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Health Risks following Exposure to Aerosols produced by the use of Depleted Uranium Weapons

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1. Background

Veterans of the recent war in Iraq have been suffering from a mysterious ailment called 'Gulf War Syndrome' which has all the indications of a consequence of chemical or radiation poisoning. The spectrum of ill health effects in this group of people suggesting exposure to a mutagen, or carcinogen. In addition, the population of Iraq in the areas where DU weapons were used seems to be suffering a similar fate, but in these territories also there have been reported increases in childhood cancer and malformation rates, again indication of a mutagen source.

It is now generally conceded that about 350 tonnes of Depleted Uranium was used in the war and that sub-micron diameter oxide particles became dispersed in the areas that were bombed or strafed. Uranium is known to be a radiation hazard, and radiation exposure is a known cause of all the effects observed in the veterans and the children of Iraq. These facts taken together suggest that the exposure to DU may be the main cause or one of the causes of the observed effects

More recently, there have been reports of increases in ill health, particularly leukemia, in soldiers involved in peacekeeping duties in Kosovo, where about 10 tons of DU ammunition was used by the NATO forces. Investigations by UNEP and others confirmed the widespread existence of DU in soil and water in Kosovo and recent measurements made on the population confirm the existence of DU in urine specimens. There are also reports of sharp and anomalous increases in cancer rates in Bosnia, where DU was also used in the mid-1990s.

The argument marshalled against the suggestion that radioactive exposure to DU is the cause of all these health problems is that Depleted Uranium is not considered to be a serious radiatiological hazard since it is so weakly radioactive. This is owing to its long half-life and the fact that its alpha emissions have a very short range. It is argued that on the basis of the 'known relationship between radiation dose and subsequent cancer' the exposure to DU suffered by the Gulf War veterans, the Iraqi children, or the Kosovo peacekeepers cannot have been sufficiently high to be a cause of cancer or mutagenic illness. This is familiar territory to any scientist who has looked into the area of the health risks of exposure to man-made radioactivity. Similar arguments are routinely advanced to exonerate radiation as a cause of childhood cancer and leukemia clusters near nuclear reprocessing sites like Sellafield, Dounreay and La Hague, increases in infant mortality and cancer in populations exposed to weapons fallout and fallout from nuclear accidents, cancer increases in nuclear workers and their children, and whole ranges of observations and experience which to most people seem clear evidence of causation. For these people, therefore, the questions about Depleted Uranium, are the latest in a long series of questions about the health effects of low level radiation [Busby, 1995].

In this presentation, I will begin showing that recent incontrovertible evidence defines the existence of a very large error in the presently accepted model for the health consequences of exposure to low-level man-made radioactivity, and that therefore this same model which underpins the presently accepted assessment of harm from Depleted Uranium, is likely to be similarly flawed. In addressing this issue, I will ask if Scientific Method has been properly used in the historical assessment of risk from exposure to low-level radiation and suggest that it has not.

In order to explain how DU may be having a serious impact on health at what is conventionally seen as low dose, the cellular and molecular basis of radiation action must be examined. I will outline two possible mechanism which address the particular type of radiation exposure involved with Depleted Uranium and argue that these types of exposure cannot be modelled by the system of assessment of risk used by ICRP and based on the external irradiation which occurred at Hiroshima. I will briefly review some of the evidence from the studies of my group which support this new model and show how it applies to the Depleted Uranium controversy. Finally I will review recent evidence on the dispersion of battlefield DU and its consequences.

2. Depleted Uranium: Properties

Depleted Uranium is a by product of the nuclear industry where the fissile isotope U-235 in natural Uranium ore is concentrated to produce reactor fuel consisting of 'enriched Uranium'. The isotope discarded by this process is Uranium 238 which is generally classed by the risk agencies as a low radiation hazard material owing to its long half life (4.47×10^9 years) and its weak gamma emission of 48keV. However, it is an alpha emitter and thus poses an ingestion risk owing to the high ionization density of alpha tracks and their high biological effectiveness in inducing mutation. In addition, there is a major risk from the beta-emitting daughter isotopes Thorium234 (beta, 0.26MeV, half life 24 days) and Protoactinium-234 (beta; 0.23MeV, half life 6.75 hours) which decay through one another to Uranium-234, also an alpha emitter with a half life of 2.47×10^5 years. The overall activity of Uranium 238 therefore increases as soon as it is produced due to ingrowth of the beta daughters and by 30 weeks these are in total secular equilibrium. The activities per kilogram are given in Table 1 below.

Weeks	**U-238 (a,g)**	**Th-234 (b)**	**Pa-234 (b)**	**U-234 (a,g)**
0	12.43	0	0	0
5	12.43	7.89	7.84	0.001
10	12.43	10.77	10.75	0.004
20	12.43	12.21	12.21	0.01
30	12.43	12.4	12.4	0.017

Table 1. Increasing specific activity (MBq/kg) of DU due to ingrowth of daughters.

Over centuries, the specific activity of U-234 should be the same as that of the parent U-238, and thus the environmental concentrations of these isotopes is generally the same if the source is natural. The specific total activity is thus about 37MBq/Kg. It should be pointed out that DU material recently found in battlefields in Europe contains small quantities of isotopes of Plutonium, Neptunium and other fission products: thus the source of this DU is refinement of nuclear reactor waste. However, the quantities are very small and are not considered by the authorities to be of serious radiological significance.

Owing to the high density of Uranium, ($19 g.cm^{-3}$ metal and $10.96 g.cm^{-3}$ for the dioxide) and the fact that the metal is pyrophoric (burns in air) the substance is used in the manufacture of armour piercing shells, missile nose cones and penetrators and certain ballast materials in some aircraft (e.g. helicopter rotors, commercial aircraft counterweights). A single Abrams 120mm tank shell contains about 3kg of DU (111MBq of radioactivity) and there is 275g in a 30mm GAU3A A-10 Thunderbolt Gatling Gun round.

The military penetrators explode on impact with hard targets with about 80% conversion to micron diameter Uranium Oxide particles of a 'ceramic' nature. These particles are highly mobile and extremely long lived in the environment, owing to the very high degree of insolubility of Uranium Oxides UO_2 and U_3O_8. They can be inhaled and the sub-micron diameter particles are translocated from the lung to the lymphatic system, building up in the tracheobronchial lymph nodes and potentially able to circulate everywhere in the body. Alpha and beta disintegrations from these particles cause very high and repetitive doses to cells local to the range of the disintegration i.e. about 30microns for the alpha and 450 microns for the beta tracks.

3. Errors in the ICRP low level radiation risk model

The model used by the risk agencies and the military to predict the health consequences of such exposure is that of the ICRP and is based on the cancer yield of the Hiroshima bomb. The group of survivors of this single large acute irradiation exposure (in which many people were killed) have been collected into the Life Span Study or LSS and their cancer rates have been compared with controls from the same town who were shielded or outside the town at the time of the bomb. The cancer yield in this LSS cohort has been used as a basis for predicting cancer risk and other health detriments for all types of radiation exposure. It has been assumed that the relationship between dose and cancer yield is linear and so low levels of exposure have been assumed to carry no significant risk on this basis.

This approach has been criticized extensively, and considerable evidence has become available in the last twenty years to suggest that the increases in cancer and leukemia near nuuclear sites are examples of a failure of the model to adequately address risk from internal radiation. However these arguments have always been countered by the risk agencies on the basis that other possible causes for the observed phenomena exist. However, very recently, two unequivocal pieces of evidence have defined errors of between 100 and 2000-fold in the ICRP risk models as applied to internal radiation risk. This evidence has forced the UK government to set up a new committee to examine the situation and assess the failures of the ICRP risk model applied to internal radiation exposure [CERRIE, 2001].

In addition, the European Parliament has called for a similar process to be undertaken by the European Commission [EU,2001], and the recent WHO conference on Chernobyl in Kiev in 2001 came to a similar conclusion [WHO 2001].

3.1 The Chernobyl Infants

Following the Chernobyl accident in 1986, in five different countries, the cohort of children who were exposed in their mother's womb to radioisotopes from the releases suffered an excess risk of developing leukemia in their first year of life. This 'infant leukemia' cohort effect was first reported in Scotland [Gibson et al, 1988], and then in Greece [Petridou et al, 1996], in the United States [Mangano, 1997] and in Germany [Michaelis, et al. 1997]. We first reported increases in childhood leukemia in Wales and Scotland following the Chernobyl accident in 1996 [Bramhall, 1996] but more recently examined the specific infant leukemia cohort in Wales and Scotland [Busby and Scott Cato 2000].

Unlike the earlier researchers, who merely showed the existence of a significant rise in infant leukemia, we decided to examine the relationship between the observed numbers of cases and those predicted by the present radiation risk model. This was an invaluable opportunity since the specificity of the cohort enabled us to argue that the effect could only be a consequence of the exposure to the Chernobyl fallout. There could be no alternative explanation, like the 'population mixing hypothesis' advanced to explain away the Sellafield childhood leukemia cluster. However implausible such theories may be, they have acquired popularity, and their proponents status, as a consequence of their utility to the nuclear lobby. However, population mixing may not occur at Sellafield but it cannot occur in the womb.

Because the National Radiological Protection Board had measured and assessed the doses to the populations of Wales and Scotland and because they themselves had also published risk factors for radiogenic leukemia based on ICRP models it was a simple matter to compare their predictions with the observations and test the contemporary risk model. The method simply assumed that infants born in the periods 1980-85 and 1990-92 were unexposed, and defined the Poisson expectation of numbers of infant leukemia cases in the children who were *in utero* over the 18 month period following the Chernobyl fallout. This 18 month period was chosen because it was shown that the *in utero* dose was due to radioactive isotopes which were ingested or inhaled by the mothers and that whole-body monitoring had shown that this material remained in the bodies of the mothers until Spring 1987 because silage cut in the Summer of 1986 had been stored and fed to the cattle in the following winter. The result was startling. First, there was a statistically significant 3.8-fold excess of infant leukemia in the combined Wales and Scotland cohort (p = 0.0002). Second, the leukemia yield in the exposed 'in utero' cohort was about 100 times the yield predicted by the model. Table 2 compares the effect in the three main studies. In passing it should be noted that this number, 100, is very close to the error required to explain the Sellafield childhood leukemia cluster.

It should be noted that the possibility of the effect being due to chance may be obtained by multiplying the p-values for the null hypothesis that the effect was due to chance in each of the separate countries and studies to give an overall p-value less than 0.0000000001. Thus it was not a chance occurrence: it was a consequence of the exposure to low-level radiation from Chernobyl.

And since the World Health Organization has given approximate exposure levels in Greece, Germany and the United States, it was also possible to examine the leukemia yield in the infant 'exposed cohort' reported by the several other studies and establish a dose response relationship. This is shown in Fig 1. It is a curious shape and goes up, down and up again, and this shape should be noted. I will return to it below.

3.2 Minisatellite DNA in Chernobyl children

Since the discovery of the DNA minisatellite characterisation method, 'DNA testing' it has been increasingly applied to those who were exposed to the fallout from the Chernobyl accident. In a series of papers, Dubrova et al. showed an association between exposure of children in Belarus [Dubrova et al.1997] found a doubling in the mutation rate in children from the high exposure territories of Belarus compared with controls from low exposure territories. This discovery was astonishing to those who adhered to the ICRP risk model for genetic mutation since this was based on the belief that the Hiroshima exposures, which were hundreds of times higher than the average dose in Belarus, had produced no genetic effect on any offspring of those exposed. A doubling of the mutation rate thus pointed to an error of some 1×10^5 . Others pointed out that even if the minisatellite DNA was mutated, this was not an effect which had any significance since there were no phenotypical changes associated with minisatellite DNA. Shortly after this, it was reported that barn swallows which migrated to Belarus had similar changes in their minisatellite DNA and these were assocated with plumage pattern alterations which destroyed their camouflage and thus might be harmful. [Ellegren et al. 1997]

The question of proper controls and the reality of the effect was answered very recently in an elegant study by Weinberg et al.[2001]. They examined minisatellite DNA changes at various loci in the offspring of the Chernobyl 'liquidators' who were born after the accident and compared their DNA to their siblings born before the accident. Results showed that there was a significant difference of up to seven-fold. The dose response relationship appeared to be biphasic. Based on the natural mutation rate in the minisatellite DNA, the finding showed an error in the ICRP risk factor for mutation of between and 700-2000 fold. This series of studies thus demonstrates finally and unequivocally that the ICRP risk model for internal exposure is wildly inaccurate.

I must ask how it is that some fifty years after the atom bomb, and following a huge amount of research into the subject, we can have discovered such a huge error in the science of radiation risk. To understand the answer, we must look at the scientific method a little more closely.

4. Radiation Risk and Scientific Method

The classical exposition of the scientific, or inductive method (originally due to William of Occam) is what is now called Mill's Canons, the two most important of which are:

- The *Canon of Agreement* which states that whatever there is in common between the antecedent conditions of a phenomenon can be supposed to be the cause, or related to the cause, of the phenomenon.
- The *Canon of Difference* which states that the differences in the conditions under which an effect occurs and those under which it does not must be the cause or related to the cause of that effect.

In addition, the method relies upon the *Principle of Accumulation* which states that scientific knowledge grows additively by the discovery of independent laws, and the *Principle of Instance Confirmation*, that the degree of belief in the truth of a law is proportional to the number of favourable instances of the law.

Finally to the methods of inductive reasoning we should add considerations of *plausibility of mechanism.*

These are the basic methods of science [Mill, 1879; Harre, 1985; Papineau, 1996]

Let us first define our question. It is this. What are the health consequences of exposure to novel internal radioisotopes at whole organ dose levels below 2mSv? Because we are looking at battlefield DU, we should add that in this case, although the element is 'natural', the exposure is novel, and due to internal sub-micron Uranium Oxide particles embedded in tissue.

Although risks from exposure to high levels of ionizing radiation are generally accepted, since they are fairly immediate and graphic, the situation with regard to low-level exposure is curious. There are now two mutually exclusive models describing the health consequences of exposure to low-level radiation. There is a nuclear establishment one, which is that which is presently used to set legislation on exposures and argue that DU is safe, and a radical one, which is espoused by the anti-nuclear movement and its associated scientists. I show these two models schematically in Fig 2.

The two models arise from two different scientific methods. The conventional model is a physics-based one because it was developed by physicists prior to the discovery of DNA. Like all such models it is mathematical, reductionist and simplistic, but because of this is of great descriptive utility. Its quantities, dose, are average energy per unit volume or dE/dV and in its application, the volumes used are greater than 1kg. Thus it would not distinguish between the average energy transferred to a person warming themselves in front of a fire and a person eating a red hot coal. In its application to the problem at hand, the internal, low-level, isotopic or particulate exposure, it has been used entirely deductively. The basis of this application is that the cancer and leukemia yield has been determined following the external acute high-dose irradiation by gamma rays of a large number of Japanese inhabitants of the town of Hiroshima. Following this, arguments based on averaging have been used (quite spuriously) to maintain that there is a simple linear relationship (in the low-dose region) between dose and cancer yield. This Linear No Threshold (LNT) assumption enables easy calculations to be made of the cancer yield of any given external irradiation.

By comparison, the radical model shown in Fig.2 arises from an inductive process. There have been many observations of anomalously high levels of cancer and leukemia in populations living near nuclear sites, especially those where the measurements show that there is contamination from man-made radioisotopes, e.g. reprocessing plants. In addition, populations who have been exposed to man-made radioisotopes from global weapons tests, downwinders living near nuclear weapon test sites and those exposed to these materials because of accidents (like the Chernobyl infant leukemia cohort) or because of work in the nuclear industry or military. A review of these findings is available [Busby, 1995] and a more recent literature review of studies showing these effects if published by the Low Level Radiation Campaign [LLRC, 2000]. In addition, the radical model is based on biological considerations and considers each type of exposure according to its cellular radiation track structure in space and in time. It is not, therefore, possible to employ this model to predict risks from 'radiation dose' to 'populations' but only from microscopically described doses from specific isotopes or particles whose decay fractionations are considered to interact with cells which themselves respond biologically to the insults and may be in various stages of their biological development. The dose-response relationship following from this kind of analysis might be expected to be quite complex.

These models are mutually exclusive: which one is correct? What considerations can we use to choose?

The answer is that the conventional LNT model must be rejected because it is not scientific. Its conclusions are based on deductive reasoning. It falsely uses data from one set of conditions, high-level, acute, external exposure to model low-level, chronic, internal exposure. It is scientifically bankrupt, and were it not for political considerations, would have been rejected long ago. On the other hand, it should be clear that the radical model conforms to all the requirements of the scientific method listed above. Man-made radioisotopes, often in the form of 'hot particles' are common contaminants to the areas near nuclear sites where there are cancer and leukemia clusters, and to the downwinders, and to the fallout-exposed populations. This satisfies the *Canon of Agreement*. The contingency analysis tables with control populations for such studies show that the *Canon of Difference* is also satisfied: people living in more remote regions than the downwinders show lower levels of illness. We must by now also have some faith in a *Principle of Instance Confirmation*, since so many studies have shown that increases in cancer and leukemia follow these exposure regimes at low dose. Indeed, the Gulf War Syndrome, might be considered as such an instance confirmation. We are left only with 'Plausibility of Mechanism', which will be addressed briefly below.

5. Mechanistic Considerations

Averaging Dose

I want to look more closely at the averaging model and its predictions at low dose. It is essentially what used to be called a colligative model: the dE/dM formulation of dose requires that energy transfered from absorption of the consequence of a radioactive disintegration is averaged over the target site, usually the whole body or organ. Whatever lip service is made to considerations of what is now called 'microdosimetry', close examination of calculations done to establish risk near nuclear sites shows this to be the case. The documents NRPB R-276, *Risk of Leukemia and other Cancers in Seascale from All Sources of Radiation* published in 1995 is a good example. In this document, doses to the lymphatic system were calculated by modelling it as 'liver, lung, kidney, spleen, pancreas, uterus and intestines'. A physiologist would not recognise this list as the 'lymphatic system', so why was it used? The answer is that breathing introduces the particles of plutonium that exist in the air near Sellafield into the lungs of the children who live there. From the lungs, these particles are scavenged to the two small tracheobronchial lymph nodes which have a combined mass of perhaps one gram. If NRPB had divided dE by 1 gram, the resultant dose to this part of the lymphatic system would have been extremely high. Given that this organ has been identified as a source of lymphoma and leukemia in animals, this sounds very like the cause of the Sellafield leukemia cluster. But dilution of the plutonium decay energies into the whole mass of guts used for dM reduces the 'dose' to an acceptable small level. This process, incidentally, is very relevant to the DU exposures.

