Depleted Uranium in Kosovo

Post-Conflict Environmental Assessment

UNEP Scientific Mission to Kosovo
5 – 19 November 2000

Table of contents

Appendices

Foreword

This report presents the findings of the first-ever international assessment of the environmental impact of depleted uranium (DU) when used in a real conflict situation. It has been carried out as part of the post-conflict assessments conducted by the United Nations Environment Programme (UNEP) in the Balkans.

The report builds on an earlier theoretical study by UNEP. In October 1999, as part of its assessment of the Kosovo conflict's impact on the environment and human settlements, UNEP carried out a Desk Assessment study of the potential effects of the possible use of DU during the conflict. The study was limited by the lack of information on the actual use of DU. In July 2000, however, the North Atlantic Treaty Organization (NATO) provided UNEP with the information required, enabling a field mission to be planned and conducted. The information included a map indicating the location of 112 separate strikes by DU ammunition, and a table showing the number of DU rounds used and the coordinates of the targeted areas.

During the field mission to Kosovo, from 5 – 19 November 2000, soil, water and other samples were collected from eleven sites where DU had reportedly been used during the conflict. Five separate laboratories then analysed the samples.

When the laboratory phase was finalised in early March, the analyses of the samples collected showed only low levels of radioactivity. Furthermore, the results suggested that there is no immediate cause for concern regarding toxicity. However, major scientific uncertainties persist over the long-term environmental impacts of DU, especially regarding groundwater.

Due to these scientific uncertainties, UNEP calls for precaution. There is a very clear need for action to be undertaken on the clean-up and decontamination of the polluted sites, for awareness-raising aimed at the local population, and for future monitoring.

Just as the Desk Assessment conducted in October 1999 advised precaution, the recommendations of this report have also been guided by this approach, with the objective of protecting the environment and human health.

This difficult task was conducted effectively and efficiently thanks to the close cooperation of several key partners, to whom I am very grateful. NATO provided information and excellent cooperation. The NATO Kosovo Force (KFOR) assured the basic safety and security of mission staff, and provided other important logistical support. The United Nations Interim Administration Mission in Kosovo (UNMIK) contributed expertise to the team and assisted with field logistics. The International Atomic Energy Agency (IAEA) has been our partner in the initial desk assessment and the field mission, and has assisted with the laboratory analysis. The WHO is conducting a parallel desk assessment on the health impacts, and the two reports together should provide comprehensive information on the issues surronding DU. Several governments, including those of Finland, Italy and the USA, have provided in-kind contributions, and I am especially grateful to the Government of Switzerland, which has provided generous financial support for this assessment.

Above all, my gratitude goes to the team of dedicated experts that conducted this historic mission, under the able and professional leadership of Pekka Haavisto. The team undertook demanding scientific field investigations at short notice to be sure of completing the work before the onset of winter in Kosovo. The laboratory work was conducted at an astonishing pace so that results could be made available in record time to a public concerned about the potential risks of DU.

Throughout the exercise, special efforts have been made to ensure the objectivity and scientific credibility of the analysis, by drawing on an international team of experts and by using a range of different laboratories for the sample analysis. It is hoped that the data we have collected in the field will advance further analysis of this topic in related fields, such as the impacts of DU on human health.

UNEP now recommends, following its precautionary approach and to reduce uncertainties about the environmental impacts of DU in the longer term, that ways and means be explored for undertaking similar missions in other Balkan regions where DU was used in earlier conflicts.

Klaus Töpfer
United Nations Under-Secretary General
Executive Director of the United Nations Environment Programme

1. Introduction

"Perhaps the most endangered natural resource in times of war is truth", stated the introduction of the joint UNEP/UNCHS Balkans Task Force (BTF) report published in October 1999. For the safety of the local population and international workers in post-conflict situations it is essential to obtain truthful and correct information regarding the environmental situation and any possible connected health risks.

Depleted uranium (DU) was one the issues that confronted us during the environmental assessment work in the summer of 1999. As part of the BTF process, a special international group of experts – the 'Depleted Uranium Desk Assessment Group' – was established to assess the potential effects on human health and the environment arising from the possible use of DU. At the time the Group conducted its assessment, information on the use of depleted uranium during the Kosovo conflict was not available to the UN. The Group did, however, conduct a field mission in August 1999, during which it visited areas in and around the towns of Pristina, Klina and Pec that might have been struck by DU ordnance. The field mission did not find any evidence or indication of depleted uranium at the locations visited. In preparing precautionary recommendations, the Group concluded that it would not be meaningful to conduct further field searches for possible DU contamination without confirmation that DU had indeed been used in Kosovo and without data on the corresponding targeted areas.

Following a request made to NATO by the Secretary General of the UN, Mr. Kofi Annan, in October 1999, NATO confirmed in February 2000 the use of DU during the Kosovo conflict and provided the UN with information consisting of a general map indicating the areas targeted and the total number of DU rounds fired. This information was not considered sufficient to justify a further field mission because of the absence of detailed site coordinates.

A request for additional information was made to NATO by the UN Secretary General. In July 2000, NATO provided the UN with a detailed map indicating sites where DU munitions had been used. This was accompanied by a table of coordinates for each of 112 attacks during which DU ammunition had been used, together with the number of rounds used in each case, where this latter information was known.

This additional information was reviewed at a meeting convened by UNEP in Geneva in September 2000. The meeting was attended by members of the Depleted Uranium Desk Assessment Group, by representatives of NATO, as well as by the UN partners concerned with the issue: the International Atomic Energy Agency (IAEA), the United Nations High Commissioner for Refugees (UNHCR), the United Nations Interim Administration Mission in Kosovo (UNMIK), the United Nations Medical Service in Geneva, and the United Nations Department for Disarmament Affairs. The meeting recommended that UNEP, in close cooperation with relevant UN partner agencies and other interested parties, conduct a field study on sites in Kosovo that were struck by DU ordnance, as early as possible, preferably in autumn of that year.

A field mission was carried out from 5 – 19 November 2000, by a team composed of 14 experts from inter-governmental agencies, well-known institutions, and other interested parties. Additional cooperation was received from NATO, KFOR and UNMIK. During the mission, soil, water and other samples were collected and sent for analysis to five laboratories well reputed in matters of radiological or toxicological analysis. The use of several laboratories allowed comparison of different methods for assessing impacts. Each laboratory was responsible for its own methodology and results.

UNEP alone, however, had responsibility for the selection of sites for sampling. UNEP chose sites that were most heavily targeted, as well as sites that were in or closest to inhabited areas. In selecting the sites, variation was also sought in the surrounding natural environment, soil types and biodiversity. Sampling in some areas was limited by the fact that the sites had not been cleared of mines and unexploded ordnance. Furthermore, the fact that the sampling was conducted one and a half years after the conflict presented a number of scientific challenges. Owing to better-than-expected weather conditions, however, eleven sites were visited rather than the initially planned number of six. Thus, sampling occurred at approximately 12% of the total number of DU-targeted sites listed by NATO, in two different KFOR sectors – the Italian sector MNB (W) and the German sector MNB (S).

Experience obtained in the field suggested that the site coordinates provided by NATO were accurate. Measurements taken during the August 1999 field mission – which had no information on the exact sites where DU had been used – did not detect any elevated levels of radiation. During the November 2000 field mission, no evidence was found of DU presence outside of the NATO-listed sites. UNEP field experience also supports the information provided by NATO on the type of DU ammunition used. There are no indications of the use of any other type of DU ammunition in Kosovo.

Nevertheless, even after one and a half years had elapsed since the conflict, the UNEP team found slightly radioactive material at many sites, including the penetrator and jacket parts of DU ammunition. On tarmac roads and areas covered with concrete that had been struck by DU ammunition, radioactivity was measurable in the immediate vicinity of the impact holes. The samples collected around the sites where DU ordnance had been used show that DU dust is also measurable near the targeted sites. Even if alarming environmental risks do not now exist at these sites, UNEP recommends several precautionary measures – among others, marking the DU sites and decontaminating them when possible. In the areas most at risk of groundwater contamination, we recommend the monitoring of the water quality.

Apart from concern over the possible impacts of DU on local populations and the field staff of international organisations, there has also been considerable concern over the possible impacts of DU on military personnel. Three specific situations should be taken into account. First, the additional risks – beyond the obvious ones – of being at or very close to the site of an area under attack by DU. Clearly this circumstance could not have been investigated within the scope of the UNEP mission, some 18 months after the conflict had ended. Secondly, during the clean-up of targeted sites, loose contamination might pose a risk, thereby requiring protective measures – especially when entering partly destroyed armoured vehicles. No such vehicles were present at the sites visited by UNEP in November 2000 and it is therefore likely that military clean-up had already taken place. UNEP has no information of the removal or possible current locations of any DU-damaged vehicles from the visited sites.

The third situation concerns mine clearance at sites where DU has been used. There are significant parts of Kosovo that have yet to be de-mined and cleared of unexploded ordnance, including areas that were targeted with DU. De-mining is sometimes carried out by exploding the mines, which could lead to increased exposure to DU fragments and dust.

However, there is a lack of information on the behaviour of DU (and related risks) in cases where penetrators are present in minefields being cleared by explosion.

The observations made at the sampling sites also provide the basis for extrapolation to other areas in Kosovo targeted by DU ordnance. Based on the findings of the report, a number of recommendations are made both for the areas where sampling occurred and for all sites in Kosovo where DU has been used.

DU is certainly not the main environmental problem in Kosovo at the moment. Nevertheless, it is an additional negative factor in the equation, and action should be taken to eliminate all possible risks to the environment. It is important that the military organisations, NATO and KFOR, continue to take part in the elimination of all DU-related risks, particularly as many of the DU sites remain at risk from mines and other unexploded ordnance.

UNEP also recommends that ways and means be explored for undertaking similar missions in other Balkan regions where DU has been used. The first steps should be a similar field studies at the few sites in Serbia and Montenegro struck by DU ordnance during the Kosovo conflict, to ensure that the findings in Kosovo are valid also in other parts of the region. Secondly, a broad-based environmental assessment, including the issue of DU, should be carried out in Bosnia-Herzegovina, bearing in mind that a comprehensive post-conflict environmental assessment was never conducted following the war in the 1990s.

Conducting post-conflict environmental assessments differs from ordinary environmental assessment in that the security aspect overshadows the whole work, due to unexploded ordnance and other serious security risks. I am therefore most grateful to KFOR, and especially its Multinational Brigades, West and South, for their strong commitment to ensuring the protection of the members of the UNEP DU expert team during the mission.

UNEP wishes to acknowledge the cooperation of experts who participated in the field mission. At the conclusion of the mission, these experts, through their institutions, provided UNEP with the analyses of samples they had taken during the mission. The results of these analyses were used as a basis by UNEP to prepare the present report. However, the conclusions and recommendations reflect solely the views of UNEP.

While carrying out this exercise we have noted that there is a lack of information on the nature and effects of DU, as well as the associated risks. For this reason, I note with great pleasure that IAEA has announced that, together with relevant UN organisations such as WHO and UNEP, it will organise courses for scientific institutions, national and local authorities, international agencies and NGOs regarding the issue of depleted uranium.

The success of this scientific work is due to the commitment and expertise of colleagues both from the UN system, and from the academic world. I am most grateful for the outstanding efforts by the DU experts from Bristol University – Department for Earth Sciences, the Finnish Radiation and Nuclear Safety Authority (STUK), the International Atomic Energy Agency (IAEA), the Italian Environmental Protection Agency (ANPA), the Swedish Radiation Protection Institute (SSI), the Swiss AC-Laboratorium Spiez, and the US Army Center for Health Promotion and Preventive Medicine (USACHPPM).

Pekka Haavisto
Chairman, UNEP Depleted Uranium Assessment Team
Geneva, 12 March 2001

2. Background

2.1 UNEP's role in post-conflict environmental assessment

In May 1999, the Joint UNEP/UNCHS (Habitat) 'Balkans Task Force' (BTF) was established with the aim of making an overall assessment of the consequences of the Kosovo conflict for the environment and human settlements, focusing in particular on the Federal Republic of Yugoslavia (Kosovo, Montenegro and Serbia). As part of this work, an international expert group on depleted uranium (DU), the 'Depleted Uranium Desk Assessment Group' was appointed to "assess the potential health and environmental impact of depleted uranium used in the Kosovo conflict". However, it should be noted that use of DU in Kosovo had not been officially confirmed at this time and no information was available on the locations of sites possibly targeted by DU. The work was carried out, *inter alia* by:

- collecting background information on the potential effects of depleted uranium on human health and/or the environment, the quantity and quality of depleted uranium used in the conflict, and the locations of affected sites;
- assessing, by means of a scenario-based desk study, the medium- and long-term potential health and environmental impacts of depleted uranium used in the Kosovo conflict;
- undertaking a fact-finding mission to Kosovo to make preparations for a possible future sampling campaign;
- analysing information in order to quantify problems 'on the ground' in potentially affected areas and to provide qualitative answers concerning the possible risks to human health and the environment.

The fact-finding mission did not encounter elevated levels of radiation, either in and around the wreckage of destroyed military vehicles, or on/alongside roads. Based on these preliminary measurements, the team concluded that there was no evidence or indication of the presence of DU at the locations visited. However, it was also stressed that any further investigations could only be meaningful if and when confirmation was received of whether DU ammunition had been used and, if so, where. This was deemed essential for making additional measurements, for verifying provisional risk assessments, and for assessing the necessity of remedial or precautionary actions. Further information is contained in the report 'The potentials effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. A preliminary assessment' (UNEP, 1999).

In July 2000, following approaches from the UN Secretary General, NATO made available a detailed list of sites where DU had been used. UNEP then moved quickly to assemble a team of international experts to prepare a scientific mission to Kosovo. The mission itself took place from 5 – 19 November 2000.

2.2 Depleted uranium

What is depleted uranium?

Depleted uranium (DU) is a by-product of the process used to enrich natural uranium ore for use in nuclear reactors and in nuclear weapons. It is distinguished from natural uranium by differing concentrations of certain uranium isotopes. Natural uranium has a uranium-235 (abbreviated as U-235 or ^{235}U) content of 0.7%, whereas the content of U-235 in DU is depleted to about one third of its original content (0.2 – 0.3%).

Like natural uranium, DU is an unstable, radioactive, heavy metal that emits ionizing alpha, beta and gamma radiation. Because of its radioactivity the amount of uranium in a given sample decreases continuously but the so-called half life (the period required for the amount of uranium to be reduced by 50%) is very long – 4.5 billion years in the case of the isotope uranium-238 (U-238 or ^{238}U). In practice, therefore, the level of radioactivity (which is measured in units per second known as 'becquerels' – Bq) does not change significantly over human lifetimes.

The UNEP studies in Kosovo showed that the material in the DU penetrators found there also contained traces of transuranic isotopes such as uranium-236 and plutonium-239/240 which are created during nuclear reactions. This indicates that at least part of the material in the penetrators had originated from the reprocessing of nuclear fuel. However, the amounts of these isotopes were very low and not significant in terms of the overall radioactivity of penetrators.

The applications of DU and its use during the Kosovo conflict

DU has been used for civil and military purposes for many years. The civil applications include use in radiation shielding and aircraft ballast. Because of its high density (19.0 g/cm^3) and resistance, DU also has major military applications, particularly in defensive armouring for tanks and other vehicles. However, the properties of DU also make it ideal for offensive use in armour-piercing munitions. Both tanks and aircraft can fire depleted uranium munitions, with tanks firing larger calibre rounds (100 and 120 mm) and aircraft smaller calibre rounds (25 and 30 mm). During the Kosovo conflict, DU weapons were fired from NATO aircraft, and it has been reported that over 30,000 rounds of DU were used (UNEP, 2000).

Characteristics and behaviour of DU anti-armour rounds fired by A-10 aircraft

The type of DU round fired by NATO A-10 aircraft has a length of 173 mm and a diameter of 30 mm. Inside the round is a conical DU 'penetrator', 95 mm in length and with a diameter at the base of 16 mm. The weight of one penetrator is approximately 300 g. The penetrator is fixed in an aluminium 'jacket' (or 'casing') 60 mm long and 30 mm in width. When the penetrator hits an armoured vehicle, the penetrator continues through the armouring, but the jacket usually remains outside. The A-10 aircraft is equipped with one gattling gun capable of firing 3,900 rounds per minute. A typical burst of fire occurs for two to three seconds and involves 120 to 195 rounds. These hit the ground in a straight line, one to three metres apart, depending on the angle of the approach, and cover an area of about 500 m^2. The number of penetrators hitting a target varies with the type of target, but does not normally exceed 10% of the rounds fired (CHPPM, 2000).

Penetrators that hit either non-armoured targets, or miss targets, will generally remain intact, passing through the target and/or becoming buried in the ground. The depth depends on the angle of the round, the speed of the plane, the type of target and the nature of the ground surface. In clay soils, penetrators used by the A-10 attack aircraft may reach more than two metres depth. Conversely, penetrators hitting hard objects such as rocks and stones may ricochet and be found lying on the surface some distance from the targeted area.

Normally 10-35% (maximum of 70%) of the round becomes aerosol on impact with armour and the DU dust catches fire (Rand, 1999). Most of the dust particles are < 5 µm in size, and spread according to wind direction. DU dust is black and a target that has been hit by DU ammunition can be recognised by the black dust cover in and around the target (U.S. AEPI, 1994). The DU dust formed during the penetration of armoured vehicles can be dispersed into the environment, contaminating the air and the ground. However, such contamination should be limited to within about 100 metres of the target (CHPPM, 2000). It is important to note that hits on non-armoured ('soft') targets do not generate significant contamination because the DU penetrators do not generate significant amounts of aerosols on impact.

