

**VIDEO AND OTHER MATERIAL AND DATA
ACQUIRED BY GREENPEACE INTERNATIONAL AT
AND AROUND THE IRAQ TUWAITHA NUCLEAR
SITE DURING 2003**

COMMENTS AND OPINION ON THE INFORMATION

JOHN H LARGE

LARGE & ASSOCIATES – CONSULTING ENGINEERS

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GREENPEACE SORTIE AT TUWAITHA NUCLEAR RESEARCH CENTRE

- 1.1 I am **JOHN H LARGE**, Consulting Chartered Engineer, Fellow of the Institution of Mechanical Engineers, Graduate Member of the Institution Civil Engineers, Member of the British Nuclear Society and a Fellow of the Royal Society of Arts. I am Chief Executive of the firm of Consulting Engineers Large & Associates specialising in nuclear technology.
- 1.2 I consider myself adequately qualified and sufficiently experienced to provide opinion on this matter.¹

2 PREPARATIONS OF GREENPEACE INTERNATIONAL CAMPAIGN TEAM

- 2.1 Prior to this particular Greenpeace campaign the team leader, William Peden, instructed me to advise Greenpeace on a number of radiological protection matters, including review and evaluation of the risk assessment for the campaign.²

¹ From the mid-1960s through to the late-1980s, John Large was a full-time member of the research and teaching academic staff of Brunel University, undertaking postgraduate research for the United Kingdom Atomic Energy Authority (UKAEA) and teaching in the School of Engineering. Since 1986, he headed the firm of Consulting Engineers, Large & Associates. Large & Associates provides engineering and analytical services relating to nuclear activities, systems failure and engineering defects. Over the last 20 or so years, John Large have given evidence to a number of United Kingdom House of Commons parliamentary select committees on nuclear and related environmental topics, represented and provided evidence at a number of public inquiries for local authorities on nuclear issues in the United Kingdom, and also given evidence and/or advised a number of overseas governments, states and commissions on nuclear matters, including the Government of Italy on irradiated fuel transportation; Japan on decommissioning nuclear power plants; New Zealand on MOX fuel transportation and, separately, the risks and hazards associated with the berthing of nuclear powered vessels; the Republic of Ireland on the environmental and health impact of sea discharges from the British Nuclear Fuels plant at Sellafield, UK; the State of Bulgaria on the preparedness of emergency plans at the Kozloduy nuclear power complex; the Oblast (state authority) of Sverdlovsk (now Ekaterinburg) on decommissioning; the Finnish Parliamentary assembly on the vulnerability of nuclear facilities to terrorist attack; the government of South Africa on a confidential matter; and I have visited and reviewed a number of radioactive waste regional facilities in the now former Soviet Union. More recently, John Large acted for the Government of Gibraltar advising on the safety of the repairs being undertaken to the reactor of the Royal Navy nuclear powered submarine HMS *Tireless* whilst emergency berthed at Gibraltar during much 2000, involving assessment of the nuclear safety case for the reactor (pressuriser pipe saddle) repairs with this role including evaluation of issues relating to security of the submarine whilst berthed in the busy commercial port of Gibraltar. Throughout 2001, John Large organised, headed and was responsible for the specialist team assessing the nuclear reactor and conventional weapons hazards of the sunken Russian Federation nuclear powered submarine *Kursk*, advising the Russian Federation government and the salvers Smit-Mammoet through the salvage operations, being responsible for the nuclear risk assessment and the implementation radiological protection regime on board all of the salvage vessels. The team comprised 8 to 10 specialists of reactor technology, naval weaponry, radiation protection and submarine design, including a serving Commander from the Royal Navy's Naval Nuclear Regulatory Panel seconded to Large & Associates for the duration of operations. The team was required to negotiate directly with the submarine designers RUBIN and the Russian Federation Northern Fleet, and to approve all procedures prior to each stage of the salvage being permitted to proceed – John Large was responsible for the overall radiological safety of all 250 or so personnel involved in the salvage operations. John Large was awarded a commemorative medal by the Russian authorities for my contribution to the successful salvage of the *Kursk*. During his research work for the UKAEA John Large was involved with and/or attended UK facilities involved in the manufacture and enrichment of fuel and fissile components, with radioisotope production and with chemical separation of irradiated fuel, so in these respects he is very familiar with these processes and the arrangements and equipment dating from the mid-1960s.