Figure 3 shows a phantom used by ICRP to calculate doses from external radiation fields. This is the model that is presently used to calculate internal doses. Of course, in the low dose region, cells are either hit or not hit, so the cell dose is very different from the tissue dose. Nevertheless, the model is valid as a means of establishing a quantity, 'dose' which can be correlated with some health consequence like cancer, so long as each cell in the body, or target region, has an equivalent probability of being hit (or more properly intercepted by a track). Dudley Goodhead has written of the low-dose region [Goodhead, 1988]:

Most situations of practical interest are characterised by cells receiving occasional single tracks well separated in time from any other tracks which may impinge on the same cell. From Natural Background, there is, on average, about one track per year through each cell nucleus. Therefore it is highly unlikely that there will be multiple tracks in short times (< 1 day) over which repair of radiation induced damage within cells is usually observed to take place.

It is these (essentially external irradiation) considerations that enable the model to assume the linear dose response relationship that is the basis for radiation risk. But there are two situations of practical interest that Goodhead's arguments do not address. The first is that a cell's response to radiation damage is not constant over its lifespan: cells are very sensitive to radiation when they are in their repair and replication cycle. The second is that for internal radionuclide decays, either from sequential emitters or from 'hot particles' the microscopic local radiation flux, or energy density, may be very high, even though the average dose may be low. For internal exposure, these are common situations. Here the concept of 'dose' no longer applies and the conventional model breaks down. I will address these in turn.

Cellular responses to radiation: the Burlakova dose response

It has been known from almost the beginning of the radiation age that rapidly replicating cells are more sensitive to radiation damage [Bergonie and Tribondeau, 1906]. Indeed, this is the basis of radiotherapy for cancer where it is the rapidly proliferating cancer cells that are preferentially destroyed. Most cells in a living organism are in a non-replication mode, sometimes labelled G0. These cells are contributing to the organism as part of the normal living process and do not need to replicate unless there is some signal requiring this, perhaps because of tissue growth, damage or senescence. Throughout the growth and lifespan of individual organisms, there is a constant need for cellular replication, and therefore there are always some small proportion of cells which will be replicating: the magnitude will naturally depend upon the type of cell. When cells receive the signal to move out of stasis or G0, they undertake a fixed sequence of DNA repair and replication, labelled G0-G1-S-G2-M, with various identifiable check points through the sequence which ends in replication M or Mitosis. The period of the repair replication sequence is about 10 to 15 hours and the sensitivity of replicating cells to damage including fixed mutation is extremely high at some points during this sequence. This has been known for some time: Fig 4 shows the results of early experiments on Chinese hamster cells indicating up to 600-fold variation in the cell radiation sensitivity over the whole cycle. [Morton and Sinclair, 1966] If we display this response variation on a scale that shows the normal cell lifespan in the organism, rather than just over the cell cycle *in vitro,* the window of opportunity for cell mutation at high sensitivity becomes apparent Fig 5.

So the picture of isotropic dose to equivalent cells, the 'bag of water' phantom model outlined by Goodhead has to be reviewed. Perhaps 1 percent of these cells are actively dividing and are in repair replication sequences that we will assume, for argument, are 600 times more sensitive to being 'hit' by a track. What would we expect the dose-response to look like? Well as the dose was increased from zero, the sensitive cells would begin to be damaged and a proportion of these hits would results in fixing a mutation and increasing the possibility of cancer. As the dose increased further, eventually this rise in response would peak as these sensitive cells were killed. The mutation yield would then begin to fall. However, at some point, the insensitive G0 cells would begin to be damaged and the whole process would begin again, with a rise in cancer. Ultimately there would be a second fall, but this level of exposure would probably result in the death of the organism (although such considerations have been used to explain an observed fall-off in effect from alpha emitters at high dose). So the dose response would look like that in Fig 6. This type of response was shown to occur in several experiments by Burlakova, although she gave a different explanation for it, involving a combination of increasing damage and induced repair curves.

She showed that such an effect can be seen by plotting the results of a large number of separate radiation and leukemia studies, a graph reproduced in Fig 7.

The results of animal studies on beagle dogs and mice also show these biphasic effects in the low-dose region [Busby, 1995] . Note that this type of curve is seen in the Chernobyl infant studies collected together in Fig 1.

The Second Event Theory

There is large variation in sensitivity over the cell lifespan. Although naturally dividing cells may accidentally receive a 'hit', this process can be modelled by averaging over large masses of tissue, even if the dose response curve is not linear, as thought. However, unplanned cell division, preceded by DNA repair can be forced by a sub-lethal damaging radiation track: this is one of the signals which push the cell out of G0 into the repair replication sequence. It follows that two hits, separated by about eight hours, can generate a high sensitivity cell and then hit this same cell a second time in its sensitive phase. This idea, the 'Second Event Theory' is described and supporting evidence advanced in Busby 1995 and its mathematical description has been approached slightly differently in Busby 2000. It has been the subject of some dispute by NRPB (Cox and Edwards, 2000, Busby, 2000a)

Very recently, developments in micro techniques have enabled some new evidence that supports the two hit idea to emerge. Miller et al., [1999] in a consideration of Radon exposure risks, have been able to show that the measured oncogenicity from exactly one alpha particle hit per cell is significantly lower than for a Poisson distributed mean of one alpha particle hit per cell. The authors argue that this implies that cells traversed by two alpha particles or more contribute most of the risk of mutation, i.e. single hits are not the cause of cancer.

There are two types of internal exposure for which there would be expected to be an enhancement of risk from this Second Event source. The first, due to sequentially decaying radioisotopes like Strontium-90 has been discussed in

Busby 1995, Cox and Edwards, 2000 and Busby, 2000. Following an initial decay from an Sr-90 atom bound to a chromosome, the second decay from the daughter, Yttrium-90, whose half-life is 64hrs can hit the same cell in the induced replication sequence with a probability that is simple to calculate. The same dose from external radiation has a vanishingly small chance of effecting the same process. The second type of Second Event exposure, referred to in Busby 2000a, is from micron or sub-micron sized 'hot particles'. If lodged in tissue, these will decay again and again increasing the probability of multiple hits to the same cell inside the 10 hour repair replication period. It is this process that is relevant to the Depleted Uranium problem.

Second Events from DU particles.

The US Defence Department commissioned research into the levels of Uranium Oxide particulates produced by the impact of Abrams M1A1 Tank ammunition at the Nevada test site in 1986 [USBRL 1986]. The impact on armour of Depleted uranium penetrators results in about 80% conversion to Uranium Oxides UO_2 and U_3O_8 in the form of ceramic particles of diameters in the micron region. These aerosol particles are very mobile and can clearly be inhaled. In this regard the hazard is of a similar nature to that from the Plutonium oxide particles resuspended from Sellafield discharges to the Irish Sea which were considered as a possible cause of the Sellafield leukemia cluster by COMARE and NRPB and referred to earlier where it was recorded that the ICRP66 models used to estimate doses did so by diluting the particles energy into large masses of tissue.

For particles below 1 micron diameter, self absorption of the alpha particle decays may be considered second order and the dose to tissue in the range of these alpha decays calculated. Table 3 shows the calculated doses in spheres of tissue within the 30micron range of the alpha decays. Also tabulated is the number of hits per day to this sphere of tissue. The table shows that for particles as small as 0.2 microns diameter, average annual alpha dose to the (lymphatic) tissue surrounding the particles is about the same as the total annual average background dose of 2mSv. For larger particles the dose rapidly increases. Between 0.5 and 5 microns, Second Event processes are stochastically likely. This is shown by Fig 8 where the number of hits per day is plotted against the particle diameter.

These 'hot particle' processes have been known about for a long time: Fig 9 shows a radiographic photomicrograph of a plutonium oxide 'hot particle' in lung tissue. Overlapping tracks can be seen.

Energy density and risk

The consequence of aggregating decays into a small sphere around a 'hot particle' is, of course, that the number of different cells capable of being hit elsewhere is necessarily reduced: we have converted a number of tracks well separated to the same number of tracks close together. If all tracks carry the same risk of mutation in cells in the track, i.e. all hits are equivalent, then there should be no hazard enhancement. The hazard enhancement proposed arises not from some 'hot coal' type of energy concentration process but from the fact that cells may be triggered into a sensitive repair replication sequence which carries a very high sensitivity weighting. It may, of course be true that there would be other reasons why concentrated irradiation of a small cluster of cells could produce unstable cell replication or cell communication fields such as those recently proposed by Sonnenschein and Sato [1999] and this itself may lead to a tumour promotion advantage but this is another matter.

Beta emissions from DU

Before collecting together these considerations there is one further matter which may have been overlooked in the case of DU. It was pointed out that Uranium-238 is an alpha emitter but depleted Uranium is also a beta emitter: indeed in the solid form the two beta-emitting daughter isotopes, Thorium-234 (beta; 0.26MeV, 24 days) and Protoactinium-234 (beta 0.23MeV, 6,75 hrs) are in equilibrium with the parent after 20 weeks (Table 1). These beta emissions are the main radiological hazard in handling the bulk material. In Iraq, I recently measured 24,000 counts per second at the surface of a stray A-10 30mm penetrator which was just lying on the ground. This represented a dose of about 1mSv/hour to the hands of anyone holding the penetrator. However, most of the beta (and alpha) decays were absorbed inside the bulk material, and only surface disintegrations were emerging to be absorbed in the scintillation counter head.

The equilibrium beta activity of DU is about 37MBq/kg. But most of this energy is absorbed in the bulk material: oxidation of the material on impact to produce some 10^{14} 1 micron diameter Uranium Oxide spheres per kilogram would enable all of the decay energy to be potentially available for human exposure. The enhancement of efficiency in release of beta radiation is thus greater than 1000-fold.

Environmental Mobility of the DU particles

In order to be define the population at risk, it is necessary to know the fate of the Uranium particles subsequent to impact. At the Nevada test site, the atmospheric concentration at 100m from impact exceeded the UK NRPB Generalized Derived Limit for Uranium in Air by a factor of about 5 [Busby 1999]. Dietz has reviewed data which establishes that DU particles are able to travel at least 100km from their impact source [Dietz, 1997]. I recently made measurements of alpha radiation levels in Iraq in three areas, the southern battleground near tanks destroyed by DU fire, the same area remote from the tanks, the town of Al Basrah and the city of Baghdad. Results showed that the alpha activity in the battleground area was more than five times higher than in Basrah and ten times higher that in Baghdad. In addition, and remarkably, levels on the surface of the ground near the damaged tanks did not generally show high levels of alpha or beta signal from Uranium and its daughters except in the case of one tank where a yellow contaminant, probably UO_3, showed high levels of beta activity. In addition, the insides of tank turrets which had radioactive holes in them from A10 hits, did not show high levels of beta or alpha activity. The generally higher alpha levels in the whole area, coupled with these observations suggest that the Uranium particles has been efficiently dispersed by some mechanism. I believe that this mechanism is the repulsion of charged particles by themselves and by the earths permanent electric field of 150V/m. I have argued elsewhere that this effect operates in the Kennet Valley near the Atomic Weapons plant at Aldermaston and results in the preferential concentration of charged radioative particles near electrostatic discontinuities between strata with different conductivity [Busby, 1997] . A similar effect near high voltage power lines was recently found by Henshaw et al. [1999].

Conclusions on Mechanism

Thus we can conclude that the external bag-of-water model is not an accurate representation of the kind of processes that occur at the cellular level and that the physics-based descriptions do not apply to internal irradiation. The Uranium Oxide particles are capable of travelling very large distances [Deitz, 1997]. They may then be inhaled and will become trapped in the lymphatic sytem where they may be transported to any part of the body. Here they may cause sequential moderate dose irradiation of local tissue volumes where the risk of mutation is far higher than is suggested

The enhancement of mutation efficiency that follows from exposure to inhaled Uranium oxide hot particles is capable of explaining the 'anomalous responses to low dose exposure' found near Sellafield and other nuclear sites and also 'Gulf War syndrome' etc. We are not, however, reduced to looking only at the Gulf War Syndrome and the Iraqi children for supporting evidence though I shall return to these later. There are other indicators, and our springboard for these is the 1983 observation of a childhood leukaemia cluster at Sellafield. In the last four years Green Audit been funded by the government of the Republic of Ireland to study cancer incidence close to the Irish sea. The study has used both Wales Cancer Registry and Irish Cancer Registry data to examine and explain variations in cancer risk with distance from the sea. The results of this work will be published elsewhere but since they cast considerable light on the DU problem, some of the findings will be briefly reviewed here.

6. Sea coast cancer risks and resuspended hot particles.

In three separate investigations between 1997 and 2000, Green Audit discovered profound and statistically significant evidence of excess risk of cancer incidence and mortality in coastal populations in Wales, Ireland and Somerset. The excess risk has been found for most of the cancer types and sites and in the following data:

- Incidence data for small areas in Wales from Wales Cancer Registry from 1974-89

- Incidence data for small areas of Ireland from the Irish National Cancer Registry for 1994-1996.

- Mortality data for census wards in Somerset from the Office for National Statistics for 1995-1998

In each area the trend with distance from the sea shows a sharp rise in the group of people living within 800m of the sea coast. It is driven by proximity to areas of intertidal sediment known to be contaminated with radioisotopes from Sellafield discharges. In the case of the Somerset study, which was investigated as a hypothesis test the drying, offshore, mud bank, known as the Steart Flats, was contaminated by historic releases from the adjacent Nuclear Power site at Hinkley Point.

As one example of the type of result found, the all malignancy relative risk for populations of all ages in Wales from 1974-89 is shown plotted against distance from the Irish Sea in Fig 10. Note the sharp rise in risk near the coast. Sufficient evidence has now accumulated from these studies to support the hypothesis that this cancer risk is a consequence of an exposure route involving inhalation of resuspended radioisotopes, particularly Plutonium Oxide particles. The trend in concentration of Plutonium with distance from the sea in Cumbria has been established and is shown in Fig 11. The radioactivity is brought inland by seaspray scavenging mechanisms which are quite well understood: indeed, the ocean is the source of about 30% of all PM10 particles in the UK. It is therefore not surprising that NRPB workers found Plutonium in the tracheobronchial lymph nodes of autopsy specimens from all over the UK in proportion to their distance from the west coast, particularly Cumbria [Popplewell, 1986]. Table 4 shows some results of these studies, which were, incidentally, omitted from the considerations in the COMARE report on the Sellafield leukemia cluster. Nor is it surprising that Plutonium is found in children's teeth in the UK at levels which reflect a similar trend with distance from the Irish Sea [Priest et al, 1996]

7. Recent evidence on DU exposure risks and response by UK government

DU, leukemia, cancer and birth defects in Iraq

There have been reports from within Iraq of serious health problems emerging after the Gulf War. These problems are apparent in the soldiers, in civilian adults living in the south near the war zone and also in children. They take the form of a range of conditions similar to those categorised as 'Gulf War Syndrome' in the US and UK veterans and also in large and significant increases in cancer and leukemia in adults and children and also birth defects including novel types of birth defect. I visited the country in september 2000 with Al-Jazeera TVand toured the hospitals in Baghdad and Basrah, speaking to senior doctors and health service researchers. Cancer registry data reflect the increases in cancer and show that the main increases are also in the parts of the country, south and north of Baghdad, where DU ammunition was mainly used. Significant pieces of evidence are the first, the geographical pattern of cancer and second the cohort effect in childhood leukemia which shows the main excess in the cohort aged 5-9 in 1998. This is an unusual finding for childhood leukemia which normally peaks in the 0-4 age group and indicates that it was the war birth cohort that showed the greatest leukemia effect. The geographical pattern of cancer also broadly correlates with the measurements I made of alpha activity in air in the country, which again reflects the distribution of DU based on the areas where the material was mainly used.

DU in Kosovo

No cancer data is available in Kosovo owing to the large changes which have been taking place there after the war. I was able to visit western Kosovo in January 2001 with Nippon TV and we used UN maps supplied by the Italian Army to locate areas where DU had been used. Using a survey scintillation counter I found areas where high beta counts indicated the presence of significant amounts of DU and took samples for analysis by alpha and gamma spectroscopy and also thermal ionisation mass spectrometry. Two main conclusions could be drawn from the results, which are shown in Table 5.

First, some 18 months after its use, significant quantities of DU either were resuspended in or remained suspended in the atmosphere to be precipitated with snow and to pool under the snow when it melted. The ratio of daughter isotopes to parent U-238 was remarkable. Instead of there being a 1:1:1 equilibrium ratio, the activity of U-238 in the sample was much smaller than the activity of the daughter isotopes. Since Uranium is largely insoluble (or would not have been there if it were soluble) this result shows that the Uranium particles had become resuspended between the time the snow melted and the time I measured the activity (about 2 weeks)

UNEP report on Kosovo

Following concerns about the possible health effects of radioactive contamination from Depleted Uranium weapons used by NATO in the actions in Kosovo in 1999, a number of scientists and experts were assembled under the auspices of the United Nations Environment Programme to visit Kosovo between 5-19th November 2000 to investigate levels of contamination and report on possible health hazards. Details of the expedition and its protocols and findings are to be found in the report [UNEP, 2001]. I have analysed their findings in a presentation to the European Parliament in Strasbourg in 2001 [Busby 2001, www.llrc.org] but will briefly outline UNEPs findings and their conclusions.

UNEP made three main claims relating to their findings.

a. There was no widespread dispersion of DU in areas of Kosovo where the shells were fired. DU measurements showed only local contamination, i.e. there was no evidence of DU further than 10-50 metres from a direct hit site.

b. There was no contamination of water sources.

c. There was no health hazard to humans anywhere with the possible exception of some slight danger from handling shell fragments for a long period.