Small penetrator fragments and DU dust are gradually transported into the upper soil layer by water, insects and worms. Wind, rainwater, or surface water flow may also redistribute the dust. Due to the varying chemical properties of different soils and rocks, the effects of buried penetrators on the environment will also vary. The mobilisation of DU in the soil profile and its possible contamination of groundwater will depend on a range of factors such as the chemistry and structure of the surrounding soil, rainfall and hydrology.

2.3 Assessing the risks

The concept of risk, its meaning and application are discussed in detail in Appendix I. The following is a summary, intended to equip readers with the necessary background for interpreting the findings, conclusions and recommendations presented in sections 4, 5 and 6 of this report.

'Risk' can either refer to the probability of occurrence of an event, or to the consequences of an event if it occurs. A third possibility is a combination of probability and consequence.

Irrespective of how the term is used, it is clear that scientific quantification of a given risk has to be expressed clearly and concisely, so that appropriate judgements and responses can be made.

The effects of being exposed to DU are both radiological (i.e. due to radiation) and chemical (i.e. as a result of biochemical effects in the human body). Corresponding health consequences may, depending upon the dose or intake, include cancer and malfunction of body organs, particularly the kidneys.

In order to avoid such consequences arising from day-to-day procedures in which radioactive and toxic materials are used, a range of applicable standards have been established. These include limits for exposure to radiation and toxic materials.

However, the existence of such limits and standards does not mean that at any point above these values there will automatically be severe adverse consequences such as serious illness. There are still wide safety margins built in before an unconditionally unacceptable threshold is reached.

One possible way of judging the consequences of events or circumstances where exposure to DU may have occurred is to compare findings, measurements or assessments with natural levels, and with given ‘safety’ limits or standards.

In this report the consequences are those that might be caused by intake of DU by ingestion or inhalation and by external exposure to radiation from DU.

The consequences of radiation may be expressed directly in terms of the radiation dose, which is measured in millisieverts (mSv) or microsieverts (µSv). Comparisons can be made with natural levels and with established limits and action levels.

With regard to chemical toxicity, the consequences are expressed in concentration or total intake and compared with given health standards.

In this way it should be possible to express the risk (consequence) as ‘insignificant’ or ‘significant’ bearing in mind the basis for the comparisons drawn. In this report, the consequences of radiation are considered insignificant for doses less than 1 mSv per year (or per infrequent event) and significant for doses higher than 1 mSv. In relation to chemical toxicity, consequences are treated as insignificant for concentrations or total intakes below applicable health standards, and significant for those above health standards.

In the discussions of site-by-site results in section 7, judgements of risk are made on the basis of DU ground contamination measured. The relation between measurement results and risks are discussed in Appendix I. There is also a summary of risk assessments in relation to a given situation (known as the *Reference Case* and taken from the report of the 1999 UNEP DU Desk Assessment). This assumes ground surface contamination of 10 g DU/m^2. Some means of exposure lead to significant risks (consequences), others to insignificant risks. If the ground contamination is less than 0.1 – 1 g/m^2 the consequences are normally all insignificant.

In the present report, the risks considered and assessed – in terms of significance or insignificance of consequences for the environment and human health – are the following:

- If there is widespread measurable contamination of the ground surface by DU, there is a risk that some DU will become airborne through wind action and be subsequently inhaled by people. There is also a risk of contamination of food (fruit, vegetables, meat etc.) and drinking water.

- If there are localised points of concentrated contamination (referred to in this report as ‘contamination points’), there is a risk of contamination of hands and/or of direct ingestion of contaminated soil. There is also a risk of possible airborne contamination and contamination of drinking water.

- Solid pieces of DU lying on the ground surface – either complete penetrators, or fragments of them – can be picked up by someone completely unaware that they are handling uranium. Consequently, there is a risk of being exposed to external beta radiation and to internal radiation (i.e. from inside the body) if dust or fragments of DU enter the body.

- A large percentage of DU rounds that either hit soft targets, or missed the target completely, will have penetrated into the ground where they will corrode (to a widely varying degree, depending on site-specific environmental conditions) over time. As a result, there is a risk of future contamination of groundwater and nearby wells used to supply drinking water. There is also a risk that fragments of DU will be brought up to the surface during reconstruction of houses, roads etc.

3. UNEP mission to Kosovo

3.1 Mission objectives

Because one and a half years had elapsed since the Kosovo conflict, the overall aim of the UNEP mission was to examine the possible risks from any remaining DU contamination of ground, water and biota and from solid pieces of DU (i.e. intact or fragmented penetrators) still in the environment.

The key questions facing the mission were:

- What are the present levels of DU contamination in Kosovo?
- What are the corresponding radiological and chemical risks, both now and in the future?
- Is there any need for remedial measures or restrictions?
- If so, which measures are reasonable and realistic?

The operational objectives and scope of the mission were directed at answering these questions, bearing in mind the conclusions and recommendations of the October 1999 UNEP DU Desk Assessment, the possible constraints on the mission, and the need to conduct the mission in a way that was as scientifically sound as possible. These conditions and prerequisites are further developed in Appendix II.

The operational objectives and scope for the mission were as follows:

- To confirm the presence of DU at given locations;
- To determine how widespread was any contamination of soil, water etc. at the sites visited;
- To determine the distribution of solid pieces of DU (penetrators, jackets, fragments) in the environment and associated localised points of concentrated contamination (or 'contamination points') at the sites visited;
- To judge the degree of dispersion on and below the ground surface and any possible contamination of groundwater at the sites visited;
- To assess the corresponding risks from DU;
- To judge the necessity of taking remedial actions;
- To gain experience with regard to the possibilities and limitations that need to be taken into account when planning and executing similar missions in the future;
- To draw conclusions and to recommend possible follow-up activities;
- To inform concerned parties.

3.2 Composition of the team

The team consisted of 14 experts representing their own competence and capacity but coming from two international organisations: UNEP and the International Atomic Energy Agency (IAEA); one military organisation: the US Army Center for Health Promotion and Preventive Medicine (USACHPPM); and four national laboratories/authorities: AC-Laboratorium Spiez in Switzerland, National Environmental Protection Agency (ANPA) in Italy, University of Bristol – Department of Earth Sciences in the UK, and Swedish Radiation Protection Institute (SSI) in Sweden.

The composition of the team was determined mainly by the need for a diversity of technical experience and competence in order to ensure a suitably qualified, scientific and wide-ranging examination of the DU problem. It was also necessary to have members with appropriate positions of seniority for conducting negotiations with the military and administrative authorities during the mission.

For that purpose the team comprised the following functions and expertise:

- team leader
- scientific leader
- technical leader

- experts in the fields of
  - health and environmental effects of depleted uranium
  - radiation protection
  - equipment
  - measurement
  - sampling
  - laboratory work
  - military advice
  - safety and security
  - logistics
  - reporting
  - public relations

In practice, one person was often able to cover several functions and areas of expertise, so that a number of areas were dealt with by two or more experts.

3.3 Selection of sites

The final choice of which general areas should be investigated was made by UNEP, based mainly on information received from KFOR, together with the previously supplied NATO list of locations where DU had been used. Within each chosen study area, a more detailed selection of specific sites suitable for investigation was made *in situ*, based mainly on instructions from KFOR about the presence of mines and unexploded cluster bombs.

The criteria for selection of sites were that:

- use of DU in the area had been confirmed by NATO;
- the approximate number of DU rounds fired was known;

- DU penetrators and/or jackets had been found by KFOR;
- the sites taken together represented a range of environmental conditions and properties;
- the areas to be examined were safe from mines and unexploded ordnance.

The following 11 sites were visited during the Mission (place names are given in Albanian and Serbian versions):

Site name	NATO reference number*
• Gjakove/Djakovica	28
• Vranoc/Vranovac	100, 103
• Radoniq/Radonjic	98
• Irzniq/Rznic	97
• Pozhare/Pozar	88
• Rikavac	69
• Ceja	83
• Planeje/Planeja	60
• Bellobrade/Belobrod	30, 35
• Kuke/Kukovce	64
• Buzesh/Buzec	37

The locations of these sites are shown in an accompanying map. *The NATO reference numbers correspond to the list of DU-targeted sites provided to UNEP by NATO (see Appendix VIII for complete list).

3.4 Fieldwork, sampling and laboratory analysis

The mission used three complementary technical methods in conducting its investigations:

- field measurements of beta radiation;
- field measurements of gamma radiation;
- field sampling with subsequent laboratory analysis.

The surveys of radiation in the environment were made using beta and gamma instruments held close to the ground, with the team members often employing the 'line-up survey' technique described in Appendix III. This involved team members walking several abreast at fixed distances from each other and sometimes along parallel transect lines. As a complement to these formal searches for DU, individual measurements were made. Although carried out in a more random way than the 'line-up surveys', likely search areas were selected by observing the assumed direction of attack and looking for signs of ammunition impacts. These individual surveys were often very effective. The results of field measurements of radioactivity are given as 'counts per second' – abbreviated as 'cps'. The results of laboratory samples (of soil, water, milk etc.) are given either in terms of weight, i.e. milligrams of uranium isotope (U-238 etc.) per kilogram of sample (abbreviated as 'mg U/kg sample'), with DU expressed as a percentage of total uranium concentration; or in terms of activity, Bq/kg.

Each measurement taken was governed by uncertainties that had to be estimated. Besides the usual statistical uncertainties there are possible systematic errors in the field measurements caused by absorption of the radiation, and in laboratory work by varying technical conditions. In order to overcome differences between various laboratories inter-lab comparisons were made using IAEA standards. The results of these quality tests are presented in Appendix III.

Specific components of the measurement and sampling campaign included:

- field measurements using beta or gamma instruments held close to the ground to search for possible widespread contamination by DU and localised points of concentrated contamination (‘contamination points);

- field measurements using a gamma instrument held close to the ground to find DU penetrators and jackets lying on or close to the surface;

- sampling of soil from around and beneath penetrators and contamination points, in order to study the migration of DU in soil;

- sampling of soil from the wider environment to search for possible widespread DU contamination (complement to the field measurements);

- sampling of water to search for possible DU contamination of water supplies;

- sampling of milk to identify possible DU contamination of food;

- sampling of biota (e.g. grass, roots, moss, bark and lichen) in order to check for the possible presence of DU as evidence of earlier or ongoing contamination.

The number of samples taken in each site, the number of penetrators and jackets found, and the approximate number of DU rounds fired against the respective site are given in Table 1. The results of all the laboratory analyses are given in detail in Appendix X which also gives the geographical (UTM) coordinates of the locality where the respective sample was taken. The sampling sites can be found on the maps in section 7. The analytical methods used are described in Appendix III.

Table 3.1 Summary of samples taken at the 11 sites visited

Site name	Soil	Water	Botanical	Milk	Smear tests	Contamination points found	Penetrators found	Jackets found	DU rounds fired
Gjakove/Djakovica	71	2	2		7	30	1+1/2	0	300
Vranoc/Vranovac	11	12	2			0	0	0	2,320
Radoniq/Radonjic	68	2	1		2	9	1	1	655
Irzniq/Rznic	40	8	11	1		5	0	0	532
Pozhare/Pozar	1	12	3	1		0	0	0	945
Rikavac	16	3	0			2	0	0	400
Ceja	24	0	14		4	1	2	4	290
Planeje/Planeja	9	3	2	1		1	2	1	970
Bellobrade/Belobrod	7	3	1			0	0	0	1,000
Kuke/Kukovce	2	0	1			0	1	0	500
Buzesh/Buzec	0	1	0			0	0	0	200
Totals	**249**	**46**	**37**	**3**	**13**	**48**	**7+1/2**	**6**	**8,112**

Notes on Table 3.1: the columns of figures represent the number of samples in each category from each site. The number of contamination points located, the numbers of penetrators and jackets found, and the approximate number of DU rounds fired against the site, are also shown.

'Contamination points' are those very localised areas, often holes in the road, which were identified as being DU-contaminated, but at which no penetrator or jacket was found. In addition, the soil underneath any penetrators and jackets located was most often shown to be contaminated. All penetrators and jackets were removed from the sites.

4. Findings

The findings at the 11 sites are summarised below, with the corresponding overall conclusions presented in section 5. The assessments of risk (where applicable) are based on the approach outlined in section 2.3 above and discussed in more detail in Appendix I.

(a) Widespread contamination

If a great number of penetrators hit hard targets and become aerosols on impact, there is a risk of people inhaling airborne DU dust if they are close to the target at the time of attack. As the aerosols disperse and fall out there will be a contamination of the ground that might be localised or widespread, depending on the properties of the aerosols and the meteorological conditions.

The UNEP team could not find significant contamination of the ground surface or the soil except at localised points of concentrated contamination ('contamination points' see (b) below) close to penetrator impact sites or penetrator holes. The level of DU detected decreased rapidly from contamination points, with the maximum distance at which contamination was still measurable being 10 – 50 m.

Non-measurable contamination of the ground means that any widespread DU contamination at the investigated areas is so small that it is not discernible from the natural uranium concentrations of the soil.

Assessment of risk

The corresponding radiological and chemical risks from all points of view are consequently insignificant.

(b) Localised points of concentrated contamination

At many of the investigated sites there were clear marks and/or holes caused by projectile impacts in asphalt roads and in concrete slabs or walls. The holes were sometimes contaminated with DU indicating that a penetrator had hit the surface and entered the ground or disappeared as a ricochet far away in the surrounding environment. Sometimes the holes were partly filled with sand or gravel, with the major part of the radioactivity attached to this material. Exceptionally, small fragments of a penetrator were found. When a penetrator (or jacket) was found on the surface of the ground, the soil below the penetrator was normally contaminated.

The areal extent of contamination points was normally small, i.e. less than 20 x 20 cm. The relative concentration of DU at such a point could be high, up to 100 % of the uranium content of a soil sample. The absolute concentration of DU in soil varied from a few mg DU/kg soil, up to about 18 g DU/kg soil. The major part of DU is U-238 and therefore this high concentration of DU meant U-238 showed concentrations about 10,000 times higher than normal. However, the total amount of DU is small and varies – depending on the amount of contaminated soil – from less than 1 mg DU up to 10 g DU. This last value corresponds to 4 % of the weight of a penetrator.

The depth of contaminated soil below contamination points in the ground or on the road was normally in the range of 10 – 20 cm with declining activity concentration relative to increasing depth. This vertical distribution probably resulted from dissolution and dispersion of DU from the initial superficial contamination (or from the penetrator lying on the surface). For further information see point (c) below.

Assessment of risk

One risk related to contamination points is the possibility of some contaminated soil becoming airborne through wind action and being inhaled by people. Another risk could be that the DU from the contamination points eventually contaminates ground water and plants through leakage. However, in both these cases, the amount of DU at the contamination points is too low to cause any radiological and chemical problems at present or in the future. The corresponding risks are insignificant..

The only risk of any significance related to contamination points would be from the possibility that someone came into direct physical contact with the contamination point and thereby contaminated their hands or directly ingested contaminated sand/soil. However, even if gram quantities of soil are ingested, the resulting exposure is insignificant with regard to the radiation from ingested uranium (<10 mSv). On the other hand, such exposure might be significant from the heavy metal toxicity point of view, meaning that the intake of uranium could be higher than health standards.

(c) Dispersion in ground

Several investigations were made on the vertical distribution of DU contamination in the ground caused by an initial superficial ground contamination or a penetrator lying on the surface. The major part of the contamination was normally found in the upper 10 – 20 cm. The most reasonable explanation is that this is an effect of vertical dispersion during the one and a half years that had elapsed since the military conflict in 1999. It is therefore also an indication of the corresponding behaviour of any initially widespread contamination which is no longer detectable. However, any widespread contamination must have been small (and insignificant from a health point of view), i.e. less than 0.1 g DU/m^2, otherwise it would have been detected during the mission.

There are reasons to believe that the chemical and physical properties of DU make it more liable to dispersion in soil than is the case for natural uranium. The issue of DU dispersion into the ground is also of particular relevance in judging the risk of future contamination of groundwater and, ultimately, drinking water supplies. More detailed discussion of this point is contained in Appendix V. The possible consequences for groundwater arising from DU at contamination points or slightly more widespread ground contamination are insignificant, as indicated above. However, for penetrators left in or on the ground, there may be a risk, see (d) below.

(d) Penetrators

As outlined in section 2.2 above, and discussed in more detail in Appendix VII, the fate of a DU penetrator when fired is governed by a wide range of variable factors (e.g. type of target, resistance of surface substrate). Consequently, there are several possible explanations of why penetrators were found at some sites but not at others. Altogether, 7.5 penetrators were found during the mission, representing five of the 11 sites investigated. In six locations no penetrators were found, although according to NATO data, two of these locations had been attacked by the highest number of rounds used at any of the sites visited. In most cases, the penetrators were located either on the surface, or superficially covered by leaves and grass. They had been only slightly affected mechanically and were found on both rocky and soft, soil-covered ground.

Because of the security risks it was only possible to investigate in detail a small part of the sites visited by the mission. Consequently, it is likely that there are still unfound penetrators lying on the surface in other parts of the sites, as well as in other locations on the NATO list of DU targets.

The soil below the penetrators was contaminated by DU, as described under point (b) above.

On visual inspection, it appeared that the surface of penetrators was susceptible to oxidation. From smear tests on some of the penetrators, it was concluded that a part of the radioactivity is easily removed from the oxidised surface. However, the amount is very low, about 10^{-3} % of the mass of the penetrator, i.e. a few mg. Even though the amount may be small, it illustrates one possible pathway for internal exposure by ingestion from contaminated hands.

Penetrators were also analysed with regard to their content of plutonium (Pu) and uranium-236 (U-236), see Appendix VII. It appears that in some cases the activity was too low to be measurable. In other cases, however, traces of the plutonium isotopes Pu-239 (and some Pu-240 which can not be separated from Pu-239 in the measurements) were found in four different penetrators. The amount of plutonium in the penetrators varied from less than 0.8 to 12.87 Bq/kg penetrator. U-236 was also found in penetrators as well as in some of the soil samples, see section 7 of this report (site-by-site findings). The concentration of U-236 in DU is 0.003% of the U-238 concentration in terms of weight and 0.5 % in terms of activity.