² This included:-

- a) to arrange for the maintenance and recalibration of radiological equipment and personal electronic dosimetry;

- 2.2 Previously I had provided William Peden and other Greenpeace personnel with essential training and practice in the use of the radiological equipment, in the procedures to be adopted when working in a suspect radiological area, particularly respiratory protection, personal decontamination, taking and removal of samples, and for the maintenance of personal dosimetry records.
- 2.3 Following being informed of the destination of the campaign, that being in and around the nuclear facility at Tuwaitha,³ I provided the Greenpeace team with an illustrated review of the range of radioisotopic sources and nuclear materials that I would have expected to have been present on the site during normal and peace times, and that would (or should) have been secured at the site by the incoming Coalition Forces.
- 2.4 **In summary:** I am satisfied that the Greenpeace International team involved in this sortie in Iraq were adequately equipped, trained and informed to undertake their objective tasks in a safe, competent and reliable manner.

3 ANALYSIS OF THE VIDEO ENTITLED '*IRAQ EXPEDITION – 27 JULY 2003*'

- 3.1 I have been specifically instructed to review the *Iraq Expedition* video but, in addition to the video, previously I received short video clips and still photographs, a complete log of the personal radiation dose records (both electronic dosimeter and film badge results) for all campaign team members, and I have examined and checked the calibration of all of the radiation measuring equipment used during the campaign.
- 3.2 From my assessment of the radiation dose records and urine sample analysis I am satisfied that the campaign was indeed conducted in a radiologically contaminated area,

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- b) to identify the appropriate protective clothing and equipment, sample containers, etc.;
 - c) similarly, to arrange for the purchase of the appropriate body and extremity film badges (and for the subsequent development of these);
 - d) to arrange, in advance, for urine samples to be analysed at an accredited laboratory, together with the provision of the appropriate grade of sample phials; and
 - e) to review the HAZOP (Risk & Hazard Assessment) for the campaign.

³ The Tuwaitha Nuclear Research Centre (TNRC) is located 20 km south of Baghdad and operated as the centre of the Iraq nuclear research program and as an administration and servicing centre for industrial and medical radio-isotopes. The TNRC comprises 2 separate areas, a main complex (Sites A/B) which is comprised of approximately 90 buildings surrounded enclosed by earth banks, and a smaller area (Site C) consisting of 3 buildings surrounded by a barrier-wall used to store processed uranium (yellowcake). Many of the buildings at Sites A/B were damaged by bomb and/or missile attack and subsequently heavily looted and stripped of equipment and materials..

that all individual members of the campaign team were subject to radiation exposure (to varying levels that loosely corresponded to their respective tasks).⁴

- 3.3 From the urine samples, the dominant presence of uranium isotopes 235/238 in the proportion of that natural abundance (ie 0.7% U-235) indicates to be that that some or all of areas visited by the campaign were freely contaminated with dusts of natural uranium (probably in yellowcake form).
- 3.4 I also had analysed a batch urine samples collected by the campaign team taken from other individuals. I have been asked not to discuss these in detail, other than to note that the levels of these other samples were exceptionally high consistent, in my opinion, with these individuals being continuously exposed to a uranium contaminated environment. One urine sample of this batch, included a slightly enriched (2.9%) uranium contaminant suggesting both that this individual had been subject to a different source and that there had been no cross contamination between this and the other samples (and it follows, between all samples).
- 3.5 The *Iraq Expedition* video shows views of residential settlements nearby the Tuwaitha centre, including a school, one or two collections of scrap (ie scrap yards) nearby; a very crude lead smelting facility; and various locations within the Tuwaitha A/B site.
- 3.6 **APPENDIX I** identifies nuclear materials and equipment that most probably originated from the Tuwaitha centre, although it is illustrative rather than an exhaustive itinerary.
- 3.7 At all of the localities outside the Tuwaitha centre the Greenpeace team found evidence of equipment and materials that had been removed from the centre, and here and there (ie with no obvious pattern of distribution) radiological activity was present.
- 3.8 The video records suggest that two modus operandi of equipment and materials removal: First, there is the obvious looting by individuals (see women wearing black garb sorting through debris) which primary relates to relatively small scale items being carried away by hand and on improvised trolleys. Then, second, there is the removal of large items, far too large to be removed by hand and which must have required disassembly and
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demolition experienced groups with mechanical handling equipment (cranes, fork lifts, etc) to the extreme where it seems that an entire factory building and its storage area has been dismantled (see unclad factory building with large items of ventilation equipment, etc strewn about the floor).