	Sample A5	Sample A6*	Sample A5A
	Gjakove	Gjakove	Cermjan
	Surface road dust	Surface road dust	Soil
Field Beta cps at 5cms	14	27	4.5
NATO Grid Reference	DM545937	DM545937	DN534026
Number of A10 rounds	225	225	655
Date of attack (NATO)	7th June 1999	7th June 1999	7th June 1999
U238	353 (6.5)**	5443*	19.6*
U235	6.8 (1.20**	69.6*	0.86*
U234	26.1 (2.3)**	91.08 (18)*	NA
Th234	1721 (52)	4988 (98)	NA
Pa234m	1836 (98)	5352 (433)	NA
Pb214	1.7 (.2)	1.1 (.3)	NA
Bi214	1.5 (.3)	1.3 (.3)	NA
Mass Ratio U238/U235	353	504	146 or 138.4[a]
Natural Uranium Ratio	137.8	137.8	137.8
DU present	Yes	yes	Yes

*Note 1: * Uranium by Thermal Ionisation Mass Spectrometry; **Uranium by Alpha Spectrometry; all others by Gamma Spectrometry.*

Note 2: Electra with DP2 Dual Phosphor 4-inch Scintillation Counter (NE Beenham Reading) gave average background beta counts per second in the field of 3-3.4cps. This is slightly greater than average levels in the UK of about 2.7cps.

[a] 146 was the value using ammonium carbonate extraction of Uranium, 138.4 was using nitric acid extraction which dissolves all the Uranium, not just the adsorbed Uranium.

Table 5 DU dust does not harmlessly disperse in the environment. Results of tests on samples from Kosovo collected 19th - 20th Jan 2001, more than 18 months after the attack

Examination of the tables of results shows that all three of these conclusions are incorrect and that the results showed the presence of widespread contamination by DU both by aerosol dispersion of particles greater than 0.2 micron diameter and decay products of U-238.

I conclude that the analysis of the results given in the tables was either biased or badly interpreted. Significantly, the tables of results were not attached to the report when it was sent to the Press. Consequently it was only the conclusions which were addressed at the Press conference [Parsons, 2001, Fleming, 2001]

Nic Priest's study for the BBC

Shortly after my visit, which followed UNEP's visit, in Spring of 2001, BBC Scotland commissioned Nic Priest, of Middlesex University to visit Kosovo and Bosnia and measure DU in urine samples taken from members of the population living in Eastern Kosovo in areas where bombing had occurred. I advised them to visit Djakove, where I had found DU and so had UNEP, and they took samples from inhabitants of this town, among others. Astonishingly, the samples showed that all the people tested had significant amounts of DU in their Urine samples. This included the BBC cameraman who had only been there for the week of the visit. Nic Priest's report is to be published and so I cannot give them here, but have made some averages of his results which were reported by the BBC and which I have given in Table 6 below.

Location	**Number of adults**	**Mean 24hr DU excretion (ng)**
Djakove, Kosovo	5	8.3
Klina, Kosovo	6	24
Bratunac, nr Sarajevo, Bosnia	3	22
Cameraman, Scotland	1	6.9

Table 6 Mean DU in urine samples from the areas in Kosovo and Bosnia visited by BBC Scotland in Spring 2001.

Epidemiology of Balkan peacekeepers

There have been many misleading statements from government ministers regarding the significance of leukemia deaths among Balkan peacekeepers. Recently a UK government minister suggested that 42 leukemia deaths per 100,000 peacekeepers was a reaonable sum and that therefore the handful of deaths observed should be seen as a normal situation.

Table 7 shows the numbers of deaths from leukaemia by age in males in England and Wales in 1998 and calculates the overall rate.

ages	Leukaemia deaths males 98	Population males	
20-24	27	1984394	
25-29	24	2168819	
30-34	24	1967765	
35-39	41	1711844	
40-44	27	1760461	
45-49	49	1700017	
50-54	86	1360926	
55-59	106	1281777	
60-64	138	1228076	
65-69	217	1129274	
70-74	316	919901	
	1055	17213254	Rate = 6.12e-5
			Rate = 0.612 per 10,000

Table 7 Leukemia deaths in men in England and wales in 1998 by age group

The value, 0.612 is for all ages 20-75 combined and is not correct for soldiers who are younger. Leukaemia rates increase markedly in people above 50 as you can see from the table and this would suggest a higher expected number of deaths if this large age group were used as a basis for any comparison. It is unlikely that there would have been many soldiers older than 40. Assuming an age range of 20-40 (which is conservative) there should be 0.15 deaths per 10,000 exposed per year (i.e. the death rate in the men aged 20-40 is about 116/7832822 = 1.48 E-5 which is 0.148 per 10,000 per year. So in the year since the bombing we should expect approximately 0.15 per 10,000 or 1.5 deaths in 100,000).

n January 2001, Nippon TV were told of there were 7 leukemia deaths in Italian peacekeepers (50,000) and more recently Eddie Goncalves, a journalist in Portugal, reported 5 deaths from leukemia in the Portuguese peacekeepers (5 deaths in 10,000 with two in the 20-30 age group). Thus in those groups we observe 12 leukaemia deaths where 0.9 are expected, a relative risk of 13. Even if we use a two-year period since the war the Relative Risk is still 6.5

Cancer increases in Sarajevo

There has been an extraordinary increase in cancer and leukemia in Sarajevo since the bombing. Sarajevo is close to the town where Nic Priest took urine samples and found DU contamination in people at least 6 years after the bombing. I append the latest figures from the Sarajevo Registry in Table 7.

Tumour Site	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Mouth and Throat	1 (1.1)	-	--	2 (2.1)	4 (4.3)	4 (4.3)
Digestive	15 (16.0)	50 (53.2)	36 (38.3)	55 (58.5)	68 (72.4)	82 (87.3)
Respiratory	12 (12.8)	15 (16.0)	20 (21.3)	34 (36.2)	44 (46.8)	51 (54.30
Skin and ligaments	-	2 (2.1)	1 (1.1)	10 (10.6)	8 (8.5)	9 (9.6)
Breast	3 (3.2)	11 (11.7)	14 (15.0)	29 (30.9)	34 (36.2)	37 (39.4)
Urogenic	8 (8.5)	8 (8.5)	11 (11.7)	18 (19.2)	27 (28.7)	28 (29.6)
Eyes	3 (3.2)	-	1 (1.1)	2 (2.1)	1 (1.1)	4 (4.3)
Lymphatic and Blood	1 (1.1)	6 (6.4)	1 (1.1)	7 (7.4)	19 (20.2)	26 (27.7)
Divers	-	1 (1.1)	11 (11.7)	18 (19.2)	11 (11.7)	7 (7.4)
All above	43 (45.3)	93 (99.0)	95 (101.0)	175 (186.)	216 (230)	248 (264)

Table 7 Cancer incidence in Sarajevo 1996-2000. Cases (crude rates per 100,000).

(*Source: Sarajevo Tumour Registry*)

Time lag considerations.

It is incorrect to discount such increases on the basis that the time lag is too short. The time lag between initiation and expression is given by the theoretical equations of Armitage and Doll, developed in the 1950s. The outcome of an exposure is biphasic [Busby 1995] since cancer development may follow immediately in cells which have a pre existing genetic lesion or later in cells for which the exposure causes a first lesion which is then developed following geometrical expansion of the cell line.

Chromosome testing UK vets

UK Gulf War veterans have recently had blood samples tested for chromosome aberrations in Germany. Results show a significant excess number of aberrations relative to German controls and are compared with Chernobyl levels reported by Shevchenko and Snigiryova [Burlakova 1995] in Table 8.

Group	**Number of chromosome aberrations DiC + CR per 1000 metaphases scored**	**Mean Dose in excess of natural background**	**Number of metaphases scored**
Gulf Veterans	7	0 + DU?	1001
German controls	0.5	0	34791
Chernobyl NPP staff	5.8	300-470mGy	6015
Chernobyl liquidators	4.4	220-350mGy	4937
Chernobyl controls	0	2mSv	3605

Table 8 Chromosome aberrations in Dicentric Ring and Centric Ring rearrangements in Gulf War veterans compared with measurements made on groups exposed to the Chernobyl accident. (Schott 2001, Burlakova, 1996)

There is a fourteen-fold increase in the frequency of the unstable rearrangements leading to centric rings and dicentric rings relative to German controls. Data from the Chernobyl exposures published by Shevchenko and Snigyryova in Burlakova 1996 suggests that the DU exposure of the veterans is equivalent to more than 500mGy externally delivered, supporting the belief that the ICRP calculations of dose are in error by an amount of the order of 2000-fold or more if we assume that the maverage dose of the veterans tested was 0.25mSv. Similar unexpected chromosome aberrations following exposure to Uranium dust have been recently reported for Uranium miners by Zaire et al [1997]

8. Overall Conclusions

The Gulf War Syndrome and the increases in cancer and congenital effects in veterans of the Gulf War, the Balkans and in Iraqi populations are merely more and recent evidence of the serious error in the way in which the health consequences of ionizing radiation exposures are presently modelled.

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DEPLETED URANIUM IN NATO ATTACK ON YUGOSLAVIA: POLITICAL BACKGROUNDS AND CIRCUMSTANCES

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NATO's war on Yugoslavia was waged with all available means. The most advanced military technology was employed without any slightest concern for the consequences for the environment and for human existence. Faceless politicians were pushing the buttons. In vain scientists warned that such political willingness to use tools of mass destruction such as DU could bring tragic consequences.

What is the political background of the use of Depleted Uranium in the Balkan War of 1999? NATO used this kind of ammunition even before 1999, that is in the "Gulf War" against Iraq, in Bosnia against the Bosnian Serb Republic (Republika Srpska), and then in the attack on Serbia and Yugoslavia. The political reasons given for the use of depleted uranium (DU) are several:

1. The breakdown of political negotiations;

2. The argument that the age of chivalry is over in 20th century warfare, and that consequently all kinds of weapons are allowed;

3. The great effectiveness of DU anti-tank weapons.

These three political arguments can serve as the model for every similar political situation in the future, which can lead to war. The claim of *"failure of political negotiations "* can justify the use of chemical and radioactive weapons, including DU. This amounts to ad hoc political justification of the use of armaments and ammunition that are deadly for the human environment. Politically the Machiavellian concept that the end justifies the means is applied here as an anti-ecological axiom.

"*Chivalrous warfare*" concept died in the 15th century and now all means are justified. The struggle of scientists for real, and not just pro-forma, defense against the use of DU munitions is explained by the use of "humanitarian war" or "the struggle for human rights". This attack on pacifism identifies pacifism not as a product of the modern age, but as "left-wing and liberal utopianism"

The argument " DU munitions are effective" is, again, classical Machiavellianism in military-political application. It will provide an excuse, not only for what was done in Iraq, in Bosnia and Serbia, but also be used to justify what is to take place in future wars. It has been shown that DU is indeed an effective weapon, but in an unintended sense. DU was effective not only in the number of tanks destroyed, military targets, but DU was also "effective" against human health. It leads to panic, the proliferation of rumor, and manipulation of facts. Meanwhile, it is absolutely certain now and can be foreseen that the use of such weapons provokes specific pathological effects. The NATO command structures were fully aware of the effects of DU ammunition. It means that a population can be terrorized about possible radiation sickness for decades to come, and not merely years. One can also get the impression that the NATO command was unsure of success on its mission in Kosovo and for that reason approved the use of DU with the goal of gradual and continual exposure of the population of Kosovo and southern of Serbia to radiation. With the signing of the so-called "Kumanovo agreement" and the implementation of UN Resolution 1244, it happened that the first to suffer the effects of DU were in fact NATO soldiers themselves.

In addition, these little sandbox wars are necessary for *conducting experiments* in order to perfect DU ammunition. The NATO command and scientific structures surely possess concrete data on the effectiveness of DU in the number of destroyed armored vehicles. That is at once the motive, both political and economic, for the further use of DU ammunition.

What are all the *political consequences* of the use of DU munitions? We have the following in mind:

1. There is political propaganda denying that such weapons were at all used in the NATO war of aggression against Yugoslavia in 1999.

2. There is political propaganda that DU munitions are not at all harmful to the human environment and human health;

3. There have been belated measurements taken in areas where DU munitions were used;

4. There is varying interest by the Serbian mass media in the problem of DU in Serbia;

5. Promises of the international community to clean up the "ecological" consequences of the NATO war of aggression on Yugoslavia have not be kept.

The *secret of the condition of the environment* of Yugoslavia was carefully concealed for over a year by Western politicians. All warnings of physicists, chemists, and biologists found a deaf ear, which shows that individual Western politicians considered as a subversive activity any engagement for discovery of the truth. One can ask why "The West" so feared the truth. That truth came out when NATO soldiers who had fallen ill could no longer hide their illness from public scrutiny. Only then was the classic policy of ignoring or denial given up: politicians could no longer tell their untruths about the "Gulf Syndrome", the "Balkan Syndrome", and finally the "NATO syndrome". Everything was now clear. This was the Illness of an age, the illness of civilization that had resolved to wipe out the basis of its own existence.

The German Minister of Defense Rudolph Scharping even went so far to accuse the media of panic mongering. Other politicians saw the reason for "DU-mania" activism and disinformation by peace movements and the Serbs with the aim of getting KFOR troops stationed in the Serb region of Kosovo to withdraw and go home. At the same time, the discovery of the increasing numbers of ill soldiers virtually knocked the wind out of the malicious declarations of the politicians. It had become crystal clear that the politicians had no intention of acknowledging their guilt but offered instead the alibi that the real intent of using these weapons was to minimize deaths and to enhance the value of nuclear weaponry and munitions.

The use of DU munitions and the environmental catastrophe thus became a political question unifying politicians, peace activists and scientists of various kinds.

In a belated attempt to demonstrate "openness" to truth and to the media, NATO released detailed maps with "exact" coordinates for finding spent DU munitions. Meanwhile, scientists and investigators report erroneous codes for these locations. For another thing, no exact evidence exists on how many DU rounds were fired. NATO never reported the flight plans of its A-10 aircraft, on which one could precisely locate where spent rounds. It is absolutely certain that evidence is being covered up the would reveal ineffectiveness of DU weapons.

In the context of investigating the environmental catastrophe on Balkan it is possible to confirm several connections between politics and politicians, on the other hand, the use of DU munitions. DU ammunition is exceptionally cheap and therefore extremely profitable. This may confirm the connections between politics and the industrial military complex. Politicians encourage production of radioactive weapons, pointing out the economic values of its production. On the other hand, this possible connection for which evidence is still being collected, points in the direction of political guilt and responsibility. Precisely the question of guilt and responsibility is one, which by its nature is especially rooted in the domain of ethics and the ethical. Can humanity call to ethical accounting and responsibility those who did lacked sufficient conscience and consciousness when they prepared, ordered and organized the systematic devastation of the environment? Another question is what in fact happened in world political structures to place military and imperial goals highly valued above preservation of the environment? The world does not have enough time to wait until least pang of the "bite of conscience" appears, because it will never happen.

Separately from Yugoslav scientific institutions, UNEP conducted its own radiation measurements in the period from 27 October to 4 November this year. In a press conference after completion of the measurements, Peko Haavisto (President of the UNEP-DU team) made the following contradictory statements: "Surface radioactivity *was not present* or was confirmed in *very small measure*. That means that there is no concrete risk for people who pass through or are located in those regions". If there is no danger of radioactivity, does this mean that there is also no responsibility for committing ecocide? Or, could it be that the claims "there is no radiation" or "there is only a little" mean that evidence of ecocide has been eliminated? The UNEP measurements came very late, long after our nuclear experts had already conducted their investigations.

The mass media in Serbia and Yugoslavia were particularly interested in the Depleted Uranium problem in the period from November to March 2001. Here are some results of an unbinding mini-investigation conducted together with third year students of the Department of political Sciences in Belgrade, working on the subject "Social and Political Ecology." Distribution of up to three signed newspaper articles (there were five dailies being published in Belgrade then) in which facts were brought out concerning, firstly, the scientific fact and characterization of Depleted uranium. Then there were articles about the dangers of DU to human, animal, and plant health. A third group of articles dealt with individuals who were exposed to DU, especially from the Bosnian Serb Republic, and the phenomenon of drastic deterioration of health of people in the Republika Srpska who detected effects of DU munitions on them after NATO attacks. Therefore, in Serbia and Yugoslavia proper, as opposed to Bosnia, there were very few direct and verified indications of those health problems. After March 2001, two years after the NATO attack, media interest in the matter dropped off considerably. Not a single article was published right up to the appearance of the control measures of the UNEP team from October 2001.

A report of the government of Serbia on "the condition of the human environment for the year 2001," (presented in the Environment Committee of the Serbian Parliament) said about DU that "the situation is not alarming." However, since the effects of DU are delayed and it takes some five years for symptoms to appear, one should be very careful about making such claims. One should also keep in mind tat the government of Serbia does not define this problem as "committing ecocide". The former government of the Federal Republic of Yugoslavia published a report "FR YUGOSLAVIA REPORT -2001 - Environmental consequences of the NATO Bombing of the Federal Republic of Yugoslavia, (Federal Ministry for development, science and environment). This contains all the relevant data dealing with the problem that were gathered right after inception of hostilities. In a program of 11 November 2001 about ecology on the Second Network of Radio TV Serbia, Andjelka Mihajlov, Manager of the Administration of Environment of the government of Serbia, declared that the total ecological damage caused by the NATO bombing in 1999 exceeded 40 million US dollars. The money from the international community needed to clean up the damage amounted 20 million dollars. But up to the present day, as Mihajlov pointed out, the "donors" have "donated" only 7 millions dollars. Such a paltry contribution shows the disregard of the international community for the human environment not only in Serbia, but in all of Eastern European. Moreover, we must express our gravest doubts about the paltriness of the sum of 40 million (not billion) dollars estimated by the international community for ecological damage. Independent expert in Serbia estimate that the damage comes to about one thousand million dollars (US one billion). All of which shows that state organs of Serbia and Yugoslavia have not succeeded in internationalizing the problem. The international community has a slogan "Think globally, Act locally!". It is time for them to live up to their word.