The presence of these radioactive elements in the DU indicates that at least some of the depleted uranium had come from material reprocessed from spent nuclear fuel or from the contamination of equipment in the processing plant during the reprocessing of spent nuclear fuel. However, the amount of plutonium and U-236 found in the DU penetrators was very low and did not have any significant impact on their overall radioactivity or the health risk.

Assessment of risk

Penetrators on the surface of the ground can be picked up by people. One possible consequence is contamination of the hands. As shown by the smear tests the amount of DU that will be removed is a few mg DU; 5 mg DU has been measured. Only a small part of that is expected to pass into the body and will give very small radiation dose (of the order of 1 mSv). The possible intake is also small in terms of chemical toxicity health standards, at least in relation to annual tolerable intakes.

Another possible consequence is the external beta radiation on the skin if a person put the penetrator in his or her pocket or used it as an ornament on a neck chain. This could mean a continuous exposure of skin, leading to quite high local radiation doses (in excess *of radiation safety guidelines) after some weeks of continuous exposure, even though there will not be any skin burns from radiation. The resulting gamma radiation exposure will be insignificant and, at most, of the same order of magnitude as natural radiation.*

Penetrators on the surface and particularly those in the ground may dissolve in time and slowly contaminate the groundwater and the drinking water (see further discussion in Appendix V). As discussed in point (g) below, drinking water has a natural content of uranium. The normal natural concentration of uranium and the annual intake of natural uranium by water in the visited areas is low, 10^{-5} – 10^{-3} mg U/l water and 0.01 – 1 mg uranium/year, respectively, leading to radiation doses of less than 1 mSv/year.

When the number of penetrators shot against an area is of the order of 1,000 it means a substantial additional amount of uranium. The relative contribution depends on the size of the affected area. Assuming 1,000 m^2 only and that the water table is at 3 m depth and the natural uranium concentration is 1 mg uranium/kg soil, 1,000 penetrators in the ground would increase the uranium content by a factor 100. Nevertheless, the radiation doses will be very low but the resulting uranium concentration might exceed WHO health standards for drinking water. However, that very much depends on local circumstances and the chemical and physical properties of the DU penetrators, soil and groundwater. There are too many uncertainties to predict the fate of the penetrators and even more uncertainties in predicting any possible water contamination in the future.

Penetrators currently hidden in the ground may be dug up during construction works in the future. Were this to occur there would be corresponding risks of external exposure from beta radiation and the risk of contamination of hands will occur as described above.

There are no risks of any significant increased uptake of DU in plants at present or in the future as a consequence of penetrators remaining in the environment, (compare point (b) above).

There is no risk of inhalation of possibly contaminated dust from penetrators; compare point (b) above.

The measured concentration of plutonium in DU was 12.87 Bq/kg DU at the most. This has to be compared with the activity of U-238 in DU which is 12,400,000 Bq/kg DU i.e. 1,000,000 times more. The radiation dose per Bq of Pu is much higher than per Bq of DU, particularly with regard to doses caused by inhalation, by a factor of 100 to 240, depending of the properties of the inhaled particles and the age of the person. By combining the relative activity and the dose factor, it is concluded that the Pu contained in the investigated penetrators is at least 5,000 times less hazardous than the DU itself.

Analysis of uranium-236 in the penetrators showed a concentration of 0.0028% of the total uranium. The content of U-236 in the penetrators is so small that the radiotoxicity is unchanged compared to DU without U-236.

(e) Jackets

A jacket is the part of the projectile that holds the penetrator. It stops at impact on a hard surface while the penetrator enters the target. All together, six jackets were found. The small number of jackets found is another indication that most of the penetrators missed hard targets and penetrated the ground with the jacket attached. The soil underneath a jacket was contaminated – as in the case of penetrators – to a depth of 15 – 20 cm, with the contamination levels being up to the same level as for penetrators.

<u>*Assessment of risk*</u>

The potential risks from jackets are much lower than those from penetrators because they are not made of DU and are only slightly contaminated with depleted uranium.

(f) Contamination of vehicles, houses etc.

No contamination of houses, vehicles or other objects was found.

Table 4.1 Total uranium concentration in water samples from Kosovo

Location	UNEP Code	ANPA mg/kg	BU mg/kg*	SSI mg/kg
Dakovica public water	124, 326		6.20E-04	5.99E-04
Radonjico lake water	045, 133	5.49E-04	6.00E-04	
Vranovac pond	128, 327		7.79E-05	2.38E-04
Vranovac farm 1 well	129, 328		2.15E-03	1.63E-03
Vranovac farm 2 well	035, 130, 336	1.62E-03	1.64E-03	1.60E-03
Vranovac next to school well	036, 131, 337	3.15E-04	3.24E-04	3.06E-04
Vranovac spring at farm 1	132, 335		8.28E-04	7.50E-04
Rznic farm 1 well	049, 126	4.38E-05	ND	
Rznic school well	050, 127, 329	4.52E-05	ND	2.52E-05
Rznic channel water	080, 125, 330	4.40E-04	4.70E-04	4.13E-04
Bandera farm 1 well	061, 134, 331	5.27E-05	ND	3.86E-05
Bandera farm 2 well	062, 135, 332	4.16E-05	ND	1.63E-05
Bandera farm 3 well	063, 136, 333	1.94E-04	1.30E-04	1.51E-04
Bandera river water	064, 137, 334	7.31E-05	4.17E-05	7.67E-05
Planeja well	077, 139, 338	2.17E-04	2.17E-04	2.67E-04
Belebrod/Opoja Co-op well	079, 140, 339	2.36E-05	ND	6.50E-06
Ricavac stream water	080, 138, 340	4.01E-04	3.56E-04	4.18E-04
Buzec co-op water	141		9.65E-05	

*The BU samples were filtered through 0.2 micron filters on site and acidified with nitric acid
ND = Not Detected, below the detection limit

Notes: Results of analyses on samples collected by ANPA, Bristol University and SSI Team Members. At each site one to three samples were collected from the same well or surface water body. ND = not detectable.

Information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

(g) Contamination of water

In all, 46 water samples were taken and analysed in laboratories. They were taken from 10 of the 11 sites, see Table 3.1 above. In Table 4.1 (see above), all the water measurements are summarised.

The uranium concentration varies from 6.5 10^{-6} to 2.15 10^{-3} mg U/kg water. There are no signs of DU in water. As can also be seen from Table 4.1 the results of the various laboratories agree very well.

(h) Contamination of botanical material

At several sites, samples were taken of botanical material such as grass, roots, moss, bark and lichen in order to search for possible DU uptake and to identify whether some types of botanical material could serve as good indicators of earlier or continuing airborne contamination. Because of difficulties in avoid cross-contamination of uranium in soil, the results are not conclusive except with regard to lichen (and possibly bark), which appears to be an indicator of airborne DU contamination (see Appendix VI). This is not a new scientific finding. Lichen is known, for instance from studies on fallout of the atomic bomb tests in early 1960s, to be a good indicator of airborne contamination.

While many of the mission's observations suggested that very few penetrators had been aerosolised and mostly passed into the ground, additional research into bioindicators might provide additional data allowing more definite conclusions to be drawn on events immediately following a DU strike.

(i) Milk

Milk samples were taken from three sites and from cows that grazed in potentially contaminated fields. None showed any DU contamination.

(j) Contamination checks on UNEP team members

After every visit to a site and before breaks for lunch in the field, all team members were measured for possible contamination by DU on the soles of their footwear, on gloves and on clothes. No contamination was found at any time.

5. Conclusions

Introductory notes:

(a) The conclusions and observations in this section refer to the UNEP mission to Kosovo from 5 – 19 November 2000, and to the 11 sites that were visited and investigated at that time. Because of the risks posed by mines and unexploded ordnance, the investigated sites were limited in extent when compared with the total area potentially affected by the use of DU in Kosovo. Nevertheless, the results from the 11 sites studied are at least indicative for other affected areas. The mission made a number of important new findings and gathered a variety of experience that will be of value in planning and implementing further work.

(b) A 'significant' radiological risk is one where the expected radiation dose would be > 1 mSv per event, or per year. A 'significant' toxicological risk means that the expected concentration or intake would exceed World Health Organisation (WHO) health standards. 'Insignificant' radiological or toxicological risks are those where the corresponding dose or concentrations/intakes are < 1mSv, or below WHO health standards, respectively.

(c) Based on the findings discussed in section 4 (and on a site-by-site basis in section 7), the overall conclusions, of the UNEP mission are as follows:

1. There was no detectable, widespread contamination of the ground surface by depleted uranium. This means that any widespread contamination is present in such low levels that it cannot be detected or differentiated from the natural uranium concentration found in rocks and soil. The corresponding radiological and toxicological risks are insignificant and even non-existent.

2. Detectable ground surface contamination by DU is limited to areas within a few metres of penetrators and localised points of concentrated contamination ('contamination points') caused by penetrator impacts. A number of contamination points were identified by the mission but most of these were found to be only slightly contaminated. The majority of the radioactivity was attached to the surrounding asphalt, concrete or soil, with some attached to the loose sand present in some penetrator holes. In many cases, the radioactivity was so low that it was hardly detectable.

3. There is no significant risk related to these contamination points in terms of possible contamination of air, water or plants. The only risk of any significance would be that someone touched the contamination point, thereby contaminating their hands (with a risk of subsequent transfer to the mouth), or directly ingested the contaminated soil. However, with reasonable assumptions on intake of soil, the corresponding radiological risk would be insignificant, while from a toxicological point of view, the possible intake might be somewhat higher than the applicable health standards.

4. No DU-contaminated water, milk, objects, or buildings were found.

5. Seven and a half penetrators and six jackets were found during the two-week mission. The fact that no more were found, in spite of intensive searching, may mean that:

– other penetrators are not on the surface but buried in the ground;
– they are spread over a larger area than assumed;
– they have already been picked up, for instance during military site clean-up or mine clearance.

6. There are probably still penetrators lying on the ground surface. If picked up they could contaminate hands. However, the probable intake into the body is small and both the radiological and toxicological risks are likely to be insignificant.

7. If a penetrator is put into the pocket or elsewhere close to the human body, there will be external beta radiation of the skin. That can lead to local radiation doses above safety standards after some weeks of continuous exposure. Even so, it is unlikely that there will be any adverse health effects from such an exposure.

8. Penetrators oxidise and the outermost layer of the surface of the penetrator can then be removed easily and thereby contaminate its surroundings. Some DU has dispersed into the ground beneath penetrators and jackets lying on the surface and is measurable to a depth of 10 – 20 cm.

9. It is probable that many penetrators and jackets are hidden at some metres depth in the ground. These penetrators and jackets as well as those on the ground surface, constitute a risk of future DU contamination of groundwater and drinking water. Heavy firing of DU in one area could increase the potential source of uranium contamination of groundwater by a factor of 10 to 100. While the radiation doses will be very low, the resulting uranium concentration might exceed WHO health standards for drinking water.

10. However, there are too many uncertainties to predict the future levels of groundwater contamination with any reliability. To reduce these uncertainties, it would be valuable to undertake a mission to areas where DU was used at an earlier time than in Kosovo, e.g. Bosnia-Herzegovina where buried or surface DU ordnance has persisted in the environment for 5-6 years.

11. Hidden penetrators and jackets may be dug up to the ground surface in the future. The corresponding risks are than the same as for penetrators and jackets now lying on the surface.

12. The uranium isotope U-236 and the plutonium isotopes Pu-239/240 were present in the depleted uranium of those penetrators analysed in very small concentrations and do not pose a significant risk.

13. There are signs that some plant material, such as lichen, and possibly bark, may be good environmental indicators of DU. The preliminary results should be verified by additional analysis.

14. The sites visited by the UNEP mission represent some 12% of all sites attacked using DU ammunition during the Kosovo conflict. Based on the mission’s findings, it is possible to make certain extrapolations for other DU-affected sites in Kosovo, but also for sites in Serbia (about 10% of sites targeted with DU) and Montenegro (amounting to approximately 2% of sites targeted with DU), where there are similar circumstances and environmental conditions, and which had been targeted by DU ammunition during the same conflict. However, further work would be needed to confirm the validity of such extrapolation.

6. Recommendations

These recommendations are valid for all sites in Kosovo where depleted uranium (DU) has been used. Similar precautionary action is also recommended to the authorities responsible for sites in Serbia and Montenegro that were also targeted with DU ammunition in spring 1999.

1. At all sites in Kosovo where DU has been used, the appropriate authorities should undertake visits with suitable measuring equipment to search for possible widespread ground contamination, the presence of penetrators and jackets on the ground and contamination points, as well as to assess the feasibility of clean-up and decontamination. NATO and KFOR should be fully involved in these tasks owing to the security risks posed by mines and unexploded ordnance.

2. The appropriate authorities should undertake the marking of all DU-affected sites, where and when appropriate, until the site is cleared from solid DU (penetrators and jackets) and loose contamination at contamination points.

3. At all sites, penetrators and jackets should be collected and disposed of safely, as determined by the responsible authorities.

4. Contamination points should be decontaminated where feasible and justified, particularly where they are close to inhabited areas. Contaminated material should be disposed of safely as determined by the responsible authorities. In some cases, contamination points could be covered by concrete or other durable material.

5. Within and adjacent to areas where DU has been used, groundwater used for drinking should be checked by the appropriate authorities for possible DU contamination. The type and frequency of checks would depend on local environmental, geological and hydrological conditions.

6. When analysing DU penetrators and samples, transuranic elements should also be taken into account, as appropriate.

7. Information should be provided to the local population on the precautions to be taken on finding material containing DU, possibly through on-going mine-awareness activities.

8. The site-specific recommendations contained in section 7 of the report (and expanded in Appendix V) should be implemented as soon as the security situation allows.

9. Further scientific work should be carried out to reduce the scientific uncertainties related to the assessment of the environmental impacts of DU.

10. In order to reduce scientific uncertainty on the impact of DU on the environment, particularly over time, UNEP recommends that scientific work be undertaken in Bosnia-Herzegovina where DU ordnance has persisted in the environment for over 5 years. This could be part of an overall environmental assessment for Bosnia-Herzegovina.

7. Site-by-site findings

7.1 Introduction

This chapter summarises the results of the investigations made at the 11 sites visited in Kosovo. Maps showing the locations and co-ordinates of each site are given together with the results of sample analyses. The findings, and the conclusions derived from them, are given on a site-by-site basis. For ease of reference by the local authorities, local people and other interested parties, all the information relating to a particular site is presented in a ‘stand alone’ section and not grouped with potentially distracting information relating to other sites.

All results from the laboratory analyses are given in Appendix X. Each sample was allocated a unique UNEP reference code and this code is referred to, as far as practicable, in the discussion.

In the assessment of results and the corresponding conclusions about possible environmental contamination and consequential risks to people both now and in the future, there are comparisons with natural levels of radioactivity and with international limits and standards for radiological and chemical risks. There are also references to what is called the ‘Reference Case’. For further information, please consult Appendix I, ‘Risk Assessment’.

In both the tables and the text the concentrations of the various uranium isotopes are expressed as a measure of radioactivity (unit Bq per kg of sample), or as a measure of weight (unit mg per kg of sample). The relationship between these two measurements is given in Appendix IX.

One problematic issue discussed in this chapter is the possible future contamination of drinking water. Even though it is most unlikely that any problems will arise in the future as far as water is concerned, there are a number of uncertainties. As a consequence, particularly bearing in mind the desirability of taking a precautionary approach, certain actions are recommended. The necessity for, and modalities of, such actions are further discussed in Appendix V.

7.2 Gjakove/Djakovica garrison

Site description and general information

Gjakove/Djakovica garrison (NATO reference no. 28). Co-ordinates: DM52450 91200.
See map of general location in Kosovo and two sketch maps of site.
Investigated by the UNEP mission on 7 and 8 November 2000.

The site is comprised of a former Yugoslavian army (VJ) garrison situated some 200 m south of Gjakove/Djakovica Old Town. The size of the garrison area is approximately 200 x 300 m. The garrison was attacked by NATO forces on 14 May 1999, probably in order to destroy the armoured vehicles situated there as well as to cause losses to other VJ facilities. The site was formerly used as a Serb garrison for military armoured vehicles and as an ammunition depot.

When the team visited the site it had been largely cleared of building remains, while destroyed vehicles had been piled together. This clean-up effort had been initiated under KFOR supervision and a stone crusher from a mine had been used to crush concrete and brick rubble. Pieces of metal were separated from the rubble using a strong magnet. The work was suspended when DU penetrators were found among the scrap metal.

At the time of the UNEP mission, the central part of the site was dominated by a large concrete platform (60 x 170 m). The surface of the platform showed clear traces of more than 30 impact holes, which evidence suggests were caused by DU penetrators. The site also held a number of destroyed army vehicles and other military equipment. Although nearby buildings had also been hit, the nature of the impact holes, which indicated small calibre arms fire, together with the absence of any detectable DU, suggested that they had probably not been targeted by DU ammunition.

Information received from NATO indicated that a total of about 300 rounds had been fired at the area.

Gjakove/Djakovica Garrison is situated on flat land between the town and a river. To the north there is a slope up towards the Old Town. The concrete platform is surrounded by grassland. At the time of the UNEP mission, cows and sheep were grazing in the area and children were playing. The ground consists of black clayey silt. UNEP soil samples taken from outside the concrete platform showed low uranium content (0.8 – 3 mg/kg U) and low gamma radiation (0.05 – 0.1 µSv/h).

