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Sandia National Laboratories Support of the Iraq Nuclear Facility Dismantlement and Disposal Program

John R. Cochran and Jeffrey J. Danneels

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Abstract

Because of past military operations, lack of upkeep and looting there are now enormous radioactive waste problems in Iraq. These waste problems include destroyed nuclear facilities, uncharacterized radioactive wastes, liquid radioactive waste in underground tanks, wastes related to the production of yellow cake, sealed radioactive sources, activated metals and contaminated metals that must be constantly guarded.

Iraq currently lacks the trained personnel, regulatory and physical infrastructure to safely and securely manage these facilities and wastes. In 2005 the International Atomic Energy Agency (IAEA) agreed to organize an international cooperative program to assist Iraq with these issues. Soon after, the Iraq Nuclear Facility Dismantlement and Disposal Program (the NDs Program) was initiated by the U.S. Department of State (DOS) to support the IAEA and assist the Government of Iraq (GOI) in eliminating the threats from poorly controlled radioactive materials. The Iraq NDs Program is providing support for the IAEA plus training, consultation and limited equipment to the GOI. The GOI owns the problems and will be responsible for implementation of the Iraq NDs Program.

Sandia National Laboratories (Sandia) is a part of the DOS's team implementing the Iraq NDs Program. This report documents Sandia's support of the Iraq NDs Program, which has developed into three principal work streams: (1) training and technical consultation; (2) introducing Iraqis to modern decommissioning and waste management practices; and (3) supporting the IAEA, as they assist the GOI. Examples of each of these work streams include: (1) presentation of a three-day training workshop on "Practical Concepts for Safe Disposal of Low-Level Radioactive Waste in Arid Settings;" (2) leading GOI representatives on a tour of two operating low level radioactive waste disposal facilities in the U.S.; and (3) supporting the IAEA's Technical Meeting with the GOI from April 21-25, 2008. As noted in the report, there was significant teaming between the various participants to best help the GOI.

On-the-ground progress is the focus of the Iraq NDs Program and much of the work is a transfer of technical and practical skills and knowledge that Sandia uses day-to-day. On-the-ground progress was achieved in July of 2008 when the GOI began the physical cleanup and dismantlement of the Active Metallurgical Testing Laboratory (LAMA) facility at Al Tuwaitha, near Baghdad.

Acknowledgments

The Iraq Nuclear Facility Dismantlement and Disposal Program is managed by Mr. David Kenagy of the U.S. Department of State's Bureau of International Security and Nonproliferation. The accomplishments detailed in this report are a direct result of David's efforts.

Several technical specialists at Sandia National Laboratories contributed to the success of this work. These specialists include: Bill Arnold, Carolyn Daniel, Stacy Griffith, Sid Gutierrez, Marvin Hadley, John Inman, Tim Jackson, Franz Lauffer, David Miller, Joe Schelling, Ken Sorenson, Brian Thomson and Anisha Quiroz.

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Executive Summary

There are a number of sites in Iraq which have been used for nuclear activities and which contain or potentially contain significant amounts of radioactive waste. The principal nuclear site is the Al-Tuwaitha Nuclear Research Center, located 18 km from downtown Baghdad. The Al Tuwaitha Nuclear Research Center contains about 18 nuclear facilities including two research reactors, hot cells, a fuel fabrication facility, plutonium separation facilities, and other support facilities. Many of these sites suffered substantial physical damage during the Gulf Wars and have been subjected to subsequent looting. All require decommissioning and proper management of the radioactive wastes in order to ensure both radiological and non-radiological safety.

Unfortunately, Iraq has lacked the infrastructure needed to decommission its nuclear facilities and manage its radioactive wastes. Examples of this lack of infrastructure include the facts that:

- Iraq has no decommissioning or waste disposal laws
- The Government of Iraq (GOI) has not appointed a regulatory body to govern decommissioning or was-e disposal
- Iraq has no national radioactive waste management strategy
- Iraq has no system for classifying radioactive wastes
- Iraq did not have an interim storage facility for radioactive waste
- Iraq has never had a licensed radioactive waste disposal facility, and
- Iraq lacks professionals with experience in decommissioning and modern waste management practices.

The U.S. Department of State (DOS) initiated the Iraq Nuclear Facility Dismantlement and Disposal Program (the NDs Program) to provide international expert advice, training and capacity building to Iraq's former nuclear scientists so the GOI can execute nuclear facility dismantlement and waste management in accordance with international standards. The Iraq NDs Program has given priority to achieving "on-the-ground progress." Implementation of the Iraq NDs Program will also build human capacity so that the GOI can manage other environmental cleanups in their country.

Sandia National Laboratories (Sandia) is a part of the DOS's team implementing the Iraq NDs Program. The U.S. members of the Iraq NDs Program include the U.S. Department of Energy (DOE), Texas Tech University, the U.S. Environmental Protection Agency, the U.S. Nuclear Regulatory Commission and others. This report documents Sandia's participation in the Iraq NDs Program from September, 2006 through March, 2009. This Sandia participation has developed into three principal work streams:

(1) Training and technical consultation
(2) Introducing Iraqis to modern decommissioning and waste management practices, and
(3) Supporting the International Atomic Energy Agency (IAEA), as they assist the GOI.

In implementing the first work stream, training and technical consultation, Sandia:

- Provided electronic copies of Sandia's *Radiological Worker II Training Materials* to the GOI.

- Made sustentative recommendations to Iraq's Ministry of Science and Technology (MoST) for improvements to MoST's *LAMA Quality Assurance Project Plan.*
- Provided *Project Management Plan Training* and helped the MoST write a project management plan (PMP) for the Stage 1 Decommissioning of the LAMA facility. Sandia provided the instructors, training materials and per diem for the Iraqis, and the IAEA provided the air fare for the Iraqis, a quality assurance (QA) expert and the meeting facilities in Vienna (this is an example of teaming to help the GOI). The value of this training has been twice demonstrated. First, when MoST chose to submit the LAMA Stage 1 PMP to Ministry of Environment's Radiation Protection Center (MoENV's RPC) for regulatory consideration, and second, when MoST chose to begin the decommissioning of the GeoPilot Plant in Baghdad by preparing a PMP.
- Provided a *Conceptual Design of a Sort and Store Facility for Radioactive Waste,* based on the sort and store facilities at Sandia and tailored to the situation at Al Tuwaitha.
- Trained RPC trainers (train-the-trainer) in how to teach U.S. DOE-style *Radiological Worker II classes.* The training, coupled with the electronic copies of Sandia's Radiological Worker II Training Materials, gives the GOI a long-term resource for training their workers in safe radiological work practices.
- Provided very detailed, experience-based advice presented in Appendix C on *Considerations for Purchase and Use of Radiation Protection Equipment* for the decommissioning work at Al Tuwaitha.
- Provided a four day training class to the MoENV and MoENV's RPC on *Monitoring Groundwater at Liquid Radioactive Waste Tanks.* The training was a combination of classroom instruction and field trips to observe operating equipment.
- Provided a three day training workshop on *Practical Concepts for Safe Disposal of Radioactive Waste in Arid Settings* in Amman, Jordan. The training was synchronized with the IAEA and IAEA Consultancy Meetings, with Sandia providing all meeting facilities. In addition to the six Iraqis, five representatives from the Jordanian Nuclear Regulatory Commission and the Jordanian Atomic Energy Commission participated in the training. The training gave technical staff and government officials from Iraq and Jordan a detailed understanding of the activities necessary to develop and operate safe facilities for the disposal of radioactive waste.