HEALTH AND ENVIRONMENTAL EFFECTS OF DEPLETED URANIUM

William Angus Millar, Independent Depleted Uranium Monitoring Group, Canada

Current global reality of international confrontation brings the issue of the weapons of mass destruction to the international community as one of the most threatening problems of today's world. World atomic power represented on slide one indicates the presence of the large number of nuclear reactors mainly present in the industrialized world. Parallel to the production of nuclear energy they also produce millions of tons of radioactive waste mainly consisting of depleted uranium. Depleted uranium is composed of predominantly U238 and U235 which is reduced from 0.7 to 0.3%. It has high specific weight being two times as heavy as steel and 1.7 times heavier than lead. It's property of igniting in the presence of air together with high weight makes it an ideal penetrator through the heavy materials such as steel for which reason it has been used for the military purposes with devastating effects on the population of Iraq, Serbia and Kosovo. It is currently being used in Afghanistan. Upon the impact of air it vaporizes producing billions of microscopic particles of a micron size which when inhaled can lodge in the body tissues and organs causing somatic and genetic changes including cancer and genetic malformations. A number of Allied troop soldiers were accidentally contaminated with DU in the Persian Gulf and Balkan Wars. In 1914 H.G. Wells wrote a novel with a prophetic vision of the nuclear war which took place three decades later. The countries with the most demand for nuclear energy are also the most protective and the most secretive about adverse effects of the nuclear and radioactive contamination of the environment and human health. It is indescriminent whether these countries are from the eastern or western block. The former Soviet Union denied any adverse effects of radioactive contamination until the events in Chernobyl which is illustrated on the slide of the official policy to deny any adversity of the nuclear energy. Natural uranium predominately consists of the three isotopes U238, U235, and U234 with the respective half lives of 4.5x109, 7.1x108, 2.5x105 years. All decay by alpha, beta and gamma radiation.

The history of uranium toxic effects of the human organisms can be traced to the silver mines of Czechoslovakia. The young miners dying of the mountain sickness and black lung disease and suffering from the similar symptoms in the later generations has correlated these illnesses with the later evidence of the similar symptoms caused by the uranium inhalation poisoning. Today's literature confirms by the studies by the eminent actinide researcher Patricia Durbin that uranium isotopes induced bone cancer published in the renowned journal of Health Physics in 1997. In the same year there was a published report of the increase of the lung cancer in Uranium miners of S. Africa. The Canadian study of 1993 published in the British Journal of Industrial Medicine indicates elevated mortality of uranium miners in Canada. The study of the lung cancer in the uranium miners of the United States published in 1997 confirms malignant changes in the bronchial tree in the uranium miners. It is further verified in the report of 1995 of the increase lung cancer mortality among the uranium miners in New Mexico, Arizona and Nevada predominately Native Americans of the Navajo tribe. The study of Czechoslovakia uranium miners confirmed elevated death rate as reported in 1994. The critical organ of uranium contamination is the bone and kidney. Renal damage is usually functional and reversible while the changes in the skeletal can include damage to the stem cells and induction of the bone cancer. Uranium also causes pathological changes in the reproductive system recently reported in the animal experiments in the U.S. and in the human population in China published in 1994 in the Chinese Journal of Preventive Medicine. Uranium also causes increased incidence of systemic sclerosis recently published in the German study of 1996. It is well established that uranium contamination causes increased genetic damage in the cancerous changes in uranium mine workers in the African studies of 1996. Systemic Lupus increased incidence in uranium miners was reported two years ago by the researchers in Israel in the International Journal of Rheumatology. It is a well-known fact that micro gram concentrations of injected uranium cause lethal effects in experimental animals which have been supported by the evidence of 200 years. The same toxicity applies to DU. The recent study of increased rates of lung cancer in the U.S. published in 1998 shows elevated cancer rates in the vicinity of Ohio DU fuel facility. This particularly applies to Fernald Uranium Plant with evidence of increased mutations in the local population. Inhaled soluble compounds of DU present chemical threat to the kidneys and both functional and structural changes to the bone tissue including cancer.

Recent studies of uranium contamination of the Persian Gulf and Balkan War veterans have been conducted in the U.S. and Canada by studying distribution of isotopes of DU in the veterans of the NATO and Allied forces who were accidentally contaminated with DU either in the form of imbedded shrapnel or inhalation of uranium contaminating dust. The studies of the U.S. armed forces Research Institute in Bethesda Maryland on the shrapnel wounded veteran's demonstrated increased concentration of the isotopes of DU in the urine eight years after the Persian Gulf War. In contrast non-governmental uranium research groups such as Uranium Medical Centre reported increased urinary excretion of four isotopes of DU in the Allied forces veterans exposed to DU containing dust ten years after the exposure. These studies were confirmed by two methods. Neutron activation analysis confirmed presence of DU in the urine of seven Persian Gulf veterans with ratios significantly different from the natural uranium and in the range of DU, ten years after exposure from inhalation. The veterans of the Allied forces contaminated by inhalation in the Persian Gulf War were also analyzed for the uranium presence for their body fluids, tissues and urine by the method of mass spectrometry. These results presented at the International Conferences in Dublin Ireland, Paris France and New York U.S.A. indicate significant presence of four uranium isotopes in over 60% of contaminated veterans being in the range of DU. The ratio of the uranium isotopes 235/238 is in the range of DU if higher than 137.8. It was found to be in the DU ratio 62% examined by the mass spectrometry analysis. Isotopic composition of natural enriched and DU should be for U238/99.3, U235/0.7 and U234/0.006 and for enriched uranium 99.01, 2.96 and 0.03, while for DU respective ratios are 99.75, 0.25 and 0.005. This is in the range seen in most contaminated Gulf War veterans.

The stockpiles of DU present a problem of the containment of radioactive waste to the nuclear industry with the essential commitment of each country using the nuclear reactors to provide adequate management of the low level radioactive waste. The U.S. Department of Energy estimate the cleanup costs of radioactive waste of 1989 is well in excess of 200 billion dollars. Numerous methods of the disposal of radioactive waste none being satisfactory from the viewpoint of long half-lives of uranium isotopes, containment costs and the risk to the environment. Future management of the accumulation of radioactive waste should be the prevention and reduction of the environment exposure to radioactive waste. The excess to DU is getting easier by the day. The aim of various terrorist groups of exposing large segments of population to radioactive contamination is made a practical probability for the smuggling of uranium and plutonium mainly through the routes of Central Asia. DU is inexpensive and can easily be obtained on the clandestine market. If terrorists go nuclear it is relatively a simple task to disperse DU containing aerosols in the air conditioning systems of the large buildings or in the water supplies of the big cities thus gaining the excess to the large segments of the population with both physical and psychological consequences including panic and disruption of the routines of life of the society. The future of DU must be restricted to ALARA concepts (As Low As Reasonably Achievable Use]. Current evidence of the environmental and health impact of DU makes a real state of affairs easily evident that environmental and health effects of DU presents a threat to the biosphere and must be addressed accordingly. Current environmental deposits of over 200 thousand metric tons of mill tailings per reactor in a year present a progressive threat to the limited containment capacity of the planet earth. Poisoning a nation in the name of national security is unacceptable solution as stated by the first American astronaut and senator John Glenn. The specter of the nuclear holocaust must be curbed in the civilized world together with the elimination of other weapons of mass destruction.

FACTS ON DEPLETED URANIUM

The Use of DU Ammunition by NATO in 1999 in the War against Yugoslavia

Truth under DU Carpet

Vladimir Ajdacic, former member of the Institute for Nuclear Sciences Vinca,Yugoslavia (vlajda@yubc.net), and Predrag Jaksic, Faculty of Natural Sciences, University of Pristina, Krusevac, Yugoslavia.

On the 24th of March 1999 NATO attacked Yugoslavia by planes and rockets. According to the Yugoslav army sources depleted uranium ammunition (rounds of 297 grams) for the first time was used on the 30th of March near the city Prizren. American general Chuck Wald on the 6th of April confessed the use of DU in undeclared war that lasted till the 10th of June 1999.

For the long time after the end of this war NATO tried to minimize the use of DU ammunition in Yugoslavia. First NATO maps of locations that were under the fire of A-10 planes, which used dangerous DU shells, had only 25-30 "hot spots". The picture has changed after the arrival of UN peacekeeping forces to Kosovo. When the soldiers of this forces started becoming ill and dying many of the NATO countries wanted to know the full truth about the sites contaminated by DU. Finally, on the 24th of January 2001 NATO released the information (updated: 08-Feb-2001): "Data concerning the locations of depleted uranium ordnance during Operation Allied Force". This was the list of grid locations where NATO aircrafts engaged targets. This NATO list presents data for 112 air strikes with DU. However, while the attack numbered 101 contains 2 locations; one can take that NATO delivered DU to 113 locations. NATO claims that the first use of DU was on the 6th of April and the last one on the 11th of June 1999, day after the end of the war!

Careful analysis of NATO data (used in our map for presenting DU locations) shows some surprising, almost unbelievable results. Besides Yugoslavia, two other sovereign countries of Balkan were exposed to DU. In Albania 16 locations and in FRY Macedonia 26 locations got their shares of DU. Altogether this makes 37.2% of all locations cited by NATO, more than one third of total number! Up to now, according to our knowledge, not a single NATO or UNEP map or written information reveals this fact.

Self contradictory NATO data are full of mistakes which are not of technical but of political nature. From the list of 112 (read 113) locations under the name Kosovo and two other lists: FRY(Serbia) and FRY (Montenegro), one can conclude that FR Yugoslavia is a part of Kosovo! Twelve locations from the Kosovo list appear in FRY(Serbia) list and 2 in FRY(Montenegro) list. But now we come to even greater surprise - only 2 of the first mentioned 12 "Serbian locations" are really in Serbia, the other 10 are in FRY Macedonia!

NATO data do not contain 3 undisputed locations: peninsula Lustica in FRY (Montenegro), Reljan, site east of Presevo FRY(Serbia) and one location close to city Vranje FRY(Serbia), which are characterized by reach collection of DU rounds found by the Yugoslav Army.

There are great doubts about the quantity of used DU ammunition in some air strikes. If it is well known that the A-10 plane gun GAU-7 delivers 3,900 bullets per minute (65 bull./sec). So, it is hardly believable that planes in their actions used only 50, 65 or 70 bullets (e.g. "fired" less than 1.5 seconds). There are 38 cases in the NATO list in which shooting lasted less than 3 or only 3 seconds. In 83 air strikes numbers of fired bullets represent round figures (given in tenths). There is only one case with "no round number" (907) in which the counter of fired bullets was working! It is highly unrealistic that the NATO planes would fly from Avianno, Italy, to the southern part of Yugoslavia in order to deliver their DU ammunition in one or two seconds.

It astonishes that in 3 cases the dates of actions and number of used bullets are not known, while the locations of actions are known. In two of them they were defined with the precision of 1 meter! Another wonder is that one location in international water of Adriatic see was twice targeted by DU with the precision of 10 meters!

Dilemma about the NATO data even grows up after comparing "NATO map" with the UNEP map. UNEP is giving 72 DU "hot spots" (locations) in Kosovo, while NATO is listing only 51! Whom to believe: NATO or UNEP? And how UNEP came in possession of so different result. Who was the source of UNEP information - NATO or Yugoslav Army!?

Summing up available data leads to inevitable conclusion that we are far from the truth about NATO destructive use of DU ammunition in Balkan. Taking into account "unknown" fired bullets (using average values for them), we get the figure of 13 tons of DU as the minimum which NATO used in this area. Search for the truth should continue. We cannot accept that anyone has the right to burry the truth under the carpet of DU.

FACTS ON DEPLETED URANIUM

Depleted Uranium in Japan

Yuki Matsuoka (Japan), Student (European University Center for Peace Studies in Austria)

In Japan the topic of depleted uranium has not been noticed generally. But in peace movement in Japan, this topic has been tackled from two perspectives.First, peace movement against nuclear weapon has been dealt with this issue. After Hiroshima and Nagasaki, this peace movement have supported Hibakusya, victims of Hiroshima and Nagasaki, and have appealed ' No more Hiroshima, Nagasaki ' to the world. Depleted uranium bullets are regarded as one of the nuclear weapons because they damage human beings and environment seriously even after end of war. The Japan Council against Atomic and hydrogen Bombs (Gensuikyo) is one of the leading organization about this issue and made an appeal a Ban on Use of Depleted Uranium Shells in and around Kosovo, where DU shells were massively used in the NATO bombing over Yugoslavia in Spring 1999. (See page 4-5)
Second, from the perspective of anti U.S. basement. US Marines mistakenly fired bullets containing depleted uranium on an island off Okinawa, Japan, during training exercises in December 1995 and January 1996. After World War II, U.S. established the U.S. basements in Japan, especially in Okinawa, the southern island. There have been many issues related in U.S. basement, for example noise pollution, accidents during the training and outside the training, rapes and environment pollution. The accident of depleted uranium added another environment problem in Okinawa. (See page 2-3) And also some journalist and media have pointed out this issue. One Japanese newspaper company located near Hiroshima published a book in English about depleted uranium recently. (See page 6-7)DU bullets mistakenly fired in Japan and US
Sources:
Asahi Shimbun (Newspaper Japan), 12 February 1997

US Marines mistakenly fired bullets containing depleted uranium on an island off Okinawa, Japan, during training exercises in December 1995 and January 1996. Officials of the US Ministry of Defense apologized on February 11 for the one-year delay in notifying Japan of the 'incidents'. US military authorities did not notify Japanese officials until January 16 this year.
(467.4649) WISE-Amsterdam -The firing of the 1,520 bullets containing depleted uranium on Torishima island, 100 kilometers west of Okinawa's main island, occurred on December 5 and 7 in 1995, and again on January 24, 1996. US military officials said they did not discover the mistake until after the January 24, 1996, practice when servicemen repaired one of the guns on the aircraft after it jammed. The use of such bullets is prohibited on any training ranges in Japan, including uninhabited islands, under US Marine regulations.

The AV-8B Harrier aircraft fired the 25-mm bullets filled with the radioactive depleted uranium because the bullets had been incorrectly labeled, according to US forces. The depleted uranium in the ammunition is used to pierce tanks and other hard materials. Each 25-mm bullet contains 147 grams of depleted uranium.

US troops cleaned up Torishima Island from March to April 1996 and recovered 192 bullets, according to the US military. (For more information on Depleted Uranium, see WISE NC 463/4.4610)

On February 11, 1997, the US Nuclear Regulatory Commission (NRC) was informed of another DU event: about 100 rounds of 7.62-mm DU military ammunition were apparently missing. In 1984, 400 rounds of this ammunition were received from Letterkenny Army Depot for storage. In 1994, the 400 rounds were mistakenly transferred along with thousands of rounds of nonradioactive ammunition to another federal agency and subsequently to a local police department. While in the possession of the police, 100 rounds (containing about one pound of DU) were fired at a local police firing range. The remaining 300 rounds were recognized as military ammunition and returned to Picatinny.

Picatinny Arsenal personnel were not aware that only 300 rounds had been returned until January 31, 1997, when a detailed inventory was conducted. They are to visit the police firing range in an attempt to locate and recover residual DU. The licensee plans to conduct a thorough investigation and inventory to determine if other similar situations have occurred.Uranium scare in Nishihara
Sources:
Okinawa Times (Newspaper Japan), 3 June 2000
About 470 depleted uranium shell casings were found in a private metal scrapyard in Nishihara Town on May 31st. The casings had been stored for seven years in the yard. On the 1st of June, staff from the Science and Technology Agency, the Defense Agency, the Ministry of Foreign Affairs, and a radiation survey team from Tokyo took measurements of the material and declared there was no danger.

Keisho Karimata, owner of the scrapyard, bought the shells from the US military's Defense Reutilization and Marketing Office on Camp Kinser in Urasoe City. The DRMO is where individuals, both military and civilian, can obtain used military goods such as tools, furniture, and metal scrap in sealed bid auctions. Karimata was taken by surprise that the casings had depleted uranium and could be potentially harmful. He said "I didn't know they might be so dangerous. I am very angry at the irresponsible management of the US military."

On June 1, the survey team held a meeting at the Nishihara Town Office to announce that the radiation was minute and that the shells did not pose any danger. Nishihara Mayor Seitei Onaga, Town Council Chair Sosuke Miyahira and a few others attended the meeting. Mayor Onaga said that it was good news there was only a tiny amount of uranium and no danger to people and the environment. However, he said that the US military must be take better care of their used goods. He also demanded that the Japanese Government investigate how used US military ordnance could get into private hands so easily. The Japan Council against Atomic and Hydrogen BombsSince the founding in 1955, the Japan Council against Atomic and hydrogen Bombs (GENSUIKYO)
is working for prevention of nuclear war, elimination of nuclear weapons and relief and solidarity with A & H Bomb victims in Japan and the world.
http://www.twics.com/~antiatom/E-contents.htm

Letter to the Governments of the USA and the UK, the NATO Headquarters, and the United Nations:
We Call for a Ban on Use of Depleted Uranium Shells
January 13, 2001
Japan Council against Atomic & Hydrogen Bombs
Dear Sirs,
As an anti-nuclear peace movement representing the Japanese people, who suffered the damage from the bombing of Hiroshima and Nagasaki, we are deeply concerned about the reports that many people are suffering from leukemia and other problems inferred as having been caused by the depleted uranium shells in and around Kosovo, where DU shells were massively used in the NATO bombing over Yugoslavia in Spring 1999. The DU shells had been massively used by the US forces during the Gulf War in 1991, and high incidence of radiation diseases among not only Iraqi residents but also US military personnel who took part in the war operation developed into a serious issue. Nevertheless, the US and its allies again massively used DU weapons in Bosnia and Herzegovina, and then in Kosovo. The US has even sold a large number of DU weapons to other allied countries, encouraging them to use these weapons. As known, the DU weapons, albeit they are not in the category of nuclear weapons that produce explosive energy by nuclear fission or fusion, have been warned from early days that they cause serious, anti-human radiation effects directly and through environmental contamination. The responsibility of the NATO, and the US and the UK in particular, who continued to use the DU weapons in spite of their position to know about their anti-human nature, is very heavy. We of the Japan Council against Atomic and Hydrogen Bombs, on behalf of the Japanese people, who suffered the tragedy of Hiroshima and Nagasaki, file a strong protest against NATO, and particularly the Governments of the USA and the UK, who keep trying to justify the use of DU weapons, and urge NATO and the Governments of all its member states not to use nor to deploy DU weapons. We demand that they should conduct a thorough investigation on the damage by the DU weapons used in all the conflicts in which NATO was involved since the outbreak of the Gulf War, and make public the outcome of the investigation. We also request that the United Nations Organization will make an inquiry into the damage caused by DU weapons, and that it will take the initiative in enacting international rule banning the military use of depleted uranium.