Summary of samples taken at Djakovica garrison*:*

- 71 soil and concrete samples
- 2 grass + roots samples
- 2 samples of public tap water from the same tap
- 7 smear tests
- 1 penetrator

Field investigations

The beta/gamma radiation survey was made by 'line-up survey' (see Appendix III for a description of this technique) with 10 m between the lines ordered in an east-west direction along the concrete platform and extending about 10 m beyond the platform in all directions (see sketch map). These measurements were complemented by a number of measurements at specific places on the platform (all surface holes) and beyond it at various distances of up to 200 m.

Measurements were also taken from inside the destroyed vehicles and both the interior and exterior of destroyed buildings. Soil samples were taken where penetrators were found, and at some contaminated points on the slab and in the surrounding grassland, as well as from a park, UNEP 245 a and b, close to the old town. Two samples of public tap water, UNEP 124 and 326 were taken from a house north of the platform.

Furthermore, some experiments were made to study the effect of decontamination and the outcome of a smear test on the concrete platform.

Summary of results

General contamination

The beta/gamma instruments used showed no detectable DU either on the concrete platform or outside it, except where a few small patches of the slab were covered by a thin layer of sand, close to the two penetrators found (see below), and in the cavities in the surface of the concrete (see localised contamination, below).

Penetrators and jackets

Two penetrators were found: a complete penetrator just outside the concrete slab, and a half penetrator in one of the holes in the concrete. The complete penetrator was lodged in the top layer of the ground (at 5 cm depth) partly hidden by grass. No jackets were found.

Localised points of contamination

The measured activity of the localised points of contamination ('contamination points') varied from near background levels (1 cps) to 160 cps (beta radiation) corresponding to about 500 Bq (40 mg DU). The activity of the majority of the points sampled (30 all together) was within 10 ± 5 cps, corresponding to 30 ± 15 Bq (2 ± 1 mg DU).

The contamination points were in the form of small cavities in the concrete slab. These contained small amounts of sand, gravel and small stones in a layer varying in thickness from 0.5 to 2 cm. Measurements of initial activity were made in four such cavities, with portions of sand, gravel and stones then taken out for analysis. It was found that the major part (more than 90 %) of the activity was bound to the sand, gravel and stones. The small part bound to the surface of the concrete was very tightly fixed, with smear tests showing no activity.

The activity of DU contamination of sand/gravel/soil in three other holes varied between 11 and 36 kBq/kg (UNEP 019, 021, 022). With an assumed total of 10 – 100 g contaminated material, between 100 and 4,000 Bq or 10 to 300 mg of DU would be generated. All three holes together would therefore correspond to only 0.01 – 0.3 % of the weight of a penetrator.

Samples of concrete fragments from around another hole probably caused by DU fire, and taken at 0 – 15 cm depth, showed DU activity of 16 kBq/kg or 1,326 mg DU/kg, corresponding to about 1 g of DU (UNEP 172). The contamination of the surface covered an area no more than 10 x 10 cm. The total activity would correspond to about 0.3 % of the weight of a penetrator

Soil samples

Soil samples taken from around and below a penetrator lodged in the ground a few metres west of the concrete platform contained DU contamination to a depth of about 20 cm. The samples were divided into two parts for analysis at two different laboratories. The activity ratio U-234/U – 238 is a measure of the concentration of DU. Values significantly lower than 1.0 indicate the presence of DU. The results from one of the laboratories are shown in Table 7.1 below.

Table 7.1 Soil profile measurements around and below DU penetrator, Djakovica garrison

Sample number	Sample depth (cm)	U-238 (Bq/kg)	U-234 (Bq/kg)	U-235 (Bq/kg)	Utotal (mg/kg)	U-234/ U-238
UNEP 017	0 – 5	225760±5538	30111±4740	3800±110	18253±2961	0.13
UNEP 001	5 – 7.5	45731±1121	6502±1543	750±22	3697±889	0.14
UNEP 002	7.5 – 9.5	684±93	103±11		59±10	0.15
UNEP 004	11.5 – 13.5	389±48	69±7	8±2	30±8	0.18
UNEP 005	13.5 – 15.5	90±24	40±14	4±2	8±5	0.44
UNEP 006	15.5 – 17.5	230±36	65±18	5.0±0.5	31±10	0.29
UNEP 011	25.5 – 27.5	30±4	29±3	3±1	3±1	0.94
UNEP 016	39.5 – 44.5	29±7	28±5	1.8±0.5	3±1	0.95
UNEP 018	Blank*	31±5	30±6	2.1±0.4	3 ±1	0.98

* = soil sample from Gjakove/Djakovica taken outside the attacked area.

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The total activity of the DU contamination at and below the level of the penetrator was about 150 kBq, equivalent to 12 g of DU. That means that the penetrator had lost about 4 % of its total mass (initially about 300 g) at the time of impact and subsequently (over a period of 1.5 years) by dissolution. The soil profile in terms of the ratio U-234/U-238 is shown in Figure 7.1 below.

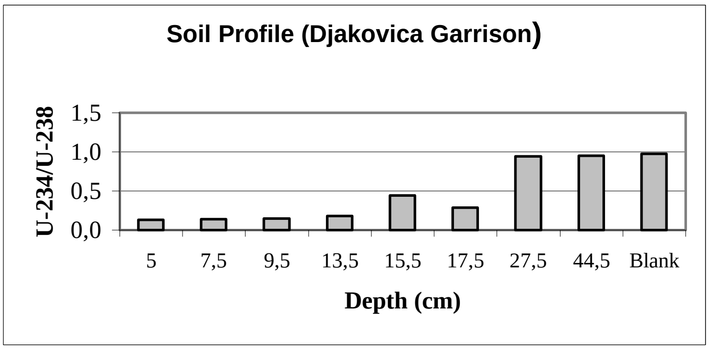

Figure 7.1 U-234/U-238 ratio in soil profile at site of DU penetrator, Gjakove/Djakovica garrison

Note: the ‘Blank’ sample was taken from outside the attacked area.

The results from the other laboratory are shown below in Table 7.2 and refers to samples UNEP 082 – 090. The high values in Table 7.2 are caused by a DU fragment in the soil. Note: the laboratory did not take part in the quality control exercise (NAT-9).

Table 7.2 U content of soil profile above, around and below DU penetrator, Djakovica garrison

Location of soil sample	Sample depth or radius from penetrator	mg U/kg sample
Above penetrator	Surface covering	28
Around penetrator	10 – 20 cm radius	40,300
Below penetrator (samples taken from deeper than 14.5 cm showed normal levels of U and are not listed here)	0 – 2.5 cm depth	2,640
	2.5 – 4.5 cm depth	29
	4.5 – 6.5 cm depth	8.9
	6.5 – 8.5 cm depth	51
	8.5 – 10.5 cm depth	51
	10.5 – 12.5 cm depth	17
	12.5 – 14.5 cm depth	4.1

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The uranium concentration of all samples taken from 14.5 cm down to 40 cm depth was normal, i.e. 1.7 – 3.4 mg U/kg sample, with an average of 2.4 mg U/kg sample. The total amount of the DU contamination around and below the penetrator was about 40 g.

Two other samples, one of surface soil (0 – 5 cm) and one slightly deeper (5 – 15 cm), taken two metres away from the position where a penetrator was found, clearly showed DU contamination of the soil (UNEP 162, 163). The surface layer was contaminated with 4.6 mg DU/kg soil, while the lower sample contained 0.8 mg DU/kg soil. The contamination by DU in the surface layer accounted for 75% of the total amount of uranium present in the sample. The corresponding figure for the deeper sample is 32%. The concentration of DU in the soil two metres from the penetrator was found to be three orders of magnitude less than around the penetrator itself.

Two further soil samples taken from a grass area within the concrete platform showed surface (0 – 5 cm) contamination of 1.5 mg DU/kg soil and sub-surface (5 – 15 cm) contamination of 0.02 mg DU/kg soil. DU made up 51.9% of the total amount of uranium (mg) in the surface sample and 1.2% in the lower sample (UNEP 164, 165).

Samples were also taken systematically at distances of up to several hundred metres from the concrete platform. No detectable DU contamination was found further than five metres from the platform, i.e. any contamination was below 0.1 g/m^2 (1 % of the Reference Case, non-covered surface).

U-236

In a surface layer (0 – 5 cm) sample taken two metres away from the position where a penetrator was found, U-236 analysis showed a value of 116 ng/kg soil, which corresponds to 0.28 Bq/kg (UNEP 162). The U-238 concentration of the same sample was 6.07 mg/kg soil, equivalent to 75 Bq/kg. The ratio U-238/U-236 by weight is therefore 52,000 and by activity 270. Considering that only part of the total U-238 is accounted for by DU (6.07 –

1.5 mg/kg), with 1.5 mg/kg being the normal natural uranium concentration, the ratio by weight will be 4.5 mg/116 ng = 39,000 and by activity 56 Bq/kg / 0.28 Bq/kg = 200.

In the surface sample (0 – 5 cm) taken from the area of grass inside the concrete platform, the U-236 concentration was 40.6 ng/kg soil, which equates to 0.1 Bq/kg (UNEP 164). The U-238 concentration of the same sample was 2.8 mg/kg soil, corresponding to 35 Bq/kg soil. The ratio U-238/U-236 by weight is therefore 69,000 and by activity 360. Considering again that DU is only responsible for part of the U-238 recorded (2.8 – 1.5 mg/kg) the ratio by weight will be 1.3mg/40.6 ng = 32,000 and by activity 16Bq/kg / 0.1 Bq/kg = 170.

Measurements on a fragment of penetrator gave a ratio U-238/U-236 by weight of 34,000 and by activity 170 (UNEP 172).

The sample of concrete from an impact hole in the concrete platform contained 1,326 mg U-238/kg sample, equivalent to 16,400 Bq/kg, and 36,140 ng U-236/kg sample, corresponding to 87 Bq/kg. The ratio U-238/U-236 by weight is therefore 37,000 and by activity 190 (UNEP 172).

For a summary and average see Table 7.3.

Table 7.3 U-238/U-236 ratio by weight and by activity, Djakovica garrison

Sample type	**U-238 concentration mg/kg soil**	**Bq/kg**	**U-236 concentration ng/kg soil**	**Bq/kg**	**U-238/U-236 By weight**	**By activity**
Surface layer, 0 – 5 cm, 2 m from a penetrator	6.07	75	116	0.28	52,000 39,000*	270 200*
Surface layer in the grass area	2.8	35	40.6	0.1	69,000 32,000*	360 170*
Penetrator					34,000	170
Concrete from a hole	1,326 mg/ /kg sample	16,400	36,140	87	37,000	190
Average					36,000	190

* These values represent the DU part of the sample. The averages also only represent the DU components.

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

Smear tests

Vehicles: in the smear tests carried out on vehicles with bullet holes suggesting they had been hit by DU penetrators, the activity values of U-238 and U-235 were both lower than the minimum detectable levels. These results suggest that either DU ammunition did not in fact hit these vehicles, that the DU ammunition easily penetrated these thin-skinned vehicles leaving minimal, non-detectable levels of contamination, or that the DU dust had been removed from the vehicle surfaces by rainfall and wind (UNEP 023, 029).

Drinking water

Two samples of public water were taken from a nearby house just to the north of the concrete platform. No excess activity was found and there was no indication of the presence of DU (i.e. the ratio U-238/U-235 was normal). The agreement of analyses performed at two different laboratories (UK and Sweden) was good, with values of 0.6 and 0.60 µg/l respectively (UNEP 124, 326).

Site-specific conclusions

Measurements

Penetrators, jackets and surface contamination:

Only one and a half penetrators were found from the 300 rounds reportedly fired. The intended targets were probably the military vehicles located on the concrete platform and in the immediate vicinity. Some penetrators had been found and removed from the site during earlier clean-up work.

A proportion of the DU penetrators would have become aerosolised during the attack and dispersed on and around the platform. However, no evidence of DU contamination was found more than a few metres from either the penetrators located, or the holes left by other penetrators. Very little was found on the platform itself, except in the penetrator cavities which had measurable quantities of DU reaching a total of just 0.1 – 1 g. Assuming that at least 100 penetrators became aerosolised on impact, about 30 kg of DU would have been deposited in the surrounding environment. 0.1 – 1 g is clearly a very small amount in comparison with 30 kg spread over 1000 m^2 (the approximate size of the concrete platform and its immediate vicinity). Furthermore, 30 kg is three times the Reference Case and would be easily detected by direct external measurements and/or by laboratory measurements of soil samples. There could be several possible explanations:

> (a) The DU dust was initially dispersed over a much wider area than the targeted site of about 1,000m^2, and activity was therefore not detectable by field measurement. In order for this to be the case, a dispersal area of at least 300,000 m^2 would be needed in order to reduce the surface contamination to a level barely detectable by field beta measurement, and assuming that DU dust was lying on the surface. An area of 30,000 m^2 would be required if the DU was slightly covered by soil. Non-detectable activity means that the surface contamination is less than 0.1 g DU/m^2 (1 % of the Reference Case, non-covered area) and less than 1 g DU/m^2 (10 % of the Reference Case, covered area).
>
> For these figures to be attained, wind dispersion would need to be over an area 1 – 10 km in length and 30 m wide with an even fallout across the whole of this surface. This is not a probable scenario when compared with experience from experimental studies (UNEP DU Desk Assessment Report, October 1999). However, very windy conditions could certainly have contributed to wider dispersal than the target area itself.

(b) The great majority of penetrators either missed the target or hit a 'soft' target. Therefore they did not shatter, but entered the ground on and around the concrete platform. The large number of holes in the concrete, many of them slightly contaminated, suggests that this could be the case. No holes were found outside the concreted area but their presence cannot be excluded since the softer substrate would make holes more difficult to detect.

(c) Another possibility is that there was a ricochet effect, a conclusion that is based on studies of the characteristics of the holes in the concrete platform, and the pattern and angle of impacts.

In conclusion, the most probable scenario is that 300 rounds were fired, but that most of them hit soft targets or missed the target area and then entered the ground or disappeared as ricochets some distance from the concrete platform. A few penetrators were aerosolised, temporarily contaminating the surface of the platform until washed away by rainfall. Some contamination remains on the platform, attached to sand whilst other contamination has collected in holes as result of rain and wind action, again mainly attached to sand. The DU is not attached to the surface of the concrete itself except in the deeper parts of holes which have either been hit by penetrators and/or gathered DU leaked from the overlying sand.

Many penetrators might also have been cleared from the site during initial clean-up operations.

Residual risks

Because there was no detectable contamination of the ground beyond the edge of the concrete platform, except in the immediate vicinity of where a penetrator was found, the contamination in this area is probably less than 0.1 g DU/m^2 (1 % of the Reference Case). The residual radiological and chemical risks of DU exposure, either by inhalation of contaminated dust in the air or by ingestion of contaminated food, is insignificant.

There may still be some penetrators (and jackets) on the ground at, close to, or relatively far from the target area. If these were picked up by people, there would be a potential risk of external radiation exposure, which might be significant. There may also be some risk of contamination of hands and subsequent ingestion. Corresponding radiation exposure is insignificant but from a heavy metal toxicity point of view the exposure may be significant.

Because of localised ground contamination close to the penetrator, there may be some risk of internal contamination by ingestion of soil or contamination of hands. While such exposure would be insignificant with regard to radiation (<10 µSv) it could be significant from a toxicological point of view.

Many penetrators may remain hidden in the ground and therefore be vulnerable to solution and ultimate dispersal into the groundwater. Hence, there is a possibility that the drinking water from some nearby wells could become contaminated in the future.

The concrete platform is still subject to a degree of contamination contained in the bullet holes and in loose sand lying on the surface. Most contamination was removed by the UNEP team as a consequence of sampling, but around 0.1 – 1 g DU remains as contamination. Some of it is bound tightly to the concrete, with the rest is attached to sand or similar substrates. The possible potential risks are related to inhalation of dusty air caused by wind blowing across the platform, or ingestion of contaminated sand. The total amount of contaminated sand may be of the order of 100 g spread over the concrete surface, which would result in 1 – 10 mg DU/g sand or dust. That could be expected to lead to insignificant radiation doses less than 10 μSv effective dose after spending two hours in dusty air (compare the Reference Case, 6 mg DU/g dust). The toxicological risks are also insignificant. After a few hours all sand should have blown away and thereafter constitute an even smaller risk.

Alternatively, the sand does not blow away and there is no inhalation dose but there is a risk of ingestion. The only possible way to ingest the DU is by ingesting the contaminated sand itself. Ingestion of 1 g sand would be a realistic maximum for a human being (compare the Reference Case). If that happens, the exposure is insignificant as regards radiation (<10 μSv) but could be significant from a toxicological point of view.

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity now or in the future.

However, it is advisable to inform people about the possible presence of penetrators and jackets in the environment, and that all penetrators or jackets found should be dealt with by the local authorities or by KFOR. They should not be kept in homes or by children.

The village receives piped water, but any nearby wells used for drinking water should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

As a matter of prudence the concrete platform could easily be cleared of loose contamination by using a vacuum cleaner. The collected dust should be disposed of safely as determined by the responsible authorities. Alternatively, the existing platform can be covered with a layer of new concrete.

7.3 Vranoc/Vranovac hill

Site description and general information

Vranovac hill (NATO reference nos. 100 and 103). Co-ordinates: DN52640 12370.
See map of general location in Kosovo and two sketch maps of site.
Investigated by the UNEP mission on 9 and 12 November 2000.

Vranoc/Vranovac hill forms part of a series of sandy ridges (‘eskers’) which run eastward from the mountains to the west. The ridge of the hill rises about 30 – 40 m above the surrounding country and is approximately 200 – 300 m wide and 1 km long. On top of the hill is a flat area used by the Serbian army for 12 anti-aircraft artillery positions. A road and farmhouses lying beneath the south side of the hill were partly destroyed by bombing. Along the northern side of the road, against the hillside, there are several excavations used for protecting tanks and other military vehicles. The village of Vranoc/Vranovac is situated on the western part of the ridge. The site was targeted twice by NATO forces on 8 June 1999. According to information received from NATO, about 2,320 rounds were fired.