- 3.9 The radiological activity, reported by the Greenpeace team in terms of *times-over-background*, relates to both dispersed radioactive emitting materials and discrete point radioactive sources.
- 3.10 An example of a sealed radioactive source is the black cylindrical object (about 200mm diameter by 150mm height) shown in the video and which was subsequently removed by US soldiers. Smaller radioactive source terms are shown in the video, some of these remain in the original packaging and there is at least one that has been removed from its shielding (by the penknife).
- 3.11 Of the larger objects, the Greenpeace team located a uranium yellowcake feed hopper (the tundish-shaped object) which was heavily contaminated with encrusted yellow cake powder – the hopper was laying alongside a public road, its internal space was completely open with the inspection panel (of about 1000mm by 400mm) removed, and samples of yellowcake were easily removed. This open hopper, laden with loose yellowcake powder presented a source of continuous radioactive contamination, readily dispersed by passing vehicles.
- 3.12 Another section of the video shows young men operating an ad hoc lead smelter, casting lead into ingots. Although not confirmed, it seems that the primary source of the lead feedstock to the smelter was looted from the Tuwaitha centre. The centre would have utilised lead for shielding for radioisotope packaging, in hot cells and other ‘activity’ work,⁵ so this crude open air smelting could result in efficient dispersion of any radioactive contaminants and/or contents of looted lead components from Tuwaitha. If, on the other hand, the contents of any packaging were removed by looters prior to feeding to the smelter then their individual radiation exposures could be expected to be very high.

⁴ These individual exposures were within the whole body dose equivalent limits prescribed for the campaign.

- 3.13 **In summary:** My viewing and analysis of the video, together with my assessment of the individual dose exposures of the Greenpeace team members and the uranium-urine sample results for them and others, suggest to me that a considerable amount of radioactive material and contamination has been removed from the secure areas of the Tuwaitha Nuclear Centre.
- 3.14 Whereas some of this radioactivity may have been taken far away from the Tuwaitha centre and some may have been secured (part of which has been removed completely) by the Coalition Forces, it is clearly demonstrated by the Greenpeace video that unacceptable levels of radioactive materials are present in the local environment and that the communities living in that environment have and continue to be subject to intolerable levels of radiation exposure (both externally and, as confirmed by the urine results, by internally deposited emitters).
- 3.15 The video footage suggests at least two waves of looting: The first wave seems to have been highly organised and well equipped for the task in hand, judging from the several factory and storage areas stripped bare of what must have been heavy machinery and bulky materials – much of this equipment and material seems to have disappeared. The second wave of looting seems to have been completed relatively well organised groups of individuals, stripping out semi-valuable materials such as the lead shielded packaging to be subsequently smelted into lead ingots.
- 3.16 The video shows that this looting continued (at least until June-July 2003) with second/third waves of looters picking over the remnants left behind by others. These looters, and those that have preceded them, have no means of detecting radioactivity, they have no protection whatsoever, and there are no (apparently) signs and notices warning them of the dangers of their seemingly desperate activities.
- 3.17 Also, I note that the US Army Center for Health Promotion and Preventive Medicine (USACHPPM)⁶ stated that ‘a comprehensive radiation health risk had not been

⁵ Later in the video when the yellowcake hopper is being put into storage, there is a brief shot of what seems to be lead smelting equipment.

⁶ Some of the US soldiers and the Lt Colonel interviewed in the video wore the insignia of USACHPPM.

performed prior to June 2003', although a radiation survey had been undertaken between 17 to 27 June 2003.⁷

- 3.18 It seems to me that from the evidence of the Greenpeace video, the USACHPPM radiation survey was either ineffective or, at least, did not cover the areas surveyed by Greenpeace. For example, for the USACHPPM '*experts in radiation, health physics, environmental science, and nuclear medical science*'⁷ overlooked the large and obviously contaminated yellowcake feed hopper abandoned in a public place.
- 3.19 Another oversight by the Coalition Forces is that as one facet of radiological protection US military personnel are assigned (on average) to the Tuwaitha Centre for no more than 5 days. These personnel are classified into three groups of potential exposure with the highest *Category I* group receiving a maximum of 1.1 Rem (11 mSv)⁸ exposure for such a 5 day stint.
- 3.20 On this basis, and as the Greenpeace video clearly shows, those looters picking through the Tuwaitha Centre day after day after day, are at high risk of grossly exceeding the relatively high whole body dose exposure limit set for US occupational forces. Much the same conclusion on the potential for excessive exposure may be assumed for the other locations identified by Greenpeace, that is by schools and in residential communities where there is little or no knowledge of the health risk and detriment resulting from uncontrolled radiation exposure.