Letter to the Japanese Government On the Problem of Depleted Uranium Weapons

January 13, 2001
The Japan Council against A and H Bombs
The news reports about a heavy human damage, including the cases of leukemia, and environmental destruction caused in Kosovo and other areas by depleted uranium shells, massively used by NATO forces during the bombing over Yugoslavia, are eliciting serious concern internationally, and even among NATO member states. The danger for depleted uranium to cause such damage, if used for military purpose, has long been pointed out by many experts. In fact, in Iraq and even among the military personnel of the NATO side who handled DU weapons during the Gulf War in 1991, symptoms arising from the exposure to radiation later developed. This became known as the "Gulf Syndrome". We have already demanded from NATO and all its member states that they should immediately stop deploying and using DU weapons. We also requested UN that it take the initiative in enacting international law banning the military use of depleted uranium. At the same time, we are concerned that along with the other nuclear weapons states, the USA has produced massive DU weapons and deployed them for the US forces operating worldwide. It has deployed DU weapons in the territories of other countries and has even exported to its allies. In consideration of the desire of Japanese people, who suffered the tragedy of Hiroshima and Nagasaki, we urge the Japanese Government: 1. To make a thorough investigation on the bringing, deployment and/or actual use in military practices of DU weapons by the US forces in Japan and release its outcome, and; 2. To urge the US Administration to stop once for all the deployment or use of DU weapons; and to demand that it should remove all DU weapons from Japan, if already brought in at all.One Japanese newspaper company(Chugoku-newspaper) editied and published a book about depleted uranium on June 2001.
http://www.chugoku-np.co.jp/abom/uran/booksale_e.html

To order this book: https://www.jcafe.net/transnet-jp/order.html

Discounted Casualties - The Human Cost of Depleted UraniumStory and Photos: Akira Tashiro
Translation: Transnet
Foreword: Leuren Moret, President, Scientists for Indigenous People
Published in Japan by The Chugoku Shimbun
Price: US$12, 1,500 Yen
The books are in! Order Now! (Transnet) The contentPart I On the Wrong Side of a

Superpower
US Gulf War veterans watch their bodies deteriorate as the Veteran's Administration holds fast to its claim that DU munitions pose no threat to human health.

Part II The Threat in our Backyards
Evidence is mounting that radioactive uranium has contaminated air, soil, and water near the plants that produce DU munitions, harming the health of workers and nearby residents.

Part III Contaminated Earth
People living near facilities where DU weapons are test-fired or discarded face environmental contamination, mounting cancer rates, and an official "stone wall."

Part IV Heavy Burden for an Ally
British Gulf War veterans are also struggling for government recognition that they are suffering due to DU exposure.

Part V The Scars of War
Economic sanctions against Iraq pit physicians against overwhelming odds in their struggle with the post-war upsurge in cancers, stillbirths, and congenital deformities.
Part VI Finishing the Story
Contamination spreads from areas where DU penetrators leach toxic uranium with a half-life of 4.5 billion years into the ground.Grassroots groups are working steadfastly for a cleanup and a ban.
Get to the Heart of the Matter
Some scientists claim depleted uranium is harmless. Some claim it's deadly. Others call for more research. Meanwhile, Akira Tashiro takes us into the homes, families, and hearts of people suffering and fighting the effects of DU. As a journalist from Hiroshima, Tashiro knows that conclusively proving radiation effects is next to impossible. That's not because there are no effects. It's because radiation produces so many different effects. It's impossible to get a complete picture of radiation damage by counting cases of leukemia or breast cancer. Low levels of radiation can get you in so many ways; no one problem rises high enough

above the horizon to draw attention. Scientists have yet to go into communities and look for higher incidences of "everything." What happens is, people get sick, then start to look around and wonder why so many of their friends, relatives, or fellow veterans are also sick.

The personal experiences you will encounter in this book are more convincing than science. They leave little room for doubt that DU is a cruel, frightening menace that needs to be treated like the chemically toxic radioactive waste it is, not turned into bullets and scattered around the world.

During the Gulf War, the multinational force combat-tested a formidable new weapon--depleted uranium (DU) penetrators. These projectiles performed admirably, burning their way through enemy tanks on contact. But at what cost?

Hiroshima-based reporter Akira Tashiro traveled through the US, UK, Iraq, and Yugoslavia pursuing this question. Here is the ominous picture that emerged:

FACTS ON DEPLETED URANIUM

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UK and USA aerospace workers, the silent victims of mass industrial D.U. contamination ?

Davey Garland, Daamdu/Pandora Project, November 2001

In early 1985 a happy, healthy, 30 years old man (author of this paper) was thrilled to be offered a new job as technician within the south west of UK aerospace techologies industry, like many such establishments around the UK MoD procurement is the major industry and biggest employer in this westcountry town. He was not surprised because of the tight security in getting into the premises to be told that he had to sign the official secrets act register where all employees are then thoroughly checked for criminal record etc. before eventually joining the company.

The work was interesting, challenging, and seemingly very clean, he often wondered where the components he was asssembling ended up, in general these components and systems controlled the environment 0xygen/heating/air conditioning/toilets inside all manner of aircraft, mainly military aircraft but often used in civil aircraft. The systems and components went to virtually every UK and USA aircraft manufacturer. By design the whole industry is a secretive closed shop guarded by all manner of international governmental legislation. The materials used to make components were almost all imported, to conform to International Airworthiness certification all manufacturers have to be able to trace all materials back to producer to ensure quality materials are always used. Additionally, all materials whether metal/plastic/wire/resin/glue/solvemts are unusual in that the general public would be unable to buy or in any other way obtain or handle such unusual materials, If any worker was to remove a lump of metal or epoxy resin from the premises he could not pretend that such material had been bought, he would lose his job and probably never be employed within the industry again? The author of this paper suffered a decline in health in the decade that he worked within the industry, he was sure that other quite young colleagues were also generally unwell, some died of cancer which was never medically attributed to the aerospace industry, but many of us within the industry suffered disease and illness which seemed extremely rare among the general public ?

In 1995 a cough developed into a severe disability, unable to breathe,walk, or get out of bed through a sudden arthritis effecting all joints and muscles effectively terminated his working life, by July he was sick never to return to employment. A lung biopsy confirmed an industrial disease, which is usually quickly fatal and is untreatable. However, this particular disease is not registered as a disease attributed to engineering, which immediately invalidated any DHSS claim for injuries or any form of benefit. The author is an unusually strong character a non smoker and with the help of Chinese acupuncture managed to defy the doctors prognosis, within one year he was not only still alive but appeared to be improving, helped by clean country air away from the aircraft factory. He was convinced that his lung disease was caused by exposure to substances at work, and by chance saw a TV news bulletin regarding the Gulf veterans that were now sick and dying 4 years after being incredibly fit, fighting in the Gulf war of 1991.

He could not believe his eyes when a young female major was filmed trying to get out of a car to visit the grave of a comrade, it was clear that the pain she was in was identical to his own symptoms. He contacted then attended the first AGM of the NGVFA where he met many with the same rare problems, he joined the association and they too could see a military link with aircraft but nothing obvious enough to link him as a Gulf veteran. Gradually, over the years spanning 1996-2000 much evidence started to emerge that Gulf veterans were poisoned, this was linked to vaccinations and organophosphates, he had not been vaccinated but it was possible that many chemical solvents are similar to organphosphates which remains a possible contributor to his ill health.

In 1997 access to a powerful computer revealed a story which was fascinatuing, Boeing the worlds largest aircraft maker had used all manner o f secrecy laws to cover the fact that many hundreds possibly thousands of its workforce had been made seriously ill through exposure to toxic substances used in manufacturing aircraft. Even the metal was being sited as chemically toxic. The story was made doubly strange because the U.S Government/doctors /lawyers/unions decided that the story should be censured and kept from the public media, Boeing is the biggest exporter of aircraft earning the U.S Government so much revenue that in the land famous for freedom of speach and freedom of information, the whole legal case was forced to collapse, which effectively labelled the industrial victims of ill health as having criminal intent against their employer and country because they had signed secrecy acts preventeing them speaking against their employer? During early 1999 an amazing person addressed an NGVFA open day in Portsmouth UK. He was none other than Asaf Durakovic, Ex chief of nuclear science at the Pentagon, Washington DC. Everyone was spell bound at what this man was revealing was scientific fact: Anti tank shells used in the Gulf war were actually made of Nuclear waste metal it is the first many had ever heard of D.U.

Although none of them believed that a UK civilian could have been contaminated with DU it was agreed that his urine sample should be included with the first batch of samples sent for laboratory testing, in February 2000 he was amazed to learn that he had proven positive to D.U contantamination, his results were among those paraded around the world for the scientific peer review studies to accept new science as being correctly researched! Although the lung disease has all but disappeared, he has continued to feel incredibly ill with terrible joint and bone pain, this was thought to be linked to a very low potassium level. After a series of tests and medicines failed to elevate his potassium level, he was diagnosed as having an incredibly rare genetic kidney condition. The renal specialist aware of the positive DU result did some research and discovered that rats exposed to DU develop the same rare kidney malfunction of leaking tubules unable to store potassium. he is currently awaiting DNA testing to proove whether he have been gentically modified as none of his family or ancestors appear to have carried this defective gene.

A local TV company filmed a documentary about the author and another colleague that worked for the same employer but at a different factory, that documentary also covered factual information that DU is built into many civil aircraft fo ballasting reasons, particularly Boeing 747's several crashes revealed how DU either burned or somehow went missing from crashed aircraft. His employer with backing from the HSE had always stated to him that DU had never been used with the factory! Contrary to this was a company statement read out in the documentary explaining that DU had been used between 1966-1982 and gradually phased out since, we have no idea where this phased out DU ended up some say it is scattered in boxes around many MoD factories or military establishments, it is even though to have got into the scrap metal supply chain. he does not have to worry about trying to prove this anymore, but another material used extensively is now believed likely to contain DU.

Aero Grade Heavy Metal Alloy is used right across the industry for making all kinds of aero components, it is produced by GEC of USA transported to the UK under cover of of military sensitive import/export special concession, machined into all types of component re-exported to the USA military/civil aircraft manufacturers as complete systems or components ready to assemble, there is no technical dividing line between military or civil aircraft construction most companies produce both types, their technicians and fitters will all have signed some form of government secrecy register. Aero Grade Heavy Metal Alloy, which used to be stored on the factory premises is identical to video evidence seen presented to the United Nations, the secretly filmed DU producer happened to be GEC of USA producing metal for export. We cannot say much more at present, but there are many unusual coincidences emerging almost daily which seem to confirm that both UK and USA governments are trying to keep the lid on any word of DU being routinely used in aircraft production, the raft of Secrecy laws, employment laws, HSE laws, company confidentiality laws, all makes allegations very hard to prove and effectively mutes the industry workers that are unaware of the true nature of substances they have to encounter daily!

R. David

An ex U K aerospace worker

Daamdu (direct action against militarism and DU) is working at a grass-roots level with the victims of DU, attempting to make their stories and articles available on the website www.pandora.project.on.to

The video described above is also available, and copies can be obtained through the group, contact Davey or Jo on daamdu@c4.com Daamdu also produces a weekly DU bulletin, that contains recent news articles, research documents and lists of conferences etc, pertaining to the DU issue. To register either contact daamdu email, or contact Davey directly on thunderelf@yahoo.co.uk to be added to the list.

Use, Effects and Legal Standing Of Depleted Uranium Munitions

By Dan Fahey[1]

In the last decade, international interest in the health and environmental effects of depleted uranium (DU) munitions has steadily increased. Veterans' organizations in the United States and Europe have expressed concern about the long-term effects of depleted uranium on their health. Humanitarian and environmental organizations have called attention to the potential health and environmental impacts in areas where DU munitions have been used. Politicians, scientists, and military officers from various nations have either downplayed or supported the public's concerns. In addition, legal experts have offered conflicting opinions on the legal standing of depleted uranium under international humanitarian law.

The many uncertainties about the health and environmental consequences of the use of depleted uranium munitions have not been resolved despite increased investigation and research. Although DU has been shown to cause serious health effects in laboratory animals, evidence of similar effects in humans is lacking, due at least in part to the near absence of studies on exposed soldiers and civilians. Similarly, the environmental effects of DU are unclear due to a lack of timely battlefield assessments, although even proponents of DU munitions agree that contaminated areas should be identified and potentially cleaned up.

Despite limitations in the status of knowledge about depleted uranium, it is possible to draw some tentative conclusions about its effects. The use of DU munitions in combat may result in localized contamination of equipment, infrastructure, air, soil, and water in the form of fragments and a fine dust. Depleted uranium persists in the environment and will disperse over time unless the contamination is cleaned up. Under certain conditions, people may be exposed to amounts of DU that could cause short- and long-term health effects.

While most investigations have exclusively examined the health and environmental effects of DU, there is increasing interest in the legal standing of depleted uranium under international humanitarian law. Depleted uranium munitions are not covered by any specific treaties, and their limited use has not given rise to any recognized customary norm, but some observers have suggested that their use and effects may violate certain articles of the 1977 Additional Protocol I to the Geneva Conventions pertaining to superfluous injury to humans or excessive damage to the environment. [2]

This paper provides a brief description of depleted uranium and its use in weapons. Several exposure scenarios are described, and examples of the use of DU ammunition in training, testing, and combat are provided. A summary of depleted uranium's health and environmental effects follows, and the paper concludes with a brief analysis of the legal standing of DU munitions under international humanitarian law.

Depleted Uranium and its Uses

Depleted uranium is the waste product of two processes related to the nuclear fuel cycle. DU is created when natural uranium is "enriched" to produce fissionable material for reactors and nuclear weapons. In addition, if spent nuclear fuel from power reactors is recycled, the resulting waste is added to DU stockpiles. Depleted uranium from both sources is chemically toxic and radioactive (predominantly high energy but short-range alpha particles). Additionally, depleted uranium created from the recycling of nuclear fuel may contain trace amounts of plutonium and other highly radioactive transuranics.[3]

Historically, uranium and depleted uranium have been used in the coloring of ceramics and glass, in the production of dental porcelains, and as a chemical catalyst.[4] The discovery of nuclear fission in 1938 vastly increased the mining and processing of uranium, and consequently enlarged the production and supply of depleted uranium. After World War II, increased production of enriched uranium for nuclear power plants and nuclear weapons created large stockpiles of depleted uranium in the United States.

The development of depleted uranium munitions began in the early 1960s in the United States. Weapons manufacturers experimented with the use of high-density alloys of depleted uranium in armor-piercing ammunition known as *kinetic energy penetrators*. This ammunition is simply a solid rod of dense metal stabilized by tail fins; there is no explosive charge. The large energy of motion (kinetic energy) of the rod, traveling at speeds up to 1.8 kilometers per second, is sufficient to punch a hole in the armor of tanks.[5]

Kinetic energy penetrators are designed for use against armored targets, such as tanks. The armor on modern battle tanks may resist penetration by conventional high-explosive ammunition shot from ground vehicles and aircraft, but kinetic energy penetrators and precision guided missiles generally have sufficient penetrating power to disable or destroy armored vehicles. The vast majority of the world's armies use kinetic energy penetrators made from tungsten alloy,[6] which has slightly less penetrating ability than depleted uranium, but vastly fewer health, environmental, and political problems are associated with its use.

The United States became the first nation to develop and deploy depleted uranium munitions,[7] but the British were not far behind.[8] The United States military currently employs depleted uranium in armor for the Abrams tank and ammunition fired from tanks, fighting vehicles, and aircraft.[9] A small amount is also used as a catalyst in certain mines.[10] Although some U.S. missiles contain DU,[11] Tomahawk cruise missiles apparently do not include any depleted uranium.[12] Companies in the United Kingdom, France, the Russian Federation, and Pakistan also produce large-caliber (105, 120, 125 mm) tank ammunition made from depleted uranium.[13] In addition, the list of nations known or suspected of possessing depleted uranium ammunition includes Egypt, Israel, Kuwait, Saudi Arabia, Bahrain, the United Arab Emirates, Turkey, Thailand and Taiwan.[14]

Battlefield Use and Exposure

Depleted uranium ammunition is generally used against armored targets (such as tanks and fighting vehicles) and artillery.[15] The energy of the impact of a DU round against a hard target causes roughly 20% of a DU penetrator to vaporize into an extremely fine, respirable-size dust, resulting in contamination of the impact site out to approximately 50 meters.[16] Small amounts of depleted uranium dust will also travel downwind. Depleted uranium rounds that miss the intended target may deposit in soil or water and corrode at varying rates depending on local conditions.[17]

Soldiers who survive an attack by DU ammunition may have wounds containing DU metal and dust. In addition, they will likely have inhaled and/or ingested amounts of depleted uranium dust far exceeding recommended limits on intake.[18] People who subsequently come in contact with contaminated equipment, such as children or scavengers, may also inhale or ingest DU dust or find and collect fragments of depleted uranium metal. A 1995 article in the U.S. Army magazine *Armor* offers practical advice on minimizing exposure to depleted uranium: "If you find radioactive DU contamination on a vehicle, move the vehicle to a site away from water sources, food storage or eating areas, and occupied bivouac sites…Of course, always keep personnel away from contaminated equipment or terrain unless required to complete the mission."[19]

Testing, Training, and Combat Uses

Depleted uranium munitions were developed and tested for about thirty years before they were used in combat. In the United States, the U.S. Nuclear Regulatory Commission issues licenses to the Army, Navy, and Air Force, which allow them to possess and use DU munitions at specific locations.[20] These licenses generally require training for workers and the posting of warning signs in areas containing depleted uranium.