The soil consists of fine to medium grained sand. Soil samples taken by the UNEP team from the top of the hill and from one of the farm houses on the southern side of the ridge showed low uranium concentrations (1-3 mg/kg U). The gamma radiation readings were also low, being nowhere higher than 0.1 µSv/h. Water samples were collected from five sites, as detailed below.

Summary of samples taken at Vranoc/Vranovac:

- 11 soil samples
- 2 botanical samples (1 lichen and 1 mushroom)
- 12 water samples:
  - 2 from an excavated pond used for cattle on the northern side of the ridge
  - 2 from a well in the yard of farm 1 situated at the foot of the southern side the hill
  - 2 from a natural spring along the roadside opposite farm 1
  - 3 from a well in the yard of farm 2
  - 3 from a well at a house next to Vranoc/Vranovac school

Field investigations

The beta/gamma radiation survey was made by 'line-up survey' covering an area of 150 x 70 m of the hill top (see sketch map). The remainder of the hill top (total length about 1 km) was surveyed through measurements carried out at random.

Measurements were taken from a number of holes and ditches and a few soil samples were taken from the top of the hill. Some holes were dug using a spade (to a depth of 50 cm) to search for penetrators or DU contamination. Samples of lichen from a tree and a mushroom from the ground were taken on top of the hill.

On the southern side of the hill the inside of a bombed-out farmhouse was measured. A 'line-up survey' was conducted over an area of approximately 50 m perpendicular to the road by 400 m along the southern side of the road, starting above the farmhouse and continuing in the direction of the village. Further random surveys were made along the hillside towards the village and the school house.

12 water samples including drinking water, were also collected: UNEP 128 and 327, from a pond used to supply cattle with drinking water, and alongside the road on the north side of the hill; UNEP 035, 129, 328, 130 and 336 from wells belonging to two farmhouses on the southern side of the hill; UNEP 036, 131 and 337, from a well close to the village school; and UNEP 132, 335, from a natural spring at the foot of the hill.

Summary of results

<u>Penetrators and jackets</u>

No penetrators or jackets were found.

General contamination

The beta and gamma surveys did not indicate any DU contamination of the area.

Localised points of contamination

No localised points of contamination (‘contamination points’) found.

Soil samples

None of the soil samples taken showed any measurable DU activity. The natural uranium content was very homogenous at depths of 0 – 15 cm.

Drinking water

None of the drinking water samples taken showed any measurable DU activity.

Botanical samples

The lichen sample (UNEP 033) showed clear indications of DU contamination, although the activity concentration was low, at less than 0.1 mg U/kg. The mushroom sample (UNEP 034) did not show any measurable activity of DU.

Site-specific conclusions

Measurements

Penetrators, jackets and surface contamination:

In spite of the information provided by NATO that 2,320 rounds had been fired at this locality, no penetrators were found and there were no signs of penetrator or jacket fragments, or even of penetrator hits. Nor were there any indications of contamination of the ground, water or buildings. However, the result of measurements carried out on the lichen sample indicate exposure to air contaminated by DU, presumably caused by the shattering of DU penetrators.

Of the 2,320 rounds reportedly fired, some would have hit the target and aerosolised, some would have hit the target and passed through into the ground, and others would have missed the target and entered the ground. It is also possible that some penetrators ricocheted and came to rest hundreds (or even thousands) of metres away from the top of the hill.

As there was no activity detectable either from field measurements or from soil sampling, any remaining surface contamination is less than 1 g DU/m^2 (10 % of the Reference Case) and probably less than 0.1 g DU/m^2 (1 % of the Reference Case). The area over which the DU would need to have been dispersed in order to reach these low values can be calculated.

If all the 2,320 penetrators were converted to aerosols on impact, about 700 kg DU would have been released into the environment. The area required to distribute 700 kg DU at a density of 0.1 g DU/m^2 would be 7,000,000 m^2, or more than 10 times the area of the hill.

If the targeted area was 700 m wide, the dispersion area would need to be about 10 km in length to correspond to the assumed surface contamination level. Since quite windy conditions may occur on top of the hill, this scenario is plausible, assuming that all the DU was shattered into small particles and dispersed by a strong wind.

A more likely scenario is that most penetrators either hit soft targets, or missed the targets completely, and entered into the substrate of the hillside, where they cannot be detected by field measurements or soil sampling.

Residual risks

In the case of the less probable scenario of dispersion over a very large area, the corresponding residual risk of DU exposure by inhaling contaminated dust or ingesting contaminated food is insignificant.

The more probable scenario, that most of the penetrators are buried in the ground means that there is a possibility of future drinking water contamination if groundwater from the hill enters the drinking water supply. By way of comparison, the total amount of uranium naturally contained in the hill is of the same order of magnitude as that contained in 2,320 penetrators, $4 \cdot 10^{10}$ Bq and 10^{10} Bq respectively. From this it can be concluded that drinking water would not be seriously affected. However, the penetrators are concentrated sources and it is difficult to foresee if that would result in lower or higher concentrations than those assumed.

There may still be some penetrators and jackets on the ground at, close to, or relatively far from the target area (those further away probably resulting from ricochets). If these were picked up by people, there would be a potential risk of external radiation exposure, which might be significant. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure may be significant.

Because of localised ground contamination close to the penetrator, there may be some risk of internal contamination by ingestion of soil or contamination of hands. While such exposure would be insignificant with regard to radiation (<10 μSv) it could be significant from a toxicological point of view.

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity now or in the future.

However, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators or jackets found should be dealt with by the local authorities or by KFOR. They should not be kept in homes or by children.

The drinking water in nearby wells should be kept under some surveillance by taking samples at appropriate intervals for uranium testing.

7.4 Radoniq/Radonjicko lake

Site description and general information

Radoniq/Radonjicko lake (NATO reference no. 98). Co-ordinates: DN53000 02000
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on 10 November 2000.

The investigated site is located at the large dam on the southern shore of Radoniq/Radonjicko lake. The lake is an artificial reservoir providing drinking water to a population of approximately 200,000 (i.e. most of the southern part of Kosovo) including the towns of Prizren and Gjakove/Djakovica. Several artillery positions and perhaps also tank positions were dug into the slope of a nearby ridge, just south-west of the dam. A severely damaged radio station is located on top of the ridge. According to NATO information, the area was targeted by 655 rounds on 7 June 1999. Prior to the UNEP mission, Italian army experts and KFOR Explosive Ordnance Disposal (EOD) personnel had found penetrators and jackets at the site during clearance of mines and unexploded ordnance. The size of the site is approximately 250 x 500 m.

Most of the area on the top of the ridge consists of rocky outcrops covered by a thin layer of stony and sandy red/brown soil. Basaltic volcanic lavas form the bedrock. The soil cover is thicker on the sloping sides of the ridge. Soil samples taken by the UNEP team showed very low, to low, concentrations of uranium (0.5 – 2 mg/kg U). The gamma radiation was around 0.05 µSv/h.

Summary of samples taken at Radoniq/Radonicko lake:

- 68 soil samples
- 1 botanical sample
- 2 smear samples
- 2 water samples
- 1 jacket

Field investigations

The investigations started with measurements in the wrong area. However, the correct area was identified after finding penetrator holes in the asphalt, and discussing locations with the military personnel escorting the UNEP mission. The beta/gamma radiation survey was made by ‘line-up survey’ (see Appendix III, for details) complemented by a number of individual measurements taken at random, though guided by visual observation of possible impact locations.

The measurements and sampling were carried out on both sides of the road to the dam. A large number of soil samples were taken, as well as two water samples from the adjacent lake, which – as mentioned earlier – serves as the drinking water storage reservoir for a large part of Kosovo.

Additional special investigations were conducted on and around a wall hit by a penetrator and on the soil below and close to a penetrator.

Summary of results

Penetrators and jackets

One penetrator and one jacket were found close to the road about 150 m north east of the gate (see sketch map).

At another locality, between the western side of the road and the lake, about 100 m south of the pumping station, there was an apparent indication by the gamma detector of a penetrator hidden in the soft soil. However, in spite of many digging attempts to more than one metre in depth it was not possible to find anything. Either the reading was 'false' having been caused by high natural uranium/thorium levels or it was a true indication of a buried penetrator. The first possibility illustrates one of the pitfalls of searching for DU, while the second possibility shows the difficulties of locating the exact position of a penetrator when it is hidden in the ground.

General contamination

With the beta instrument used there was no detectable DU on either side of the roads or between the roads, except at the so-called 'contamination points', i.e. marks left by penetrator impacts. These were found on the roads and in some concrete constructions, see below. The only other detection of any ground contamination was from soil samples taken close to a penetrator or from a penetrator impact site. The results are given below under 'Activity profiles close to penetrator on ground' and 'A bunker wall hit by a penetrator'.

In addition to these observations there was one finding of DU contamination (20 % of total uranium) in soil and roots, 1 – 5 cm depth, at a point close to the gate (see sketch map), and few metres from a penetrator hole in the road; another finding of weak DU contamination (6 %) in a sample of soil, roots and grass, 0 – 1 cm depth, taken 50 m north east of the gate on the northern side of the road; and one finding of DU contamination (40-50 %) in soil, 0 – 5 cm depth, 100 m north east of the gate, between the two roads.

There were no other findings and indications of ground contamination of DU.

Localised points of contamination

In total, nine contaminated holes were found, some of them only slightly contaminated (less than 10 cps or less than 300 Bq of DU, 25 mg DU, assuming 90 % absorption). Soil samples were taken from two holes caused by the impact of penetrators on concrete and on asphalt, UNEP 037 and 038. The samples contained about 2 g U/kg soil and 0.3 g U/kg soil respectively and most of the uranium (U), 80-100 %, was DU. One hole was specially investigated, see below.

Special studies

(a) Activity profiles close to penetrator on ground.

Two soil profiles were sampled. Soil samples were collected using a stainless steel core sampler (15 x 15 cm frame). The first core (core 1) was taken from just underneath the penetrator found lying on the surface of the ground down to a depth of 10 cm. The core was subdivided into two samples each 5 cm thick. The second soil core (core 2) was sampled to a depth of 15 cm, close to the road where a penetrator hole was observed. The core was taken 155 cm away from the penetrator hole, in the direction in which the rounds were probably fired. The core was subdivided into three samples, each 5 cm thick. The radiochemical results are reported in Table 7.4

Table 7.4 Soil profiles from samples taken at Radonicko lake

Sample number	Core number	Sample depth (cm)	U-238 (Bq/kg)	U-234 (Bq/kg)	U-235 (Bq/kg)	Utot (mg/kg)	U-234/ U-238
UNEP 039	2	0 – 5	21±11	20±10	1.0±0.6	3±2	0.95
UNEP 040	2	5 – 10	14±3	14±3	0.9±0.6	1±1	0.97
UNEP 041	2	10 – 15	16±3	13±2	1.2±0.5	1.5±0.8	0.77
UNEP 042	1	0 – 5	3060±523	396±50			0.13
UNEP 043	1	5 – 10	434±169	74±23	6±2	46±27	0.17

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The distribution of U-234/U-238 activity ratios within the soil profiles is shown in Figure 7.2.

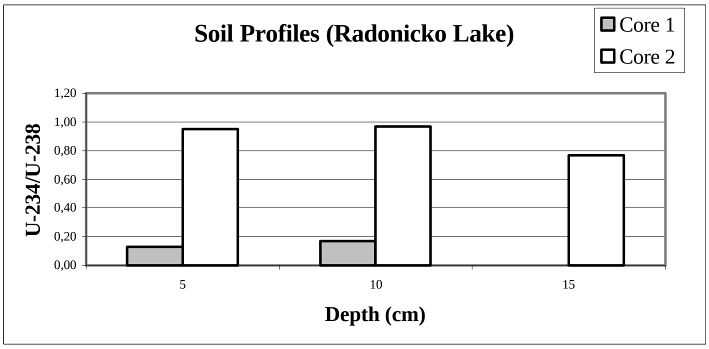

Figure 7.2 Distribution of U-234/U-238 activity ratios in soil profiles at Radonicko lake

It is concluded from Table 7.4 and Figure 7.2 that DU is present to a level of almost 100 % in both samples from core 1 (i.e. from immediately below the penetrator) but not in any significant amount in samples from core 2 (1.5 m away from a penetrator hole). The activity concentration decreases by a factor of five to seven between 0 – 5 cm depth and 5 – 10 cm depth below the penetrator.

(b) A bunker wall hit by a penetrator.

Another study was aimed at investigating in more detail the contamination by DU in the area close to a bunker in which a concrete wall had been hit by a penetrator.

The result of the analyses from around the bunker are shown in Tables 7.5 and 7.6. All samples were soil samples taken at 0 – 5 cm depth, except for sample UNEP 190 which was a sample of concrete taken from a 10 cm deep hole in the bunker.

Table 7.5 Isotopic compositions in samples from bunker

UNEP Sample no.	^{238}U		^{235}U		^{236}U	
	[mg/kg]	k	[µg/kg]	k	[ng/kg]	k
176	100.2	1.34%	206	1.43%	2715	10.4%
177	21.7	3.51%	50.9	3.54%	545	11.0%
178	1.81	1.59%	11.26	1.71%	-	-
179	1.70	2.70%	11.03	3.29%	-	-
180	1.85	2.25%	11.36	2.30%	-	-
181	2.30	1.43%	15.14	1.50%	-	-
182	2.29	3.88%	15.29	3.90%	-	-
183	1.51	2.17%	10.79	2.21%	-	-
184	1.84	5.20%	8.00	6.00%	-	-
185	1.14	1.48%	8.22	1.53%	-	-
186	59.6	5.70%	122	5.73%	1630	12.2%
187	1.32	24.7%	8.44	28.6%	-	-
188	1.66	33.2%	8.16	39.0%	24.7	36.3%
189	1.61	1.29%	11.62	1.35%	-	-
191	1.00	3.04%	7.09	3.06%	-	-
192	0.78	4.24%	5.61	4.35%	-	-
193	1.24	1.58%	8.94	1.63%	-	-
194	1.10	3.11%	7.96	3.16%	-	-
195	2.69	4.31%	17.97	5.70%	-	-

Notes: - indicated that the U-236 concentration was below the detection limit

Information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

Table 7.6 Isotopic ratio U-235/U-238 and the percentage DU of the total uranium amount

UNEP Sample no.	Isotopic Ratio ^{235}U / ^{238}U	Percentage DU of Total Uranium	RSD
176	0.002058	99.0%	0.3%
177	0.002344	93.5%	0.2%
178	0.006239	19.1%	3.0%
179	0.006339	14.3%	13.1%
180	0.006159	20.6%	1.8%
181	0.006599	12.2%	0.4%
182	0.006678	10.7%	1.2%
183	0.007143	1.9%	7.9%
184	0.007267	<1%	-
185	0.007242	<1%	-
186	0.002048	99.2%	0.3%
187 a	0.005736[1)]	28.7%	0.2%
187 b	0.007058[1)]	3.5%	0.3%
187 c	0.006323[1)]	17.5%	0.4%
187 d	0.006918[1)]	6.2%	0.3%
188	0.004917	44.3%	35.6%
189	0.007239	<1%	-
191	0.007095	2.8%	5.3%
192	0.007235	<1%	-
193	0.007242	<1%	-
194	0.007240	<1%	-
195	0.006692	10.5%	37.2%

Notes: RSD = Relative Standard Deviation

Information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The samples UNEP 176 and 177 are those taken from the bunker floor below the impact of the penetrator into the wall. These samples were contaminated with DU in the range of 93.5% – 99% which represents 20.3 – 99.2 mg DU/kg depending on the sample collected.

The soil sample UNEP 178 was taken 1.5 m away from the impact site but still within the same concrete bunker. Contamination of 19.1% DU, equivalent to 0.35 mg DU/kg was found in this sample.

The samples UNEP 179 and 180 were taken from in front of the bunker and to the right (when looking out from the bunker) at distances of 5 and 10 metres. Analysis showed contamination by DU of 0.24 mg DU/kg and 0.38 mg DU/kg.

The samples UNEP 181 and 182 were taken in front of the bunker and straight ahead at distances of 5 and 10 metres. They showed contamination by DU of 0.28 mg DU/kg and 0.25 mg DU/kg, respectively.

The samples UNEP 183 and 185 were taken to the left of the bunker (when looking out from the bunker) at distances of 5, 10 and 15 metres. They showed contamination by DU of 0.03 mg DU/kg, 0.12 mg DU/kg and no contamination.

The sample UNEP 186 was taken 5 metres behind the bunker in the direction that the attack could have taken place. Contamination of 99.2% DU or 59 mg DU/kg soil was found.

The samples UNEP 187 and 188 were also taken on the plateau behind the bunker, at road level, and within a radius of 30 metres around samples UNEP 202 – 211. Both samples were found to be contaminated by DU with respective results of 0.4 mg DU/kg and 0.7 mg DU/kg.

The sample UNEP 189 was taken far away from the impact area behind the remaining house at the top of the hill side and can be considered as showing natural background sample without contamination.

Discussion of special study results

The DU contamination in the area of the bunker is mainly located directly beyond the impact site.

In front of the bunker in an area of 30 x 10 metres DU contamination was found to be in the range of 0.03 – 0.38 mg DU/kg soil (compared with the natural uranium level of 1.2 mg/kg).

Initially surprising was the high value of 59 mg DU/kg found 5 metres behind the bunker. This area was apparently constructed of large blocks of concrete covered with about 10 cm of stony soil. Samples UNEP 186 – 188 were taken in the direction in which the attack had taken place. It can be expected that during the attack DU penetrators also hit the plateau behind the bunker and, by chance, sample UNEP 186 was taken very close to a position where a penetrator hit the ground. This scenario can be confirmed with the data from the samples 187 and 188 showing DU contamination of 0.4 mg DU/kg and 0.7 mg DU/kg soil respectively.

