1; 3.3; 5.1; 5.2
		EIA, project design	2.1	2	
		remediation	13 *	3 **	
3. Khujand mine No.3	medium	EIA, design	0.05	0.3	
		remediation	0.4 *(plus operational costs)	0.5**	
4. Adrasman site	medium	EIA, project design	0.2	0.5	RT 2.3; 3.3; 5.2
		remediation	0.4	0.5	
5. Chkalovsk tailings 1-9	low	EIA	0.05	0.3	RT 2.4; 3.3; 5.2
		remediation,	0.25*	0.5**	

		monitoring			
6. Gafurov tailings	low	EIA	0.05	0.3	RT 3.3; 5.2
		remediation, monitoring	see Chkalovsk tailings 1-9		

* possibly plus operational costs of water treatment and monitoring for many years

** possibly water treatment and long term monitoring over many years necessary

Conclusions

Degmay and Taboshar sites to be selected as the candidate for the priority actions.

Degmay site:

- the status should be identified (closed or still in operation). If this tailings site will be operational, the operator should provide adequate safety assessment and assurances to the regulatory body that remediation will be undertaken;
- An environmental impact assessment should be conducted;
- the public and animal access to the tailings dump site has to be prevented.
- an adequate cover of the tailings surface has to be properly designed and established;
- the groundwater monitoring network has to be restored.
- the regular environment monitoring programme has to be developed and regular monitoring to be establishing by "Vostokredmet".

Taboshar site:

- first priority should be remediate barren ore pile;
- evaluate acid drainage and develop mitigative measures;
- repair existing covers;
- mine waters have to be monitored and treated;
- the tailings material that was dispersed along the banks of the Sarym-Sahly Say and Archa-Say creeks needs to be collected and relocated to a proper disposal facility or to an interim location where access is managed the tailings dump;
- alternative water supply system has to be constructed;
- the better risk communication and public awareness programs are also needed.

3.5.Uzbekistan

3.5.1. Introduction

The Republic of Uzbekistan is one of the leading countries in the world for uranium production. There are up to fifty industrial uranium ore deposits on the territory of Uzbekistan, and the exploration for uranium ore exploring commenced in 1944. As a result of extensive uranium ore mining and processing the large volume of residues of uranium extraction accumulated in the country in the vicinity of the uranium mines and processing plants, resulting in an adverse impact of the residues on the environment and on health and safety of the members of the general public residing in the vicinity of the uranium production legacy sites.

Between 1964 and 1995, the uranium mining in Uzbekistan was solely by conventional mining. The ore mined in the mountainous eastern part of the country at sites such as Yangiabad (Tashkent district) and Charkesar in the Fergana Valley (Namangan district) was sent for processing to the Leninabad Mining Chemical Industrial Combine in Tajikistan (now SE "Vostokredmet"). The ores from the sandstone type uranium deposits in central Kyzylkum (Navoi and Samarkand regions) were processed in Uzbekistan at the Navoi Mining Chemical Combine (NMCC). Consequently, the only uranium tailings legacy in the country is at the NMCC site. After introduction of the In Situ Leach (ISL) mining in 1995, all conventional uranium mines were closed down.

The most important legacy sites of the pre-1995 mining are the former open pit mine at Uchquduq, where the low-grade uranium ore was left piled up on the site without any safety measures, and the mines at Yangiabad and Charkesar.

These sites of uranium industry in Uzbekistan are shown in Figure 27 and Table 13.

Figure 27. Sites of uranium industry in Uzbekistan

Table 13. Sites of uranium industry in Uzbekistan

No. *	City/Name	Object	Number of objects	Status	Remediation activities
1	Uchkuduk mine	ISL**		in operation	ongoing
	Kendykijube mine	ISL		in operation	ongoing
	Uchkuduk Sugraly	ISL		in operation	ongoing
1	Uchkuduk	mine waste	23	not rehabilitated	later
3	Navoi/Navoi mill	ore processing plant		in operation	ongoing
	Navoi /Navoi mill	mll tailings	9	in operation	ongoing
4	North Bukinai mine (ISL)	ISL		in operation	ongoing
	Tokhumbet mine (ISL	ISL		in operation	ongoing
5	South Bukinai mine (ISL)	ISL		in operation	ongoing
6	Beshkak mine (ISL)	ISL		in operation	ongoing
	Lyavlyakan mine (ISL)	ISL		in operation	ongoing
7	Sabursaj mine (ISL)	ISL		in operation	ongoing
	Shark mine (ISL)	ISL		closed	completed
8	Ketmenchi mine (ISL)	ISL		in operation	ongoing
	Ulus mine (ISL)	ISL		decommissioned	completed
9	Yangiabad/Yangiabad mine gallery	mines	5	closed	planned
	Yangiabad/Yangiabad mine gallery	waste rock dump	29	not rehabilitated	planned
10	Yangiabad ore yard	ore storage yard and mine shift	3	closed	planned
11	Yangiabad/Yangiabad	waste rock dump	2	closed	partly remediated
	Angren/Angren	rock dump	1	closed	planned
12	Charkesar/Charkesar-1	mine	1	closed	no plans for remediation
	Charkesar/Charkesar-1	waste rock dump	5	not rehabilitated	no plans for remediation

	Charkesar/Charkesar-2	mine	1	closed	planned
	Charkesar/Charkesar-2	waste rock dump	6	closed	partly decommissioned
13	Uygursaj/Uygursai	waste rock dump		closed	no information
14	Rezak/Rezak	mine	1	closed	planned
	Rezak	waste rock dump	6	not rehabilitated	no plans for remediation
15	Majlikatan	mine	1	closed	no information
	Majlikatan	waste rock dump	1	no information	no information
16	Krasnogorsk -Chauli	mine waste	1	closed	planned
	Krasnogorsk	mine waste rock pile	12	not rehabilitated	planned

* the number is related to the map above

**ISL – in-situ-leaching

The following problems are considered as important by the national experts:

- to develop regulatory framework and national coordinated environment radiation monitoring programs at the legacy sites, which will help to implement modern methodology for safety assessment and remediation planning;
- to improve analytical capacity building of the regional laboratories and to create basic reference analytical (metrological) laboratory, which may lead and help other laboratories to implement basic standards and QA/QC;
- to increase basic and specific knowledge of personnel dealing with environmental impact and risk assessment, site characterization, radioactive waste management and remediation strategy planning, and ionizing radiation sources (training and re-training).

3.5.2. Legislative and regulatory framework

Radioactive waste management and the normative-legal base in Uzbekistan are based on the application of the following laws:

- About State Sanitary Control (1992);
- About Radiation safety (2000);
- About Wastes (2002).

The following Laws, Degrees of the Government, and other norms that are also used:

- Law on Environment Protection (2002);

- Law on licensing of separate types of activities (2000);
- Law on transit of dangerous goods and cargos (2001);
- Decree of the Cabinet of Ministers of the Republic of Uzbekistan No.111 dated 06.03.04 “On approving Regulation on licensing activities related to the ionizing sources” (2004);
- Decree of the Cabinet of Ministers of the Republic of Uzbekistan No.98 dated 03.04.09 “On approving Regulation on organizing system of state records and control over activities related to the ionizing sources” (2009);
- Degree of the Cabinet of Ministers of Republic of Uzbekistan No.211 dated 18.09.2008. «On a Environment Protection Programmes at the Republic of Uzbekistan 2008 -2012 »;
- Standards of Radiation Safety (SRS-2006) [31] and main sanitary rules on the provision of radiation safety (OSPORB-2006) [32], (SanPiN No.0193-06), (2006) [33];
- Sanitary regulation in radioactive waste management (SanPiN No.0251-08), (2008) [34].

3.5.3. Decision making structure

In Uzbekistan, the responsibility for the implementation of the regulatory functions, including registration of the sources, preparation of technical safety regulations, licensing and inspection of radiation facilities lies with the special division of the State Inspectorate on Safety in Mining and Milling Industry. The Centres for Sanitary and Hygiene Epidemiology (Sanoatkonnazorat) of the Ministry of Health (MOH) are responsible for the sanitary supervision of ionizing radiation sources, establishment of dose limits and other regulatory criteria.

The monitoring of the uranium legacy sites is a responsibility of the Ministry of Health, which established for the purpose of monitoring of radioactive substances in the environment and food products specialized laboratories. The work is coordinated by the Chief-Radiologist of the Ministry of Health.

The Ministry of Health is responsible for the development and establishment of the norms on radiation safety and also for monitoring of radioactive substances in the environment and food products. This ministry is also responsible for the establishment of dose limits for uranium and other mining industry and also has a mandate to supervise and monitor the safety conditions for the population living in the vicinity of uranium production facilities, including legacy sites.

In 2007 a special educational Center for Radiation Safety has been created. This centre includes analytical laboratory for training of personnel including staff of the environment and individual radiation monitoring laboratories from the uranium industry of Uzbekistan.

Specific functions of the State Committee for the Protection of Nature in the area of waste management include the following:

- state supervision of the waste management practices, in accordance with established legislative and regulatory norms;

- coordination of the activities that are undertaken in the area of waste management by the different State Agencies and companies;
- state registration and characterization of the sites for disposal and utilization of the wastes;
- reviewing and approval of the projects, concepts, feasibility studies and designs for industrial waste disposal and waste management.

The State Committee for the Protection of Nature is also responsible for environment monitoring in the areas of waste disposal sites and also conducts remediation of separate objects at the operational areas of the discharged uranium mines.

Operational bodies, which monitor the radiation situation in the mining areas, status of radioactive waste at uranium enterprises and radio-ecological situation in the disturbed areas, are:

1. Navoi mining-metallurgic combine from its own profits provides for the management of radioactive wastes and monitoring of the contaminated areas (Department on the Environment Protection). It also conducts research and project works for mining and processing enterprises on the territory of Uzbekistan and Central Asia (the "UzGEOLTEHLITI" Planning and Surveying Institute).
2. The State Committee of the Republic of Uzbekistan for Geology and Mineral Resources with the support of special sub-bodies conducts monitoring in the areas of former uranium mines (State Enterprise "Scientific-industrial Centre of Uranium Geology and rare-earth metals) and in the valleys of transboundary rivers Mailuu-Suu and Sumsar (the Lange Institute of Hydrogeology and Engineering Geology).

3.5.4. Site description, risk estimation and proposed measures

Introduction

For more than 40 years the Republic of Uzbekistan was one of the main raw material bases of the uranium industry in the former USSR. A large number of uranium deposits with a relatively high uranium content (above 0.02%, but sometimes reached 12.8 – 18.3%) were discovered here, mostly in the area between Syr Darya and Amu Darya rivers. In total, about 50 uranium deposits were discovered and exploited in the republic and the main deposits are situated near the populated areas of Uchkuduk, Zaravshan, Zafarabad, Nurabad, Angren, Charkesar and Krasnogorskiy.