Disposal of depleted uranium from testing and training ranges is controlled by the

Low-Level Radioactive Waste Policy Act (LLRWPA) and its amendments and by Nuclear Regulatory Commission regulations. According to the U.S. Army Environmental Policy Institute, "the Army must manage expended DU ammunition and vehicles contaminated with DU according to LLRWPA."[21]

Within the United States, areas contaminated with depleted uranium are generally either fenced off to restrict public access, or cleaned up through the removal of tons of contaminated soil and debris. Examples of DU sites include:

- Nellis Air Force Range, Nevada: The U.S. Air Force posts radioactive contamination warning signs on target vehicles shot by DU rounds, and it periodically removes solid penetrators from the soil.[22]

- Aberdeen Proving Ground, Maryland: The U.S. Army is overseeing the removal of tons of DU fragments and contaminated soil from a test firing range.[23]

- Jefferson Proving Ground, Indiana: The Army closed this testing range in 1995. The former firing range is contaminated with approximately 69,000 kg/DU. It is now fenced off, access is restricted, and it has been declared a National Wildlife Refuge.[24] Its future use is restricted to industrial or commercial applications; it cannot be used for residential or agricultural purposes, primarily due to the presence of depleted uranium.[25]

Contaminated soil is normally containerized and shipped to a low-level radioactive waste repository.

Two training incidents involving depleted uranium illustrate the conduct of the United States with respect to inadvertent non-combat releases of depleted uranium. In December 1995 and January 1996, U.S. jets accidentally shot 1,500 depleted uranium rounds (225 kg/DU) at an uninhabited island training range located 100 km west of Okinawa in the East China Sea.[26] Though the release of such a small amount of depleted uranium so far from the mainland posed no risk to the Japanese people, the U.S. Air Force quickly sent a team of scientists to the island to clean up as much depleted uranium as they could find.[27] When a Japanese newspaper uncovered the incident, groups opposing the U.S. military presence on Okinawa pointed to the use of DU rounds as evidence of the military's disregard for the environment. However, the Air Force's unilateral decision to clean up the expended DU rounds immediately was precisely the appropriate action to take.

A second incident occurred on February 19, 1999, when two U.S. jets shot 263 rounds of 25mm DU ammunition (39 kg/DU) at Vieques, Puerto Rico.[28] Since the use of depleted uranium at Vieques violated the license issued by the Nuclear Regulatory Commission to the Navy for use of depleted uranium, the Navy promptly dispatched scientists to recover the DU rounds[29], even though the remote location and small amount of DU released most likely present no risk to the health of the island's inhabitants.[30]

The 1991 Gulf War was the first conflict to see the battlefield use of depleted uranium munitions.[31] American aircraft and American and British tanks shot approximately 850,000 small caliber and 9,600 large caliber DU rounds (286,000 kg/DU) in Kuwait and southern Iraq.[32] Although the use of depleted uranium by the Abrams tank received the most post-war hype by Pentagon officials, American A-10 aircraft shot 83% of the total depleted uranium (by weight) released during the war.

Of the tens of thousands of coalition soldiers in Kuwait and southern Iraq at war's end, only approximately three dozen U.S. battle damage assessment and radiation control team members knew how to identify equipment contaminated by DU and were aware of the need to wear protective clothing.[33] These personnel identified and gathered contaminated U.S. vehicles in Saudi Arabia and checked captured Iraqi tanks for DU prior to shipment to the United States.[34]

In accordance with the recommendation of the Army's "DU Assessment Team," six Bradley Fighting Vehicles were buried in Saudi Arabia "based on the observed damage and radiological measurements which indicated substantial non-removable depleted uranium contamination within the hull, turret, and crew compartment."[35] The remaining Abrams tanks and Bradleys were wrapped in tarps and shipped to a new $4 million decontamination facility in Barnwell, South Carolina. Workers wearing protective suits decontaminated some vehicles, but the more heavily contaminated equipment was buried in a nearby radioactive waste dump.[36] The Kuwaiti government hired foreign contractors to gather destroyed Iraqi equipment in its territory, including vehicles contaminated with depleted uranium, in an area of its western desert.[37] The Iraqi government does not appear to have taken any steps to identify or manage contaminated equipment on its lands.

Subsequent uses of depleted uranium ammunition took place during conflicts in the Balkans. In 1994-1995, American A-10 aircraft shot approximately 10,800 rounds in Bosnia, containing 3,260 kg of depleted uranium.[38] In 1999, American A-10 aircraft shot approximately 31,000 DU rounds in Kosovo, Serbia, and Montengro, containing 9,360 kg of depleted uranium in Kosovo, Serbia, and Montenegro.[39]

Few of the rounds shot in the Balkans are believed to have impacted a hard surface with the energy required to create significant amounts of respirable size aerosol. During a typical attack, only 5 to 10 percent of the rounds shot from an A-10 typically hit a target.[40] The low hit rate was compounded in the Balkans by the fact that many of the attacks made on what appeared to be Serb tanks in fact were aimed at wooden replicas.[41] Errant rounds likely deposited in buildings, soil, or water, and may have subsequently corroded.[42] The use of depleted uranium munitions in other conflicts, such as the Russian war in Chechnya or the U.S.-led war in Afghanistan, is uncertain.

The amount of depleted uranium released in a given area during combat may vary widely. During the Gulf War, American tanks and aircraft sometimes engaged dozens of Iraqi tanks in relatively small areas, potentially resulting in large concentrations (hundreds of kg) of depleted uranium dust and debris. In Kosovo, U.S. A-10 aircraft fired between 50 and 2,320 rounds of 30mm ammunition at individual ground targets, representing releases of 15kg to 700kg at various locations.[43] In general, the greatest potential for health and environmental effects of depleted uranium takes place in a small area where large amounts of depleted uranium are used to destroy multiple targets, creating large amounts of depleted uranium dust and debris.

Health and Environmental Effects

The potential environmental and health effects of depleted uranium depend upon a number of factors including: the quantity released; the amount oxidized; the size of the area contaminated; the local air, soil and water conditions and characteristics; and the amount and method of cleanup. The use of depleted uranium munitions may directly expose human populations to DU dust and debris, contaminate food and water supplies, or, if the release is large enough, limit the use of land for agriculture or human habitation.

Most depleted uranium dust will settle in the area immediately surrounding the impact, but small amounts of respirable size DU dust may travel downwind. The hazard to downwind populations depends on the quantity of respirable depleted uranium released, its size, the strength of the wind, and the distance from the point of release. The risk decreases appreciably as the distance from the release increases,[44] but airborne depleted uranium has been shown to travel tens of kilometers.

A 1979 study at the Knolls Atomic Power Laboratory in upstate New York unexpectedly found DU particles in 16 air filters at 3 different locations. The source of the DU particles proved to be the National Lead Industries munitions plant in Colonie, NY, which manufactured 30 mm DU rounds for the U.S. Air Force. Three of the 16 air filters containing DU were located 41 km (26 miles) from the National Lead plant.[45]

Environmental monitoring at U.S. manufacturing plants and test ranges has measured the movement of depleted uranium in surface and groundwater. In 1997, a rainstorm dislodged depleted uranium buried under concrete slabs at Sandia National Laboratory in New Mexico. The depleted uranium had been buried years before during nuclear weapons development. The rain and groundwater scattered the depleted uranium in an adjacent flood plain, requiring the clean up of more than 4,000 barrels of contaminated soil.[46] At the Starmet (formerly Nuclear Metals) munitions plant in Concord, Massachusetts, hundreds of tons of depleted uranium scrap dumped in pits during the manufacturing of 30mm DU rounds has contaminated underground drinking water supplies.[47]

Conversely, the United Nations Environment Programme did not find any signs of depleted uranium in 46 water samples collected from 10 sites in Kosovo where DU ammunition was expended,[48] although it did recommend continued monitoring of groundwater in areas where hundreds of kilograms of DU had been released.[49]

Depleted uranium particles in the air, water, and soil may contaminate plants. Plant surfaces may become contaminated by DU dust, and plants growing in contaminated soil may absorb DU through their roots. The effects of DU on ecosystem function remain unclear, although contamination of farmland with uranium may have a detrimental effect on the productivity of wheat.[50]

Contamination of plants and animals may present a hazard to human populations who live in or secure food supplies from areas containing DU dust and debris. The World Health Organization notes:

> Data regarding bio-uptake of uranium into plants and animals indicates that bioaccumulation factors, while not being high may be in some cases significant over the longer term, particularly where local consumption patterns indicate a preference for foodstuffs shown to potentially bioaccumulate uranium (i.e. kidneys of cattle).[51]

Although consumption of contaminated food and water presents a risk to human health, the greatest hazard is the direct incorporation of DU into the body through inhalation, injection, ingestion, or wound contamination.

Depleted uranium poses an external radiation hazard if the metal is collected and kept close to the body for days on end, but it is most dangerous if it enters the body through inhalation or wounds. Inside the body, depleted uranium's chemical and radiological properties may act independently or cooperatively to cause immediate or delayed health problems. Research on human and animal populations exposed to uranium and depleted uranium has identified several potential health outcomes. These include cancer, immune system damage, nervous system disease, kidney dysfunction, non-malignant respiratory disease, and reproductive effects.[52]

Recent investigations by the World Health Organization and The Royal Society (U.K.) acknowledge the potential for depleted uranium to cause cancer in exposed humans if sufficient amounts of depleted uranium are incorporated into the body.[53] However, both the World Health Organization and the Royal Society downplay the risk of cancer development from brief exposures to small amounts of depleted uranium.

The U.S. Department of Defense conservatively estimates that approximately 866 to 932 American soldiers had moderate to heavy exposures during the Gulf War, including 104 soldiers who were inside vehicles at the time they were struck by DU penetrators.[54] In addition, the Department of Defense estimates untold "thousands" of other American veterans may have inhaled or ingested small amounts of depleted uranium during inspection and routine entry of contaminated vehicles.[55] However, the health effects, if any, of exposure to depleted uranium among U.S. veterans are unclear.

In nearly eight years of existence (1993-2001), the U.S. study of exposed Gulf War veterans has examined a total of just 60 veterans.[56] In 2001, while European governments assessed the health of tens of thousands of their soldiers who served in the Gulf and the Balkans,[57] the Depleted Uranium Program examined only 39 Gulf War veterans.[58]

Among 51 veterans examined by the DU Program in 1999, at least one had Hodgkin's lymphoma[59] and a second had a bone tumor.[60] Another veteran, believed to have had a heavy exposure to depleted uranium when his vehicle was penetrated during the Gulf War, has reported fathering two children born with health problems since the war, although this veteran is not included in the U.S. study.[61]

Despite the presence of records on the Pentagon's own web site confirming the existence of cancer among veterans in the U.S. study, Pentagon spokesmen have repeatedly lied about this topic. In January 2001, when European concerns about depleted uranium used in the Balkans hit a fevered pitch, Pentagon spokesman Dr. Michael Kilpatrick told the Ambassadors of the North Atlantic Council and the NATO press corps: "We have seen no cancers or leukemia in this group, which has been followed since 1993."[62] At a depleted uranium conference in June 2001 in Germany, U.S. Army Colonel Francis O'Donnell similarly told scientists from a dozen European governments that there have been no cancers among the 60 veterans examined by the Depleted Uranium Program since 1993.[63] These denials are apparently part of a Pentagon effort to downplay public concerns about the health and environmental effects of DU munitions. However, the Pentagon's failure to acknowledge publicly the existence of cancer among the few veterans in the U.S. study raises the possibility that other cancers or health effects have been observed, but not publicly reported.

Though there has been no reliable scientific study of the fate of DU in southern Iraq, the Iraqi government has blamed depleted uranium for increased rates of cancers and birth defects among its southern population.[64] Anecdotal reports from journalists and human rights workers in Iraq indicate that civilians entered battlefield areas after the war in search of usable equipment and scrap metal.[65] While Iraqi people may have been exposed to depleted uranium during and after combat, in the last two decades they have also likely been exposed to a variety of other toxins including industrial pollution and chemical warfare agents used by Iraq in the Iran-Iraq war.[66] In April 2001, the World Health Organization and the government of Iraq agreed to a framework for studies of depleted uranium and other environmental health risks. The studies will investigate diseases including cancer and birth defects, DU measurements in affected people, and exposure prevention and research.[67]

Preliminary studies of NATO soldiers who served in the Balkans have found no evidence of health problems related to exposure to depleted uranium.[68]

Legal Analysis

Superfluous Injury or Unnecessary Suffering

Under certain conditions, the use of depleted uranium munitions may result in exposures to humans that cause acute or chronic illnesses or disease. Given the current state of knowledge, it appears a soldier inside a vehicle struck by one or more depleted uranium rounds will receive the highest possible exposure on a battlefield, followed by those who come to his or her rescue. However, it is not at all clear that a child who, some days later, climbs on and enters a contaminated vehicle – or two or three – will not be at a similar or greater risk for developing health problems as the soldier. Several questions arise. In either scenario, could the resultant disease constitute 'superfluous injury' or 'unnecessary suffering', as those terms are currently interpreted under international humanitarian law? In addition, how many people must be affected before the effects reach the threshold for a finding of superfluous injury or unnecessary suffering?

The Preamble to the St. Petersburg Declaration of 1868 describes as "contrary to the laws of humanity" the use of weapons that "uselessly aggravate the sufferings of disabled men, or render their death inevitable."[69] This early codification of the laws of war proposes that it is sufficient to render men *hors de combat* without needlessly increasing their suffering or causing their death. With this principle in mind, the Declaration sought to prohibit any projectile of less than 400 grams, which "is either explosive or charged with fulminating or inflammable substances,"[70] an ancient relic when compared to today's cluster bombs and fuel-air explosives.

The Hague Regulations of 1907 declared, in Article 23, paragraph 1(e), that it is "especially forbidden" to "employ arms, projectiles, or material calculated to cause unnecessary suffering."[71] Interpretation of this declaration turns on the word "calculated." Indeed, depleted uranium may cause illness or disease in people, but its primary purpose is not to cause health effects. Depleted uranium munitions were carefully designed and tested to penetrate the armor on tanks, and to kill the occupants of those vehicles.[72] For these reasons, depleted uranium cannot be described as a weapon "calculated" to cause suffering in the sense that chemical or biological weapons are. Depleted uranium weapons are calculated to disable vehicles and kill people immediately. Any other effects are inadvertent and accidental, even if they are unnecessary and avoidable.

The key test of depleted uranium falls under Article 35 (*Basic rules*) of the 1977 Additional Protocol I to the 1949 Geneva Conventions. Paragraph 2 of this Article states: "It is prohibited to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering."[73] This principle must also be read in conjunction with Paragraph 1: "In any armed conflict, the right of the Parties to the conflict to choose methods or means of warfare is not unlimited."[74]

According to Paragraph 1, a weapon must meet a threshold of necessity. That is, the weapon must serve a legitimate military purpose and be used in a manner that does not exceed the level of violence necessary to ensure the success of an operation.[75] In addition, military necessity must be in accordance with international law applicable to armed conflict, including the rules of the Protocol.[76]

The military necessity of depleted uranium has been strongly asserted by both the U.S. Department of Defense and the U.K. Ministry of Defense,[77] although assertions of necessity by the user of a weapon hardly establish its necessity as a fact. When these assertions are mentioned in the same breath with other statements about the superiority of depleted uranium over tungsten for armor penetration,[78] however, they do carry a probative value.

Evidence against the claim of military necessity is found is the fact that the vast majority of the world's armies use armor-piercing penetrators made from tungsten alloy instead of depleted uranium.[79] While the reasons for the choice of tungsten vary,[80] the fact it is preferred over depleted uranium by a majority of nations does take some air out of the claims of DU manufacturers and users that its necessity is a foregone conclusion.

As it now stands, DU munitions appear to meet the military necessity threshold, although there are significant gaps in information. Depleted uranium munitions serve a legitimate military purpose (destruction of enemy vehicles), they are not normally used in a manner that exceeds the level of violence necessary to destroy enemy vehicles, and their use does not appear to violate any international treaties, customs, or case law applicable to armed conflict. When additional information emerges from an objective source to clarify the comparative advantages and disadvantages of tungsten and depleted uranium munitions, the necessity issue should be revisited.

Depleted uranium weapons could be considered illegal if they cause "unnecessary suffering or superfluous injury" not justified by their military utility. In this case, if the utility is "considerably outweighed"[81] by the suffering caused, the use of depleted uranium munitions could be considered to violate this principle. To date, there is little hard evidence of superfluous injury or unnecessary suffering among combatants related to depleted uranium. The absence of evidence is not evidence of absence of those effects, however, but merely a sign of the lack of scientifically rigorous investigations of the health of soldiers and civilians exposed to depleted uranium.

Signs of the manifestation of excessive injury or suffering would be most likely to arise in veterans from both sides of the Gulf War, for several reasons:

- Large quantities of DU munitions were used;
- Scores or hundreds of vehicles were hit by DU rounds,[82] creating large amounts of DU dust;
- Thousands of soldiers encountered destroyed equipment, some portion of which was potentially contaminated with depleted uranium; and
- Soldiers had little or no knowledge of the presence of DU contamination or methods to avoid exposure.

Studies of the veterans from the Gulf War have been incomplete and inadequate. At least in the United States, this appears to be by design.[83]

Though the U.S. Department of Defense admits "thousands" of U.S. soldiers may have been exposed to depleted uranium, and while it places nearly 1000 in the moderate to high exposure categories, the U.S. study (jointly developed and funded by the Defense and Veterans Affairs departments) has inexplicably examined only 60 veterans in the decade since the war.[84] Some have described this phenomenon as "don't look, don't find": if the government does not investigate the possible effects of depleted uranium on its soldiers, it can plausibly deny the existence of any evidence suggestive of adverse effects.[85]

A British study has not identified any excess cancer deaths among its Gulf War veterans,[86] but given that depleted uranium may have a ten to thirty year latency period for the development of cancer,[87] it is entirely possible that 'superfluous' cancers among exposed veterans have not yet manifested. The Iraqi claims of excessive cancers and birth defects due to depleted uranium merit investigation, but they should be taken in context of their source.