In implementing the second work stream, introducing Iraqis to modern decommissioning and waste management practices, Sandia:

- Hosted GOI representatives at the WM'07 Symposium, the largest waste management symposium in the world with over 600 scientific and policy presentations and exhibits by over 100 vendors of equipment for decommissioning and waste management. Sandia made a presentation on the Iraq NDs Program on the opening day of the Symposium.
- Led Iraqi scientists through two operating U.S. radioactive waste disposal facilities with climatic and geohydrologic conditions similar to those in some parts of Iraq; exposing GOI representatives to modern radioactive waste management practices and equipment. Seeing these operating low-level radioactive waste (LLW) disposal facilities, in settings

similar to those in some parts of Iraq, helps make tangible the possibility of a licensed LLW disposal facility in Iraq.

- With support from the IAEA, Sandia helped the Chairman of the Iraqi Radioactive Sources Regulatory Authority present a paper and a poster on the characterization and cleanup of the nuclear facilities in Iraq at the International Conference ICEM'07.
- In collaboration with the IAEA, supported a GOI representative making a presentation at the International Decommissioning Challenges Conference in Avignon, France in the fall of 2008.

In implementing the third work stream, <u>support of IAEA technical meetings</u>, Sandia:

- Provided technical support to the IAEA's Working Group 3 Technical Meeting of 13 - 17 November 2006. Sandia contributed to the general discussions and made a specific presentation on the value of developing a PMP and Sandia created a draft law for disposal of radioactive waste in Iraq.
- Participated in the IAEA's Technical Meeting of 21 - 25 April, 2008 on the decommissioning of Iraq's former nuclear complex. Sandia provided a presentation and a Conceptual Design for a Waste Sorting and Storage Facility in Iraq.

In 2006, the GOI had almost no plans, no procedures, no teams and *no infrastructure* to initiate on-the-ground decommissioning at Al Tuwaitha. Two years later, in July 2008 the GOI began the on-the-ground dismantlement of the LAMA facility at Al Tuwaitha. This fieldwork marked the great progress made by the GOI, with support by the international community, the IAEA and the Iraq NDs Program.

The Iraq NDs Program will require U.S. / international support for 2-3 more years after which GOI will be able to continue almost independently. The exceptions are decommissioning and disposal of problematic wastes.

Mr. Kenagy writes:

> The Iraq NDs Program is helping the GOI demonstrate to their citizens and the world that Iraq is ready for partnership in the international community. Iraqi citizens have long been gravely concerned about the environmental impacts and health consequences of the contaminated skeletal remains of Sadam's nuclear program at Tuwaitha. The GOI has the manpower and money to fix the problem; but needs scientific advice and technical training. The Iraq NDs Program has created a framework for Iraq's former nuclear scientists to collaborate with the IAEA and international experts to ensure their nuclear facilities are disposed in accordance with international standards. This will help Iraqi citizens realize that the GOI is on their side. The bombed buildings are all that remain of Sadam's nuclear weapons ambition and their final disposal will appropriately end this chapter in history. The United Nations (UN), the IAEA and the international community are already taking note. Iraq NDs is well suited to build positive links between Iraq, IAEA, UN and cooperating countries to help Iraq become a full partner in the international community.

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1. Introduction

The U.S. Department of State (DOS) contracted Sandia National Laboratories (Sandia) to join the team supporting the Iraq Nuclear Facility Dismantlement and Disposal Program (the Iraq NDs Program). The Iraq NDs Program provides expert advice, training and limited equipment to Iraq, so the Government of Iraq (GOI) can cleanup its radioactively contaminated facilities / locations and safely dispose of its radioactive wastes. The program is organized in association with the International Atomic Energy Agency (IAEA) and has participation of several countries (see http://www-ns.iaea.org/projects/iraq/). The DOS is coordinating the U.S. government assistance from Sandia, the U.S. Department of Energy (DOE), Texas Tech University, the U.S. Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC) and others. As noted in the report, there was significant teaming between the various participants to best help the GOI.

There are a significant number of nuclear facilities / locations in Iraq. Of these facilities / locations, the Al Tuwaitha Nuclear Research Center, located 18 km southeast of downtown Baghdad, is the most important. The Iraq NDs Program has focused on Al Tuwaitha, which contains major facilities left from civilian research and Sadam Hussein's nuclear weapons program. The Al Tuwaitha central nuclear complex (the area inside the security berm) covers more than a square kilometer and includes the remains of two research reactors, a fuel fabrication facility, plutonium separation facilities, and other support facilities. The Osiraq research reactor at Al Tuwaitha was bombed by Israel in 1981. The remaining facilities were destroyed and disabled during Operation Desert Storm in 1991. In 2003, following Operation Iraqi Freedom, looters removed contaminated scrap metal and tens of 50-gallon yellowcake barrels from which they had dumped out the yellowcake. There are other sites in the country that are contaminated and will require decommissioning and remediation to ensure radiological safety.

Because of past military operations, lack of upkeep and looting there is now a safety and radioactive waste problem within the Al Tuwaitha central nuclear complex and other locations which contain various:

- uncharacterized radioactive wastes
- uncharacterized liquid radioactive waste in underground tanks
- wastes related to the production of yellow cake
- sealed radioactive sources
- activated metals, and
- contaminated metals.

Iraq has never had an authorized radioactive waste disposal facility and the lack of a disposal facility means that ever increasing quantities of radioactive material must be held in guarded storage.

Iraq currently lacks the trained personnel, regulatory and physical infrastructure to safely and securely manage these facilities and wastes. The Iraq NDs Program is providing training, consultation and limited equipment to the GOI. The GOI owns the problems and will be responsible for dismantling and disposing of the facilities.

As described in this report, Sandia has provided support to Iraqi professionals from the Iraqi Radioactive Sources Regulatory Authority (IRSRA), the owner of the Al Tuwaitha complex (the Ministry of Science and Technology (MoST)), and MoST's Radiation Protection Center (RPC).

This report documents Sandia's support of the Iraq NDs Program, which has developed into three principal work streams: (1) Training and Technical Consultation; (2) Introducing Iraqis to Modern Decommissioning and Waste Management Practices; and (3) Supporting the IAEA, as they assist the GOI.

On-the-ground progress is the focus of the NDs Program. Much of the work is a transfer of technical and practical skills and knowledge that Sandia uses day-to-day, although the cleanup of a destroyed and looted nuclear complex is unique, with no direct analogues in the U.S.

Layout of this Report

This report is divided into seven topical areas. These topical areas, in the order of their presentation are:

- Background information on the nuclear facilities in Iraq and the conditions at the beginning of the Iraq NDs Program (Chapter 2)
- A brief history of the Iraq NDs Program and Sandia's work scope (Chapter 3)
- An overview of the training and technical consultation provided to the GOI by Sandia (Chapter 4)
- A description of work activities that introduced Iraqi scientist and engineers to modern decommissioning and waste management practices (Chapter 5)
- An overview of work activities supporting the IAEA, as the IAEA assists the GOI (Chapter 6)
- A summary of recent Iraqi progress in cleaning-up and dismantling the LAMA facility (Chapter 7), and
- Summary and Conclusions (Chapter 8).

Because this report is organized by topic and not chronologically, it is important to explain the focus of the Iraq NDs Program on the Active Metallurgical Testing Laboratory (LAMA) stage 1 dismantlement. All of the nuclear facilities / locations in Iraq require dismantlement in order to ensure both radiological and non-radiological safety. However, it is not possible to undertake the dismantlement of all sites and facilities at the same time. The IAEA and the GOI developed and used a prioritization methodology to aid the decision-making process. The methodology ranked the sites and also determined that none of the facilities / locations posed an eminent threat to safety. Because of Iraq's isolation from the international nuclear community over the last two decades and the lack of experienced personnel, the ranking was modified and the decision was made to initiate dismantlement operations on a low risk facility in order to build capacity and prepare for work to be carried out in more complex and high hazard facilities. The LAMA facility at Al Tuwaitha was the lowest risk facility and was therefore chosen as the first facility to undergo dismantlement. LAMA was then divided into four stages. For these reasons, much of the Sandia support of the Iraq NDs Program is in support of the start of the stage 1 dismantlement at LAMA.