Sample UNEP 186 with its 59 mg DU/kg can be considered as a contamination point resulting from a penetrator having hit the sub-surface concrete platform. Except for localised points of contamination, an area of about 30 x 50 metres is contaminated by DU in the range of 0.4 – 0.7 mg DU/kg soil. This contamination lies within the range of the natural uranium level for that site.

That the levels of contamination behind the bunker seemed to be a little higher than those in front might be the result of more penetrators having hit the plateau, or be a consequence of the wind direction during attack having matched the trajectory of attack, thus depositing DU dust in that direction. Based on the data presented here, contamination sufficient to warrant the term 'contamination point' is limited to a few square centimetres, with DU levels lying in the range of a few mg DU/kg soil up to about 100 mg DU/kg. About two metres away from this contamination point the level of contamination drops to below 1 mg

DU/kg soil. Values of about 0.5 ± 0.2 mg DU/kg soil were measured, decreasing rapidly with further distance.

Sample UNEP 195 was taken far away from the hilltop site, close to the lake and in front of the dam controlling the lake level. This sample was expected to be show background activity only but this was not the case. Due to DU contamination of 0.28 mg DU/kg soil it can be concluded that DU penetrators also hit the concrete wall of the dam. In addition, the natural uranium level in the soil close to the lake was found to be about 2.4 mg/kg soil, a factor of two higher than the hill top.

U-236

U-236 was measurable in four samples. Its quantity is relatively constant, 2.6 10^{-5} times the U-238 concentration in case of pure DU, and consequently only about half of that for a sample with 50 % DU, UNEP 188. In all the other samples the DU concentration was too low for U-236 to be measurable.

Smear tests

The one smear test was made on a penetrator. The amount of activity that was easily smeared away was about 5 mg of DU, sample UNEP 044.

Drinking water

Two water samples were taken from the lake, UNEP 045, 133. The natural uranium concentration of 0.6 µg/l was very low.

Botanical samples

Samples of roots and grass contained uranium levels in the order of 0.5 – 1.5 mg/kg sample and there was no indication of the presence of DU.

Site-specific conclusions

Measurements

Penetrators, jackets and surface contamination:

According to the information given by NATO, 655 rounds were fired at the area investigated. However, only one penetrator was found, plus two jackets. On the other hand there were several clear indications of penetrator hits. The search for a possible buried penetrator was unsuccessful and illustrated the difficulties that can be encountered.

As at other sites, no widespread surface contamination by DU was detectable with either the field beta instruments or from soil sampling. This means that any surface contamination was less than 0.1 g DU/m^2 (1 % of the Reference Case).

If all the penetrators were aerosolised on impact, about 200 kg DU would have been dispersed. The area needed to distribute 200 kg DU to a contamination level of less than 0.1 g DU/m^2 would be 2,000,000 m^2. As the size of the targeted area is of the order of 100,000 m^2, a much wider area, including the nearby lake, would have been contaminated.

Because very limited surface contamination was found in the target area, which would have been the most heavily contaminated in the case of a ground level release on impact, the widespread contamination scenario is not very likely. Therefore, it seems probable that the majority of penetrators are hidden in the ground.

The results from two specific investigations are discussed below.

(a) Soil contamination under a penetrator

In one case, soil contamination was detected in the upper 10-20 cm beneath a penetrator. At a distance of 1.5 m away from a penetrator hole no DU could be detected. The total amount of DU under the penetrator can be estimated to be 0.1-1 % of the penetrator's mass. The contamination could have occurred on impact or by chemical dissolution during the period of 1.5 years that had elapsed since the attack. Because the impact must have been quite soft – the penetrator was lying on the surface – the latter explanation would seem more probable. On the other hand, there is also some surface contamination, albeit low level, around the penetrator, which indicates air dispersal at the moment of impact.

(b) Contamination after penetrator impact on a concrete bunker wall

The special studies on the effects of a penetrator hit on the thick concrete wall of a bunker illustrate the highly complex contamination situation. Unlike in other situations, DU contamination could be identified over a relatively large area of 10 x 30 m. The explanation is the presence of hard materials such as concrete which contribute to shattering of DU on impact. There were also signs of several shots in the investigated target area. The results clearly prove the initial presence of some dust in the target area.

Botanical samples:

Some measurements were also made of roots and grass but there was no indication of DU. That might mean that there was no DU available or alternatively that the uptake by roots had been very low. Both explanations are likely.

<u>Residual risks</u>

In case of the less probable scenario of dispersal over a very large area, the corresponding residual risk of DU exposure by inhaling contaminated dust or ingesting contaminated food is insignificant.

The more probable scenario that most of the penetrators are hidden in the ground means that drinking water could possibly become contaminated in the future. Radonjicko Jezero dam, which supplies drinking water for several hundred thousand people is close to the targeted area. The total water volume is approximately 4×10^7 m^3 (1.5 km x 5 km x 5 m). In the worst case that all 200 kg of DU had been dispersed into the lake, the concentration would be of the same order of magnitude as the WHO provisional guideline for drinking-water quality of 0.002 mg/l and one to two orders of magnitude lower than the drinking water standard in many countries from both toxicological and radiological points of view. Assuming that there is some water turnover during the time it takes for DU to reach the lake, if it ever happens, the concentrations will be even lower, by one to several orders of magnitude.

In conclusion, any significant future DU contamination of the drinking water reservoir can be ruled out.

There may still be some penetrators and jackets on the ground at, close to, or relatively far from the target area. If these were picked up by people, there would be a potential risk of external radiation exposure, which might be significant. There may also be some risk of contamination of hands and subsequent ingestion. Corresponding radiation exposure is insignificant but from a toxicological point of view the exposure may be significant.

Because of local contamination of the ground close to the penetrator, some risk may occur of internal contamination by ingestion of soil or contamination of hands. Were this to occur, the exposure would be insignificant in terms of radiation (<10 μSv) but could be significant from the toxicological point of view.

The level of U-236 concentrations is insignificant from health point of view (UNEP 145, 176, 177, 186, 188).

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity now or in the future.

However, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets found should be dealt with by the authorities or KFOR. They should not be kept in homes or by children.

7.5 Irzniq/Rznic barracks

Site description and general information

Irzniq/Rznic barracks (NATO reference no. 97). Co-ordinates: DN46500 08200
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on 7 and 11 November 2000.

Irzniq/Rznic barracks is a former Yugoslavian army (VJ) arms depot 500 m to the north of Irzniq/Rznic village. The site contained several partly or completely destroyed buildings and military vehicles. The barracks are surrounded by fields and pasture where cows were grazing at the time of the UNEP mission. According to NATO information A-10 aircraft attacked the barracks and the adjacent areas on 7 June 1999. During the attack, 530 rounds were fired. Prior to the UNEP mission, an Italian KFOR EOD unit had found a penetrator hole in a water tank at the barracks and a penetrator lying in a field 400 m south east of the barracks. The size of the attacked area is approximately 500 x 500 m.

The ground in the area is red-brown silty-clayey soil. There are no rock outcrops but four newly formed karst holes in the area studied indicate that the bedrock consists of limestone. The uranium concentration in the soil is low (2-3 mg/kg U). The gamma radiation is about 0.1 μSv/h.

Summary of samples taken at Irzniq/Rznic barracks:

- 40 soil samples from a total of 21 localities
- 11 botanical samples
- 8 water samples of which 3 were taken from the canal north of the barracks, 2 from the school well and the rest from other wells in the area
- 1 milk sample

Field investigations

In the asphalt road 100 m south east of the barracks there were clear indications of four impacts by penetrators or other ammunition. In addition to these observations there was a contamination point inside a concrete underground water tank east of the barracks. However, there was no other indication or sign of the actual penetrator.

The beta/gamma radiation survey was made on both sides of the road to a distance of 50 m from the holes in the road. A ‘line-up survey’ (see Appendix III) was made along lines of 30 m parallel to the road, with 2 m between each person, in fields adjacent to the road.

A ‘line-up survey’ was also made in the field east of the barracks running from the road up to the irrigation channel (see sketch map). The field contained destroyed vehicles, a destroyed house and a water tank. Other areas were measured at random.

A number of soil samples were taken, particularly south east of the barracks near the holes and in the fields on both sides of the road. Water samples were taken from wells at two farms and the school. Surface water was collected from an irrigation channel situated just north of the barracks. Some biological samples were also taken.

Summary of results

<u>Penetrators and jackets</u>

No penetrators or jackets were found.

<u>General contamination</u>

Except in the penetrator holes and other slightly contaminated points, the beta and gamma surveys did not indicate any measurable contamination of the ground surface or of soil, i.e. there was no measurable widespread contamination of the area.

<u>Soil samples</u>

Close to the holes and other contamination points soil samples were taken at various depths. At one location (UNEP 281 and 282) west of the road and 2 m from a slightly contaminated hole in the road south of the barracks there was a clear indication of DU in the grass, as well as in soil 0 – 1 cm below the surface but not any deeper. The concentration of uranium was within the range of natural variation.

Another soil sample, which was taken close to contaminated points on the road is the sample numbered UNEP 197 (surface soil 0 – 5cm). This sample was collected 2 m away from the positions where holes with increased beta- and gamma activity (penetrator shot holes) in the road were found. The DU contamination in the surface was low, at about 0.1 mg DU/kg soil.

The sample UNEP 200 (surface soil 0 – 5cm) was taken 10 m away from the positions where penetrator impact holes with increased beta- and gamma activity were found in the road, and on the opposite side of the road from sample UNEP 197. Based on observation of the impact holes, this was considered to be the direction in which the attack had occurred. The DU contamination in the surface was in the same range as for sample UNEP 197, i.e. about 0.1 mg DU/kg soil.

All other samples taken further away from the impact holes showed no measurable contamination.

These results show that contamination by DU can occur in a very limited area if penetrators hit an asphalt road. However, the DU contamination recorded in this situation was very low, at about 0.1 mg DU/kg soil. This low level of contamination might result from the fact that only a few DU penetrators hit the asphalt road surface, which, though harder than the surrounding soil, is relatively soft when compared with concrete. In any case the level of DU found is negligible in comparison with the natural uranium level at the site.

Two other soil profiles were taken in the Riznic area. The samples were collected using a stainless steel core sampler (with a 15 x 15 cm frame) down to a depth of 15 cm. Each core was subdivided into three samples each 5 cm thick. The first core (core 1) was taken from the field behind the Italian KFOR camp, close to the wrecks of bombed and burnt-out vehicles. The profile was taken 155 cm away from the underground concrete water tank where enhanced beta and gamma radiation had been measured, and in the direction in which the rounds were probably fired. The second core (core 2) was taken 50 cm from the penetrator holes on the asphalt road leading to the Italian KFOR camp. The results of uranium assay in the soil samples are presented in Table 7.7.

Table 7.7 Soil profiles at Irzniq/Riznic barracks

Sample number	Core number	Depth (cm)	U-238 (Bq/kg)	U-234 (Bq/kg)	Utot (mg/kg)	U-234/U-238
UNEP 055	1	0 – 5	591±874	130±18	25±51	0.22
UNEP 056	1	5 –10	82±30	62±9	4±2	0.76
UNEP 057	1	10 –15	77±19	64±8	5±1	0.85
UNEP 051	2	0 – 5	51±11	50±4	5±1	0.99
UNEP 052	2	5 – 10	69±9	69±10	5±1	0.99
UNEP 053	2	10 – 15	66±7	70±7	5±1	1.06

Note on table: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The distribution of U-234/U-238 activity ratios within the soil profiles is shown in Figure 7.3.

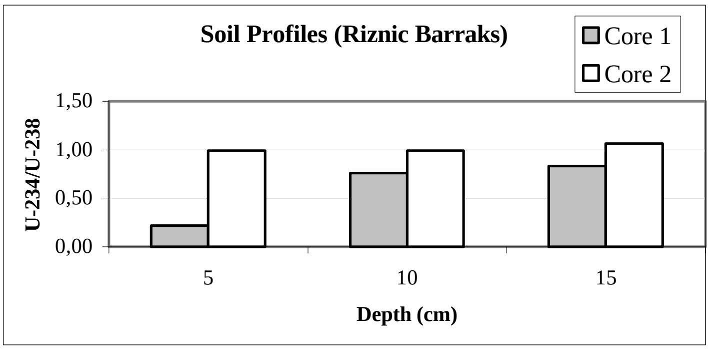

Figure 7.3 Soil Profiles (Irzniq/Riznic Barraks)

In other soil samples taken close to the underground concrete water tank (UNEP 146 – 151) there was a strong indication of DU (70-80 % DU) in the sample taken at 0 – 5 cm depth and a weak indication (15-20 % DU) at 5 – 15 cm depth. The total uranium concentration in the upper 5 cm was 11 – 13 mg/kg, or about 4 times the normal natural uranium concentration.

U-236

The concentration of U-236 in soil was not measurable (i.e. less than a few ng U-236/kg sample) in the samples taken close to the road because the DU concentration was rather low. At the underground water tank the concentration was 0.2-0.3 µg U-236/kg soil in the upper 0 – 5 cm, corresponding to $2 \cdot 10^{-5}$ times the U-238 concentration. Levels of U-236 were 10 times lower at 5 – 10 cm depth.

Localised points of concentrated contamination

Measurable contamination was found by beta/gamma field measurements at the holes in the road (less than 10 cps) and at a concrete underground water tank.

Drinking water

The water samples were collected from three nearby wells and the irrigation channel north of the barracks. The uranium content was found to be very low, at 0.03-0.5 µg/l. With regard to possible DU contamination, the results are not conclusive.

Milk sample

The milk sample, UNEP 341, had a uranium content that was below the detection limit.

Botanical samples

Samples were taken from moss, fungus and lichen. Only the lichen sample (UNEP 046) provided an unambiguous measurement result, with a clear indication of the presence of DU (60-100 %).

Site-specific conclusions

Measurements

Penetrators, surface and soil contamination:

According to the information provided by NATO, 530 rounds were fired against Rznic barracks in June 1999. While the UNEP team found no penetrators, an Italian EOD unit had previously found one on a nearby field. Furthermore, the UNEP mission found clear evidence of penetrator holes in the road and a number of other slightly contaminated points.

The field measurements of beta and gamma radiation did not indicate any detectable surface contamination apart from the localised points of contamination in penetrator impact marks. Soil samples taken any further than 10 m from these points did not indicate any measurable contamination. From these results it is concluded that any widespread surface contamination is less than 0.1 g DU/m^2 (1% of the Reference Case; a maximum of 10 cm migration depth is assumed).

530 rounds equate to approximately 160 kg DU. In the extreme case that all penetrators converted to aerosols on impact and were dispersed by strong winds over an area of at least 160,000 m^2 the inferred surface contamination of less than 0.1 g DU/m^2 could theoretically be achieved. The targeted area is approximately 500 x 500 m (i.e. 250,000 m^2).

Another extreme scenario is that all except a few penetrators never became aerosolised but simply buried themselves in the ground, where they remain hidden.

Some soil samples taken alongside the road close (≤ 10 m) to the penetrator holes in the road surface were contaminated by DU, indicating the shattering of one or more penetrator and subsequent dispersal into the air and fallout onto the ground. The very low contamination (about 0.1 mg DU/kg) might be due to only a few DU penetrators a surface harder than soil, i.e. the asphalt road, which itself is soft when compared with concrete.

One interesting observation is that from the same general area at approximately the same distance from contaminated penetrator holes one UNEP team member obtained a contaminated soil sample, while another did not. This indicates that surface contamination was uneven.

Localised points of concentrated contamination:

The amount of measurable DU at the contamination points is small, of the order of 10-100 mg DU.

Botanical samples:

The contamination found in the lichen sample appears to be a good indicator of earlier atmospheric DU contamination. However, further investigations are needed before any quantitative or qualitative conclusions can be drawn.

Residual risks

In the less likely scenario of DU dispersion over a very large area the corresponding residual risk of DU exposure by inhaling contaminated dust or ingesting contaminated food is insignificant with regard to both radiological and toxicological risks.

The more probable scenario is that most of the penetrators remain intact and buried in the ground. This means that there is a chance of drinking water becoming contaminated in the future.

There may still be some penetrators and jackets on the ground at, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure through being picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to the penetrator, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, however the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

Nevertheless, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators or jackets found penetrators should be dealt with by the local authorities or by KFOR. They should not be kept in homes or handled by children.

The drinking water in nearby wells should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

7.6 Bandera and Pozhare/Podzhar

Site description and general information

Bandera and Pozhare/Podzhar (NATO reference no. 88). Co-ordinates: DN47500 09100
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on12 November 2000.

The site consists of two small villages surrounded by fields and pasture. A forest and a small river lie to the south. During the Kosovo conflict, the whole area was a theatre for a range of military operations involving tanks and armoured vehicles. A mortar position was located in the forest. During the UNEP mission it could be seen that the area had been attacked by cluster bombs, and that some of houses were partly destroyed. According to NATO, the site had been attacked by A-10 aircraft on two occasions on 6 June 1999. During these attacks, 945 rounds had been fired. By November 2000, the area had only been partly cleared of mines and unexploded ordnance, which hampered the investigation. The size of the attacked area was approximately 400 x 500 m.

The ground in the area consists of red-brown silty-clayey soil. The uranium concentration is low (the one soil sample taken in the area had a concentration of 2 mgU/kg sample). The gamma radiation was found to be about 0.08 µSv/h.

Summary of samples taken at Pozhare – Bandera/Pozhar:

- 1 mixed soil sample
- 12 water samples (3 of river water, 3 from a well at 'farm 1', 3 from a well at 'farm 2', and 3 from a well at 'farm 3')
- 3 botanical samples (1 fungus, 2 bark)
- 1 milk sample

Field investigations

The area was visited because a large number of rounds had reportedly been fired during the conflict and there were possible signs on the walls of one building that it had been hit by several times (though not necessarily by DU rounds). However, at the time of the UNEP mission the area had not been made safe from landmines and unexploded cluster bombs, meaning that regular 'line-up survey' measurements were not possible.