In Bosnia and Kosovo, few soldiers from any force were likely exposed to significant amounts of depleted uranium dust and debris for the simple reason that the vast majority of the rounds fired apparently impacted the ground, thereby minimizing contamination of equipment and the creation and spread of respirable size dust. Nonetheless, the Yugoslav government complained to the International Court of Justice that NATO's use of depleted uranium during the Kosovo conflict was not only having unspecified "far-reaching consequences for human life," but also was "deliberately creating conditions calculated at the physical destruction of an ethnic group, in whole or in part."[88] Unfortunately, the Yugoslav and the Iraqi claims of damage contain little hard evidence to aid international assessments of the existence of superfluous injury.

If current and future investigations link the battlefield use of depleted uranium munitions to cancers, birth defects, or other diseases, it is possible depleted uranium would violate the superfluous injury or unnecessary suffering principle protecting combatants,[89] or rules condemning civilian casualties in excess of the expected military advantage anticipated from an attack.[90] However, it is not clear how many people must be affected before the threshold is crossed. If one soldier developed cancer from exposure to depleted uranium, is the standard met? How many civilians must develop diseases directly linked to depleted uranium to exceed the military advantage of an attack? How many children?

The British Royal Society provides the only reliable prediction of possible excess cancer deaths for combatants and civilians exposed to depleted uranium. For soldiers in the highest category of exposure (in or near vehicles at time of attack), the Royal Society predicts 12 excess lung cancer deaths per 10,000 persons exposed due solely to depleted uranium's alpha radiation.[91] It is worth mentioning again the 1999 finding of one cancer and one bone tumor among 51 U.S. veterans with high DU exposures. While these diseases could plausibly be linked to DU, no nexus has been made.

The Royal Society cancer-death estimate also offers evidence that exposure to depleted uranium may theoretically result in cancers among combatants. For each 100,000 persons (combatant or civilian) with casual exposure to contaminated equipment, the Royal Society predicts only 2.5 excess cancer deaths.[92] This estimate is purely theoretical, but a prosecutor would be hard pressed to justify a claim that two excess cancer deaths among 100,000 people exceed the military necessity of an attack, which the user of DU munitions, at least, would argue was needed to protect three people or more.

If there is any risk to civilian populations, particularly where DU dust and debris are not cleaned up after a conflict, a reasonable minimum standard of behavior could include identification of contaminated areas to local populations, and posting of warning signs. Indeed, the need to carefully record the locations of minefields at sea[93] and minefields, mines, and booby-traps and on land[94] is recognized by international humanitarian law. A similar requirement for depleted uranium seems reasonable and wise.

Although no international law or treaty requires belligerents to report locations of DU use, it is worth mentioning that the North Atlantic Treaty Organization complied with a request from UN Secretary General Kofi Annan to provide a map specifying the locations of DU expenditure in Kosovo, Serbia, and Montenegro, along with quantities of rounds shot at each location.[95] The information was reluctantly provided fifteen months after the cessation of hostilities, but it was provided voluntarily. Authorities of the Federal Republic of Yugoslavia, Montenegro, and NATO subsequently posted warning signs at contaminated sites.

The World Health Organization has recommended cordoning off contaminated areas for testing and possible remediation.[96] The United Nations Environment Programme advises "the appropriate authorities" to undertake the marking of DU-affected sites and provide basic information about the hazard to the local population.[97] The British Royal Society notes "it should be incumbent on nations using DU munitions in future conflicts to advise the local population of the potential dangers of handling fragments of penetrators."[98] These actions and advisories may reflect an emerging *opinio juris* on the need to warn civilian populations about areas of depleted uranium expenditure.

Some suggest the use of DU munitions is a war crime, but depleted uranium appears to fail the requirements for superfluous injury or unnecessary suffering included in the Statute of the International Criminal Court (ICC). The crime of "wilfully causing great suffering" to "one or more persons"[99] can be dismissed, since any superfluous harm resulting from the use of DU munitions is inadvertent and not directly related to the intended use of the weapon. Similarly, there is no transgression of the crime of intentionally launching an attack with the knowledge that the attack would cause incidental death or injury to civilians, or widespread, long-term and severe damage to the environment, which is clearly excessive to the overall military advantage anticipated.[100] However, if depleted uranium munitions were to be listed among the prohibited "weapons, projectiles, or materials or methods of warfare"[101] in the Annex to the Statue, their use would constitute a crime under the ICC Statute.

In the absence of hard evidence from a scientifically rigorous investigation linking depleted uranium to specific health effects in exposed human populations, and clarification of the legal threshold for excessive or needless damage, depleted uranium can not be considered to violate rules prohibiting superfluous injury or unnecessary suffering.

Widespread, long-term, and severe damage

Not even proponents of DU munitions argue that the release of depleted uranium into the environment might have positive effects. A 1990 U.S. Army report, unusual for its candor, notes: "Following combat, however, the condition of the battlefield and the long-term health risks to natives and combat veterans may become issues in the acceptability of the continued use of DU kinetic energy penetrators for military applications."[102] This prediction appears to refer to the acceptability (or un-acceptability) of depleted uranium in the moral and political realms, but perhaps not the in the legal sphere.

The use of depleted uranium munitions generally results in localized areas of contamination around impacted vehicles, and contamination points where DU rounds hit or come to rest in soil or water. Depleted uranium persists in the environment, and over time geophysical and meteorological factors will corrode larger chunks of the metal and disperse particulate in the air, soil, or water. The risk to the environment is related to the amount of the release, the area contaminated, and the extent of measures to cleanup the contamination.

In the wake of the intentional environmental destruction that took place during the American war in Vietnam, international jurists sought to afford the environment greater protection under international humanitarian law.[103] By Article 35, para.3, and Art. 55, para. 1, the 1977 Additional Protocol I prohibits not only the intentional infliction of damage to the environment in the course of warfare, but also purely unintentional and incidental damage that is widespread, long-term, and severe. [104]

Article 35, para. 3, states: "It is prohibited to employ methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment."[105] Article 55, para. 1, similarly states:

> Care shall be taken in warfare to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods or means of warfare which are intended or may be expected to cause such damage to the natural environment and thereby prejudice the health or survival of the population.[106]

Taken together, these articles endeavor to prevent catastrophic effects on the environment and collateral effects on public health.

The Article 35 provision is understood by some commentators to apply to the methods of war, while Article 55 (*Protection of the natural environment*) is aimed at ensuring the survival or the health of the civilian population living in a particular wartime environment.[107] Article 55 appears to be more relevant to the discussion of depleted uranium, since the use of DU munitions does not itself cause serious disruption or damage to the environment. Under certain conditions the presence of contamination in the environment could potentially have effects on water and land use that prejudice, over a long term, the health of a civilian population. The usual collateral environmental damage caused by conventional warfare is excluded from these protections, but it is subject to the basic requirement of military necessity. [108]

The definitions of *widespread*, *long-term*, and *severe* are the essential elements of this prohibition. Unfortunately, the meaning of these terms is unclear. The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) sheds some light on this problem, but the thresholds for damage by ENMOD and Additional Protocol I are not identical and must be interpreted separately.[109] Nontheless, ENMOD defines "widespread" as encompassing an area of several hundred kilometers, and "severe" as involving serious or significant harm to human life or natural economic resources.[110] While ENMOD defines "long-term" as lasting a period of months, or approximately one season, the interpretation of "long-term" under the Protocol is understood to mean decades.[111] Under Protocol I, these terms are understood to collectively proscribe "a major interference with human life or natural resources which considerably exceeds the battlefield damage to be regularly expected in a war."[112]

The vagueness of the determinative terminology complicates an interpretation of depleted uranium under these standards. Under certain conditions, such as the release of thousands of kilograms of depleted uranium in a confined valley, the effects on farmland and water supplies could be severe, but they would not appear to be widespread. Further, they are reversible, provided the area is decontaminated by removal of contaminated soil and treatment of contaminated water. Like landmines, the effects might last for decades, but they need not.

A more likely scenario, played out during combat in the Persian Gulf region and the Balkans, is the use of depleted uranium in varying amounts in disparate locations, in some cases resulting in the release of hundreds or a few thousand kilograms spread over areas of several kilometers, and in other cases resulting localized contamination by a few kilograms consisting of relatively little hazardous and transportable dust.

Ironically, the U.S. Department of Defense's own conduct acknowledges the fact that depleted uranium can cause environmental harm. Cleanups or containment of current and former manufacturing, testing, and training ranges undertaken by the Defense Department within the United States are solidly grounded in municipal law requirements. The military's prompt remediation of insignificant amounts of DU expended in Vieques and Japan reflect not a customary practice rooted in a sense of legal obligation, however, but sensitivity to the moral and political ramifications of the release of depleted uranium in communities actively opposing the U.S. military presence and activities. Although the U.S. removed its contaminated vehicles from Gulf War battlefields and buried or decontaminated them, the U.S. Army Environmental Policy Institute denies any legal obligation for battlefield cleanup of depleted uranium: "No international law, treaty, regulation, or custom requires the United States to remediate the Persian Gulf War battlefields."[113]

The lack of a reliable environmental assessment of the fate of depleted uranium in Kuwait and Iraq limits efforts to assess the environment impact in those areas. One U.S. Army assessment conducted in 1994 found small amounts of depleted uranium in the soil next to contaminated Iraqi tanks that had been gathered in western Kuwait. Some of the entry and exit holes on the tanks exhibited radioactivity levels 20 to 24 times above background. The Army concluded the DU posed little hazard to U.S. troops as long as soldiers did not work in the vicinity of contaminated tanks. [114]

Although most DU rounds shot in the Balkans apparently did not hit a hard target, the United Nations Environment Programme (UNEP) significantly did not find widespread or severe damage from depleted uranium one and a half years after the war in Kosovo. UNEP has, however, recommended future monitoring of groundwater in areas of large DU expenditure.[115]

If the thresholds of widespread, long-term and severe damage could be clearly defined and quantifiable, it is conceivable the use of DU munitions could surpass them in certain circumstances. To date, however, evidence of the effects of the use of depleted uranium in combat does not substantiate a finding of widespread, long-term, and severe damage. In the context of the actual use of depleted uranium munitions in combat, therefore, depleted uranium munitions do not appear to violate rules of international humanitarian law for the protection of the environment.

Conclusion

During the last decade both the interest in and confusion over depleted uranium's health and environmental effects have steadily grown. The governments of Iraq, Yugoslavia, and the United States have all engaged in reckless and unnecessary propaganda on this issue,[116] limiting genuine debate and scientifically rigorous investigation. Claims about the safety or harm of depleted uranium munitions have bounced between the continents, often on the coattails of other geopolitical issues.

Even the ardent defenders of depleted munitions acknowledge that under certain conditions DU may cause acute or chronic health problems. The United States, which is simultaneously the main producer, user, and proponent of DU munitions, places municipal law limits on the release of depleted uranium into the environment, including requirements for public warnings, restricted access, and in some cases remediation. These facts are not easily overlooked.

In an ideal world, the United States would warn civilian populations about areas of DU expenditure, and oversee or undertake cleanup of contaminated battlefields. The recent events of September 11 and its aftermath have provided us with a vivid reminder that this is not an ideal world. There is no consensus on international morality, let alone international law, therefore finding a common ground on depleted uranium is exceedingly difficult. It is not, however, impossible, as demonstrated by the recent success of international efforts to prevent the manufacture and use of land mines.

At this point in time there is a lack of hard evidence to determine conclusively whether depleted uranium causes health and environmental effects sufficient to violate rules of international humanitarian law. The absence of scientifically rigorous investigations of the effects of depleted uranium is a *lacuna* so large and readily apparent that it demands redress if the debate over depleted uranium's effects is ever to be settled.

The most prudent course of action for those concerned about depleted uranium to take is to press for scientific studies of exposed populations and contaminated battlefield areas, while supporting local, national, and international efforts to identify and cleanup areas contaminated with depleted uranium. The use and effects of DU munitions deserve to be vigorously debated in the moral, scientific, and political realms. International law, however, is the improper forum at this time for a substantive discussion on depleted uranium, for the simple reason that there is insufficient evidence to determine whether depleted uranium's effects cross the threshold of excessive and needless harm to human health or the environment. ■

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[2] Since the debate over health and environmental effects is at the core of the depleted uranium controversy, other possible violations of international law (prohibiting against attacks on civilians populations, requiring the use of weapons to fulfill a military necessity, or requiring warnings to civilian populations) are discussed only in passing.

[3] U.S. Department of Energy, "Commercial Recycling of Uranium and Plutonium from Spent Fuel," undated, <http://www.eia.doe.gov/cneaf/nuclear/special/comrecyc.html>; J.R. Hightower, et al, Strategy for Characterizing Transuranics and Technicium Contamination in Depleted UF6 Cylinders ORNL/TM-2000/242, (Oak Ridge National Laboratory, October 2000) 1.

[4] World Health Organization, Depleted uranium: Sources, Exposure and Health Effects (Geneva: WHO, 2001) 23.

[5] The Royal Society, The health hazards of depleted uranium munitions, Part I

(London: The Royal Society, 2001) 2; R. Pengelley, "The DU Debate: what are the risks," Jane's Defence Weekly 15 January 2001.

[6] Jane's Defence, "Depleted Uranium – FAQs", 8 January 2001.

[7] Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), Ad Hoc Working Group for Depleted Uranium, Special Report: Medical and Environmental Evaluation of Depleted Uranium, Volume 1, 1974, vi.

[8] Memorandum by the Ministry of Defence, "Anti-Armour Ammunition with Depleted Uranium Penetrators," March 1979, 2.

[9] Large caliber 105 mm rounds are shot from M60-series tanks and first-generation M1 tanks; 120 mm ammunition is shot from M1A1 and M1A2 Abrams tanks. The U.S. Army's Bradley Fighting Vehicle and the Marine Corps Light Amphibious Vehicle shoot 25 mm DU rounds. The Marine Corps' AV-8B Harrier jet fires 25 mm DU rounds, and the Air Force's A-10 aircraft shoots 30mm ammunition. The F-16 can be modified to an A-16 ("A" signifying "Attack") with the addition of the GPU30 gun pod for close air support. Flown only by the New York National Guard's 174th Tactical Fighter Wing, the A-16 flew only one Gulf War mission (on February 26, 1991), firing approximately 1,000 30mm DU rounds. The Navy uses 20 mm DU rounds for its Phalanx gun, but when its current stockpiles are expended, the Navy will use tungsten alloy munitions. The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 99-104.

[10] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 99-100.

[11] US Army Environmental Policy Institute, Health and Environmental Consequences of Depleted Uranium Use by the U.S. Army, Technical Report (Atlanta: AEPI, 1995) 25.

[12] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 100.

[13] T. Gander and C. Cutshaw, Eds., Jane's Ammunition Handbook, 9th Edition, 2000-2001 (Surrey: Jane's Information Group Limited, 2000) 189, 226-227, 230, 231-232; "Pakistan joins DU producer nations," Jane's Land Forces, 9 May 2001, <http://www.janes.com/defence/land_forces/news/>; C. Foss, Ed., Jane's Armour and Artillery, 2000-2001, 21st Edition (Surrey: Jane's Information Group Limited, 2000) 76.

[14] US Army Environmental Policy Institute, Health and Environmental Consequences of Depleted Uranium Use by the U.S. Army, Technical Report (Atlanta: AEPI, 1995) A-11. T. Gander and C. Cutshaw, Eds, Jane's Ammunition Handbook, 9th Edition, 2000-2001 (Surrey: Jane's Information Group Limited, 2000) 190, 226.

[15] During the Gulf War, A-10 aircraft flew 3,367 flights against artillery and armor units; 175 strikes to destroy Iraqi electronic warfare and ground control intercept sites; 135 attacks against Scud missiles and launchers; 49 strikes to suppress enemy air defenses; and one mission in support of a search and rescue unit. In addition, A-10 aircraft shot down two Iraqi helicopters. U.S. Air Force, Gulf War Air Power Survey Vol. IV, Weapons, Tactics, and Training and Space Operations (Washington, DC: U.S. Government Printing Office, 1993) 53-54.

[16] U.S. Army testing found normally 10-35% (but up to 70%) of the round oxidizes into an aerosol upon impact with a hard target. Twenty percent is commonly used to determine the amounts of dust created by an impact. The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 203.

[17] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 11, 119-122.

[18] The Royal Society, The health hazards of depleted uranium munitions, Part I (London: The Royal Society, 2001) 41-43. See also Annexe C of the Royal Society Report online at <http://www.royalsoc.ac.uk/policy/du_c.pdf>.

[19] Pat Paulsen, "Depleted Uranium Without the Rocket Science," Armor July-August 1995: 34.

[20] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 99.

[21] U.S. Army Environmental Policy Institute, Health and Environmental Consequences of Depleted Uranium Use by the U.S. Army, Technical Report (Atlanta: AEPI, 1995) 71.

[22] U.S. Air Force, Air Combat Command, "Final Environmental Assessment for Resumption of Use of Depleted Uranium Rounds at Nellis Air Force Range Target 63-10", (September 1998), 3-8, 3-9.

[23] Allied Technology Group, "Aberdeen Proving Ground: Transonic Range Depleted Uranium Study Area, Detailed Work Plan" (Oak Ridge, TN: September 1999), 1.

[24] The wildlife refuge covers a large area including the DU impact area. The DU impact area and other portions of the wildlife refuge also contain unexploded ordnance.

[25] Jefferson Proving Ground Restoration Advisory Board, "Meeting Minutes," August 22, 2001, Madison, Indiana.

[26] U.S. Air Force, Detachment 3, Armstrong Laboratory, memorandum for 18th Medical Group, "Consultative Letter (CL), AL/OE-CL-1996-0004, Site Assessment at Aerial Gunnery Range Whiskey 176, Tori Shima, Japan," 18 March 1996.

[27] Ibid.

[28] U.S. Department of the Navy, letter to the U.S. Nuclear Regulatory Commission, Subject: "Improper Expenditure of Depleted Uranium Munitions," Washington, DC, 1 June 1999.

[29] U.S. Nuclear Regulatory Commission, "Technical Evaluation Report: U.S. Navy – Vieques Island Review of Survey Work Plan", Atlanta, GA, 21 March 2000.