2. Nuclear Facilities in Iraq

2.1 Nuclear Facilities in Iraq

There are a significant number of facilities and locations in Iraq that handled/processed radioactive and nuclear materials in support of peaceful research and Saddam's nuclear weapons program. These facilities / locations include:

1. Al-Tuwaitha Nuclear Research Center
2. Location C (Al-Wardia)
3. Al-Qaim (Unit 340)
4. Al-Jesira (Al-Ramah building)
5. Adaya Disposal/Dump Location (Location 7)
6. Tarmiya
7. Geo Pilot Plant, Bagdad
8. Al-Atheer
9. Rashdiya
10. Naddaf (Location B)
11. Facilities which may have minor contamination
    i. Metallurgy Centre (Taji)
    ii. Basra Magnesium Plant

Of these facilities / locations, the Al Tuwaitha Nuclear Research Center, located 18 km southeast of downtown Baghdad, is the most significant. The Al Tuwaitha central nuclear complex covers over one square kilometer within the bermed area and was the main site for peaceful nuclear research as well as the Iraqi nuclear weapons program.

Activities at Al Tuwaitha included several research reactors, plutonium separation and waste processing, uranium metallurgy, neutron initiator development and work on a number of methods of uranium enrichment. One reactor (French OSIRAQ 40 MWT) was destroyed by Israel in 1981, just before the reactor was fueled. The remaining nuclear facilities were bombed and disabled during the 1991 Operation Desert Storm. A detailed description of the facilities at Al Tuwaitha is provided by the IAEA in Appendix A.

<u>Current Situation</u>

The fresh highly enriched nuclear fuel, spent nuclear fuel and low enriched uranium and all the yellowcake have been removed from the country, along with approximately 1,000 radioactive sealed sources. Bunker B at the Al-Tuwaitha site was secured in 2003 and then used as a storage site for radioactive materials from the site and elsewhere in Iraq. Aside from this activity, the sites that previously housed Iraq's nuclear facilities remain in a radioactively-contaminated and hazardous condition. Figure 2-1 shows some of the Russian low-level radioactive waste (LLW) cemetery at Al Tuwaitha. Each well in Figure 2-1 is believed to be 4 m deep, and the inventory documentation was lost. Figures 2-2 and 2-3 were prepared by Mr Kenagy and present a collection of photographs taken by the Multi-National Force - Iraq and DOS of the current conditions at Al Tuwaitha; which is in urgent need of final decommissioning, dismantlement and site remediation.

Figure 2-1: Russian "Cemetery" for LLW at Al Tuwaitha

Figure 2-2: Photographs of the Osirqa Reactor site at Al Tuwaitha Nuclear Complex

Figure 2-3: Photographs of Waste Management Facilities at Al Tuwaitha

2.2 Conditions at Beginning of Iraq NDs Program

In addition to the urgent problems at Al Tuwaitha, Iraq faced a number of other problems when the program began:

- The security situation limited all types of travel and work in Iraq
- Iraq has never had a licensed radioactive waste disposal facility
- Iraq's radioactive waste conditioning facility and radioactive waste storage facility are in disrepair
- It does not have an interim storage facility for radioactive waste
- Radioactively contaminated materials have been dumped at border crossings
- Iraq has no national radioactive waste management strategy
- Iraq has no system for classifying radioactive wastes
- There is a lack of some basic resources, in particular electricity (which prevents the use of computers and email)
- The GOI has not appointed a regulatory body to govern decommissioning and radioactive waste disposal
- There are no decommissioning or waste disposal laws, and
- Iraq lacks professionals with experience in decommissioning and modern waste management practices.

The Iraq NDs Program is helping the GOI resolve many of these issues and thereby insure radiological safety and security for its citizens. The human capacity and physical infrastructure being developed to cleanup Al Tuwaitha could be used by the GOI to address many other environmental problems Iraq faces.

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3. Iraq NDs Program and Sandia's Scope

3.1 Iraq NDs Program History

The following history of the NDs Program is extracted from the 27 July, 2006 "U.S. Proposal for International Cooperation in the IAEA Iraq NDs Program," Overview and Year One Funding Proposal," written by W. David Kenagy.

> Iraq began discussing its radioactive waste problems with the IAEA during a DOS-arranged July 2004 meeting between Minister Rashad Omar of the Iraqi Ministry of Science and Technology and senior IAEA officials. In late 2004, Iraq officially requested that the IAEA assist Iraq with decommissioning, dismantlement, and disposal of its former nuclear facilities, including organizing an international assistance program for this purpose. The IAEA agreed to assist.
>
> The groundwork for the Iraq NDs Program was set at an IAEA meeting in Vienna in February 2006, attended by the Iraqi Minister for Science and Technology plus forty-two participants from sixteen countries and the European Commission. The purpose of this meeting was to determine the extent of damage on Iraq's nuclear facilities that used radioactive material prior to the Gulf wars, with the view of assessing the impact on the general public and the environment. A number of presentations were made to define the scope of the project and indicate challenges that will be faced. A proposed general approach to move forward was discussed and agreed upon. In the broadest sense, the Iraq ND's Program is best categorized as a radioactive waste, health and safety issue.
>
> However, the Iraq NDs Program also addresses several issues that overlap US nonproliferation goals in Iraq by:
>
> - making possible the final disposal of dangerous radioactive sources through construction of a licensed disposal facility
> - providing rewarding professional employment for former Iraq WMD scientists, and
> - making it possible to collect and dispose contaminated scrap metal which hampers efforts to monitor Iraq borders.
>
> In addition to these goals, it is expected that the program will also provide a mechanism to continue support to the newly formed Iraq Radioactive Source Regulatory Authority (IRSRA) which was formed by CPA Order 72.
>
> Following the meeting the DOS organized an interagency working group to develop a proposal to assist in the IAEA Iraq NDs Program. The working group members are as follows:

→ DOS - ISN/NESS David Kenagy - coordinator for US project to develop a radioactive source regulatory infrastructure in Iraq

→ DOS Iraq WMD Scientist Redirect Program

→ U.S. Nuclear Regulatory Commission (NRC) – NRC's International Nuclear Regulatory Development Projects

→ U.S. Environmental Protection Agency (EPA) - EPA's International Nuclear Cooperation Projects in Russia

→ Oak Ridge National Laboratory - DTRA/DOE MAXIMUS project to remove enriched uranium and 1000 radioactive sources from Iraq

→ Sandia National Laboratories – John Cochran and Jeff Danneels – Risk Assessment, International Project: Egypt

→ Texas Tech University - Dr. Carlton Phillips DOS/PTR Fellow, nonproliferation coordinator in Iraq under CPA, developed Iraq WMD Scientist Redirect Program and Dr. Ronald Chesser, Director of TTU's Center for Environmental Radiation Studies and currently managing the environmental monitoring project at Tuwaitha.

The working group met and held consultations for several months to develop the proposal presented here. The proposal that emerged is limited to helping train and organize the Iraqis to do the cleanup job on the ground themselves. We also expect to provide a limited amount of specialized equipment. This said, we believe that helping the Iraqis prepare to do the work on the ground is no small task. In addition to the actual work on the ground, there is normally a massive amount of scientific and technical preparatory work required to organize and execute a radioactive waste management program and to develop a radioactive waste disposal facility, if the demolition and disposal is to be done in accordance with international standards.