4 **INSTALLING ORDER AND RADIOLOGICAL MANAGEMENT SAFEGUARDS**

- 4.1 My understanding is that until the commencement of military hostilities on 19 March 2003 the regime was maintaining order at the Tuwaitha Centre. The International Atomic Energy Agency (IAEA) inspection team removed itself from Iraq two days earlier on 17 March. The hostilities formally ended on 9 April at which time Coalition Forces had effective control of Iraq.

⁷ Tuwaitha Nuclear Research Center, Information for Health Care Staff, USACHPPM. 17 November 2003 - <http://chppm-www.apgea.army.mil/usachppmresources/TNRCProviderFactSheet-17Nov03.pdf>

⁸ For comparison, 50mSv per year is the US Nuclear Regulatory Commissions recommended exposure limit for peacetime occupation of US military personnel – this also compares to the ICRP annual dose limit recommendation of 1mSv per year for the general civilian population (in peacetime and for those not directly employed in nuclear activities)..

- 4.2 However, Coalition Forces did not arrive at the Tuwaitha Nuclear Centre until early May and, as previously noted, a radiation survey was not undertaken until 17-27 June. So, with central government control broken down and in the absence of any security at the Tuwaitha Centre, about one month passed with no security presence at the site during which wide scale looting was rife (including, so it seems, the complete disassembly and removal of a factory), and thereafter another month passed until the USACHPPM undertook a radiation survey. Even after the Coalition Forces had established themselves at the Tuwaitha Centre looting on the site openly continued.
- 4.3 We now know from the Greenpeace video that the USACHPPM radiation survey was either ineffective or was not carried out beyond the Tuwaitha Centre site boundary.
- 4.4 The role of the forthcoming IAEA Safeguards Inspection⁹ is to check and verify remaining nuclear material in Iraq,¹⁰ in line with Iraq's NPT safeguards agreement with the Agency. The problem confronting the inspection team is that large amounts of nuclear material and radioactive components have been removed by the United States,¹¹ that unknown quantities and types of radioactive materials and source terms have been looted, either being removed from the locality or discarded in the locality without any regard for or knowledge of the health harm and environmental damage that will surely ensue.
- 4.5 Judging from the degree of looting and the state of dereliction and abandonment of the areas shown in the video, I gauge that it would be virtually impossible for any team of IAEA inspectors now to reconstruct a reasonably reliable record of the activities and

⁹ IAEA Director General ElBaradei said that the Agency is planning to conduct a safeguards inspection in Iraq this month., IAEA 20 July 2004 - Since 17 March 2003, the IAEA has not been in a position to implement its mandate in Iraq under United Nations Security Council resolution 687 (1991) and related resolutions.

¹⁰ The range of radioactive materials under preparation and/or storage at Tuwaitha prior to the invasion would have included new radioisotopes under preparation/packaging and, more likely, spent isotopes in storage or final disposal, as well as relatively small quantities of uranium yellowcake, and laboratory quantities (grammes) enriched uranium and plutonium. The number of spent radioisotopes in storage/disposal at Tuwaitha could have been very large, accumulating from industrial and medical diagnostic use over three or more decades.

¹¹ The United States informed the IAEA on 30 June that approximately 1.8 tons of uranium enriched to a level of 2.6 percent, another 6.6 pounds of low-enriched uranium, and about 1,000 highly radioactive sources had been transferred on June 23.

radioactive inventory of the Tuwaitha Centre prior to invasion by Coalition Forces. In effect, this means that it will not be possible to determine, to any reasonable prospect, the quantities, types and chemistry of any radioactive material that has been moved off site, some of which is now known to have been dispersed amongst the local communities and into the environment.

- 4.6 **In Summary:** Even with the best intent, the IAEA inspection team is unlikely to succeed in reconstructing what remains of Iraq's nuclear stockpile, just like the nursery rhyme:

*Humpty Dumpty sat on a wall:
Humpty Dumpty had a great fall.
All the King's horses and all the King's men
Couldn't put Humpty Dumpty in his place again.'*¹²