In the period of intensive mining, ores were mined, sorted and then sent for processing to the Navoi Mining and Smelting Plant in the town of Navoi (Uzbekistan) and the Leninabad Mining and Chemical Plant (currently GE "Vostokredmet" in the town of Khujand, Tajikistan). A considerable part of the waste from the sorting of the ore was stored on the mine sites, particularly on the slopes of the river valley from Yangiabad to Angren. A similar picture could also be seen in other mining areas.

Low grade ores from mining areas in the central Kyzylkum region were mainly transported into the suburbs of Uchkuduk, where they were dumped and are still there today. The majority of mines in Uzbekistan stopped operating in the 1980s and the working areas at the majority of the mines have not been remediated. Underground workings (galleries and mines) are flooded and mine water with high levels of uranium, radium and associated toxic metals can be seen in some of the old mines. Some working openings are not concrete-sealed and mine water flows into the nearby streams and rivers or infiltrate water-permeable sediments and can, therefore, leak into the ground water.

At present, uranium mining in Uzbekistan is carried out using the underground in-situ leaching. A large part of low grade ores and waste from uranium mining and processing facilities originated from earlier activities.

In the past in the central Kyzyl-Kum area remediation was typically not carrired out (up to 1992), mostly due to the excess of unoccupied land and lack of the need to for the re-use of the land that was allocated for mineral resources' production. During the last 15 years, 10 projects have been developed in the Republic of Uzbekistan, aimed at the remediation of contaminated land and former waste dumps at 14 former uranium processing facilities.

As agreed with the authorities, only Charkesar and Yangiabad in eastern Uzbekistan (which are not the responsibility of active uranium producers such as the company Navoi MCC) are discussed as applicable projects for possible international financing of direct remediation measures.

Charkesar uranium mining site

Short site description

Uranium deposit of Charkesar is located in the foothills of the Kuraminskiy Range, in the Papskiy Rayon of Namanganskaya Oblast of Uzbekistan, in the north-west part of the densely populated Fergana Valley. There were two mine sites at this ore deposit: Charkesar-1 and Charkesar-2. Charkesar-2 is located at the outskirts of Charkesar village, in the valley of a small mountain river. Charkesar-1 is located 5–6 km to the west, in arid and unpopulated valley in the highlands. The total volume of radioactive wastes is 482 000 m^3 and spread over an area of 20.6 ha. The site is periodically examined visually and samples are taken from the soil, wastes, mine water and vegetation. Radiation monitoring is performed in the houses and administrative buildings of the village of Charkesar.

The Charkesar-2 site is in the neighbourhood of the village of Charkesar, which has a population of about 2500 people. Uranium production ceased in the mid 80s and the mines were partly decommissioned. After mine closure, most of the miners and professionals left the village because of lack of other work opportunities in the area. Today, in spite of the difficult social situation, the local population is growing and the improvement of the environmental situation in Charkesar is being seriously contemplated by the Government of Uzbekistan (Figure 28).

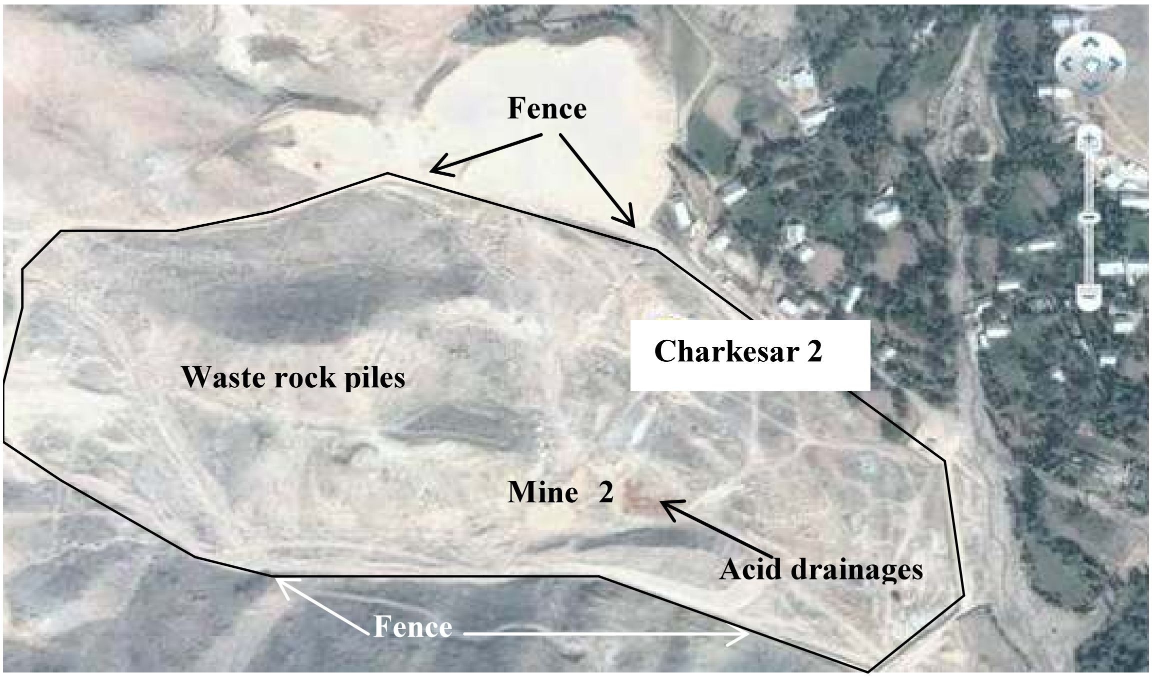

Figure 28. Charkesar-2 uranium mining legacy site

Partial remediation of the site was attempted some time ago and the low-grade ore and waste rock piles were partially covered. The dose rate at most locations of the site is reportedly comparable to the local background at 0.3-0.4 μSv/h. Approximately 53 000 m^3 of local soil were used for covering the dumps, in two lifts, with a final thickness of 0.8-1.0 m. There are signs of erosion on the cover that may be explained by the fact that the slope of the covered dumps appears to be too steep to be stable.

However, based on results of the IAEA expert mission in 2007 in some places at the mine site the gamma dose rates were found to be as high as 1.7 μSv h^{-1}. Radon emanation rate from the surface of the waste rock piles (exhalation) varies from 2 to 20 Bq m^{-2} s^{-1}. These levels demonstrate that there appears to be insufficient cover over the tailings [15].

After the mine was abandoned, the shaft was not sealed, thus presenting a safety hazard for the local population, who frequently visit the site. The ventilation shaft was located on the small hill and now it discharges contaminated mine water (about 3-5 litres per second), under artesian pressure. Water flowing out of mine shows all the visual characteristics of acid rock drainage. The measured ^{238}U activities in the drained water were in the range of 26-40 Bq l^{-1}, and ^{226}Ra activity in range 1-3 Bq $l^{-1.}$

The gross alpha activity in the river water upstream of the drainage water outfall was estimated by one sample only and found to be 2.5 Bq l^{-1} and downstream - 4.7 Bq l^{-1} (measurements were done by the IAEA's experts in 2007) [15].

In this mine, uranium mining was carried out by underground leaching. An acidic solution was pumped into the mining excavations, which dissolved minerals in the ore rocks. Since the closure of the mine, the water, enriched with uranium and associated heavy metals, flows from the mine along the populated part of the village for a distance of 600-800 meters before leaking into the ground. As result of infiltration, the soil is impregnated with bright yellow-and-orange iron ochre (Figure 29).

Figure. 29. Mine water draining to the surface via galleries and mine mouth, leaving ferruginous deposits

Risk estimation and proposed measures

A “medium risk” can be assigned to this site. Main factor is the risk of increased radiation exposure of the members of the public visiting accessible tailings dumps. The exposure may be increased due to the radon-222 inhalation, exposure to gamma radiation and direct ingestion of contaminated material and use of contaminated mine water.

The worst case of exposure has been assessed for the local inhabitants, whose houses are located relatively close to the industrial sites and for the case where tailings materials were used for domestic purposes and house construction. In some houses the indoor Rn-222 concentrations were between 1000 and 1200 Bq m^3), relatively high gamma dose rates were also measured. Depending on the scenario of exposure, the maximal possible doses for representative persons living in close vicinity to the site in contaminated buildings are expected to be in the range between 2.9 to 28.0 mSv per year, significantly above the internationally accepted level of the exposure for members of the general public, 1 mSv/year. The most significant contribution to this level of exposure is the inhalation of radon indoors, as radon indoor concentrations in some houses are relatively high (up to 1.5 µSv h^{-1}).

The following measures are proposed:

- EIA, FS and design of the proper cover for the industrial site;
- Gamma-dose survey to be carried out to identify of the individual houses with high exposure factors;
- Establishing the long term monitoring program of radon in houses;
- Covering of the Charkesar-2 waste dumps in places where cover is not sufficient;
- Collection and treatment of contaminated mine water;
- Safe closure of shafts and open mine workings.

Yangiabad Uranium Mining Site

Short site description

There are five uranium mines in the vicinity of Yangiabad. The low grade ore and waste rock piles were left around these mines and at the surface of some of them the gamma-dose rates reach 3.5 µSv h^{-1} . The ore storage yard is located in the central part of Yangiabad village the ore storage yard is situated and the former mine shift are released directly to the storage yard. At some location in this storage yard gamma-dose rates were found in the range between 1.4 and 7.5 μSv h^{-1} (140-250 μR h^{-1}).

Figure 30. Yangiabad uranium legacy site (former mine site and waste rock piles in vicinity of the village on the slope and covered by gravel).

The shaft gallery is filled by mine water with relatively high uranium content (up to 30 Bq $l^{-1)}$. Other trace metals are also present in this water, which is flowing directly into the river that is one of the main sources of water at the valley site. Some local citizens living downstream use the water for irrigation and/or drinking. It is suggested that a regular water sampling programme at this river in Yangiabad and Angren needs to be established, under regulatory control; as it appears that no ground- and surface water monitoring had been undertaken. Perhaps an alternative water supply should be considered.

Risk estimation and proposed measures

A “medium risk” is assigned to this site. Main factor is the risk of increased radiation exposure of the population though the pathways of radon inhalation, exposure to external gamma radiation, and direct ingestion of contaminated material and use of contaminated water.

The following measures are proposed:

- EIA, FS and design;
- Long-term measurement of radon in the valley and in houses;
- covering of waste dumps near dwellings;
- monitoring, collection and treatment of contaminated mine water;
- safe closure of shafts and open mine workings;
- clean-up of the ore storage yard in Yangiabad.

3.5.5. Project and risk related ranking

Table 14 lists all sites described above, with the Framework Document of the UNDP prepared for Geneva Conference in July 2009.

Table 14. Project list

Site	Risk estimation	Measure	Costs (million €)	Time frame (years)	Reference to Project -number of UNDP FD
Charkesar-2	medium	EIA, FS, engineering	0.5	1	RU 3.4
		remediation	2.4	1.5	
Yangiabad mining site	medium	EIA, FS, engineering	0.6	1	RU 3.4
		remediation	7.4	3	
Angren storage site	medium	remediation	2.8	1,5	

Conclusions

The priority sites for remediation are Charkesar-2 village and former uranium production legacy site, and Yangiabad village located at the site of uranium storage yard facility.