<u>Objectives</u>

The overall goals of the Iraqi NDs Program are to cleanup radioactively contaminated facilities and safely dispose of the radioactive wastes in Iraq. There are several near-term objectives for the program:

1. Developing Management Plans to organize, schedule, monitor and ensure the integration of a multitude of participants to meet all operational, quality assurance, safety, and security requirements.
2. Develop draft regulations to protect the citizens, workers and future generations from the hazardous effects of ionizing radiation.
3. Characterize the sites and wastes to determine what the inventory of materials will be for disposal. Part of the characterization task will involve the development of a prioritization scheme for the sites and the waste streams.
4. An enormous task will be carrying out the actual decommissioning and demolition program to segregate, stabilize and package the wastes. This objective will likely include the development of centralized and/or secure storage facilities. Once remediated, sites will be demolished and closed.
5. Siting, characterizing, licensing, constructing and operating appropriate waste disposal facilities to permanently eliminate the hazards of radioactive waste in Iraq.

U.S. Proposal

The U.S. proposal for assistance to the Iraq NDs Program is illustrated in Figure 3-1.

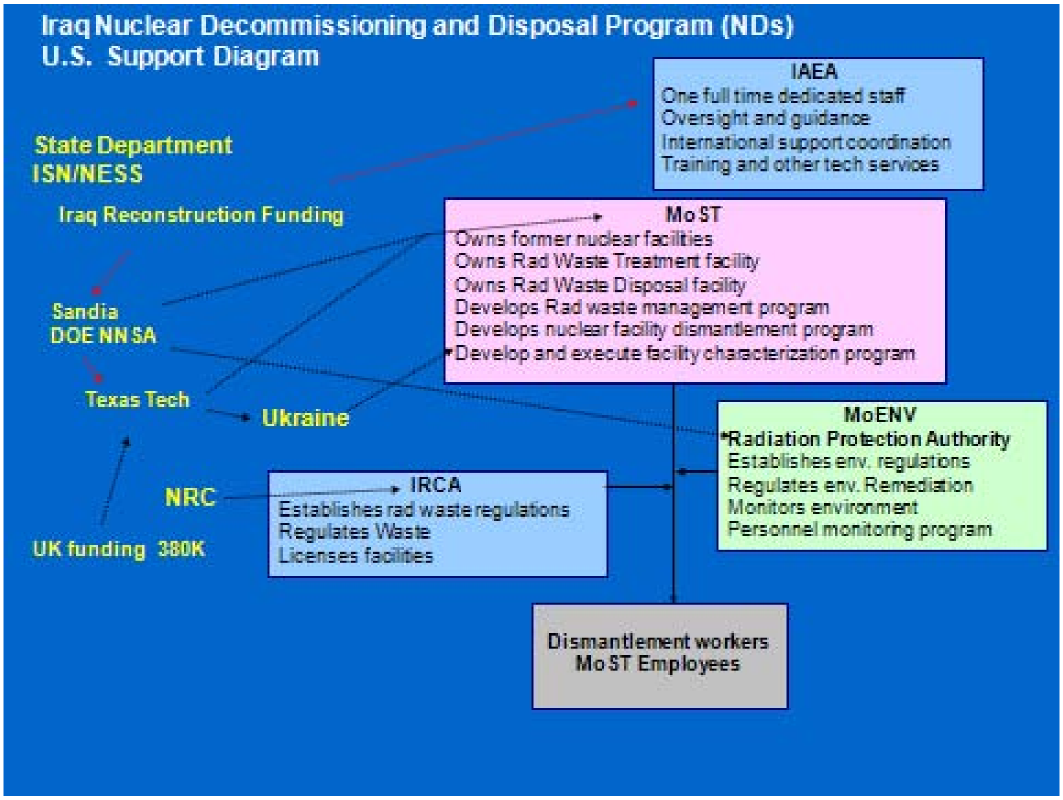

Figure 3-1: Diagram of U.S. proposal for assistance to the Iraq ND's Project

In the proposal the IAEA will provide overall guidance and a mechanism to organize other international participation. ISN/NESS will coordinate the U.S. program of assistance to the Iraq ND's Program.

In Iraq, the Ministry of Science and Technology (MoST) owns the former nuclear facilities. They also own the existing Radioactive Waste Treatment facility. The existing waste treatment facility has suffered from significant looting. It is not clear that it is feasible to restore the facility to operation or that the radioactive waste treatment processes and machinery it contains are those appropriate to the needs. The facility was designed to support a different program. The proposal hypothesizes that MoST will also own the radioactive waste disposal facility when it is constructed. (Iraq has never had a disposal facility). For these reasons the proposal is that MoST should take the lead in developing the radioactive waste management and disposal program, and nuclear facility dismantlement program. MoST should also execute the dismantlement program via contracts with a proposed new "Iraq Nuclear Services Company" formed from WMD Scientists. In the proposal for U.S. support, Sandia

National Laboratories will provide training and technical consultative assistance to MoST to help them accomplish their tasks.

The Iraq Radioactive Sources Regulatory Authority (IRSRA) has been authorized and staff are working to develop a program to manage sources of ionizing radiation in Iraq. In addition to the physical problems, and young regulatory infrastructure, the current security situation in Iraq hampers all aspects of radioactive waste management.

IRSRA will establish the radioactive waste regulations. As the program progresses, IRSRA will license the waste treatment and disposal facilities and regulate the radioactive waste. In the proposal for U.S. support, NRC will provide training and technical consultative assistance to IRSRA to help them accomplish their tasks.

Iraq did not have a Ministry of Environment (MoENV) in the past. The MoENV was established under the CPA. Within the MoENV there already exists an Iraq Radiation Protection Center (RPC). The RPC will be responsible for establishing radiological environmental regulations**,** regulating the environmental remediation as the dismantlement and disposal process progresses and performing radiological environmental monitoring. The RPC is also going to manage Iraq's personnel monitoring program. In the proposal for U.S. support, EPA will provide training and technical consultative assistance to MoENV/RPC to help them accomplish their tasks.

The overall goals of the US Iraq NDs Support program are:

1. Improve the radiological health and safety conditions for citizens living near nuclear facilities
2. Final disposition of Iraq yellowcake by sale and removal from the region
3. Secure final disposal of Iraq's dangerous radioactive sources
4. Help relieve border monitoring problems associated with contaminated scrap metal
5. Developing and strengthening Iraq governmental regulatory institutions, IRSRA and MoENV
6. Constructive employment of Iraq WMD scientists, and
7. Develop MoST's project management skills.

As of this writing regulatory authority issues in Iraq are still unclear – IRSRA, the MoENV's RPC and other appropriate government officials are working to resolve the issue.

Characterization, collection and management of the contaminated scrap metal at border crossings remains a problem, but has receded in priority. The Iraq NDs Program has approached this problem several times and from several angles. What has been decided is that MoST will be responsible for cleaning up radioactive waste, including scrap, at their former nuclear facilities and the RPC is involved in a project to identify and monitor depleted uranium and other radioactive scrap in the countryside (not clean up). Finally, the owner of Tuwaitha, MoST, has taken the lead in dismantlement of the nuclear facilities. MoST is executing the work using their own personnel.

3.2 Sandia National Laboratories Support of the Iraq NDs Program

In 2002, Sandia staff approached DOS staff with a proposal to improve the infrastructure to manage radioactive sealed source in Iraq. The fist few sentence of that proposal are presented below:

> Construction of Infrastructure to Manage the Radiation Sources in Iraq
> J Cochran, Sandia National Labs draft 5/29/2002
> ***jrcochr@Sandia.gov***
>
> OVERVIEW
> The reconstruction plan for Iraq must include the development of an infrastructure to safely locate, secure, and manage highly radioactive materials. Exposure to radioactive sources (RS) poses a serious threat to the populace and environment in Iraq as well as U.S. and other peacekeeping forces in the area. The accidental mismanagement and exposure to RS has caused a large number of people to receive very high, and even fatal doses of radiation. The need for this infrastructure is also especially critical in Iraq at this time, because unsecured radioactive materials can be weaponized for use in a dirty bomb or as a direct killing device. This is growing area of international concern in the post-September 11th environment.

