FIELD STUDIES TO DETERMINE ACCEPTABLE LEVELS OF CONTAMINATION AT FORMER UK NUCLEAR TESTING SITES, MARALINGA AND EMU IN AUSTRALIA

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INTRODUCTION

The Maralinga and Emu regions of South Australia were used between 1953 and 1961 for the UK nuclear weapon development program. Two types of trials were conducted - the major trials involved the detonation of fission weapons and the minor trials dealt with weapon design and operational safety.

The minor trials led to substantial environmental degradation having uncertain consequences since they involved the widespread dispersion of plutonium, beryllium and natural uranium. It is not possible from historic records and contemporary measurements to account for all the material involved in the minor trials. In the case of plutonium, for example, 22 kg was initially dispersed: somewhat less than 2 kg is identifiable as fragments or smaller particulate on or near the surface to a distance of ~ 4 km from ground zero or along well-defined plume deposition zones; some is buried in a series of concrete-capped disposal pits; and the remainder is dispersed, presumably at low deposition concentrations, over a large area.

In 1986, as a result of the findings of the Royal Commission on Nuclear Testing in Australia[2], the UK and Australian Governments agreed to set up a Technical Assessment Group (TAG) with one American, two Australian and two British members to review the Maralinga-Emu situation. TAG was to advise on a series of clean-up options and their associated costs and examine land-use options ranging from unrestricted use by the traditional Aboriginal owners to options involving various degrees of administrative and physical control.

In its interim report, presented in May 1986, TAG observed that the existing data base was inadequate and suggested a series of field and laboratory studies that would partly correct this situation. Six of these studies were concerned with redefining the existing levels of contamination and establishing acceptable levels of contamination for a range of land-use options. This paper discusses the rationale, organisational support, scope and experimental protocol adopted for each of the six studies.

EXTENT OF SURFACE CONTAMINATION

Previously staff of ARL[1] had contoured the levels of ^{239}Pu contamination (by measuring the associated ^{241}Am radioactivity) using hand-held monitors and radiochemical determinations of the ^{239}Pu:^{241}Am ratios. In the main this work described the situation out to open contours equivalent, for example, to about 2 Bq g^{-1} of ^{239}Pu at a distance of 600 m from ground zero at the Taranaki site. ARL also identified several plumes of Pu contamination originating from Taranaki; the north-west plume, was followed to a distance of 32 km where the contamination level was 20 m Bq g^{-1} of ^{239}Pu[1].

TAG proposed an aerial survey followed by a vehicular survey in order to more fully map the contamination levels. The contract for the former was let to EG&G through the US Department of Energy. The Royal Air Force supplied the two Wessex helicopters. In all, 223 on-line survey flying hours were completed for a survey distance of 39 000 km over an area of about 1 500 km^2. The advanced data reduction programs used by EG&G achieved detection limits that were better than expected and significantly reduced the scope needed for the land survey which is to follow.

LAND USE

It is anticipated that the most restrictive land use will revolve around those Aboriginal groups which have claims on the Maralinga and Emu lands. Some rural Australian Aboriginals have, over the last twenty years, reverted to a more traditional life-style. This is due largely to changing social attitudes amongst Aboriginals and non-Aboriginals and has been made possible by political change and the relaxation of legislative control. The change is evident in the formation of 'outstations' where the traditional social relationships have been re-established. These groups derive some of their food supply from 'bush-tucker', particularly for those food items that were traditional favourites (e.g. kangaroo, some reptiles and grubs).

The anthropological study will concentrate on quantifying the life-style of an out-station community living at Oak Valley (100 km north-west of Maralinga) to determine the nature and importance of the various exposure routes. Key elements of this study include dietary composition, methods for food preparation, practices that enhance the intake of soil and fire-ash through inhalation and ingestion, exploitation of the various land systems and the likely occupancy of the Maralinga and Emu lands when these are returned to them.

EXPOSURE ROUTES

INHALATION

Conventional wisdom suggests that inhalation of ^{239}Pu-^{241}Am is the most restrictive exposure route. The studies deal with five aspects of the problem.

Between 1957 and 1966, dust hazes, local dust storms and regional dust storms were recorded. The yearly frequency and mean associated wind speed (m s^{-1}) were - dust haze : 1.6, 11.6; local dust : 1.6, 12.2; dust storms : 1.2, 12.7[3].

To record the air concentration of Pu/Am that will arise from such events, eight battery-operated/solar-charged continuous air samplers have been installed. These low volume samplers are cut-in and cut-out by a built-in anemometer set 7 and 6 m s^{-1} respectively.

To emulate dust-raising activities, a series of human activities (shovelling, digging etc) will be carried out up-wind of a high volume air sampler. A dust-raising unit (large fan, wind chambers, high volume air sampler) will also be run at several of the locations to acquire information on particle size and specific activity of wind-suspended contamination.