Charkesar site:

- The first priority action should be gamma-dose survey, which will help to identify individual houses and other buildings with high exposure factors. Based on the monitoring data the radiological assessment will need to be carried out and possible remediation actions will be implemented, depending on the results of this assessment.
- Second priority actions at the Charkesar-2 industrial site should be the old mining shafts should be blocked to stop the release of mine water to the surface;
- eroded tailings covers needs to be repaired.
- The other contaminated locations at this site should be covered by clean soil cover.
- The public communication and institutional control measures to be established.

Yangiabad site:

- An extensive gamma survey and indoor Rn-222 survey has to be carried out.
- The covering of waste dumps in the vicinity of residential areas is recommended, pending the identification of "hot spots".
- The contaminated mine waters should be monitored and treated, if necessary.
- Safe closure of shafts and open mine entrance is also necessary.
- The clean-up of the uranium ore storage yard in the Yangiabad is also recommended.
- The long-term site specific monitoring and regular surveillance inspection program needs to be developed and established at both sites.

4. PROPOSALS FOR REGIONAL COOPERATIVE ACTIVITIES

4.1. Introduction

As previously discussed many of the uranium legacy sites in Central Asia are concentrated along the tributaries to the Syr Darya River which runs through the densely-populated Fergana Valley, particularly in the Sogdian region of Tajikistan, in the Jalal-Abad region of Kyrgyzstan and in the Tashkent and Navoi regions of Uzbekistan.

Figure 31. Syr Darya River Drainage

The issues related to the uranium legacy sites have been described earlier in this document both in terms of regional and site specific issues.

4.1.1. Regional proposals

Each of the regional proposals is based upon observations and recommendation of either experts from the region or external experts who have worked extensively in the region. The proposed recommendations address strengthening regulatory capabilities, a comprehensive assessment of the sites followed by their prioritization, regional water monitoring, increasing analytical capacity in the region, training and education, and the development of an Internet-based database as a means of confidence building and information exchange.

4.1.2. Legislative and regulatory framework

Legacy sites were created at a time or within a context where regulatory supervision of operations for nuclear safety and radiation protection of human health and the environment was weak or absent. Now strong and independent regulatory supervision is seen as a critical factor in provision of radiation and nuclear safety during operations at nuclear sites. This implies sometimes a major cultural move from the operators of legacy sites and some adjustments from the regulatory supervision side. Much has been done through international cooperation, to enhance regulatory supervision of nuclear power plants and other aspects of the nuclear fuel cycle operations. Up to now, very little have been done internationally or regionally in relation to regulatory supervision of the remediation of legacy sites and shared experiences in addressing multi-facetted aspects of radiation and nuclear safety at legacy sites have been limited. It is recommended that an international network of regulators be established with a specific focus on remediation. This would enable regulatory authorities to network in the context of the remediation of legacy sites and facilitate an exchange of experience and ideas.

Objectives

The overall objective would be to promote high standards of regulatory supervision for the management of legacy sites, in line with the IAEA Safety Standards and good international practices. This will be achieved through the collection and collation of information on nuclear legacy sites; the exchange of information on nuclear legacy sites; and the generation of mutual support through presentation and discussion on how regulatory supervision can be made effective and efficient.

The group should assist IAEA Member States in deriving practical interpretation of generic radiation protection guidance to nuclear legacy sites, and will identify the needs for further development of international guidance specific to nuclear legacy sites. This will include the extent to which guidance needs to be prescriptive as opposed to allowing for regional, national and local variations. Good practices in stakeholders' engagement to regulatory supervision will be identified.

Scope and activities

The scope of the group should include all the types of nuclear legacy sites and covers development of effective and efficient regulatory processes for themes such as:

- Nuclear safety;
- Operational radiological protection for workers;
- Radiation protection of the public and the environmental protection;
- Environmental and source monitoring;
- Control of effluents discharge;
- Emergency preparedness and response;
- Radioactive waste management (categorization, conditioning, storage);
- Clearance of radioactive materials from regulatory control;
- Criteria for site release and termination of activities; and
- Waste acceptance criteria for disposal.

Activities to deliver the objectives should include:

- Support for development of new regulations and regulatory guidance, which address unusual situations arising in actual legacy situations at specific sites;

- Support for development of regulatory procedures for licence application review, and for monitoring compliance with licence conditions in actual legacy situations at specific sites;
- Development of guidelines for representative sampling, interpretation of measurements, remediation/restoration, long-term surveillance and monitoring;
- Support for development of methods for environmental impact assessment, so as to build confidence into prospective assessments of possible future situations. These assessments relate to the demonstration of compliance with safety limitations, but also the demonstration of optimisation from among a set of alternative management strategies;
- Development of guidance and Proposals regarding the application of optimisation at the national strategic and site specific levels, based on the practical experience from different countries;
- Development of international guidance on regulatory supervision of legacy sites;
- Peer reviews of regulatory supervision of remediation projects.

The risk management will involve the trade-off of different types of risk to different groups of people on different temporal and spatial scales. The regulatory supervision process faces important challenges in accommodating these issues.

4.1.3. Comprehensive assessment of the sites followed by their prioritization

The second recommendation is a mechanism be established to carry out a comprehensive assessment of the sites, following by their prioritization – with the final outcome being a list of first priority “bankable” projects”.

The following steps should be taken:

Application of safety assessment methodology to the legacy sites

The main aim is to continue data collection and analyses of hazards (supplemented by expert missions where required) and to characterize the sites in a manner similar to the one used in the frame of the IAEA RER9086 project [15].

Additional radiation dose, chemical hazards and ecological assessments will be required for each of the priority sites that would be chosen by the countries on a basis a preliminary assessment carried out in this document.

The site-specific analyses and safety assessments will allow for the creation of a short list of “bankable” projects, which then could be submitted to a potential donor. The risk matrix utilized in this document is limited due to a lack of detailed information. This recommendation would include additional evaluation criteria such as dose-risk, cost-benefit and ecological assessment; with social and economic factors taken into consideration as well based upon additional information.

Prioritization of uranium legacy sites for remediation

Based upon the assessment described above, it will be possible to select priority sites and "bankable" projects with a higher degree of certainty in comparison with preliminary assessments carried out in this document.

4.1.4. Regional Water Quality Monitoring System

Introduction

It is recommended to establish a regional watershed monitoring network in the areas that could impact or be impacted by uranium legacy sites in Central Asia for reasons previously discussed in this document. This means the watershed of the Syr-Darya river, which is formed by two major rivers, the Naryn and Karadarya. There are numerous tributaries as well.

A prior assessment of the river contamination by naturally occurring radioactive materials (NORM) and trace metals has been done in this region during 2000-2001 in cooperation with Sandia National Laboratories [35]. This recommendation builds upon these prior results and Proposals provided in the report [35, 36].

Figure 32. Naryn reservoir in Kyrgyzstan

Project aim and expected outcome

The monitoring of the river system and its catchments is a priority for the region, as both potential incidents in the course of remediation of the legacy sites and emergency situations after flash-floods or landslides may have an impact on use of water. The monitoring system will provide for the identification of potential issues and application of necessary control measures.

There is strong support for such water monitoring network coupled with data exchange and an information system as expressed by representatives of Kyrgyzstan, Tajikistan, Uzbekistan and Kazakhstan.

The goals of the activity should be:

- Establishment of a practical monitoring system for radiological and chemical contaminants;
- Establishment of a capability for analyzing the samples and reporting the results; and
- Adoption of a unified, systematic approach to monitoring and reporting.

The final long-term goal of the project is the establishment of a regional watershed monitoring system. Samples will need to be analysed on a regular basis and would need to be reported and the results published.

The technical tasks should be divided in two stages:

Stage 1: Preliminary

- Identification of potential sources of contamination (uranium legacy sites and other sources of possible industrial pollution);
- Identification of proposed monitoring points, which should be located at:
  - in the vicinity of potential sources of contamination;
  - upstream, in the vicinity of towns with high population or near water reservoirs;
  - at the site of special interest or existing monitoring services; including national boundaries where appropriate;
- Identification of appropriate infrastructure for sampling and laboratory data analysis;
- Identification of the need for analytical equipment (including data management software);
- Development of strategy, sampling plans and technical documents for implementation.

Stage 2: Implementation

- Evaluation of site specific needs (infrastructure, licensing, other technical factors);
- Implementation on the national level;
- Implementation on the regional level, with data exchange modules.

Cost and time evaluation

The costs of the EU project "Monitoring and Warning System for the Ob/Irtysh River Basin" (EUROPEAID 121579/C/SV/RU Service Contract 99310, funded by the European Union) were approximately:

- 1.9 million Euro for the first stage (preparatory), and

- 2.9 million Euro for the second stage (including 10 monitoring stations in place, but no equipment for sample measurements and laboratory equipment).

The first stage of above mentioned EU project has been completed within 2 years and 9 months and the second stage within 2 years and 6 months.

However, the costs to plan and implement this proposal should be significantly less. Due to the fact the radiochemistry is uranium decay series based (as opposed to strontium and cesium) and cheaper to perform from an analytical standpoint. The program could start with a few indicator parameters and basic manual sampling methodologies until the infrastructure was in place to adapt more sophisticated methods. A scope of work should be written to design and estimate the cost of such a monitoring network taking into account current national capabilities.

4.1.5. Analytical capacity building

Introduction

While the monitoring of the regional watershed is one of the priorities, an effective analytical network of laboratories is equally important. In order to accurately quantify the levels of contaminants of concern properly equipped labs, with trained staff and proper QA/QC procedures will need to be further developed. Several international organizations have provided some assistance in this regard. It is recommended that this effort be expanded and coordinated to maximize the resources. Strong consideration should be given to sharing capabilities including utilizing and involving appropriate institutions and universities in the region.

The network of facilities should be capable of liquid or solid sample measurements such as:

- Density, weight and other ground parameters for physical characterisation;
- Radioactivity concentrations (alpha, beta, gamma, radon) – with the determination of concentrations of indicidual radionuclides of interest (Ra^{226}, Th^{230}, U^{238}), as required;
- Concentration of heavy metals and potentially toxic chemicals that are known to exist in the material located at uranium legacy sites.

Aim and expected outcome

The structure of a laboratory would significantly depend on the variety of tasks that are to be undertaken in water and soil sample measurements.

The laboratories are expected to work on standardized methods using calibration sources that can be traced to the international standards. Quality assurance programs should be implemented and technical guidelines established to ensure that different regional laboratories will obtain approximately the same result for comparable samples.

Technical design

A network of laboratories should be established based upon analytical capabilities that exist in a country (as in some cases certain basic routine measurements and sample preparation can be carried out using existing infrastructure). In some cases for more sophisticated analytical techniques, the establishment of a centralized laboratory may be necessary.