[30] See, e.g., Agency for Toxic Substances and Disease Registry, "Focused Petitioned Public Health Assessment, Drinking Water Supplies and Groundwater Pathways Evaluation, Isla de Vieques Bombing Range, Vieques, Puerto Rico," Atlanta, GA, 20 February 2001, p. 10.

[31] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 1.

[32] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 102-106.

[33] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 7.

[34] "Radiological Survey Report on T72 Iraqi Captured Tank Located at Dammaam Port Facility" Report prepared by Douglas L. Rokke, 1LT, Medical Services Corps, undated.

[35] Memorandum to Senior Command Representative (SCR), U.S. Army Armament, Munitions, and Chemical Command – Southwest Asia (AMCCOM-SWA), Subject: "Vehicle Assessment Report Depleted Uranium Contamination," 14 May 1991, 4(O).

[36] US Army Environmental Policy Institute, Health and Environmental Consequences of Depleted Uranium Use by the U.S. Army, Technical Report (Atlanta: AEPI, 1995) 87.

[37] U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), "Vigilant Warrior '94,' 'Forward for the Soldier,' Medical Problem Definition and Assessment Team," (Fort Detrick, MD: 8 May 1995) 17.

[38] U.S. Department of Defense, news briefing by Mr. Kenneth Bacon, 4 January 2001; Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments, Information Paper: Depleted Uranium Environmental and Health Surveillance in the Balkans (Washington, DC: U.S. Department of Defense, 25 October 2001) 4.

[39] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 9, 38, 147. See also, United Nations Environment Programme – Balkans, "UNEP finalises field mission to six depleted uranium sites in Serbia and Montenegro" 4 November 2001, <http://balkans.unep/ch/press011104.html>.

[40] European Commission, Directorate General, Environment (EURATOM), "Opinion of the Group of Experts Established According to Article 31 of the Euratom Treaty, Depleted Uranium," (Luxembourg, March 6, 2001) 2.

[41] See, e.g., Marlise Simons, "Radiation from Balkan bombing alarms Europe" The New York Times 7 January 2001.

[42] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 27-28, 30-31.

[43] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 38, 133.

[44] Richard W. Fliszar, Edward F. Wilsey and Ernest W. Bloore, "Radiological Contamination from Impacted Abrams Heavy Armor," Technical Report BRL-TR-3068 (Aberdeen Proving Ground, MD: Ballistic Research Laboratory, December 1989) 32, 37-38.

[45] Leonard Dietz, "Contamination of Persian Gulf War Veterans and Others by Depleted Uranium," 16 July 1996: 6.

[46] Bill Murphy, "New technology cleans up residue from Sandia's early Cold War weapons test program," Sandia Lab News 50(23), 20 November 1998, <http://www.sandia.gov/LabNews/LN11-20-98/du_story.htm>.

[47] U.S. General Accounting Office, Hazardous Waste: Information on Potential Superfund Sites, GAO/RCED-99-22 (Washington, DC: Government Printing Office, Nov. 1998) 170; Michael Orey, "Uranium Waste Site Has a Historic New England Town Up in Arms," The Wall Street Journal 1 March 2001: B1. See also, "Army, Contracting Firm Named as PRPs for Cleanup at DU site," Hazardous Waste Superfund Week 23(27) (9 July 2001).

[48] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 24.

[49] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 26.

[50] World Health Organization, Depleted Uranium: Sources, Exposure and Health Effects (Geneva: WHO, 2001) 34.

[51] World Health Organization, Depleted uranium: Sources, Exposure and Health Effects (Geneva: WHO, 2001) 41.

[52] Dr. David E. McClain, "Project Briefing: Health Effects of Depleted Uranium," U.S. Armed Forces Radiobiology Research Institute (Bethesda, MD, 1999); U.S. Institute of Medicine, Gulf War and Health, "Volume 1, Depleted Uranium, Pyridostigmine Bromide, Sarin, Vaccines," (Washington, DC: National Academy

Press, 2000) Chapter 4; A.C. Miller et al, "Transformation of Human Osteoblast Cells to the Tumorigenic Phenotype by Depleted Uranium-Uranyl Chloride," Environmental Health Perspectives 106(8), 1998: 465-471; Fletcher Hahn et al, "Depleted Uranium Fragments Cause Soft Tissue Sarcomas in the Muscles of Rats," Project Briefing to the U.S. Department of Veterans Affairs Gulf War Research Conference (Alexandria, VA: January 24, 2001).

[53] World Health Organization, Depleted uranium: Sources, Exposure and Health Effects (Geneva: WHO, 2001) 144; The Royal Society, The health hazards of depleted uranium munitions, Part I (London: The Royal Society, 2001) 22.

[54] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 7.

[55] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Annual Report, November 1996 – November 1997 (Washington, DC: U.S. Department of Defense, 1998) 30.

[56] Melissa McDiarmid, et al, "Health Effects of Depleted Uranium on Exposed Gulf War Veterans," Environmental Research 82(2), February 2000, Academic Press, Orlando, FL. Melissa McDiarmid, et al, "Urinary Uranium Concentrations in an Enlarged Gulf War Veteran Cohort," Health Physics 2001, 80(3): 270-3.

[57] Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments, Information Paper: Depleted Uranium Environmental and Health Surveillance in the Balkans (Washington, DC: U.S. Department of Defense, 25 October 2001) 9-14.

[58] Jane Stolte, U.S. Department of Veterans Affairs, Depleted Uranium Program, email to Dan Fahey, August 17, 2001.

[59] The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, "Meeting with Dr. Melissa McDiarmid and her staff on October 15, 1999 to discuss the Baltimore DU Follow-Up Program and the Extended Follow-Up Program," undated. <http://www.gulflink.osd.mil/du_ii/du_ii_refs/n52en651/0089_005_0000001.htm>. This document confirms that one veteran had lymphoma, and Dr. McDiarmid stated it was a Hodgkin's Lymphoma during a phone conversation with the author on February 12, 2001. Another document on the Pentagon's Gulf War website (GulfLink) notes that the loader of a tank penetrated by a DU round later developed cancer. It is not clear if this veteran is the same veteran later examined by Dr. McDiarmid in Baltimore. See "Interview of loader for A-14," Lead Sheet #18932, 4 November 1998, in The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000), <http://www.gulflink.osd.mil/du_ii/du_ii_refs/n52en376/8244_006_0000002.htm>.

[60] The Department of Veterans Affairs and the Office of the Special Assistant to the Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments acknowledge the existence of the bone tumor in one veteran. The VA's DU Program told the veteran the tumor was benign, but the tumor is not formally documented in a publicly released document. The bone tumor has been reported in the Hiroshima, Japan newspaper Chugoku Shimbun (4/4/00): <http://www.chugoku-np.co.jp/abom/uran/us_e/000404.html>.

[61] "Interview of dismount squad leader of C-22," Lead Sheet #19455, October 15, 1998, in The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000), <http://www.gulflink.osd.mil/du_ii/du_ii_refs/n52en656/8288_010_0000003.htm>.

[62] Michael Kilpatrick, Dr., statement at NATO press briefing, Brussels, 10 January 2001. <http://www.nato.int/docu/speech/2001/s010110b.htm>. At the time of the briefing, Dr. Kilpatrick was Director of the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments.

[63] Dan Fahey, "Meeting Notes for Expert Meeting on 'Depleted Uranium in Kosovo: Radiation Protection, Public Health and Environmental Aspects," Bad Honnef,

Germany, 19-22 June 2001. Colonel O'Donnell is Director of Medical Readiness for the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments.

[64] "Impact of Depleted Uranium on Man and Environment in Iraq," conference notes, (Baghdad, Iraq: December 2-3, 1998). Dr. Alim Yacoup et al, College of Medicine, Basra University, "Further Evidence on Relation between Depleted Uranium, Incidence of Malignancies among Children in Basra, Southern Iraq," undated. See also R. F. Mould, "Depleted uranium and radiation-induced lung cancer and leukemia", Commentary, The British Journal of Radiology, August 2001, 680-681.

[65] E.g., Scott Peterson, "A rare visit to Iraq's radioactive battlefield," The Christian Science Monitor, 29 April 1999.

[66] R.F. Mould, "Depleted uranium and radiation-induced lung cancer and leukemia", Commentary, The British Journal of Radiology, August 2001, 680. See also, Jay E. Austin and Carl E. Bruch, eds, The Environmental Consequences of War: Legal, Economic, and Scientific Perspectives (Cambridge: Cambridge University Press, 2000) 84-85, 437.

[67] Agence France Presse, "Iraq and WHO agree to explore DU and health effects," 12 April 2001. Agence France Presse, "WHO to probe depleted uranium from Gulf War in Iraq," 31 August 2001.

[68] Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Medical Readiness, and Military Deployments, Information Paper: Depleted Uranium Environmental and Health Surveillance in the Balkans (Washington, DC: U.S. Department of Defense, 25 October 2001) 9-15.

[69] Declaration Renouncing the Use, in Time of War, of Certain Explosive Projectiles. Saint Petersburg, 29 November/11 December 1868.

[70] Declaration Renouncing the Use, in Time of War, of Certain Explosive Projectiles. Saint Petersburg, 29 November/11 December 1868.

[71] Convention (IV) respecting the Laws and Customs of War on Land and its annex: Regulations concerning the Laws and Customs of War on Land, The Hague, 18 October 1907, Annex Art. 23(e).

[72] With this intention in mind, it is interesting to note that the survival rate for American crews of tanks and armored personnel carriers penetrated by depleted uranium rounds was 90 percent. One hundred four soldiers survived, some with serious injuries, and eleven were killed. The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 108. The author was unable to find an estimate for the survival rate of Iraqi vehicles penetrated by DU rounds, although it was probably lower due to design flaws, such as lack of blow-out doors, and generations-old armor.

[73] Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, Part III, Section 1, Article 35(2).

[74] Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, Part III, Section 1, Article 35(1).

[75] Sandoz, 396, 399.

[76] Sandoz, 399.

[77] See, e.g., The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, "Remarks by Dr. Bernard Rostker at the American Legion Washington Conference," (Washington, DC: March 23, 1998) 4, 5 <http://www.gulflink.osd.mil/DU_speech.html> ; U.K. Ministry of Defence, "Depleted Uranium – the facts," 2001, <http://www.mod.uk/index.php3?page=2439>; The Office of the Special Assistant to the Deputy Secretary of Defense

for Gulf War Illnesses, Depleted Uranium in the Gulf (II) (Washington, DC: U.S. Department of Defense, 2000) 5.

[78] Jane's Defence Weekly, "Depleted Uranium – FAQs," 8 January 2001.

[79] Jane's Defence Weekly, "Depleted Uranium – FAQs," 8 January 2001.

[80] "As Depleted Uranium (DU) APFSDS-T rounds are not favoured by many nations for environmental or other reasons, Alliant Techsystems has developed a 120 mm Kinetic Energy Tungsten Core (KE-T) round generally similar to the XM827/M829 but with a tungsten penetrator. It is intended to appeal to potential customers of 120 mm smoothbore guns and M1A1/M1A2 Abrams MBTs." T. Gander and C. Cutshaw, Eds., Jane's Ammunition Handbook, 9th Edition, 2000-2001 (Surrey: Jane's Information Group Limited, 2000) 219.

[81] Marco Sassòli and Antoine A. Bouvier, How Does Law Protect in War? (Geneva: International Committee of the Red Cross, 1999) 176.

[82] The author is unable to identify any estimates of the number of Iraqi tanks, personnel carriers, and other vehicles shot by depleted uranium munitions.

[83] Dan Fahey, "Don't Look, Don't Find: Gulf War Veterans, the U.S. Government and Depleted Uranium" (Lewiston: The Military Toxics Project, 30 March 2000) 4-6.

[84] As discussed elsewhere in this paper, of the 51 veterans examined in 1999, one had cancer and one had lymphoma. However, the link between depleted uranium and these diseases, if any, is unknown.

[85] For the phrase 'don't look, don't find', I am indebted to Mr. Paul Sullivan.

[86] R. F. Mould, Depleted uranium and radiation-induced lung cancer and leukemia, commentary, The British Journal of Radiology, August 2001, 680.

[87] N.D. Priest, "Toxicity of depleted uranium," The Lancet 27 January 2001, Vol. 357: 245. Hong Xia et al, "Spatio-Temporal Models with Errors in Covariates: Mapping Ohio Lung Cancer Mortality," Statistics in Medicine (1998) 17: 2038.

[88] International Court of Justice, *Case Concerning the Legality of the Use of Force (Yugoslavia v. United States of America)* Judgment of 2 June 1999, ICJ Reports 1999, General List Number 114, Para. 3.

[89] Since civilians are theoretically protected from attack by other provisions of Protocol I, Paragraph 2 of Article 35 has been interpreted to apply only to combatants. See, e.g., International Court of Justice, *Advisory Opinion on the Legality of the Threat or Use of Nuclear Weapons*, 8 July 1996, General List Number 96, Paragraph 95: "Thus, methods and means of warfare, which would preclude any distinction between civilian and military targets, or which would result in unnecessary suffering to combatants, are prohibited."

[90] Dieter Fleck, ed., The Handbook of Humanitarian Law in Armed Conflicts (Oxford: Oxford University Press, 1995) para 509 (8), (11). See also, Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, Part III, Section 1, Arts. 48, 51, 57.

[91] The Royal Society, The health hazards of depleted uranium munitions, Part I (London: The Royal Society, 2001) 21. The Royal Society expects to issue a second report on the chemical toxicity effects of depleted uranium in the near future.

[92] The Royal Society, The health hazards of depleted uranium munitions, Part I (London: The Royal Society, 2001) 21.

[93] Dieter Fleck, ed., The Handbook of Humanitarian Law in Armed Conflicts (Oxford: Oxford University Press, 1995) para. 1040, 2(b), p. 447; para. 1042 (2), p. 453.

[94] Convention on Prohibitions or Restrictions on the Use of Certain Conventional

Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects; Protocol on Prohibitions or Restrictions on the Use of Mines, Booby-Traps and Other Devices (Protocol II), Geneva, 10 October 1980, Art. 7, para. 1.

[95] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 8.

[96] World Health Organization, Depleted uranium: Sources, Exposure and Health Effects (Geneva: WHO, 2001) 128.

[97] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 39.

[98] The Royal Society, The health hazards of depleted uranium munitions, Part I (London: The Royal Society, 2001) 24.

[99] United Nations Preparatory Commission for the International Criminal Court, "Report of the Preparatory Commission for the International Criminal Court," Part II: Finalized draft text of the Elements of Crimes, PCNICC/2000/1/Add.2, 2 November 2000, Art. 8 (2)(a)(iii).

[100] Roy S. Lee, ed., The International Criminal Court: elements of crimes and rules of procedure and evidence (Ardsley: Transnational Publishers, Inc., 2001) 147; United Nations Preparatory Commission for the International Criminal Court, "Report of the Preparatory Commission for the International Criminal Court," Part II: Finalized draft text of the Elements of Crimes, PCNICC/2000/1/Add.2, 2 November 2000, Art. 8 (2)(b)(iv).

[101] United Nations Preparatory Commission for the International Criminal Court, "Report of the Preparatory Commission for the International Criminal Court," Part II: Finalized draft text of the Elements of Crimes, PCNICC/2000/1/Add.2, 2 November 2000, Art. 8 (2)(b)(xx).

[102] U.S. Army Armament, Munitions, and Chemical Command Task Group, Final Report, Kinetic Energy Penetrator Long Term Strategy Study (Abridged) 24 July 1990, App. D, Vol. 2, p. 3-4.

[103] Dieter Fleck, ed., The Handbook of Humanitarian Law in Armed Conflicts (Oxford: Oxford University Press, 1995) para. 403(1), p. 116.

[104] Dieter Fleck, ed., The Handbook of Humanitarian Law in Armed Conflicts (Oxford: Oxford University Press, 1995) para. 403(3), p. 117.

[105] Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, Part III, Section 1, Article 35(3).

[106] Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, Part III, Section 1, Article 55(1).

[107] Sandoz, 414.

[108] Dieter Fleck, ed., The Handbook of Humanitarian Law in Armed Conflicts (Oxford: Oxford University Press, 1995) para. 403(4), p. 118.

[109] Sandoz, 418.

[110] Jay E. Austin and Carl E. Bruch, Eds, The Environmental Consequences of War: Legal, Economic, and Scientific Perspectives (Cambridge: Cambridge University Press, 2000) 106.

[111] Sandoz, 416, 417.

[112] Dieter Fleck, "Protection of the Environment in Time of Armed Conflict: Environmental Protection in Military Practice," Protection of the Environment During

Armed Conflict, eds. Richard J. Grunawalt, John E. King and Ronald S. McClain (Newport: Naval War College, 1996) 530.

[113] US Army Environmental Policy Institute, Health and Environmental Consequences of Depleted Uranium Use by the U.S. Army, Technical Report (Atlanta: AEPI, 1995) 154.

[114] U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), "Vigilant Warrior '94,' 'Forward for the Soldier,' Medical Problem Definition and Assessment Team," (Fort Detrick, MD: 8 May 1995) 17, 20.

[115] United Nations Environment Programme, Depleted Uranium in Kosovo, Post-Conflict Environmental Assessment (Geneva: UNEP, March 2001) 36, 39.

[116] See, e.g., Kathleen T. Rhem, Sgt. 1st Class, "DoD report: no link between depleted uranium, illnesses" Armed Forces Press Service, 20 November 2001; Gary Sheftick, "Expert dispels myth about depleted uranium" Army News Service, 24 January 2001; The Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses, "Remarks by Dr. Bernard Rostker at the American Legion Washington Conference," (Washington, DC: March 23, 1998) 4, 5 <http://www.gulflink.osd.mil/DU_speech.html>; International Court of Justice, *Case Concerning the Legality of the Use of Force (Yugoslavia v. United States of America)* Judgment of 2 June 1999, ICJ Reports 1999, General List Number 114, Para. 3; "Impact of Depleted Uranium on Man and Environment in Iraq," conference notes, (Baghdad, Iraq: December 2-3, 1998); Dr. Alim Yacoup et al, College of Medicine, Basra University, "Further Evidence on Relation between Depleted Uranium, Incidence of Malignancies among Children in Basra, Southern Iraq," undated.