Personal air samplers are used to monitor exposure of Aboriginals to dust. The experiments are of one of three classes. Certain activities, e.g. digging for grubs and rabbits, earth-oven preparation, children's games, riding the back of a pick-up truck along bush tracks, will be simulated working in contaminated land. Other activities e.g. sleeping on the ground, ceremonial performances, being down-wind from large 'comfort' brush fires will be monitored with fixed samplers in uncontaminated areas. The third category will involve the use of Aboriginal volunteers wearing the samplers in uncontaminated areas while undertaking activities judged by the anthropologists as likely to lead to the highest dust loadings.

The samplers for the second and third categories will record only the dust loading (respirable dust in mg h^{-1} of the physical activity). The results will be converted to radioactivity inhaled, based on the ratio of particle size distribution in the uncontaminated areas to the specific activity/particle size distribution in the contaminated areas.

INGESTION

Sampling is concentrated on those bush food items found to be important by the anthropologists. Observations suggest that substantial amounts of soil and fire-ash are ingested with the food, be it of bush tucker or supermarket origin. The quantity of contaminated soil and ash consumed will be determined by preparing the food in the Aboriginal way.

WOUND CONTAMINATION

As a result of their life-style and the harshness of the environment, Aboriginals receive more cuts and abrasions than would non-Aboriginals. In the Oak Valley community, ceremonial cutting is no longer practised, but this could change over time. The potential for significant wound contamination is enhanced by the traditional treatment which can involve packing the wound with mud.

The importance of wound contamination depends markedly on two factors - the specific activity of the contamination and the metabolic fate of such discrete sources which find their way into cuts. The first is being addressed in the land survey and the second by the bioavailability studies.

BIOAVAILABILITY

The basic position is that where the ICRP has recommended values for the dosimetric parameters, they become 'default' values and the purpose of the experimental bioavailability studies is to ensure, where possible, that the default values are sufficiently conservative. The significance of this policy is detailed below for each of the exposure routes.

Inhalation

At least initially both the ICRP[5] and NVO[4] lung dosimetry models will be used. Among the more important parameters in these models are: the percentage translocated from the upper respiratory tract to the gut, the distribution of the contamination between the three classes of lung solubility (D, W,Y) and the percentages translocated to the liver, kidney, bone, thoracic and abdominal lymph nodes. The experimental program is aimed at all but the first of these parameters.

In vitro solubility in lung fluid and a few lung retention measurements on material of intermediate specific activity will provide the bridge between data obtained using high specific activity in the animal work and those for material drawn from areas having an acceptable level of contamination.

Ingestion

The primary dosimetric factor is that for the gut transfer (f_1). The ICRP recommends[6] that 'on taking account of the many factors that have been shown to influence the absorption of plutonium compounds in animal species (maturity, dietary deficiencies, fasting, chemical form), a value of 10^{-3} for f_1 is considered cautious and unlikely to be exceeded by a significant amount in any critical group of adults'. Further, it is stated that this value 'gives a sufficient margin of safety for radiation protection purposes in all situations where the intake cannot be described precisely'. From the discussion of limits for occupational workers 'precisely' can be interpreted as where 'the chemical and physical state of the ingested material can be confidently established'.

In a quasi-technical sense, there could be a range of views on the adequacy of an experimental f_1 value for soil/ash relative to, say, Pu citrate. If we assume that these are in the same ratio of animal results on Pu oxide/Pu citrate would this constitute a 'precise' description of the soil/ash contamination in terms of the ICRP recommendations?

An overriding problem with respect to f_1 values for Aboriginals living traditionally is the importance of consumption habits (fasting) and nutrient status. The anthropologists are attempting a partial quantification of these factors.

Wound Contamination

The dosimetric strategy to be followed with respect to wound contamination is to equate the annual risk coefficient for mortality to that equivalent to 1 mSv y^{-1}. The probabilities covered are: a wound being inflicted, the wound becoming contaminated, translocation of contamination from the wound site, organ distribution of the translocated contamination, and the risk coefficient for the wound site and other exposed organs.

CONCLUDING REMARKS

The field studies outlined above are derived from ideas contributed by TAG members and the individual study leaders. They take account of several unique features:

- the lack of even phenomenological descriptions for the events that caused the Pu/Am contamination;
- an arid environment;
- land uses that include Aboriginals following a fairly traditional life-style;
- uncertainties on how the Aboriginal culture and land-use will change over time;
- the more than usual amount of uncertainty that surrounds the dosimetric factors and how the recommended values may change over time.

The quality of our predictions can only be judged when we have got most of the field data. At the present rate of progress this is expected to be in 1989.

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