In 2006, Sandia was funded by the DOS to support the Iraq NDs Program. The first allocation was received at Sandia on 28 September, 2006 for $400 K (actual to Sandia $388 K) and the second allocation (titled mod 1) was received on 3 January, 2008 for $950 K (actual to Sandia $922 K). Funding and scope were defined in an Interagency Acquisition Agreement (IAA) between DOS and the DOE/NNSA/Sandia Laboratories Site Office. The total duration of the work was from 28 September, 2006 to 31 March, 2009 Funding for the IAA originates in the Iraq Relief and Reconstruction Fund of Public Law 108-106 of 2003. The funding received requisite Congressional approval in CN Approval: 07-00206.

Some of Sandia's support of the Iraq NDs Program required travel to Iraq. Due to the security situation in Iraq, DOE placed restrictions on travel to Iraq by national laboratories personnel. For this reason and others, *approximately one-half of the work and one-half of the funding described in the IAA was subcontracted* by Sandia to Texas Tech University's (TTU's) Center for Environmental Radiation Studies. The achievements of TTU, in supporting the Iraq NDs Program are highlighted in a stand-alone report prepared by TTU.

Chapters 4, 5 and 6 of this report summarize the work that Sandia completed in support of the Iraq NDs Program. Appendix B presents the allocation of funding to the major tasks.

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4. Training and Technical Consultation

4.1 Introduction

Training and technical consultation were key components of the Iraq NDs Program. The Sandia advisors and instructors that supported the NDs Program typically had 15 to 25 years of experience in their relevant fields. This depth of experience allowed the advisors and instructors to provide very practical advice to the Iraqis.

Presenting a high-quality training class was typically resource intensive. For many of the training classes, Sandia (with NDs funding) paid travel expenses for the GOI representatives. Sandia support included making air travel reservations, buying the air tickets, meeting the Iraqis in Amman, Jordan to give them per diem cash, making hotel reservations, paying for hotel rooms and assisting them in getting their travel Visas. Air tickets from and to Iraq were typically expensive and the per diem rates in cities such as Vienna were also high. Because of the security situation in Iraq and the difficulties in getting Visas, there were many last minute schedule changes that added to the costs. Examples of these schedule changes included repeated delays in scheduling the Radiological Train-the-Trainer training in Amman, Jordan and bringing MoENV representatives to the U.S. EPA's 2008 National Superfund Radiation Conference that was held in Las Vegas from 28 April to 2 May, 2008 (which in the end did not occur at all). Based on Sandia's experiences, it can cost approximately $100 K for two instructors to prepare and present a three to four day training class to six GOI representatives in an overseas country.

4.2 Radiological Worker II Training Materials Consultation

In the U.S. DOE system, successful completion of Radiological Worker II (Rad Worker II) training allows: unescorted access to contamination areas; access to high contamination areas, and access to airborne radioactivity areas. Sandia instructors have taught the Rad Worker II training class over 100 times and the viewgraphs and handouts are very refined, with color photographs and embedded video clips. Sandia modified these viewgraphs and handouts to the situation in Iraq.

The modified viewgraphs and handouts were cleared for export by Sandia's Review and Approval Process. Then, e-copies of the training viewgraphs / handouts from Sandia's Rad Worker II training program, and information on the U.S. law 10 CFR 835 that governs U.S. DOE's Radiological Protection Programs were hand carried to the RPC by TTU representatives in early February of 2008.

These teaching materials, tailored to Iraqi needs, will be a valuable resource for the GOI for many years.

4.3 LAMA Quality Assurance Project Plan Consultation

In the spring of 2008, MoST requested Sandia's assistance in reviewing and finalizing their Quality Assurance Project Plan (QAPP) for the LAMA Phase 1 Decommissioning (Figure 4-1). The QAPP was the first document produced by MoST's dismantlement program and the Iraqis were interested in receiving experienced feedback on how to improve the plan. The MoST's decommissioning program is titled the Iraqi Decommissioning Program or IDP.

In requesting assistance, MoST was interested in gathering information on many topics that were beyond the scope of a QAPP (e.g., characterization concepts of inhomogeneous rubbles, methodology for tackling unsafe structures, etc.). Many of these other topics were addressed in the Project Management Plan Training and in IAEA Technical Meetings.

Mr. Joe Schelling of Sandia corresponded with MoST representatives and provided a number of general and specific comments to improve the draft QAPP. The emails and detailed comments are not reproduced in this report. However, Tables 4-1 and 4-2 provide small examples of the suggestions and assistance provided to MoST, as MoST prepared their QAPP for their first field activities.

In addition to Mr. Schelling's support of the LAMA QAPP, one-half day of Sandia's 15 – 18 April, 2008 Project Management Plan training was focused on quality assurance with assistance from the IAEA-funded U.S. expert Doug Draper.

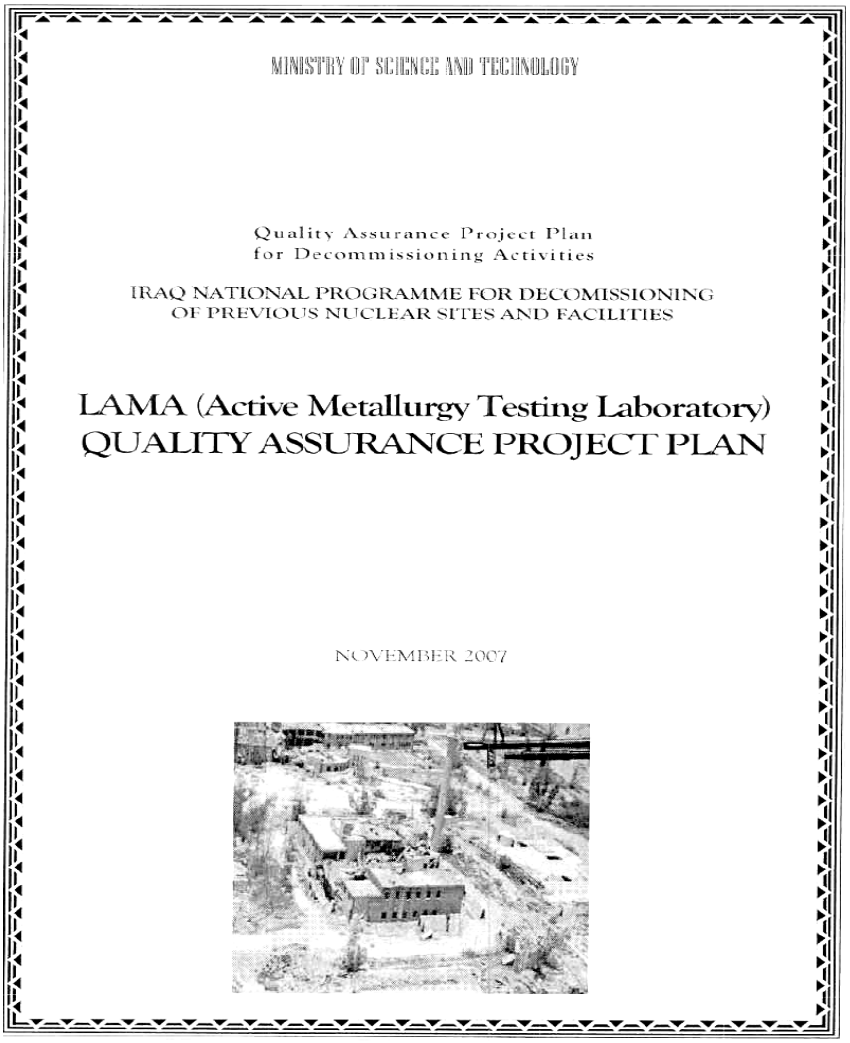
4.4 Project Management Plan Training

Sandia led and the IAEA co-hosted a Technical Meeting (a Workshop) on how to develop a Project Management Plan (PMP) 15- 18 April, 2008. The training was attended by five key individuals from MoST's IDP and focused on finalizing the PMP for the Phase 1 decommissioning of the LAMA (see Figure 4-2).