In addition there is also a need for smaller, on-site laboratories, which should be able to analyse the routine samples at least at a screening level, to establish if a level of a particular contaminant is above or below the value specified in a technical guideline. The structure of an on site laboratory will depend significantly on the type and level of expected contamination and, naturally, sampling regime will need to be much more intensive where remediation activities are carried out at the particular site.

It is essential to ensure that qualified and experienced personnel are available to operate the equipment

The implementation of this recommendation should be carried out in two stages.

Stage 1

- Identification of potential contamination sources (uranium legacy sites and other industrial pollution);
- Identification of monitoring points – described above;
- Identification of existing laboratory structure and its possible utilization;
- Identification of existing infrastructure that can be used for sampling, data analysis and transport of samples;
- Identification of the need for analytical equipment (including software);
- Development of strategy, action plans and technical documents for implementation.

Stage 2

- Evaluation of site specific needs (type and number of samples, contaminants these samples to be analysed for, licensing, availability of trained and experienced personnel and other technical factors);
- Selection of the laboratory administrative structure and responsible government department(s);
- Technical implementation – centralized laboratory;
- Technical implementation – on-site laboratories.

Cost and time evaluation

The costs of establishing an analytical laboratory network (excluding costs for a building, personnel, energy and other supplies) are expected to be in order of:

a) 300 000 € for the phase 1 activities,

b) 350 000 € for water and soil sample measurements (non-radionuclides),

c) 150 000 € for radionuclide measurements (using both stationary spectrometers and mobile multipurpose systems), and

d) 100 000 € for an on-site laboratory.

It is expected that stage 1 could be implemented within 1 year and the stage 2 will require 2 years.

4.1.6. Training and education measures

Introduction

In order to address the issues associated with the uranium legacy sites the national technical capacity must be enhanced in all Central Asian countries. In particular, training and education is needed to give the specialists in both national regulatory bodies and in operating companies the knowledge and tools to plan and implement a successful remediation. The following is the list of areas in which training is considered to be necessary and strongly recommended:

- Radiation protection, including the estimation of doses and environmental impacts;
- Environmental and personal monitoring of air, soil and water – for all stages of a remediation project: prior to commencement, during remediation activities and long term monitoring after the remediation has been completed;
- Remediation technologies and planning;
- Project management;
- Risk assessment;
- Application of quality assurance systems.

The list is by no means exhaustive and additional training in areas that are not listed above may be necessary in some or all countries.

Aim and expected outcome

The aim of this activity to develop a sustainable training program to ensure that qualified and experienced personnel are available to support remediation at the legacy sites.

The part of education process will be carried out at legacy sites.

For example, a basic course on radiation protection will be carried out in such a way that the participant will be able to take real measurements on an actual legacy site – not in a simulated environment. This will allow for much better understanding of the situation and it is believed that the practical "hands-on" experience will help the participant to develop a basic radiation monitoring program that will reflect the real situation.

A basic course on environmental monitoring will allow the participant to accurately identify both the media to be sampled and the contaminants the sample will need to be analysed for. In turn, this will enable the participant to develop an environmental monitoring plan for future implementation. It is also expected that at the completion of the course a participant will be aware of all types of monitoring and analytical equipment available, familiar with its use and will be able to select the correct equipment for a particular task. The practical work at legacy sites is also to be an integral part of education process.

Structure

The proposal is to establish a series of training courses in the region with a focus on the areas detailed above. The duration of the courses would vary between topical areas and will also depend on the depth of training required. Arrangements could be made with a local universities or scientific institutes in each country (after a screening process) to carry out the training.

Cost and timeframe

It is expected that the project would take approximately two years with an approximate cost of 300 000 € per year.

4.1.7. Internet based database for information exchange

Introduction

Taking into account the coordination of the projects in the future and need for the regional data exchange it has become apparent that an information system (coupled databases) is required.

It is strongly recommended that a regional geographic information system be established. The information system will provide comprehensive data for each country and contain the data on locations of sites, proposed/ongoing remediation projects and site-specific information and maps. The amount of information that is deemed to be necessary should be compared with the need for potential sponsors to make budget decisions on remediation projects – therefore, a simple overview of the situation on a particularly site may not be entirely sufficient. Additional project-related data (for example, technical documents, reports, engineering drawings, photos, etc) should also be included and a database should have the capacity of being searched using one or two simple key words. In a subsequent step of the development of the information system it will also include all environmental monitoring data obtained from the proposed monitoring system.

Aim and expected outcome

The goal of the information system is to provide detailed information in following areas:

- Country information;
- Relevant laws and regulations, and government departments administering these regulations;
- Sites and relevant risk estimation;

- Proposed/ongoing/finished projects;
- Remediation projects;
- Transboundary activities (monitoring);
- Education and training;
- Contact persons;
- Related/involved international organizations (IAEA, NATO, OSCE, UNDP, EBRD);
- Related documents and data available in literature.

It is expected that the database would include an overview-map for each country with the possibility to choose the different sites/objects. The map will contain the following aspects for each object: mines, mine waste, processing tailings, open pit, waste rock piles, tailings ponds, mills, processing plant. The following data will also need to be included: risk evaluation sheet(s), steps taken for the physical protection of the site, sampling data and remediation activities.

It is proposed that there will be a catalogue containing all actual, already completed and planned projects for each country to give an overview about the remediation activities. In addition to the project information a document management system will need to be developed that will allow for filing of all relevant information and/or reports, which will be accessible both via the directory and by using a key word search and will allow for the documents to be up- and downloaded.

A list providing contact data for the regulatory authorities and responsible persons, and also for companies in the specific country will be added to the database. Other data that may be added is, for example, the organisational chart for the decision making in a particular country or a "link list" of relevant organisations and other relevant information.

From the administrative point of view, the information system will provide all relevant data in an Internet browser, in both Russian and English languages.

The access will be designed to be user-specific, so that each user gets specific rights to view and modify the data. It is also recognised that some parts of the database may need to be password-protected.

Technical design, database content, structure and programming

The information system will be realised as an Internet-based database. To guarantee the security of the data, document storage will only be accessible by authorized users.

The country specific information will need to be collected and transferred into the database – including, for example, maps, information on the country and relevant legacy sites, an Internet-link catalogue, addresses, and organisational charts.

During the *first stage* of the implementation of the project it is considered necessary to include the country-relevant data described above and the project-database for proposed, ongoing and completed projects.

The information system should include the provision for the database to contain all relevant environmental monitoring data from the proposed monitoring system in a *second stage*, after the implementation of the routine monitoring and "early warning" system.

Cost and time evaluation

The costs of a comparable BMU-project "Database of Country Reports for East European Countries" (funded by the German Federal Ministry of Environment and Reactor Safety) were in order of:

a) 75 000 € for the first stage (technical preparation), and
b) 80 000 € for the second stage (completed databases).

It is expected that the first stage of the project would be completed within 6 months, with second stage requiring an additional 12 months for the completion.

5. ORGANIZATIONAL UNIT FOR REMEDIATION PREPARATION AND COORDINATION

As it was mentioned throughout the document, there is a need for project coordination and for the integration between and among international and national entities. Indeed, the United Nations Economic Convention for Europe (UNECE) Espoo Convention on Environmental Impact Assessment in a Transboundary Context calls for cooperation between nations with transboundary environmental issues. Kyrgyzstan and Kazakhstan are parties to this convention. Uzbekistan and Tajikistan are seeking membership. One mechanism might be the establishment of a Regional Framework Program for national projects aiming at the remediation and mitigation of the uranium legacy sites. The program could be based upon the concept of the Strategic Environmental Assessment (SEA [3, 4]) and National Remediation Plans (RP) approach as described in the UNEP Environmental Impact Assessment manual. If acceptable, the SEA/RP would be initiated and prepared in each participating Central Asian country. The specific projects would be based on an adequate and coordinated assessment of needs within the Framework Program.

To help prepare a "bankable" project portfolio out of the *ad hoc* project proposals, a Technical Advisory Committee may be established, with the aim of providing technical advice on the projects within the Framework Program. The Committee would consist of representatives of the relevant IAEA member states and international organizations involved in the development of the Framework Program. After an agreement with the potential international donors and financial institutions has been reached, a Steering Committee chaired by the Financial Institution responsible for management of the financial resources provided by the donors could also be established. For project appraisal and management, the Steering Committee would be advised by the Technical Advisory Committee.

Using this approach, the Central Asian countries would develop a Strategic Environmental Assessment (SEA) and Remediation Plans (RP) for their uranium legacy sites and by consolidating the submitted project proposals within a Framework Program, as previously described, create an integrated coordinated risk based approach to remediation of their legacy sites. To achieve this, the following steps may be considered in each country:

1. Initiation of a screening process of the policy, legal and regulatory framework to identify the specific needs for development of a SEA/RP. This would assist the national authority responsible for development of the SEA/RP in the proposals in regards to the necessary changes to the central government;
2. Screening of the national Policies, Programs and Plans (PPP) according to a mandatory list of PPPs recommended for a SEA/RP [37] by UNEP [3] or EU [4];
3. Scoping of the state of uranium legacy sites for SEA/RP according to the SEA Manual recommended by Espoo Convention [37], UNEP or EU and identification of the environmental impacts should be assessed at local, national and regional (cross-boundary) levels;
4. Ranking of the impact of the uranium legacy wastes in order to assess the need for an in-depth analysis of the health and environmental as well as a detailed description of the remediation strategy. The ranking will depend on the characteristics of the national

PPPs and recommended ranking guidelines. It is strongly recommended to include the preferences of the stakeholders and the general public into the ranking of the preferences.

5. Based on the results of this process the national SEA/RP and monitoring plans are to be submitted for the governmental approval.

The Framework Program Advisory Committee would assist the responsible national agency at each of the steps described above. The legal and regulatory framework and the state of the uranium legacy sites in the Central Asian countries have been researched at a preliminary level within the IAEA, TACIS, INTAS, NATO, EurAsEC, UNDP projects and the available information is considered to be sufficient for the use in partial fulfilment of the screening and scoping steps of the national SEA process.

It is likely that to align expectations of the Central Asian partner institutions with those of the donor organizations and their technical partners the various project proposals would be coordinated and guided to completion within a Framework Program. The Advisory Committee will then review and evaluate the projects in a complementary fashion; the prioritization is expected to be in accordance with the urgency of individual projects. The safety assessments and radiation protection measures are expected to follow the IAEA standards and recommended practice on a case-by-case basis.

It is suggested that the project costing be also carried out on a case-by-case basis and the range of remedial costs is therefore expected to vary between costs of recommended measures and those approved nationally. Depending on the perceived level of risk aversion in each country, the national regulators may optimize risk differently from country to country. Nonetheless, to ensure that available funds are allocated properly, a compliance with latest international standards (ICRP, IAEA, EC etc.) is considered to be necessary (in particular ICRP-101 [38].