JOHN H LARGE
Large & Associates, London

30 July 2004

¹² *Through the Looking Glass*, Chapter 11, Lewis Carroll

APPENDIX I

MATERIALS AND COMPONENTS IDENTIFIABLE IN THE VIDEO

<p>Rooms Stacked with Equipment</p>	<p>Comprises mainly loose rack stored equipment, computer components, and general debris.</p> <p>Of interest, a number of electronic radiation contamination monitoring modules, etc., indicating this equipment was removed from a radiologically active area – probably a radio-isotope preparation and/or monitoring area. Equipment manufacturers are US, UK, German, French and others</p> <p>Amongst the floor debris, there is (possibly) two HEPA filter cartridges (orange and green - new and unused), a HEPA cartridge mounting frame (aluminium), some fan/extraction volute casing (red), all confirming that this looted equipment was taken from a facility involved in radiological activities (probably, packaging and distribution of radio-isotopes).</p>	<p>1) Note, along with the computer components, this equipment dates for the 1970-80s, indicating that the subsequently applied sanctions regime was effective.</p> <p>2) There is nothing that sinister or specific in the video to suggest any nuclear weapons development programme.</p> <p>3) Assuming that all paper records have been destroyed or lost, the computer hard drives are likely to be the only source of records of the activities of the facility – the computers themselves look to be pre-network vintage, so the data held on each individual unit would have to be retrieved for analysis in order to reassemble the activities as a whole.</p>
<p>Lead Smelting and Scrapyard</p>	<p>The metal being crudely smelted and cast into ingots is lead.</p> <p>The source of this lead is unknown and there is little to indicate from the video scenes of the scrapyard (other than a few capsules lying around the pile of sacks, which could be radio-isotopic, lead shielded containers) that the lead derives from some radioactive shielding function.</p>	<p>This type of nuclear facility would deploy relatively large quantities of lead for the shielding of radioactive isotopes – it may have had its own lead smelting facility to cast various shapes of lead cloaks for radioisotope packaging.</p> <p>If the source of the lead being smelted in the video included active packaging then those retrieving the lead (either by removing the inner radioisotopes or simply burning the radioisotopes in the smelter) could have been subject to significant radiation exposure.</p>
<p>Derelict Factory</p>	<p>These factory building seem to have been exhaustively looted to the extent that it is impossible to identify the function of the disassembled equipment strewn about the floor.</p>	<p>Some of the video shots include pieces of large trunking and pipework that could have been part of an air handling ventilation system – such a system operating in a radiologically active area would be expected to be contaminated with fine dusts and debris, likely to be radioactive to a low degree.</p>
<p>Women Looting</p>	<p>These looters picking amongst the debris seem to be turning over the discarded remnants of earlier looters.</p>	<p>The plant areas appear to be in such a chaotic state that any controls applying to (in a radioactive sense) radiologically active units would have been lost, so any individual present within the perimeter of the plant would be subject to risk of exposure. Of course, removing radioactive items for the site could (and it likely to have) spread the radioactive risk off site.</p> <p>Originally the Tuwaitha A/B site was surrounded by a earth bund and security fencing which must have been breached for access of these and earlier looters.</p>
<p>Black Container</p>	<p>Typical shielded package for a sealed source term</p>	<p>The US soldier refers to a radiation rate of '6mR' by</p>

removed by US Troops	(radioisotope)	<p>which he means 6 milliRem per hour or 60μSv per hour (micro or 10⁻⁶ Sievert).</p> <p>However, it is not clear whether the rate is a surface dose rate or that taken at some distance from the surface of the source packaging. The radiation source inside the package would be emitter at a very much higher rate depending on the attenuation provided by the package shielding.</p> <p>Interestingly, as the Humbie jeep prepares to turn into the main track, in doing so turning past a Greenpeace team member standing about 1.5m from the source now in the jeep, after two seconds, the Greenpeace member's personal dosimeter rate alarm is triggered. This enables the radiation emission rate at 1.5m distance to be roughly assessed since the alarm threshold was set at 0.1μSv/hr so, at 1.5m distance, the source was emitting at (0.1/2*3600=) 180 μSv/hr which is 18mRem and not at the lower rate 6mRem stated by the US soldier.</p>
Open Scrapyard	On the foreground a set of hot cell manipulator arms, there are views of what seem to be uranium hexafluoride containers, 200 litre drums that are often used for transport of semi-processed uranium in yellowcake form, and a uranium yellowcake powder feed hopper (subsequently transported into a secure storage area by the US troops).	It is not obvious that the hot cell ends of the manipulators shown in this shot have been decontaminated.
Radioactive Sources	Various radioactive sealed sources of IAEA Category II – YELLOW with some labels showing the transport index or TI. The labelling shows the sources to have originated from the USA (Amersham International and elsewhere) and UK (UKAEA) dating from the 1980s.	This category of sealed source packaging requires the surface dose rate to be between 500 μ Sv/h and 500 μ - these surface dose rate limits apply to the transportation phases activity at the time of delivery, which, for most industrial/medical radioisotopes would have by now (20 or so years later) considerably decayed.