With NDs Program funding, Sandia funded the hotel and per diem for the five Iraqis from MoST participating in the training. The IAEA paid for air fare for the GOI representatives to come to Vienna and the IAEA provided the meeting room (as a scheduled IAEA meeting) and the IAEA brought Mr. Doug Draper to the meeting to discuss Quality Assurance. This is an example of teaming between the various participants to best help the GOI.

The goals of Sandia's PMP training were:

- Review Lessons Learned in Decommissioning
- Understand why it is important to write a PMP
- List elements of a PMP
- Review examples of existing PMPs
- Based on the draft LAMA PMP, prepare a PMP for:
  "LAMA, Phase 1 Decommissioning, Surveys and Rubble Removal"



MINISTRY OF SCIENCE AND TECHNOLOGY

Quality Assurance Project Plan
for Decommissioning Activities

IRAQ NATIONAL PROGRAMME FOR DECOMISSIONING
OF PREVIOUS NUCLEAR SITES AND FACILITIES

LAMA (Active Metallurgy Testing Laboratory)
QUALITY ASSURANCE PROJECT PLAN

NOVEMBER 2007

Figure 4-1: Cover of the LAMA QAPP

FOP 94-26	General Equipment Decontamination
FOP 94-27	Thin-Walled Tube Sampling of Soils
FOP 94-30	Health and Safety Monitoring of Combustible Gas Levels
FOP 94-34	Field Sample Management and Custody
FOP 94-39	Excavating Methods
FOP 94-40	Test Pit Logging, Mapping, and Sampling
FOP 94-52	Spade and Scoop Method for Collection of Soil Samples
FOP 94-54	Sediment Sampling/Soil Sampling
FOP 94-57	Decontaminating Drilling and Other Field Equipment
FOP 94-69	Personnel Decontamination (Level D, C & B Protection)
FOP 94-71	Land Surveying
FOP 95-23	Shallow Subsurface Drilling and Soil Sampling Using Mechanized Hydraulic Augers or the Geoprobe Soil Core Sampler

FOP 96-01	Chip, Wire & Sweep Sampling for Waste Characterization
FOP 98-04	Management of Returned Samples

Table 4-1: Partial List of Sandia's Field Operating Procedures Offered to MoST

Procedures vs. Tasks Matrix

Tasks→ Procedures ↓	Preliminary Rad Survey	Hotspot Characterization	Waste Segregation	Other tasks…
Work Plans	Applies	Applies	Applies	Applies
Sample Control		Applies		
Instrument Calibration	Applies	Applies		
Records Management				Applies
Other procedures . . .	Applies	Applies	Applies	Applies

Table 4-2: Table Illustrating the Difference between Procedures and Tasks

There are many ways to organize and manage a decommissioning project. Figure 4-3 is an example of a "matrixed" decommissioning organizational structure.

The GOI began the training with an internal planning document and revised it with Sandia's assistance using the training material and the PMP outline presented in Table 4-3. The training was very well received and at the conclusion of the training, the GOI had prepared a PMP for the Stage 1 decommissioning of the LAMA facility at Al Tuwaitha. The GOI ultimately used this LAMA Stage 1 PMP as a workplan submission to their regulatory authority.

4.5 Conceptual Design of Sort and Store Facility for Radioactive Waste

MoST does not have any facility for sorting and storage of radioactive wastes that are being generated by the decommissioning of the nuclear facilities at Al Tuwaitha. Sandia has decades of experience sorting and storing rad wastes. At the IAEA's Technical Meeting of 21-25 April, 2008, Sandia presented an overview of Sandia's waste sorting and storage area. In addition to the overall types and sizes of facilities, MoST representatives were interested in the semi-permanent buildings from Sprung Instant Structures, Inc. that Sandia uses.

Figure 4-2: Participants in the Project Management Plan Training at the IAEA

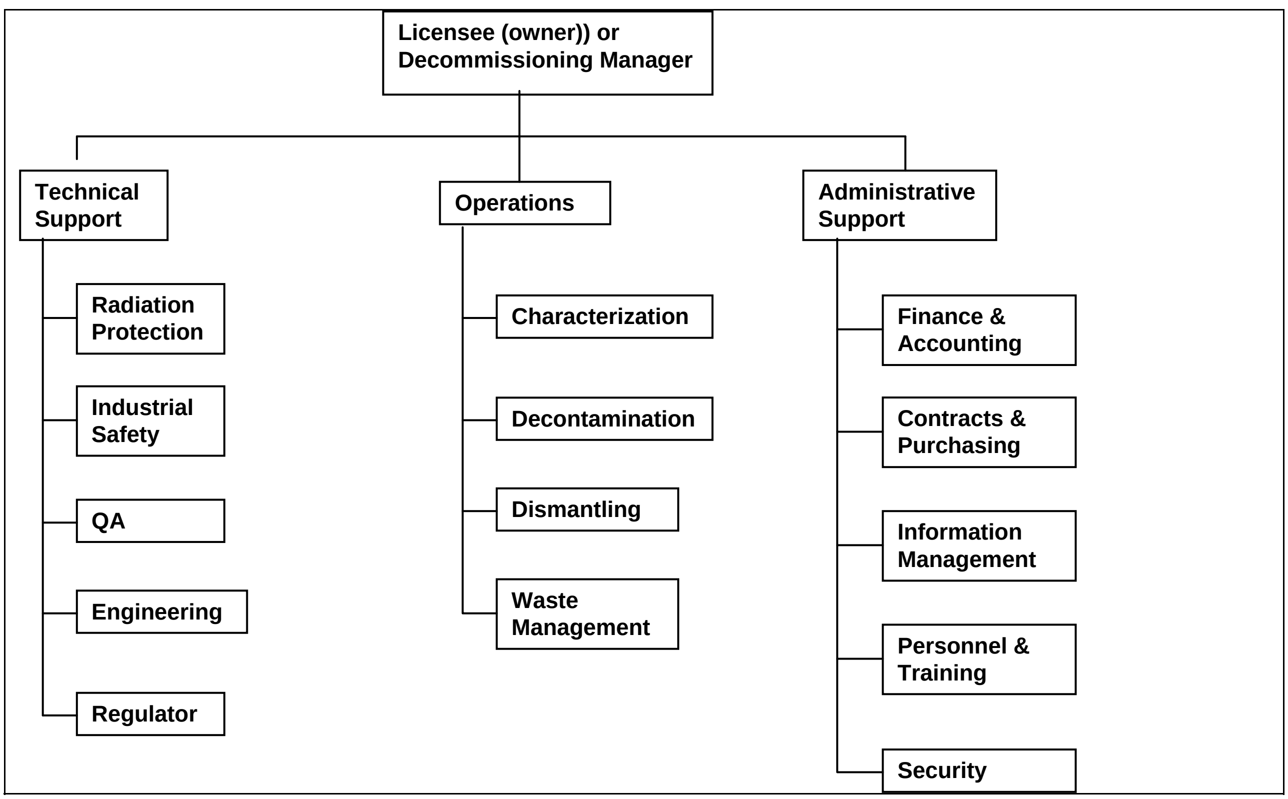


Figure 4-3: Example of a "Matrixed" Decommissioning Organizational Structure

1. INTRODUCTION and BACKGROUND
 	
2. GOALS
 	
3. MANAGEMENT PLAN
 	
    3.1 Project Activities and Work Breakdown Structure
    3.2 Participants
    3.3 Roles And Responsibilities
    3.4 Communications (Meetings)
    3.5 Conflict Resolution
    3.6 Quality Program
 	