6. SUMMARY AND CONCLUSIONS

The international community has a strong interest in the environmentally and socially responsible systematic remediation of these legacy sites, in agreement with international standards, proposals and practice. In order to accomplish this goal the following actions are necessary:

- Harmonization of the national legislation and regulatory framework with the relevant international standards and proposals;
- Preparation of environmental assessments prior to the commencement of remediation of the uranium legacy sites;
- Development of safety assessments to prioritize remedial actions;
- Development of remedial action plans;
- Implementation of remedial actions;
- Post remediation monitoring and maintenance;
- Development and delivery of appropriate educational programs for the regulatory bodies, mining and processing companies, relevant scientific institutions and representatives of the impacted communities; and
- Development of national analytical capabilities.

The goal of the IAEA is to actively contribute to the application of international safety standards and good practices as they related to the remediation of legacy sites in Central Asia. This document builds on the progress the Central Asian states have made since attaining independence while taking into account the common context in the region as well as the specific national context and requirements.

he information contained in this document complements the results obtained under the implementation of the various international projects and assistance programs that addressed the current situation at the most important uranium waste sites (TACIS, INTAS, IAEA, NATO, ENVSEC, etc.). These projects have identified the uranium legacy wastes to be the source of environmental contamination observed locally and in some cases, downstream of the former production sites, and the vulnerability of the sites (tailings storage facilities threatened by landslides from the adjacent mountain slopes, exposed to seasonally high water inflow into the impoundment and located in seismically unstable areas).

Thus, the remediation of the uranium legacy sites presents a common interest of the states of Central Asia and many international organizations.

Building upon and complementing the previous international assessment and assistance projects, this document focuses on the technical issues with the legacy sites, with the objective of the remediation and mitigation of the hazards associated with them. It provides a brief overview of the uranium legacy sites and proposes several recommended actions at a regional and national level, which are summarized in Tables 2 and 3. They include regional and national proposals and are intended to complement the UNDP Framework Document entitled” Uranium Tailings in Central Asia: Local Problems, Regional Consequences, and Global Solution”.

Table 15. Transboundary proposals

Proposals	Priority	Costs (million €)	Time frame (years)
1. Regulatory framework Development of guidelines and technical standards for the legacy sites, and of efficient regulatory processes	high	each country: 0.4	2
2. Training and education In the areas of radiation protection, environmental and long-term monitoring, project management, remediation planning, restoration technologies, experience exchange, risk assessment, operation of scientific equipment	high	each country: 0.4	2
3. Internet database for information exchange To include monitoring data, regional knowledge exchange and experiences in project management	high	0.15	1.5
4. Establishment of a regional watershed monitoring network	high	2	3
5. Analytical capacity building Effective laboratory system for site investigation (soil and ground water samples) and river water sampling	high	each country: 0.8	3
6. EIA's and safety assessments conducted region wide at priority legacy sites	high	will be determined	2

The regional proposals listed above are intended to provide a platform for the successful remediation of uranium legacy sites in the Central Asian region. This list is based upon the collective opinion of experts within and from out side the region.

A strong regulatory framework in each of the countries of the region is necessary to establish requirements, roles and responsibilities, and ensure adequate protection of the public and the environment. Currently some national legislation exists however the implementing regulations and guidance is missing. In addition there is inadequate support of regulatory infrastructure (equipment, trained personnel, facilities etc.).

Training and education is essential. There is a need to develop a trained workforce to evaluate the need, plan and implement any remedial action, otherwise the majority of the work will be conducted by foreign firms and any economic benefit which may arise from the remediation will minimized. Coordination between ministries, institutions, national and international organizations is essential to optimize the use of the limited resources in the region.

The region could benefit from increased communication and exchange of technical knowledge, information and expertise. The UNDP has assisted Kyrgyzstan in developing a website which contains a great deal of good information. This should be expanded to include other countries in the region. Many of the issues are similar and all could benefit from each others experience.

There is a high degree of concern regarding the downstream impacts to the Fergana Valley from these legacy sites. The establishment of a regional watershed monitoring system would begin to address this issue. This would serve as a trust and confidence building activity as well as establishing a baseline in the event of a catastrophic failure of a waste containment structure upstream. Initially the level of sophistication of this project needs to be consistent with the available infrastructure to support it.

The effectiveness of the analytical capacity of the laboratories needs to be increased. Several international organizations have initiated activities to address this but more needs to be done. Reliable, representative samples are essential for site characterization, modelling input, dose and risk calculation and ultimately they are part of the basis for remediation decision making. Laboratory facilities need to be upgraded not only in terms of equipment and facilities but in terms of training for staff, quality assurance and quality control (QA/QC). Laboratory resources need to be shared within country and within the region. A network of laboratory capability needs to be established which should include the universities which are a potential resource.

This document utilized currently available information and best professional judgement to assess and prioritize remedial activities at uranium legacy sites. However in most cases the data is very limited. There needs to be comprehensive Environmental Impact Assessments and Safety Assessments conducted at the legacy sites from a regional impact perspective. In other words site specific studies could be incorporated into a broader regional analysis.

Finally, there needs to be some type of coordinating mechanism in the region to address these uranium legacy sites. To optimize the use of resources and to strengthen the political impact there is a need to coordinate and integrate the results of different projects. This will require a framework mechanism and an organization to coordinate it. The United Nations Environment Program (UNEP) proposed such a mechanism in the form of a Strategic Environmental Assessment (SEA) [3, 4] and National Remediation Plan (RP). This mechanism may be an option for Central Asia and could contribute to a consistent approach for the solution of the uranium production legacy problems.

In the tables which follow, site specific proposals are presented by country. Some activities are already underway, at Mailuu-Suu for instance. Almost all require some type of safety assessment, environmental impact assessment, feasibility studies and regulatory monitoring programs. In some cases, repair of existing engineered features such as drainage channels and covers could be done at fairly low cost and protect the remediation investment already made (Tuyuk-Suu, Kadji-Say). Controlling site access would reduce risk at all of these sites.

Table 16. Proposed remediation related activities by country (the high and medium evaluated risk sites only considered)

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Kyrgyzstan (KIG)	1. Mailuu-Suu	Tailings (TP 3, 2/13 and 8)	high	Feasibility study (FS), design of relocation of TP 2, 3, 8 and 13	0.3	0.5
				Remediation	1.7	1.5
	2. Min-Kush	Min-Kush mill site and adjacent areas	high	Radiological survey of residential areas and safety assessment	0.3	0.5
				Establish surveillance and maintenance program to include radon monitoring, geotechnical monitoring, water quality monitoring program for community	0.3	1
				Selective remediation of the houses in residential area	0.3	1
		Tuyuk-Suu tailings dump	high	Safety assessment	0.1	ongoing
				Establish geotechnical monitoring program as part of long term surveillance and monitoring program	0.2	1
				Emergency response training	0.3	1
				Engineering evaluation and repair of drainage system	0.8	1

				FS: remediation (option 1, stabilization)	0.9	1
				FS: remediation (option 2, tailings relocation)	3.8	1.5
	3. Kadji-Say	Mill site and tailings piles	medium	Evaluation of erosion problem	2	1
				Develop and implement remedy	2	1
				Control site access	2	1
				Establish groundwater monitoring network	0.4	1
	4. Ak-Tyuz	Thorium ore concentrate storage facility and tailings dumps	medium	Radiological survey and safety assessment	0.2	0.5
				Environmental impact assessment (EIA), engineering design	0.4	1
				Remediation of the contaminated lands around facility	2.2	2
	5. Orlovka (Burdinskoe)	Drainage system	medium	Environmental impact assessment	0.1	0.3
				Engineering design and installation	1	1
				Remediation on assessment results	2.7	2

Continuation of Table 16.

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Tajikistan (TAD)	1. Chkalovsk Khujand industrial site	Degmay tailings	high	Environmental impact assessment, design of cover	1.3	1.5
				Remediation (cover the tailings)	15	2
				Establish long term surveillance and maintenance program to include institutional controls, environmental monitoring (radon, groundwater)	0.3	1.5
		Gafurov tailings	medium	Establish long term surveillance and maintenance program to include institutional controls, environmental monitoring (radon, groundwater)	0.2	1
				Risk-communication (public awareness)	0.1	1
		Mine 3	medium	Design mine water management system)	0.2	0.5
				Replace ion-exchange and repair and operate mine water treatment facility	0.5	1
				EIA of all areas of the site, design of cover	2.1	2
				Remediation (cover and stabilisation)	13	3

		Mine waters treatment	high	Provision of alternate water supply to eliminate local consumption of contaminated water	2	1
				Surveillance and monitoring	0.2	1
		Industrial site and tailings cover	high	Repair of existing covers	3	1
				Design of new covers to address acid water drainage	0.3	1
				Remediation (implementation phase)	30	3
				Should include backfilling and plugging mine openings, collection of material along Archie-Say and Utken-Suu river banks transported off-site by mudslides and floods	0.5	1
		Taboshar water treatment system	high	Design of sustainable water supply system	0.2	0.5
				Construction	0.7	0.5
				Risk communication and risk awareness programme	0.1	0.5

Continuation of Table 16.

Country	Site priority ranking by country	Site specific priorities	Overall priority	Specific actions	Costs (million €)	Time frame (years)
Uzbekistan (UZ)	1. Charkesar-2	Uranium production former industrial site	high	Environmental impact assessment	1	1
				FS and cover design	0.3	0.6
				Repair of waste covers where inadequate	2.4	1.5
				Backfilling and closure of mine openings and shafts	0.5	1
				Collection and treatment of contaminated mine discharge	0.7	1
				Establish long-term surveillance and monitoring program	0.3	1
		Residential area	high	Gamma dose survey in residential areas	2	1.5
				Radon monitoring program	0.3	1
				Clean-up of the buildings, including residences where contaminated materials from the legacy site used	0.4	1
	2. Yangiabad		medium	EIA	0.6	1
				FS	0.5	0.7

				Remediation of ore storage yard and waste dumps near residential areas	1	1
				Closure of open mine workings	0.5	1
				Establish long-term monitoring program	0.3	1
Kazakhstan (KAZ)	1. Koshkar-Ata		medium	Evaluation of the remedial actions completed and assessment	0.2	0.5
				Establish long-term monitoring program	0.3	1
	2. Vostochny mine		medium	Evaluation of the remediation done.	0.2	0.5
				Assessment of long-term stabilization actions	0.2	1
				Establish long-term care program.	0.3	1
Mongolia (MNG)	General			Regulation and guidelines development for remediation requirements and long-term monitoring program	0.2	2

*possibly plus operational costs of water treatment and mine water monitoring for many years

Taking into account small variation in climatic, geographic and geotechnical conditions, the technical legacy problems left behind by uranium mining and processing in Central Asia are not very different from other countries. The most important constraints to the development and implementation of an efficient monitoring system and the application of remediation activities can be summarized as follows:

Costs of remediation and limited availability of national funding

None of the Central Asian countries allocated specific funds for mine closure and remediation. Except for Kazakhstan, none of these countries has a systematic national programme for remediation of the legacy sites. The Gross National Product of some Central Asian countries is relatively low, therefore it appears to be quite difficult for the governments to allocate specific funds for remediation programs and an external help for these projects may be required. A combined national/international financing programme would be a feasible approach in these cases, having in mind that priorities for “bankable” projects have to be fully justified.