However, the roads near the two villages were surveyed with beta and gamma measuring equipment as were farmhouse gardens, yards and buildings. The area where the mortar station had been located was also measured. These measurements were made on individual, random basis. For security reasons, it was not possible to take measurements from the surrounding fields.

12 water samples were taken from wells at the farms and from an adjacent river. Two bark and one mushroom samples were also taken.

Summary of results

The results can be summarised as follows.

<u>Penetrators and jackets</u>

No penetrators or jackets were found.

<u>General contamination</u>

The beta and gamma field measurements did not indicate any measurable DU contamination of the area.

<u>Localised points of contamination</u>

No areas of elevated activity were detected.

Soils samples

Only one soil sample (UNEP 301) was taken, namely a near-surface (0 – 5 cm) sample from one of the farms. No evidence of DU contamination could be detected.

Drinking water

The drinking water samples were taken from wells at the farms, at depths of 11 m and 14 m; from a hand dug well at 4m depth; and from a nearby river. No DU contamination could be detected.

Milk sample

Milk sample UNEP 342 had a low uranium concentration of 0.036 µg/l.

Botanical samples

Samples of bark, UNEP 058, 060 clearly indicated DU contamination, but at low levels.

Site-specific conclusions

Measurements

Penetrators, jackets, surface and soil contamination:

945 rounds were reportedly fired at the area visited, but no penetrators or jackets were found. Nor were any signs of penetrator hits found (i.e. no contaminated holes or marks in the road or elsewhere). Therefore the rounds were either converted to aerosols on impact, with the DU dust dispersed over a wide area, or most of the DU penetrators are buried in the ground within an area of approximately 400 x 500 m^2.

The measurements from the bark samples indicated earlier atmospheric contamination by DU, probably as a result of DU dust dispersal. However, because of the security risk posed by unexploded ordnance, potentially contaminated areas could not be measured, or soil samples taken. Therefore, no clear conclusion can be drawn concerning this targeted area.

Drinking water:

No DU contamination could be detected and the uranium concentration was within the range of natural variation.

Botanical samples:

The contaminated bark appears to be a good indicator of atmospheric contamination by DU. However, further investigations are needed before any quantitative and qualitative conclusions can be drawn.

Residual risks

Because only very limited measurements could be made, the few results available are inconclusive for the area as a whole. However, bearing in mind the results from the other sites visited by the UNEP mission, there are no special reasons to suspect that this particular site had been contaminated to levels that would be of any concern with regard to human health.

There may still be some penetrators and jackets on the ground at, close to and relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure through being picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

However, it is likely that most of the penetrators fired remain intact and buried in the ground. This means that there is a chance of drinking water becoming contaminated in the future.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

Need for mitigation

Because of the very limited area that could be investigated in detail, it is recommended that the site should be subject to further studies once the area has been cleared of land mines and unexploded cluster bombs.

It is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators or jackets found penetrators should be dealt with by the local authorities or by KFOR. They should not be kept in homes or handled by children.

The drinking water in nearby wells should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

7.7 Rikavac

Site description and general information

Rikavac (NATO reference no. 69). Co-ordinates: DM74300 72000
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on 13 and 16 November 2000.

The investigated site lies a few kilometres south west of Prizren. It consists of an asphalt road bordered on both sides by flat farmland containing minefields that had not yet been cleared at the time of the UNEP visit (though one field had been ploughed by farmers and was considered relatively safe). Destroyed farm buildings were situated close to the road but these were considered unsafe to visit. The road provides the only access to a small village located higher up in the nearby hills. It was clear that the area had been heavily bombed, with the probable targets having been a vehicle on the road and adjacent military positions. According to NATO, A-10 aircraft had attacked the site on the 2 June 1999. During the attack, 400 rounds had been fired. The size of the attacked area was approximately 200 x 300 m.

The ground consists of black soil. The natural uranium concentration is very low (0.6-1.5 mg/kg), with gamma radiation of 0.05-0.1 µSv/h.

Summary of samples taken at Rikavac:

- 16 soil samples from 13 different places
- 3 water samples from a nearby stream

Field measurements

Because there were still mines and cluster bombs in a large part of the area of interest, it was not possible to perform field measurements and soil sampling as planned. A 'line-up survey' was carried out in a safe area at a cement factory south of the main road and on a ploughed field, while individual field measurements were made along about 200 m of the side road, starting from the main road.

There were a number of clearly identifiable ammunition holes and impact marks from DU rounds on the asphalted side road. However, only two of the approximately 15 impact marks showed any measurable DU contamination.

Soil samples were taken from the two contaminated holes, from the side of the side road close to the contaminated holes, from the ploughed field every 50 m from the side road, and from a nearby field. Along the main road in westerly direction, three samples were taken between 5 and 15 m north of the road, with one at 30 m, one at 100 m and one at 190 m from the junction of the main road and side road. These last samples, UNEP 323 – 325, were considered as background samples taken far from the target area.

Water samples were taken from a nearby stream.

Summary of results

<u>Penetrators and jackets</u>

No penetrators or jackets were found.

<u>General contamination</u>

With the beta/gamma instruments used, there was no detectable DU contamination either on the road (except in two impact holes, see below), beside the road, in the cement factory, nor in the fields.

Soil samples

Soil samples were taken at various depths in one of the contaminated holes in the road. The results are summarised in Table 7.8.

Table 7.8 Isotopic compositions of soil samples taken from contaminated hole in road surface

Sample number	Sample type and depth	U-238 mg/kg	U-235 mg/kg	U-236 mg/kg	U-235/U-238	% DU of total U
UNEP 228	Hole 0 – 5cm	529	1070	12.6	0.002025	99.6
UNEP 229	5 – 10 cm	2753	5557	71.0	0.002019	99.7
UNEP 230	10 – 15 cm	6615	13317	165	0.002013	99.8
UNEP 231	15 – 20 cm	6608	13319	167	0.002016	99.8
UNEP 232	Soil 0 – 5 cm	1.33	8.40	ND*	0.006342	17.1
UNEP 233	0 – 5 cm	1.47	10.57	ND*	0.007190	1.0
UNEP 234	0 – 5 cm	1.61	10.70	ND*	0.007277	<1

*ND = below the detection limit

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

The samples UNEP 228 – 231 were taken from an impact hole in the asphalt road where field measurements had showed higher gamma- and beta activity at the surface immediately above the hole. The samples were taken out of the hole using a stick sampler that fitted directly into the hole. The samples showed contamination by DU in the layer 0 – 5 cm depth of 527 mg DU/kg, followed by 2,745 mg DU/kg in the 5 –10 cm layer, 6,602 mg DU/kg in the10 – 15 cm layer, and 6,595 mg DU/kg in the 15 – 20 cm layer. The total weight of these samples was about 10 g. The analysis results show that the contamination within the hole consisted of some 100 mg of DU.

Two metres away from the hole discussed above, and directly beside the road, a surface (0 – 5 cm) soil sample, UNEP 232, was taken. It showed low-level DU contamination of 0.23 mg DU/kg. Sample UNEP 233 was taken from the ploughed field, 20 m away from the impact hole, and showed 0.015 mg DU/kg, a very low level of contamination.

The sample UNEP 234 was taken in the direction in which the A-10 attack could had taken place, 100 m from the impact hole referred to above, and at the edge of a mine field where the soil had not been disturbed. No DU contamination was found.

The results confirm the observations for other sites visited by UNEP, namely that low level DU contamination of soil may occur within a few metres of the point of impact of a DU penetrator.

With regard to the other soil samples taken (0 – 1 cm in the ploughed field at 1.5 m, 50 m, 100 m and 140 m from the road), there was no indication of DU and the uranium concentration did not differ significantly from those of the samples taken further along the main road some distance away from the targeted area.

Localised points of concentrated contamination

Two contaminated penetrator impact holes were found. Field measurements showed 16 cps and 22 cps respectively. The second hole was the one from which the soil samples discussed above were taken. Assuming 0.03 cps per Bq, with at least 90 % absorption, which is not unreasonable in the given situation, the reading of 22 cps would correspond to at least 60 mg of DU. This compares with the figure of 100 mg estimated above.

U-236

U-236 was measurable in the soil samples taken from one of the contaminated holes in the road, with the activity concentration varying from 2.4 – 2.6 10^{-5} times the U-238 concentration in the case of pure DU. This value is in good agreement with the values obtained from other sites (e.g. Radoniq/Radonjicko lake).

Water samples

There was no indication of DU contamination in the stream water, where uranium concentrations were found to be within the range of natural values, at about 0.4 μg/l.

Site-specific conclusions

Measurements

Penetrators, surface and soil contamination:

400 rounds had reportedly been fired against the area visited, but none was visible on the surface or elsewhere. However, several signs of penetrator hits were found, two of them still showing DU contamination. There was a clear evidence of DU dust dispersal and contamination of the ground from within the nearest few metres from the contaminated points of impact on the road.

As at other sites the question remains of what happened to all the other penetrators. The measurements at this site did not give any new information that could help to provide an answer. One possibility is that the majority of penetrators hit soft surfaces and remain buried in the ground.

There was no detectable DU concentration in the soil a few metres away from the road. The field measurements along both sides of the road did not indicate any surface contamination other than the two contaminated penetrator holes themselves. Even though the field measurements and the number of soil samples were limited by safety considerations to the area close to the road and on the nearby ploughed field, it would be reasonable to conclude that there was no detectable DU contamination of the area as a whole.

Residual risks

The only DU contamination found was that in two of the impact holes in the road. The remaining activity is rather tightly bound to soil and asphalt material in the hole but it is always possible that people could be contaminated as a result of intentional or unintentional contact with this material. However, the corresponding risks of exposure to

DU by inhalation or ingestion are insignificant from both chemical and radiological viewpoints.

The only possible way of being significantly exposed would be through direct ingestion of contaminated soil and asphalt. This would result in very low radiation doses (< 10 μSv) but could be significant with regard to the toxicological consequences.

Because there was no detectable contamination of the ground other than close to the contaminated penetrator holes, any widespread surface contamination must be less than 0.1-1 g DU/m^2. The residual risk of DU exposure through inhalation of contaminated dust or ingestion of contaminated food is insignificant.

There may still be some penetrators and jackets on the ground within, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure if picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

It is possible that many penetrators remain intact and buried in the ground. This means that there is a chance of drinking water becoming contaminated in the future through dissolution and percolation into wells and streams.

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

Nevertheless, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets should be dealt with by the local authorities or by KFOR. Penetrators and jackets (including fragments), should not be kept in homes, and children should be warned not to touch them.

The drinking water in adjacent wells should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

The contaminated penetrator holes could easily be isolated by repairing the road.

Only few measurements were possible because of safety concerns. It would therefore be prudent to carry out further investigations, once the area has been made safe, to confirm the preliminary conclusion that there is no widespread surface contamination in the area as a whole.

7.8 Ceja mountain

Site description and general information

Ceja Mountain (NATO reference no. 83). Co-ordinates: DM67100 68900
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on 14 November 2000.

This mountaintop site, which lies close to the Albanian border, was a former Serbian army and anti-aircraft position. According to information provided by NATO, A-10 aircraft attacked the site on 5 June 1999, firing 290 rounds. At the time of the UNEP mission, the site had not been cleared of mines and unexploded ordnance. Consequently, investigations had to be concentrated in an area of 35 x 70 m. A German EOD unit had previously found two jackets in this area.

The ground consists mainly of limestone outcrops with a thin layer of stony sandy-silty soil. Woody shrubs (e.g. rosemary, thyme, heather) form the main components of the vegetation. The uranium concentration in the soil is low, at 0.8-2 mg/kg, with gamma radiation being about 0.05 µSv/h.

Summary of samples taken at Ceja Mountain:

- 24 soil samples from 21 different places
- 14 botanical samples, mainly plants and roots
- 4 smear tests on the penetrators and jackets found at the site
- 2 jackets

Field investigations

Because of the very strict safety restrictions in this area, it was not possible to make any regular 'line-up survey'. Instead, individual surveys and measurements were carried out at random. These successfully located two DU penetrators, four jackets and three contaminated holes.

A number of soil samples were taken from beneath and at varying distances around the penetrators and jackets. Samples were also taken from within and around the contaminated impact holes. Some of the samples contained plant matter.

A number of smear tests were carried out on the two penetrators and four jackets located in the area.

Finally, a number of experimental measurements were taken.

Summary of results

<u>Penetrators and jackets</u>

Two penetrators and four jackets were found in a relatively small area of 35 x 70 m. This represents the highest density of found penetrators and jackets at any site investigated by the UNEP mission. The surfaces of the penetrators and jackets were smear tested for loose contamination, and the ground surface and soil around them were sampled for contamination (see below). All the penetrators and jackets were removed from the site.

General contamination

The searched area was too small to draw any conclusions with regard to any general surface contamination of the site as a whole.

Soil samples

Most soil sampling was carried out as part of the studies of contamination below and around penetrators and jackets. Only a few samples were taken to measure possible contamination further away from these specific areas. Some results are shown in Table 7.9.

Table 7.9 Soil samples from contamination points at Ceja mountain

Sample number	Sample depth	U-238 mg/kg	U-235 mg/kg	U-236 mg/kg	U-235/U-238	% DU of total U
UNEP 206	5 – 15 cm	7591	15297	233	0.002015	99.8
UNEP 207	15 – 20 cm	2774	5585	85.6	0.002014	99.8
UNEP 208	0 – 20 cm	2076	4192	61.3	0.002019	99.7
UNEP 209	0 – 5 cm	2.01	13.22	-	0.006594	12.3
UNEP 210	0 – 5 cm	1.84	12.15	-	0.007217	<1
UNEP 211	0 – 5 cm	1.59	11.49	-	0.007228	<1

Note on table: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

Samples UNEP 206 and 208 were taken from a penetrator hole which showed elevated gamma- and beta activity during field measurements of the ground surface. A penetrator jacket was found at this point. The corresponding DU contamination from this impact lies in the range of 2,100 mg DU/kg to 7,600 mg DU/kg. The area from which contaminated material was extracted measured 10 x 10 cm to a depth of 20 centimetres, though large stones could not be removed. About 2 kg of soil and stony material was removed in total and measurements showed that the penetrator had lost a few grams of DU (1 – 10 % of the weight of a penetrator) in this material. No penetrator fragments could be found in the hole. There is no clear explanation of why the beta field measurements reached natural background levels once more beyond a depth of 20 cm. It might be that this penetrator continued as a ricochet.

Sample UNEP 209 was taken 5 metres away from the impact site discussed above. It showed DU contamination of the surface soil of 12.3% or 0.25 mg DU/kg. Samples UNEP 210, taken 20 m further away, and sample UNEP 211, from 100 metres away, did not show any DU contamination of top soil.

This overall picture is consistent with the surface contamination observations made elsewhere during the mission. It also shows that localised points of contamination can be heavily contaminated and that the level of contamination can vary greatly. For example, at another contaminated penetrator impact hole, the soil contamination varied from about 100 to 700 mg DU /kg soil.

Additional measurements beneath a jacket also showed high concentrations of DU (85-90 % DU) or 4 g DU/kg soil at 0 – 5 cm depth and 1 g DU/kg at 5 – 10 cm depth. The DU contamination is evident within the upper 20 cm in all these measurements.

In another study, the ground contamination at various depths between two penetrators was measured. The total distance was 18 m and the results are presented below in Table 7.10.

Table 7.10 The relative concentration of DU in samples taken in the upper part of the ground between two penetrators found at Ceja mountain

Sample number	Distance from penetrator 1	Sample type and depth	U-238 mg/kg	U-235 mg/kg	U-235/U-238	DU % of total uranium
UNEP 302	0.3 m	grass, roots, soil	7.03	18.5	0.00263	88
UNEP 303a	0.3 m	roots 0 – 1 cm	5.84	15.9	0.00272	86
UNEP 303b	0.3 m	grass, roots, soil 0 – 1 cm	1.70	7.00	0.00411	59
UNEP 304	0.3 m	soil 1 – 5 cm	1.28	6.60	0.00516	39
UNEP 305	0.3 m	soil 5 – 10 cm	0.914	5.80	0.00634	16
UNEP 306	6 m	grass, roots	1.31	6.6	0.00504	41
UNEP 307	6 m	roots, soil 0 – 1 cm	1.28	8.1	0.00634	16
UNEP 308	6 m	roots, soil 1 – 5 cm	0.793	5.6	0.00706	3
UNEP 309	6 m	roots, soil 5 – 10 cm	1.03	7.3	0.00709	2
UNEP 310	12 m	grass, roots, soil	2.77	10.7	0.00386	64
UNEP 311	12 m	roots, soil 0 – 1 cm	1.45	8.40	0.00581	27
UNEP 312	12 m	roots, soil 1 – 5 cm	1.14	7.60	0.00665	11
UNEP 313	12 m	roots, soil 5 – 10 cm	0.862	6.10	0.00708	2
UNEP 314	17.7 m	grass, roots, soil	19.5	44.7	0.00229	94
UNEP 315	17.7 m	grass, roots, soil 0 –1 cm	24.2	55.3	0.00228	95
UNEP 316	17.7 m	soil 1 –10 cm	7.84	22.1	0.00282	84

Notes: the concentration values are related to the leachable part of the uranium, which might mean an underestimate of natural uranium and an overestimate of the DU percentage.

Information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

From the results shown in Table 7.10, it can be concluded that there is clear DU contamination in all the samples, that the DU fraction is highest close to the penetrators, and that the contamination goes deeper into the ground (0 – 10 cm) immediately below the penetrators. Half way between the penetrators the contamination is superficial. These results show once again that the surface contamination caused by a penetrator impact on the ground (though bearing in mind that soft substrate in this case) is significant only close to the point of impact.