        3.6.1 Quality Statement
        3.6.2 Scope Of The Quality Program
 	
4. PROJECT SCHEDULE AND CONTROL
 	
    4.1 Schedule
    4.2 Milestones
    4.3 Financial Management
    4.4 Project Control
    4.5 Reporting
    4.6 Project Reviews
 	
5. APPENDICES

Table 4-3: Sandia Outline for Writing a PMP

Based on the facilities at Sandia, and the assumptions listed below, a conceptual design of a sort and store facility for radioactive waste was made to MoST at the IAEA Technical Meeting:

- Wastes mildly contaminated
- No free liquids
- No significant transferable contamination
- Mostly concrete and steel
- Sort 10 m3 / day
- Wastes moved by vehicles (trucks, forklifts)
- Workers need separate entry and exit
- Workers need separate area for donning / doffing personnel protective equipment (PPE), store PPE, shower, bathroom, possible person decontamination area, monitoring exit ...)
- Located within secure area (the perimeter is a safety fence, not a security fence).

The conceptual facility would encompass 100 m x 100 m and would include a personnel trailer or building, plus a 15 x 33 m sorting / storage building plus two types of storage areas. Figure 4-4 presents the plan view of the conceptual facility. This facility could be scaled-up if necessary.

Sandia also provided general information about how Sandia stores most radioactive wastes:

- 200 liter drums and
- for large volumes of wastes, Sandia uses "roll offs"
    - Roll offs available in many sizes, (e.g., 2.4 x 6.1 m (85 m3 capacity))
    - Need forklift to move roll offs
    - Roll offs are very secure, only need level, solid area.

In followup activity, Sandia worked with Sprung Structures, who provided a price quote to MoST for a 15 m x 33 m building, with delivery of the components to Baghdad.

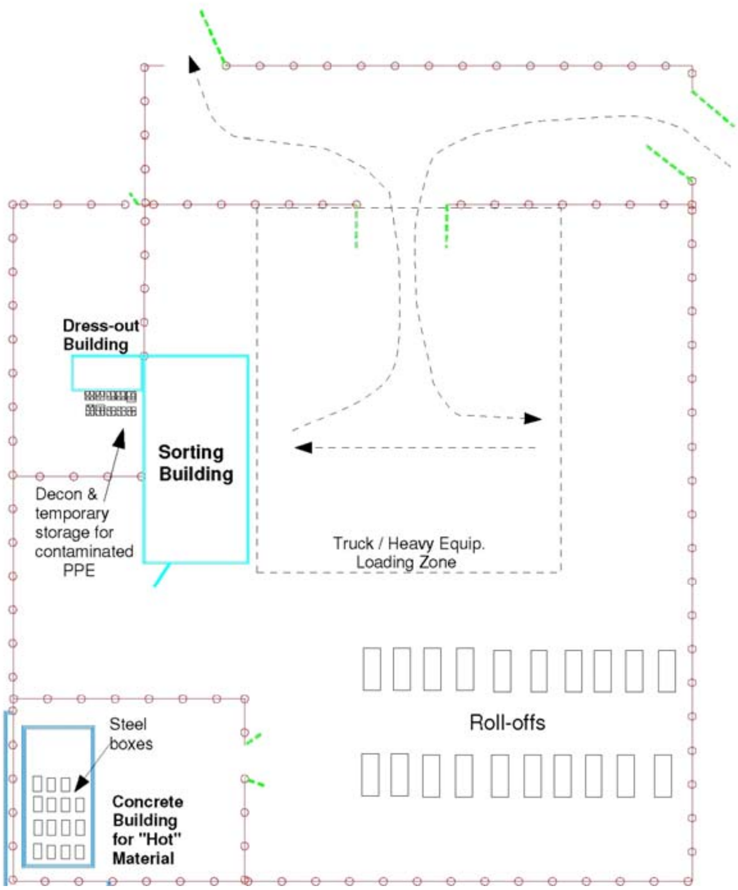


Figure 4-4: Conceptual Design of a 100m x 100m Facility for Sorting and Storing Radioactive Waste

4.6 Radiation Worker Training (Train-the-Trainer)

Representatives of the MoENV, the MoENV's RPC, the Iraqi Interim Center for Science and Industry (IICSI), and two members of the Jordanian Royal Scientific Society received two full weeks of training on how to train to the U.S. DOE Rad Worker II standards. Figure 4-5 presents a photograph of the instructors and the participants.

The training had several purposes, including the intent to make the RPC a training resource for the GOI. Additionally, the training will assist the GOI in the peaceful industrial and medical applications of radioactive materials.

Figure 4-5: Instructors and Participants in the Train-the-Trainer Training

The TTU submitted a proposal to the DOS's Civilian Research and Development Foundation (CRDF) / IICSI in February, 2008 to support the implementation of a worker safety program in Iraq. The program was funded (~$438 K). The train-the-trainer training was administered through CRDF and IICSI, with none of the funds coming to Sandia or TTU. TTU (with NDs funding) helped coordinate the program and Sandia provided the experienced trainers (Sandia's Mr. Hadley and Mr. Inman) using NDs Program funding. This is an example of teaming between the various participants to best help the GOI.

The classroom instruction and practical exercise(s) started on 13 July and ran for two full work weeks through 24 July, 2008. The outline for the course closely followed the outline used for standardized DOE Core Radiological Worker Training. Course content was covered at a reduced "train-the-trainer" pace to facilitate discussion and to allow translation from English to Arabic. Classroom demonstrations were extended to allow full participation by the new trainers.

During the course presentation, a list of open items specific to environmental remediation of Iraq's nuclear facilities was maintained. Following is a brief synopsis of the items that surfaced during the course, which were of particular interest to the participants.

Additional Training Needed

The group consensus throughout the course was that more training would be needed to support remediation of Iraq's nuclear facilities. The group will be filling roles that are normally filled by Radiological Control Technicians.

The group specifically requested the following additional training during the course:

- Radiological Control Technician (RCT) Training – Introductory course is a minimum of six additional weeks
- Instrument specific training – after instrumentation is in place
- Radiological Emergency Response training

Additional Information Requested

The group requested the following information resources during the course, which we were not able to provide before the end of the course:

- Work Control Plans – the group was very interested in how to construct Remedial Design Specifications, Programmatic documents, and work control procedures from upper tier documents down to the activity / task level.
- Sandia's template for Technical Work Documents for Radiological Work
- Lessons Learned – from similar remediation projects
- RWT Examination bank – Sandia owns a large RWT examination bank that the trainers would like to have access to
- Additional information on exam writing techniques
- Example - Applied Training Evaluation Form
- Example - Respiratory Medical Evaluation Form
- Example – Bioassay Evaluation Form
- Example - Dosimetry Request Form
- Radiation Generating Device (RGD) Safety Training Course
- Texas Tech report on Al-Tuwaitha radiological conditions
- Information on waste compaction / processing
- Methods for processing mixed liquid waste which resulted from vitrification
- Optically Stimulated Luminescence (OSL) Dosimetry
- Inter-Laboratory comparison contacts for film badges
- Methods for cleaning and reusing sample containers used in a counting laboratory
- Heat Stress Management standards (ACGIH)

Additional Technical Support Requested

The group indicated an interest in additional technical support as follows:

- Development of work plans, procedures down to the activity / task level – specifically, planning support was requested for:

- Remediation of vitrified mixed waste
- Remediation of Russian reactor

- Assistance with setup of radiation, contamination and airborne radioactivity monitoring programs in support of remediation operations
- Clarified Roles, Responsibilities, Authorities, and Accountabilities of the various agencies and participants down to the activity / task level

The details of the two weeks of agenda are not reproduced here. Table 4-4 presents the Agenda for Lesson 1 and Table 4-5 presents the Agenda for the Radiological Worker Practical Exercise.