Inadequate knowledge of the inventory of the legacy components and the risks associated with them

Except for some obvious cases, such as Mailuu-Suu, there is not sufficiently reliable data that would allow for the assessment of the real risks presented by the legacy sites. A reliable database is essential for justification and prioritization of the remediation, especially in case of sites that are less known. The preparation of the effective and efficient remediation plans requires additional data to that available for most of the legacy sites at the current stage.

It is necessary to undertake a consistent and reliable assessment of the uranium production legacy sites and their components, which should include:

- The creation of the inventory of both radioactive and non-radioactive contaminants, followed by their characterization;
- The effluent and influent streams from and to the disposal sites and the emissions to the air;
- Information on the geotechnical stability of the sites, erosion, stability of the current containment, if any, and the design details of the containment;
- Safety assessment methodology and risk assessment should become a common platform in remediation planning.

To develop the understanding of a site an appropriate monitoring and surveillance plan must be developed, including specifications of media to be sampled, monitoring locations, sampling methods, frequency and amount of samples to be taken, and analytical methods to be used for samples’ analyses. The use of the recently acquired instruments and equipment should be incorporated into these plans.

The decision regarding in-situ stabilization or relocation of residues such as tailings should be based on both the results available to-date and on the new data.

A long-term surveillance and monitoring program is essential to ensuring the effectiveness of any remedial action and continued risk reduction.

Public and social attitude toward the legacy sites

The health and environmental risks presented by the legacy sites are perceived very differently by the various stakeholders. The members of the general public residing in the vicinity of the legacy sites are quite often unaware of potential health hazards.

An example describing the complacency of local population used to the uranium mining and processing operations in their vicinity can be given from the Taboshar site in Tajikistan: A small farm is operating below a large tailings pile at the top of a valley which utilizes water that emanates from periodic seepages from the waste pile. A local shepherd appears to see no problems in grazing his animals directly on the tailings and waste rock piles overgrown with grass. In addition, different materials from the tailings storage facilities are occasionally used for construction purposes by the local population

Institutional controls must be implemented at these sites. **This is the single greatest risk reducing action the governments could take.** For institutional controls to be effective public communication about risks and hazards these sites present is essential. Equally important is the provision of alternate water supplies where local populations are utilizing contaminated water, or alternative livestock grazing areas etc.

Inadequate legislative and regulatory framework for mine closure and environmental remediation

Since independence in 1991, one of the major issues in the Central Asian countries is the lack of adequate technological and regulatory infrastructure. The requirement to assess, monitor and, if justified, remediate the legacy sites should come from a consistent set of legally-enacted health and environmental protection regulations.

A set of legal acts, decrees and regulations, which govern the remediation of sites is partially in place in Kazakhstan and, due to the understanding of the complexity of the remediation issues (prompted by the case of Mailuu Suu), some regulations are also being developed in Kyrgyzstan.

At the current stage a typical regulatory process does not include a requirement for an environmental impact assessment (EIA), at least not to the extent as in other countries where uranium is being mined and processed; not even for situations that may be considered as posing a serious hazard. A consistent set of practical regulations based on an environmental and human health risk assessment approach and using relevant international standards and guidelines is strongly recommended for adoption in the Central Asian countries. This could also facilitate, at least to some degree, the availability of international funding.

The main regulatory requirements to be established:

- Site characterization and safety assessment procedures;
- Organizational structure for site specific monitoring, surveillance programs, information exchange and data reporting;
- Criteria for cost effective remediation strategies;
- Institutional control; and
- Public involvement and risk communication.

Lack of personnel with uranium mining and milling experience or knowledge of remedial works

This problem appears to exist at all levels:

- Government administration that provides the funding,
- Regulators assessing and approving the permit requests, and
- Operators carrying out remediation works.

Personnel responsible for raising international funds and cooperation with the funding agencies, steering the national remediation programme, organizing the projects and controlling their implementation would need on-the-job training, which will need to be supported by experienced international experts.

Shortage of state of the art equipment and machinery

In addition to the need for the instrumentation needed for samples collection, analyses and data interpretation, there is also a lack of modern machinery that will be required for remediation projects. It appears that drilling rigs and sampling devices for investigation of the sites are not easily available. There is also a lack of mining equipment for the construction of covers, such as bulldozers and scrapers capable of working on steep slopes. There are no large size (100+ tonne) haul trucks available for relocation of waste rock or tailings.

The machinery that is available is typically old and relatively small in size, which would hinder the efficient implementation of remediation projects in accordance with international standards. Unless large scale investments can be made into mining machinery, the remediation plans must take into account that the pace of work will most likely to slower than in comparable projects elsewhere.

Finally, of utmost importance in overcoming the constraints to remediation, is the collection and dissemination of up-to-date information on latest technological advances and know-how in this area; preferably disseminating the information directly to the relevant countries.

In conclusion, it may be also noted that in the Central Asian countries, as in other developing and transition countries, the regulations in place may not fully cover uranium mining, processing and the management of radioactive waste. Therefore, it is considered that the assistance to these countries in the development of legislative and regulatory provisions for the remediation of uranium mining and processing facilities must remain a high priority.

It is important to facilitate cooperation among the participating project partners – to help them in developing sound environmental and social legislation and regulations and initiate remedial actions that will reduce or eliminate environmental and human health risks.

ANNEX: RISK EVALUATION SHEETS

Kyrgyzstan - overview of proposed site remediation measures

Site	Sub-objects	Risk estimation		Ranking		Preliminary measures	Probably necessary remediation measures	Main parameter	Rough cost estimation (mio €)	Duration of measures (years)
		Expert opinion	Local authority	Expert opinion	Local authority (no ranking)					
Mailuu-Suu (as complex, only objects with need for action)		4	high	1		already done for most of the sub-objects				
Tailings ponds TP 3/ TP 18		4	high	1		already done, project ongoing	relocation to TP 6 and covering		1.6	1
							FS and design for additional measures		0.3	0.5
Tailings pond complex TP 13+2+4+1 (Aylampa Say valley)		4		1		already done, temporary riverbed strengthening	relocation of TP 13 and 2 to TP 4, covering	hauling of 105 Tm³, 1,5 ha covering 2 m	1	1.5
Tailings ponds TP 8		3		2			relocation to TP 6 and covering	90 Tm³	0.7	1
Waste rock pile complex at Kara Agach River		2		3		no action				
Waste rock pile complex at Kulmen Sai River		2		3		no action				
Abandoned mining operations		3		3		archive recherché, risk assessment	closure of mine openings	no information	0.05	0.3
Min-Kush (as complex)		4	high	1			EIA , FS and design		0.8	1

Tuyuk Suu					monitoring of the landslide below Tuyuk-Suu, preparation of technical measures	option "relocation" of Tuyuk-Suu, covering	hauling of 450 Tm³, 4 ha covering 2 m	3.8	1.5
					preventing the "emergency case", stability calculation of the dam	option "enforcement" of the dam and covering of Tuyuk Suu	3.2 ha covering 2 m, movement of 50 000 m³	0.9	1
TP Dalneye, Kakk, Tardy Bulak	2				stability calculations of the dams	no action		0.03	
Mine dumps, Mine installations	3				archive recherché, risk assessment		no information	0.05	
Kara Balta Tailings Pond	3	private property, in operation	2			partial relocation, sealing layer, cover	158 ha, 21 mio m³	23	5
Shekaftar	3	medium	3			EIA and engineering		0.2	0.5
						strengthening of dumps against erosion and floods, covering	8 dumps with 57 Tm³, covering with 1m	0.5	1
Kadji-Say	3	medium	2			demolishing of contaminated buildings		0.1	0.2
Ak-Tyuz	4	medium	1		stability calculations of the dams	implementation of a long term stable cover	1.1 ha, covering 2m	0.2	1
						long-term solution for the threats by water erosion, partial relocation of a streambed		0.5	1
						EIA, FS and design		0.4	1

		TP 2 and 4 private property, in operation			Gamma-dose-rate measurements, identification of scattered contaminated material	relocation of all free accessible contaminated material to a safe place (TP 3), covering of TP 1 and TP 3	100 m³ relocation, 9 ha covering 2m	1.4	2
					temporary fencing or guarding, signs	reinforcement of dams (if necessary)	flattening (movement of 200 000 m³)	0.8	
Orlovka	4	no estimation	1		safety assessment of the dam	EIA and engineering		1.1	1.3
					prevention of water intake in the TP (repair of water catchment system)	stabilization of the dam (flattening)		0.3	2
						covering	15 ha covering	2.4	
Kann	no estimation	medium	3						

Risk Evaluation Sheet
Kyrgyzstan
Shekaftar
KIG Shekaftar risk

Risk Catalogue		**Risk categories (estimation)**		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**3**	
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	2	
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	3	
0.4	extreme storm events	3	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	3	3	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	4	3	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
2	radiological risks			

2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	3	3	
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water	3	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	3	3	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	3	3	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater			
	pollution of drinking water resources in the region of the site	3	3	
	pollution of surface water - intake in a river system, damage to ecosystems			
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	3	3	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	2	
4.2	danger of overflooding of dams or contaminated objects	4	3	
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	
4.4	danger of rock falls, sliding of steep slopes	3	2	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	

Risk Evaluation Sheet

Kyrgyzstan
Kadji-Say
KIG Kadji-Say risk

Risk Catalogue		**Risk categories (estimation)**		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**3**	
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	3	
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	3	
0.4	extreme storm events	4	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	1	1	
1.2	increased anxiety of the local population, political pressure	4	3	
1.3	obstacles for development chances in the region, deterrence of investors	5	4	

1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	4	3	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)			
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water	3	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	3	2	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	2	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)	2	2	
3.1	in water			
	pollution of groundwater	2	2	
	pollution of drinking water resources in the region of the site	2	2	
	pollution of surface water - intake in a river system, damage to ecosystems	3	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	2	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	2	
4.2	danger of overflooding of dams or contaminated objects	3	3	
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	
4.4	danger of rock falls, sliding of steep slopes	2	2	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	

Risk Evaluation Sheet
Kyrgyzstan
Ak-Tyuz
KIG Ak-Tyuz risk

Risk Catalogue		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero 2 low 3 medium 4 high 5 extreme	1 no risk 2 low 3 medium 4 high 5 extreme	Please fill in data sheets for all named single objects and mark the relevant risk parameters!
Summarization for the entire site (complex)		**4**	**4**	**TP 1+3**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	4	
0.2	landslides	2	2	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	3	
0.4	extreme storm events	4	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	4	in case of dam failures
1.2	increased anxiety of the local population, political pressure	3	2	
1.3	obstacles for development chances in the region, deterrence of investors	2	2	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	3	