The apparent DU contamination of biological material is controversial because uptake by roots is believed to be small. This phenomenon should be examined in more detail in order for firm conclusions to be drawn.

<u>U-236</u>

The concentration of U-236 was measurable in some of the samples and found to be 0.003 % of the total uranium concentration.

<u>Botanical samples</u>

The botanical samples were those described above. The measurement results were not conclusive.

<u>Smear tests</u>

Smear tests were carried out on two penetrators. One showed 52 Bq U-238 and 0.8 Bq U-235 or 4 mg U-tot. The other gave 88 Bq U-238 and 1.27 Bq U-235 or 7 mg U-tot. Both samples indicated DU (0.2% abundance of U-235).

Site-specific conclusions

<u>Measurements</u>

Penetrators and jackets:

According to information provided by NATO, 290 rounds were fired at this area. Two penetrators and four jackets were found by the UNEP team in a relatively small area. The overall target area was presumably much larger than the investigated area and it is most probable that there are still many penetrators and jackets lying on the surface elsewhere at the site. Another reason for this assumption is the fact that the ground was quite rocky which may have resulted in many ricochets. All penetrators and jackets found were taken away from the site.

Soil:

Soil was only found to be contaminated either close to or beneath the penetrators and jackets lying on the ground, with contamination extending only a few metres away. Soil contamination appeared to be mainly in the upper 10 – 20 cm, similar to the findings from other sites visited by UNEP. The amount of DU contamination is a few grams, i.e. a few percent of the activity of a penetrator.

Because of the very limited area investigated there are no conclusions regarding contamination of the targeted area as a whole.

Residual risks

Because of safety restrictions the investigated area was very small when compared with the total potentially affected area. However, in the area actually studied, there is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

There may still be some penetrators and jackets on the ground within, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure if picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

Because the large distance to populated areas there is no risk of drinking water becoming contaminated from DU that may remain in the environment. For the same reason, the other possible risks associated with remaining penetrators, jackets and contamination points are much smaller than for sites close to populated areas. Nevertheless, it is unsatisfactory that the risk cannot be assessed quantitatively because the targeted area could not been investigated in its entirety.

The findings support the conclusion that the pattern of DU contamination in rocky areas might be significantly different from that in soil-covered areas. The risks of DU ground surface contamination may be much higher than in areas with a thick soil layer. This possibility should be considered when planning and carrying out any future decontamination work.

Need for mitigation

There is no risk of high radiation doses or serious heavy metal toxicity either now or in the future.

Nevertheless, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets should be dealt with by the local authorities or by KFOR. Penetrators and jackets (including fragments), should not be kept in homes, and children should be warned not to touch them.

As few measurements were possible because of the risk to personal security, it would be prudent to complete the investigation after the area has been made safe. This would permit the drawing of conclusions for the site as a whole.

7.9 Planeje/Planeja village

Site description and general information

Planeje/Planeja village (NATO reference no. 60). Co-ordinates: DM64900 73100
See map of general location in Kosovo and sketch map of site.

Investigated by the UNEP mission on 14 November 2000.

The study area is close to the small village of Planeje/Planeja on the slopes of the Pastric mountain which marks the border between Albania and Kosovo. The site itself is at a road junction close to a cemetery. During the conflict, the Serbs held positions in and around the village. In November 2000, the whole area showed signs of heavy fighting and the village was mostly in ruins. According to NATO it had been attacked on 31 May 1999 by A-10 aircraft which fired 970 rounds. The size of the targeted area is not known.

The terrain is very solid and rocky. The uranium concentration in the soil was found to be low (1-2.5 mg/kg), with gamma radiation of 0.05-0.1 µSv/h.

Summary of samples taken at Planeje/Planeja village:

- 9 soil samples
- 3 water samples, all from the same well
- 1 milk sample
- 2 botanical samples
- 2 penetrators
- 1 jacket

Field investigations

Beta/gamma radiation survey measurements were made by 'line-up survey' in an area 150 x 200 m in a field close to the cemetery. Individual survey measurements were made at random along the road in the village and at a largely destroyed house (the first house on the right hand side of the road).

Soil samples were taken from the field close to and at varying distances from both a penetrator and a contaminated impact site.

Drinking water samples were taken from a nearby well. One milk sample, UNEP 343, was collected from a farm in the village.

Summary of results

Penetrators and jackets

Two penetrators and one jacket were found on the surface.

General contamination

Except at localised places such as contaminated impact points or close to penetrators and jackets, the beta/gamma surveys did not indicate any measurable widespread contamination of the area.

Soil samples

Samples were taken from beneath and at various distances from a penetrator. The results are summarised in Table 7.11.

Table 7.11 The ground contamination below a penetrator and at varying distances from the penetrator, Planeje/Planeja village

Sample number	Sample type and depth	U-238 mg/kg	U-235 mg/kg	U-236 mg/kg	U-235/ U-238	% DU of total U
UNEP 216	Soil 0 – 10 cm, beneath penetrator	177	360	5.086	0.002035	99.4
UNEP 217	Soil 0 – 5 cm, 1 m from penetrator	2.20	11.41	0.0257	0.005198	38.9
UNEP 218	Soil 0 – 5 cm, 10 m from penetrator	1.43	9.69	-	0.006801	8.4
UNEP 219	Soil 0 – 5 cm, 20 m from penetrator	1.32	9.38	-	0.007130	2.1

Note: information on which laboratory provided a particular result, whether that laboratory participated in the quality control exercise, and, if so, whether it passed, is contained in Appendices III and X.

As can be seen from the Table 7.11, the concentration of DU decreases drastically beyond 1 m from the penetrator. At 10 – 20 m from the penetrator DU accounts for only a few percent of the total uranium concentration.

A sample taken at a contaminated impact point contained about 790 mg uranium/kg soil, more than 90 % of which was DU.

U-236

U-236 was measurable in soil close to the penetrator. The maximum concentration was 2.9 10^{-5} times the U-238 concentration.

Drinking water

No measurable DU concentration was found in drinking water.

Milk sample

The milk sample had a total uranium concentration of 0.77 µg/l.

Site-specific conclusions

Measurements

Penetrators and jackets:

As indicated above, some 970 rounds were reportedly fired at the target area, probably only a small part of which was investigated (i.e. an area of 150x200 m at the cemetery, together with a few measurements in the village). Nevertheless, two penetrators and one jacket were found.

The field measurements and soil sample analyses showed no detectable contamination except within a few metres of penetrators or penetrator impact sites. This means that any widespread contamination was less than 1 g DU/m^2 (10 % of the Reference Case). If all 970 penetrators had aerosolised on impact, the approximately 300 kg of DU released into the environment would have to have been dispersed over an area of at least 300,000 m^2 in order to be not measurable. This is entirely plausible if the whole area of the village is taken into account. However, the conversion of all penetrators to aerosols is, in itself, not very probable.

According to the conclusions from other sites, the majority of the penetrators are probably buried in the ground after having missed the target or after hitting relatively soft targets. It is not known if there are any further penetrators on the surface of the ground inside the village.

Soil samples:

The results from soil sampling confirmed the conclusions from other sites that measurable ground contamination is limited to the immediate vicinity of penetrators lying on the surface. The very few soil samples taken at greater distances from the penetrators did not indicate any DU contamination of the soil.

Residual risks

Because of safety restrictions, the investigated area was small when compared with the total area potentially affected area during the military attack. However, within the investigated area, there is no risk of high radiation doses or serious heavy metal toxicity either now or in the future.

There may still be some penetrators and jackets on the ground within, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure if picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

Many penetrators may remain hidden in the ground. Eventually these could dissolve, with the DU entering the ground water. There is consequently a possibility that the drinking water in some nearby wells could become contaminated.

Because the village is very close to, or possibly part of, the area targeted by DU ammunition, many penetrators could be buried in the ground in the village. In the near future, during restoration of the village, some penetrators may therefore be brought up to the surface again. Should this happen, people will need to know what to do.

Need for mitigation

It is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets should be dealt with by the local authorities or by KFOR. Penetrators and jackets (including fragments), should not be kept in homes, and children should be warned not to touch them.

The drinking water in nearby wells should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

Few measurements were possible owing to security concerns. Therefore it is recommended that investigations be completed once the area has been made safe, in order to confirm the preliminary conclusion that there is no widespread ground surface contamination of the area as a whole. This additional survey work should also include a search for any penetrators remaining on the surface, particularly within the village area.

7.10 Bellobrade/Belebrod

Site description and general information

Bellobrade/Belebrod (NATO reference nos. 30 and 35). Co-ordinates: DM74000 62100
See map of general location in Kosovo and sketch map of site.
Investigated by the UNEP mission on 15 November 2000.

The investigated site lies at approximately 1,000 m altitude and consists of a flat, grassy field on soft soil. A road runs through the field and there is a village (Bellobrade/Belebrod) nearby. During the Kosovo conflict, the site had been used by Serbian heavy artillery, signs of which were still visible. There were probably also armoured vehicles in the vicinity. According to NATO the site was attacked twice on 15 May 1999, with more than 1,000 rounds fired. The size of the targeted area is not known. At the time of the UNEP mission, sheep were grazing on adjacent fields. The soil in the area was found to consist of silt and fine sand. The natural uranium concentration was low (3 – 4 mg/kg), with gamma radiation readings of 0.06 – 0.1 µSv/h.

Summary of samples taken at Bellobrade/Belebrod:

- 7 soil samples
- 1 lichen and moss sample
- 3 water samples collected from the same well

Field investigations

Beta/gamma radiation survey measurements were made by using the ‘line-up survey’ technique in an area of 250 x 100 m in a field north of the road to the village. Individual survey measurements were made at random, particularly at places where there were signs in the ground of artillery and tanks, as well as along the road. The whole area surveyed was about 200 x 300 m.

Soil samples were taken from 0 – 5 cm depth at various points in the area.

Summary of results

Penetrators and jackets

No penetrators or jackets were found.

General contamination

Neither the beta/gamma field measurements, nor the soil sample measurements indicated any measurable widespread contamination of the area (see below for more details).

Soil samples:

None of the soil samples showed any indication of DU contamination.

Botanical samples

A sample of lichen and moss taken from a tree in the area contained clear indications of the presence of DU. The U-238 concentration was 3.6 mg/kg sample, while the U-235 concentration of 0.0103 mg/kg indicated more than 80 % of DU in the sample.

Site-specific conclusions

Measurements

Penetrators, jackets and surface contamination:

More than 1,000 rounds with were reportedly fired at the area but no penetrators or jackets were found and there were no signs of any impact points or residues of penetrators or jackets. There was also no indication of any contamination of the ground.

However, the measurements from the lichen and moss sample indicate earlier airborne DU contamination which must have come from DU rounds that aerosolised on impact during the military attack in 1999. The measurements and sampling from the ground do not answer the question of how much DU became airborne. Possible contamination of the ground was not measurable either with field beta/gamma equipment or with soil sampling. This means that any ground contamination was less than 0.1 g DU/ m^2 (<1 % of the Reference Case), at least in the investigated area which covered some 25,000 m^2. 1,000 penetrators would contain about 300 kg DU. From these figures, it can be concluded that 2.5 kg of DU could be contained within the investigated area, though so thinly scattered that it was below detection limits. In any case, 2.5 kg would account for approximately 1 % of the total DU fired.

Therefore, either more than 1 % of the penetrators were aerosolised and dispersed over a much larger area, or 99 % of the penetrators remain intact and buried in the ground.

Residual risks

There may still be some penetrators and jackets on the ground within, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure if picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 µSv) but could be significant from a toxicological viewpoint.

Many penetrators may remain hidden in the ground. Eventually these could dissolve, with the DU entering the ground water. There is consequently a possibility that the drinking water in some nearby wells could become contaminated.

Need for mitigation

In the area investigated, there is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

Nevertheless, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets should be dealt with by the local authorities or by KFOR. Penetrators and jackets (including fragments), should not be kept in homes, and children should be warned not to touch them.

The drinking water in nearby wells should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

Because of safety considerations, only a limited part of the potentially contaminated area could be investigated. Consequently, some further work, particularly a search for any remaining penetrators on the ground surface, should be carried out.

7.11 Kuke/Kokouce

Site description and general information

Kuke/Kokouce (NATO reference no. 64). Co-ordinates: DM77900 60250
See map of general location in Kosovo (no sketch map of site was made).
Investigated by the UNEP mission on 15 November.

This site is situated on the slopes of Maja mountain, above the village of Kuke/Kokouce. It consists of pasture land, at 1,550 m altitude. During the Kosovo conflict the area was probably used as an artillery position. It had been heavily attacked by cluster bombs and was defended by mines. According to NATO, A-10 aircraft attacked the area on 1 June 1999, firing 500 rounds. Prior to the UNEP mission, a Turkish EOD team had found a jacket in the area. Although partial mine clearance had been carried out, the continuing presence of mines somewhat limited the team's investigations. The size of the targeted area is not known.

The site was steep in various places and rocky. The bedrock consisted largely of gneiss with quartz dykes. The soil cover was rather thick. The soil was red-brown, stony and silty. The uranium concentration in the soil was low (1-2 mg/kg), while gamma radiation readings were around 0.1 µSv/h.

Summary of samples taken at Kuke/Kokouce:

- 2 mixed samples taken at the same location, UNEP 317a (grass and roots) 317b (soil) and 318 (soil)
- 1 botanical sample

Field investigations

Because the area was considered to be very unsafe (owing to only partial clearance of mines) the measurements and sampling were very limited. Some individual random measurements were made within an area of approximately 200 x 400 m. One penetrator was found and two soil samples were taken.

Summary of results

Penetrators, jackets and general contamination

The one penetrator found on the ground surface proved that DU ammunition had been fired at this site. The very limited beta/gamma field survey did not give any indication of DU contamination of the ground. However, the soil samples gave positive confirmation of DU contamination, albeit very weak.

Site specific conclusions

Measurements

Penetrators, jackets and general contamination:

500 rounds were reportedly fired at the area. The few measurements made did not provide an unambiguous answer to the question whether there has been a substantial shattering of penetrators outside the area searched. 500 rounds are equivalent to about 150 kg DU. If all the penetrators had become aerosolised and the contamination was distributed over 80,000 m^2 and at 10 cm depth, the beta/gamma field measurements would not be capable of detecting such low level contamination.

However, from experience at other sites, the most probable scenario is that most of the penetrators are buried in the ground.

Residual risks

Because of safety considerations, a limited area was searched. However, there are no indications that many penetrators remain on the surface at this site, and the field measurements made do not indicate any ground surface contamination that could pose a significant risk. The site is relatively far from populated areas, though people graze animals in the region, and there are no wells or water reservoirs nearby.

The overall conclusion is that the area visited does not imply any significant risk.

Need for mitigation

In the area investigated, there is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

For safety reasons, only a limited part of the potentially contaminated area could be investigated. Consequently, some further work, particularly a search for penetrators on the ground surface would be appropriate.

7.12 Buzesh/Buzek

Site description and general information

Buzesh/Buzek (NATO reference no. 37). Co-ordinates: DM04750 46600
See map of general location in Kosovo (no sketch map of site was made).
Visited by the UNEP mission on15 November 2000.

This site is located along a road going towards to the village Buzesh/Buzec. There are fields on both sides. According to information provided by NATO, the site was attacked on 17 May 1999 with the use of 170 rounds. The targets were most probably army vehicles on the road or close to a nearby building, which had been severely damaged. The building was under reconstruction in November 2000. Three rows of bullet holes were found in the asphalt road surface. However, beta and gamma measurements around the holes gave no indication of DU contamination.

The fields on both sides of the road had not been made fully safe from mines and any unexploded ordnance. This prevented a fuller investigation of the site, even though cows were seen grazing in the area.

Summary of samples taken at Buzesh/Buzec:

- One tap water sample was taken

Field investigations

Because the area was unsafe, measurement and sampling work was very limited. Some beta/gamma field measurements were made along the road with a few readings taken from adjoining fields.

Summary of results

Penetrators, jackets and general contamination

No penetrators and no jackets were found and no ground contamination could be detected.

Site-specific conclusions

Measurements

Penetrators, jackets and general contamination:

According to information received and visual observation of the holes in the road, there had been military activity in the area, with NATO stating that 170 rounds were fired against targets located there. However, there was no evidence from the measurements taken of any DU in the area, meaning that any remaining contamination was below the detection limit of 1g DU/m^2 (10 % of Reference Case).

Residual risks

There may still be some penetrators and jackets on the ground within, close to, or relatively far from the targeted area. These pose a potential risk of causing a significant external radiation exposure if picked up. There may also be some risk of contamination of hands and subsequent ingestion. The corresponding radiation exposure is insignificant but from a toxicological point of view the exposure might be significant.

Because of local contamination of the ground close to penetrators, there may be some risk of internal contamination through ingestion of soil or contamination of hands. In such cases, the exposure would be insignificant with regard to radiation (<10 μSv) but could be significant from a toxicological viewpoint.

Many penetrators may remain hidden in the ground. Eventually these could dissolve, with the DU entering the ground water. There is consequently a possibility that the drinking water in some nearby wells could become contaminated.

Need for mitigation

In the area investigated, there is no risk of high radiation doses or serious heavy metal toxicity, either now or in the future.

Nevertheless, it is advisable to inform people about the possible presence of penetrators and jackets in the environment and that any penetrators and jackets should be dealt with by the local authorities or by KFOR. Penetrators and jackets (including fragments), should not be kept in homes, and children should be warned not to touch them.

The drinking water in nearby wells within the target area should be kept under surveillance by taking samples at appropriate intervals for uranium testing.

Because of safety considerations, only a limited part of the potentially contaminated area could be investigated. Consequently, some further work, particularly a search for any remaining penetrators on the surface should be carried out.