1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	4	pipelines of the active mine
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)			
	elevated concentrations of radio-nuclides in water	2	3	
	mine water	2	3	
	seepage water	2	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	4	4	free accessible highly contaminated material
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers	4	3	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)	3	3	
3.1	in water			
	pollution of groundwater	2	2	
	pollution of drinking water resources in the region of the site	2	3	
	pollution of surface water - intake in a river system, damage to ecosystems	2	4	in case of dam failures
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	4	4	free accessible highly contaminated material
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	3	4	
4.2	danger of overflooding of dams or contaminated objects	2	4	
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	
4.4	danger of rock falls, sliding of steep slopes	2	2	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	

Risk Evaluation Sheet
Kyrgyzstan
Mailuu-Suu
Entire Mining and Milling Complex
KIG MS risk

Risk Catalogue		**Risk categories (estimation)** probability of occurrence 1 zero 2 low 3 medium 4 high 5 extreme	risk potential (consequences of occurrence) 1 no risk 2 low 3 medium 4 high 5 extreme	single objects contributing to the risks (only if both risk cat. are 3 or higher) **Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**4**	**TP 3; TP 13+ 2+4+ 1; TP 8**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	4	
0.2	landslides	5	4	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	4	
0.4	extreme storm events	2	3	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	4	4	TP 3; TP 13+ 2+4+ 1; TP 8
1.2	increased anxiety of the local population, political pressure	4	3	
1.3	obstacles for development chances in the region, deterrence of investors	4	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	4	3	all objects
1.5	threat by terrorists (sensitive structures like dams,	2	3	

	pipelines)			
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment	2	3	
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	3	
	elevated concentrations of radio-nuclides in water	2	2	
	mine water	2	3	
	seepage water	2	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	2	3	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	3	3	TP 3; TP 13+ 2+4+ 1; TP 5+7
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	2	3	
	pollution of drinking water resources in the region of the site	2	3	
	pollution of surface water - intake in a river system, damage to ecosystems	2	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	2	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	3	TP 13+ 2
4.2	danger of overflooding of dams or contaminated objects	4	4	TP 3; TP 13+ 2+4+ 1; TP 8
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	
4.4	danger of rock falls, sliding of steep slopes	2	3	WD 1+2+6
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	4	3	

Risk Evaluation Sheet
Kyrgyzstan
Orlovka (TP Bourdinskoye Entire Mining and Milling Complex)
KIG Orlovka risk

		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
Risk Catalogue		**1 zero** **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**4**	**TP Bourdinskoye, risk of dam failure**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	4	
0.2	landslides	2	2	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	4	
0.4	extreme storm events	3	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	4	in case of dam failure
1.2	increased anxiety of the local population, political pressure	3	2	
1.3	obstacles for development chances in the region, deterrence of investors	3	2	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	4	

1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	4	
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	2	
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water	3	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	2	2	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	2	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)	2	2	
3.1	in water			
	pollution of groundwater	3	3	
	pollution of drinking water resources in the region of the site	3	3	
	pollution of surface water - intake in a river system, damage to ecosystems	3	4	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	2	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	4	4	
4.2	danger of overflooding of dams or contaminated objects	3	4	
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	
4.4	danger of rock falls, sliding of steep slopes	2	2	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	2	2	

Risk Evaluation Sheet
Kyrgyzstan
Kara-Balta
KIG Kara-Balta risk

Risk Catalogue		**Risk categories (estimation)**		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**3**	**3**	
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	2	
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	2	2	
0.4	extreme storm events	3	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	2	2	
1.3	obstacles for development chances in the region, deterrence of investors	2	2	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	3	

1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	2	
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water	3	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	2	2	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	2	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	
	pollution of drinking water resources in the region of the site	3	3	
	pollution of surface water - intake in a river system, damage to ecosystems	3	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	2	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	3	
4.2	danger of overflooding of dams or contaminated objects	2	3	
4.3	danger of surface cracks and strong subsistences in populated areas	1	1	
4.4	danger of rock falls, sliding of steep slopes	1	1	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	1	1	

Risk Evaluation Sheet
Kyrgyzstan
Min-Kush
KIG Min-Kush risk

Risk Catalogue		**Risk categories (estimation)** probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**3**	**Tuyuk Suu, Mine**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	3	
0.2	landslides	5	4	Tuyuk Suu
0.3	extreme precipitation rates, risk of flooding and mudflows	4	3	
0.4	extreme storm events	2	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	3	Tuyuk Suu
1.2	increased anxiety of the local population, political pressure	4	3	
1.3	obstacles for development chances in the region, deterrence of investors	4	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	4	3	
1.5	threat by terrorists (sensitive structures like dams,	2	2	

	pipelines)			
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	2	
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water	3	2	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)			
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	2	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	2	
	pollution of drinking water resources in the region of the site	2	2	
	pollution of surface water - intake in a river system, damage to ecosystems	3	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	3	2	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	3	3	
4.2	danger of overflooding of dams or contaminated objects	4	3	
4.3	danger of surface cracks and strong subsistences in populated areas	3	3	very poor information about the mine
4.4	danger of rock falls, sliding of steep slopes	3	3	poor information about the dumps
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	very poor information about the mine

Tajikistan - overview of proposed site remediation measures

Site	Sub-objects	Risk estimation		Ranking		Preliminary measures	Probably necessary remediation measures	Main parameter	Rough cost estimation (mio €)	Duration of measures (years)
		Expert opinion	Local authority	Expert opinion	Local authority (no ranking)					
Degmay Tailings Pond		4	high	1	1	safety calculation of the dam, temporary fencing and/or guarding, groundwater monitoring	EIA and engineering		1.5	1.5
							water monitoring	6 wells a 100m	0.09	0.3
							covering and drainage measures	90 ha, 2 m, 1 800 000 m³	15	3
							water treatment	unknown	unknown	
Taboshar site (as a complex problem)		4	high		1	prevent usage of water from the open pit, temporary fencing/ and or guarding of the yellow hill, groundwater monitoring, assessment of radon in houses, control of covers (gamma dose measurement)	Integrated Site Model incl. assessment of dumps and mine installations, groundwater model, EIA		1.7	1.5
							Planning and design of "hazard mitigation measures" (i.e. water treatment, covering of Yellow Hill, monitoring)		0.6	0.5
							Monitoring (groundwater and air)	20 wells a 150m	0.5	0.5
							Measures for reducing of elevated radon concentrations in houses		0.5	2

"Yellow Hill"	4	high	2 (of 10)	1a		contouring, covering	3.4 ha, 2 m,	0.6	1
TP N3	4	high	4 (of 10)	1b		repair or new covering	2.9 ha, 1 m	0.25	0.5
TP N1	3	medium	8 (of 10)	1c		repair or new covering	54.5 ha, 1 m	4.6	2
Mine dumps	3	no	no ranking	1c		contouring, covering	70 ha, 1 m	6	2
Open pit (mine water)	4	no	no ranking	1a		water treatment	10 m³/h, 1.5 g/l U	0.5	0.5
Mining installations	unknown	no	no ranking	1d		saving of open installations		0.2	1
Khujand mine No 3	3	medium	7 (of 10)	2	water analyses, control of galleries and covers	EIA and engineering	5-7 m³/h, 25-30 mg/l U	0.05	0.3
						water treatment		0.3	0.5
						saving of mine galleries		0.1	0.3
Adrasman site (Tailings Pond No. 2)	3	medium	5 (of 10)	2	control of cover (gamma dose measurement), water analyses	EIA and engineering	2,5 ha, 2 m	0.2	0.5
						repair or new covering		0.4	0.4
Chkalovsk Tailings 1-9	3	low	9 (of 10)	3	control of covers (gamma dose measurement)	EIA and engineering		0.05	0.3
						ground water monitoring (for the industrial site incl. the mill Chkalovsk downstream)	no actual monitoring data, 5-10 wells a 150 m needed	0.25	0.5
Gafurov tailings	2.5	low	10 (of 10)	3	control of covers (gamma dose measurement)	EIA and engineering		0.05	0.3
						groundwater monitoring, see Chkalovsk tailings			

Risk Evaluation Sheet
Tajikistan
Degmay
TAD Degmay risk

		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
Risk Catalogue		**1 zero** **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**4**	
Regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	4	dam stability
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	3	
0.4	extreme storm events	2	3	
General risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	3	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	5	4	difficult to fence the pond
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	4	
Site specific risks				
2	radiological risks			

2.1	elevated level of gamma radiation in the environment	4	3	
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	4	3	
	elevated concentrations of radio-nuclides in water	4	3	unknown, no monitoring
	mine water			
	seepage water			
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	4	3	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	4	4	no coverage of tailings, free access)
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater pollution of drinking water resources in the region of the site			
	pollution of surface water - intake in a river system, damage to ecosystems			
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	5	3	no coverage of tailings
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	3	4	no safety calculations
4.2	danger of overflooding of dams or contaminated objects			
4.3	danger of surface cracks and strong subsistences in populated areas			
4.4	danger of rock falls, sliding of steep slopes			
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)			

Risk Evaluation Sheet
Tajikistan
Taboshar
TAD Taboshar risk

Risk Catalogue		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**4**	
Regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	4	dams
0.2	landslides	2	2	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	4	tailings ponds
0.4	extreme storm events	2	2	
General risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	4	3	
1.3	obstacles for development chances in the region, deterrence of investors	4	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	5	4	usage of tailings material
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
Site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			

	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	3	3	dumps, Burren rock tailings
	elevated concentrations of radio-nuclides in water			
	mine water	4	4	Open Pit
	seepage water	4	3	Tailings
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	4	3	Barren rock tailings
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	3	4	all objects
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	all objects
	pollution of drinking water resources in the region of the site	3	4	all objects
	pollution of surface water - intake in a river system, damage to ecosystems	4	3	all objects
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	4	3	Burren rock tailings
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	3	3	Tailings
4.2	danger of overflooding of dams or contaminated objects	3	4	Tailings
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	no information
4.4	danger of rock falls, sliding of steep slopes	2	2	
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	no information

Risk Evaluation Sheet
Tajikistan
Chkalovsk
TAD Chkalovsk risk

		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
Risk Catalogue		**1 zero** **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**3**	**3**	**Dams, cover system, monitoring of ground water**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	3	dams
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	3	cover system
0.4	extreme storm events	2	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	5	2	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			

	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	2	
	elevated concentrations of radio-nuclides in water	3	3	no active monitoring
	mine water			
	seepage water			
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)			
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	2	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	no active monitoring
	pollution of drinking water resources in the region of the site			
	pollution of surface water - intake in a river system, damage to ecosystems			
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material			
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	3	no data about the stability of the dams
4.2	danger of overflooding of dams or contaminated objects			
4.3	danger of surface cracks and strong subsistences in populated areas			
4.4	danger of rock falls, sliding of steep slopes			
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)			

Risk Evaluation Sheet
Tajikistan
Gafurov
TAD Gafurov risk

Risk Catalogue		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
Risk Catalogue		**1 zero** **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**2**	**3**	
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	3	
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	2	3	
0.4	extreme storm events	2	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	4	4	
1.3	obstacles for development chances in the region, deterrence of investors	4	4	object is in very densely populated area
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	4	object is in very densely populated area
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				

2	radiological risks	2	2	
2.1	elevated level of gamma radiation in the environment	2	2	
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)			
	elevated concentrations of radio-nuclides in water			
	mine water			
	seepage water			
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)			
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)			
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	no monitoring data
	pollution of drinking water resources in the region of the site			
	pollution of surface water - intake in a river system, damage to ecosystems			
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material			
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	3	
4.2	danger of overflooding of dams or contaminated objects			
4.3	danger of surface cracks and strong subsistences in populated areas			
4.4	danger of rock falls, sliding of steep slopes			
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)			

Risk Evaluation Sheet
Tajikistan
Adrasman
TAD Adrasman risk

Risk Catalogue		Risk categories (estimation): probability of occurrence 1 zero 2 low 3 medium 4 high 5 extreme	risk potential (consequences of occurrence) 1 no risk 2 low 3 medium 4 high 5 extreme	single objects contributing to the risks (only if both risk cat. are 3 or higher) Please fill in data sheets for all named single objects and mark the relevant risk parameters!
Summarization for the entire site (complex)		**4**	**3**	**TP 2**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	3	
0.2	landslides	2	2	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	3	
0.4	extreme storm events	2	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	5	3	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			
2.1	elevated level of gamma radiation in the environment			

	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	3	3	
	elevated concentrations of radio-nuclides in water			
	mine water	2	2	no information
	seepage water	4	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	4	3	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	3	3	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	
	pollution of drinking water resources in the region of the site	3	3	
	pollution of surface water - intake in a river system, damage to ecosystems	4	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	4	3	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	2	2	no information
4.2	danger of overflooding of dams or contaminated objects	3	4	
4.3	danger of surface cracks and strong subsistences in populated areas	2	2	no information
4.4	danger of rock falls, sliding of steep slopes	2	2	no information
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	2	2	no information

Risk Evaluation Sheet
Tajikistan
Khujand Mine No 3
TAD Khujand Mine No 3 risk

		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
Risk Catalogue		**1 zero** **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**4**	**3**	**4 galleries, mine water from gallery No. 2**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	5	2	
0.2	landslides	1	1	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	3	dumps
0.4	extreme storm events	2	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	5	2	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			

2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	2	2	
	elevated concentrations of radio-nuclides in water			
	mine water	4	4	gallery No. 2
	seepage water			
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)			
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)			
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater			
	pollution of drinking water resources in the region of the site			
	pollution of surface water - intake in a river system, damage to ecosystems	4	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material			
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures			
4.2	danger of overflooding of dams or contaminated objects	2	3	dumps
4.3	danger of surface cracks and strong subsistences in populated areas			
4.4	danger of rock falls, sliding of steep slopes			
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	4	3	4 galleries

Uzbekistan - overview of proposed site remediation measures

Site	Sub-objects	Risk estimation		Ranking		Preliminary measures	Probably necessary remediation measures	Main parameter	Rough cost estimation (mio €)	Duration of measures (years)
		Expert opinion	Local authority	Expert opinion	Local authority (no ranking)					
Charkesar	Charkesar 2	3	high							
		3	high	1		archive recherché, risk assessment (mine and drainage water), measuring of radon in houses (long term)	EIA and Engineering		0.5	1
	Charkesar-1	2	high	2		archive recherché, risk assessment	Covering of dump of Charkesar 2	21 ha covering, 1 m,	1.8	1.5
							Water collection and treatment	< 1 m³/h drainage water, 28 mg/l U, other contaminants	0.15	0.5
							Closure of mine openings	4 shafts	0.4	0.5
Yangiabad		3	medium	2		archive recherché, risk assessment (mine and drainage water), measuring of radon in the valley (long – term)	EIA and Engineering		0.6	1
dumps and mine							covering, repair of existing covers	not enough information		
							Water collection and treatment	not enough information		

ore storage and loading facility in Yangiabad			2			not enough information			
ore storage and loading facility in Angren			1			not enough information			
Uchkuduk, Navoi, other not evaluated									

Risk Evaluation Sheet
Uzbekistan
Yangiabad
UZB Yangiabad risk

Risk Catalogue		Risk categories (estimation)		
		probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero **2 low** **3 medium** **4 high** **5 extreme**	**1 no risk** **2 low** **3 medium** **4 high** **5 extreme**	**Please fill in data sheets for all named single objects and mark the relevant risk parameters!**
Summarization for the entire site (complex)		**3**	**3**	
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	3	
0.2	landslides	3	3	
0.3	extreme precipitation rates, risk of flooding and mudflows	4	3	
0.4	extreme storm events	3	2	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	3	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	3	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				

2 2.1	radiological risks elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	3	3	uncovered mine dumps, mine openings
	elevated concentrations of radio-nuclides in water			
	mine water	3	3	
	seepage water			
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	2	3	storage and loading facilities
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	3	3	Radon by uncovered mine dumps, mine openings
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water	2	3	
	pollution of groundwater	2	3	
	pollution of drinking water resources in the region of the site	2	3	
	pollution of surface water - intake in a river system, damage to ecosystems	3	3	mine openings
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	2	3	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	1	1	
4.2	danger of overflooding of dams or contaminated objects	3	3	storage and loading facilities
4.3	danger of surface cracks and strong subsistences in populated areas	2	3	no information
4.4	danger of rock falls, sliding of steep slopes	2	3	no information
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	3	3	no information

Risk Evaluation Sheet
Uzbekistan
Charkesar
UZB Charkesar risk

Risk Catalogue		Risk categories (estimation): probability of occurrence	risk potential (consequences of occurrence)	single objects contributing to the risks (only if both risk cat. are 3 or higher)
		1 zero 2 low 3 medium 4 high 5 extreme	1 no risk 2 low 3 medium 4 high 5 extreme	Please fill in data sheets for all named single objects and mark the relevant risk parameters!
Summarization for the entire site (complex)		**3**	**3**	**Charkesar 2**
regional, "natural" environmental risks				
0.1	seismic activity, earthquake risk	4	3	
0.2	landslides	2	2	
0.3	extreme precipitation rates, risk of flooding and mudflows	3	3	
0.4	extreme storm events	3	3	
general risks				
1	"political + economical" risks			
1.1	assumed cross border impact, (possible) conflicts with neighboring countries	2	2	
1.2	increased anxiety of the local population, political pressure	3	3	
1.3	obstacles for development chances in the region, deterrence of investors	3	3	
1.4	risk of destruction of safety installations by local peoples, vandalism, disregarding of warnings	3	3	
1.5	threat by terrorists (sensitive structures like dams, pipelines)	2	2	
site specific risks				
2	radiological risks			

2.1	elevated level of gamma radiation in the environment			
	elevated concentrations of radio-nuclides in the air (radon, dust-borne)	3	3	
	elevated concentrations of radio-nuclides in water			
	mine water	4	3	Charkesar 2
	seepage water	3	3	
	elevated concentrations of radio-nuclides in solid media (soil, dust, construction material)	3	3	
2.2	exceeding of the 1 mSv/a -level of the effective dose of the local population (critical groups of the public) at the site or downstream of rivers)	2	3	
3	non-radiological risks (toxic/ carcinogen substances, e.g. U as heavy metal, As)			
3.1	in water			
	pollution of groundwater	3	3	
	pollution of drinking water resources in the region of the site	3	3	
	pollution of surface water - intake in a river system, damage to ecosystems	3	3	
3.2	possible incorporation of dangerous substances (e.g. heavy metals) from dust or uncovered soil material	3	3	
4	"geotechnical" and mining specific risks			
4.1	danger of dam failures	1	1	
4.2	danger of overflooding of dams or contaminated objects	2	3	
4.3	danger of surface cracks and strong subsistences in populated areas	3	3	
4.4	danger of rock falls, sliding of steep slopes			
4.5	danger by unsafe mine installations (open shafts, open galleries and adits)	4	3	Charkesar 2

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CONTRIBUTORS TO DRAFTING AND REVIEW

Aripov, K.	Republic of Uzbekistan
Bragin, A.	Ministry of Environmental Protection, Kazakhstan
Chyngojoev, A.	State Agency for Environment Protection and Forestry, Kyrgyzstan
Donbayev, K.	Atomic Energy Committee, Ministry of Energy and Mineral Resources, Kazakhstan
Dzhumabaev, A.	Ministry of Emergency Situations, Kyrgyz Republic
Dzhunushaliev, T.	Ministry of Emergency Situations, Kyrgyz Republic
Edge, R.	International Atomic Energy Agency, Vienna
Gigase, Y.	European Commission (EC)
Halilov, H.	State Inspectorate for Safety in Industry and Mining, Uzbekistan
Hojiyon, M.	State Enterprise Vostokredmet, Tajikistan
Jakubick, A. T.	Consultant, Germany
Kaftaranov, M.	State enterprise “Uranlikvidrudnik”, Kazakhstan
Khakdodov, M.	Ministry of Energy and Industry, Tajikistan
Logar, Z.	Consultant, Slovenia
Louvat, D.	International Atomic Energy Agency, Vienna
Manlaijav, G.-A.	Nuclear Regulatory Authority, Mongolia
Mirsaidov, U.	Nuclear and Radiation Safety Agency, Tajikistan
Musataev, M.	Eurasian Economic Community (EurAsEC)
Nordstrom, S.	Organization for Security and Co-operation in Europe (OSCE)
Noruzbaev, K.	State Agency for Environment Protection and Forestry, Kyrgyzstan
Reimov, A.	United Nations Development Programme (UNDP)
Salbu, B.	North Atlantic Treaty Organization (NATO)
Schneider, L.	Stoller Ingenieurtechnik GmbH, Germany
Shamsov, N.	Permanent Mission of Tajikistan, Vienna
Stegnar, P.	North Atlantic Treaty Organization (NATO)
Takenov, Z.	United Nations Development Programme (UNDP)
Tsurikov, N.	Consultant, Australia
Ugletveit, F.	Norwegian Radiation Protection Authority (NRPA)
Voitsekhovych, O.	Ukrainian Hydro meteorological Institute, Ukraine

Waggitt, P.	International Atomic Energy Agency
Walter, U.	WISUTEC Umwelttechnik GmbH
Zaredonov, D.	Republican Sanitary-Epidemiology Supervision Centre, Uzbekistan
Zhunussova, T.	Norwegian Radiation Protection Authority (NRPA)