LESSON 1 – RADIOLOGICAL FUNDAMENTALS

Terminal Objective

Given various radiological concepts, the participant will be able to DEFINE the fundamentals of radiation, radioactive material, and radioactive contamination in accordance with lesson materials.

Lesson 1 Outline

- Atomic Structure
- Ionizing Radiation
- Radioactive Material
- Radioactive Contamination
- Radioactivity & Radioactive Decay
- Types of Ionizing Radiation (alpha, beta, gamma, neutron)
- Units of Measure
- *Demonstration (alpha, beta, gamma)*
- Radiological Fundamentals Self Assessment

Table 4-4: Agenda for Lesson 1

RADIOLOGICAL WORKER PRACTICAL EXERCISE

Terminal Objective

Given a radiological work control procedure, a simulated radiological area, and the necessary materials and tools, the student will enter, work in, and exit the area using good contamination control and ALARA practices in accordance with radiological control procedures.

Practical Exercise Outline

- Pre-job preparations
  - Attend / participate in pre-job briefing
  - Review radiological survey information

- Review work control documents
  - Select and properly don protective clothing and dosimetry
  - Document entry in access control records
- Perform Radiological Work
  - Enter only areas allowed by work control documents
  - Minimize radiation exposure
  - Minimize spread of contamination
  - Minimize generation of radioactive waste
- Demonstrate appropriate response to unplanned situation
- Properly Exit the Area
  - Remove protective clothing in accordance with instructions
  - Minimize the spread of contamination
  - Monitor for contamination upon exit
  - Document exit in access control records

Table 4-5: Example, Radiological Practical Exercise

4.7 Considerations for Purchase and Use of Radiation Protection Equipment

Sandia experts provided detailed information to the RPC on the types and operation of equipment that would be best suited for decommissioning Al Tuwaitha. These recommendations are presented in Appendix C.

4.8 Monitoring Groundwater at Liquid Radioactive Waste Tanks Training

The representatives of the Iraqi MoENV, the RPC and the DOS received week-long training on how to monitor groundwater, with an emphasis on monitoring the groundwater around underground tanks. There is particular interest in monitoring the groundwater around the many underground tanks at Al Tuwaitha known to contain liquid radioactive waste.

The training program was held in Albuquerque, NM at Sandia's facilities and included classroom instruction and field trips to observe sampling and drilling equipment. Sandia also helped facilitate the MoENVs and PRCs participation in meetings with the U.S. EPA at the EPA's Environmental Monitoring Lab in Las Vegas. At the EPA's Lab, MoEN representatives learned about the EPA's "Superfund" cleanup program and about EPA's radiological monitoring programs, which are separate from the NRC's licensing programs.

The goals of the groundwater training and tours included:

- Receiving classroom training in fundamentals of groundwater occurrence, flow and contamination
- Exposing MoENV representatives to modern groundwater monitoring practices
- Identifying sources of information for use by the MoENV
- Observing operating groundwater drilling and sampling equipment, and
- Creating professional links for Iraqis with U.S. experts for future cooperation.

One idea proposed by Sandia was for the RPC to develop groundwater monitoring skills at Al Tuwaitha, and then to use those skills to implement groundwater monitoring at other key locations in Iraq.

Table 4-6 shows an example of one day of the agenda for the training and tours. Figure 4-6 shows the MoENV representatives receiving classroom instruction at Sandia, Figure 4-7 shows instruction during a field trip and Figure 4-8 is a photograph taken during a field trip to see the operation of a modern drilling rig used to install deep (100 m +) groundwater monitoring wells. MoENV representatives stated that the training was very useful.

19 June, 2008
 	
Morning
    Groundwater Sampling Field Trip and observation of operating equipment used by SNL to collect samples from monitoring wells – Stacy Griffith
 	
Lunch
 	
12:30 – 1:30 PM Overview of Sandia National Laboratories – Jeff Danneels
 	
Afternoon Class:
    Introduction to Contaminant Hydrogeology – Dr. Bill Arnold
    Types of contaminants
    Drinking water standards and risks
    Sources of contamination
    Advection-dispersion transport equation
 	
Evening
    Tram ride and team dinner at restaurant on top of Sandia Mountains

Table 4-6: One day of the Training Agenda

Figure 4-6: Franz Lauffer of Sandia Explains Grain Size to MoENV and RPC Representatives

Figure 4-7: Ms. Griffith Explains Sandia's Extensive Groundwater Monitoring Program

4.9 Practical Concepts for Safe Disposal of Radioactive Waste in Arid Settings Training

From 12-16 December, 2008, Sandia, the IAEA and the GOI jointly held Consultancy Meetings and a Training Workshop in Amman, Jordan. Approximately 12 Iraqis attended the Consultancy and the Training Workshop and six individuals from Jordan participated in the Training Workshop.

Figure 4-8: MoENV, RPC and DOS Representatives Observing the Drilling of a Monitoring Well at Water Development Corporation's Field Office

Sandia's focus was on the presentation of the three-day training workshop on "Practical Concepts for Safe Disposal of Low-Level Radioactive Waste in Arid Settings." Appendix D provides a copy of the bi-fold brochure advertising the Workshop. The goal of the workshop was to provide technical staff and government officials from Iraq with a detailed understanding of the activities necessary to develop and operate safe facilities for the disposal of radioactive waste. Table 4-9 presents the agenda for one day of the three days of training. An abbreviated version of the three days of training was presented to the larger IAEA Consultancy on the fourth day.

Sandia (with NDs funding) provided the meeting rooms, logistic support and a celebration dinner. The IAEA sponsored themselves and a number of Iraqi attendees. Some of the Iraqis self-funded their participation and Mr. Nokhamzon was funded by the Government of France. The training and meetings were held at the Cooperative Monitoring Center – Amman (CMC-A). The CMC-A is a non-profit, quasi-non-governmental organization at the Royal Scientific Society. The CMC-A is closely associated with the CMC operating at Sandia in Albuquerque.

Sandia formally sought the support of the IAEA's Technical Cooperation Division for Asia and the Pacific, to expand this Iraq NDs Program training course to a regional IAEA training course with a target audience of professionals and managers from neighboring, Arab-speaking countries. Appendix E is s copy of Sandia's 7 May, 2008 letter to the IAEA. The IAEA's Director of the Division for Asia and the Pacific Technical Cooperation was conceptually supportive of the proposal, but timing and other issues ultimately prevented the joint hosting of a regional training workshop for Arab-speaking countries.

Workshop participants included six staff from MoST, MoENV, and the IRSRA. Additionally, five representatives from the Jordanian Nuclear Regulatory Commission, and the Jordanian Atomic Energy Commission participated in the three days of training. A representative of France's ANDRA waste management organization made a presentation in support of the training workshop. A photograph of the participants is presented in Figure 4-8. Participants all agreed that the primary goal of the training workshop (presented above) was accomplished.

15 December, 2008 9:00 AM – 4:00 PM

- **Steps and Infrastructure Needed to Develop a Disposal Facility – Dr. Bill Arnold**
- **Regulatory Framework – John Cochran**
- **Inventory in Iraq - Mohammad Jawad Abbas**
- **How to Select and Characterize a Disposal Site – Dr. Bill Arnold**
- **Concepts in Designing a Disposal System – John Cochran**
- **Demonstrating Safety and Regulatory Approval - Dr. Bill Arnold**

Table 4-7: One Day of Agenda from Training on Practical Concepts for Safe Disposal of Low-Level Radioactive Waste in Arid Settings

Figure 4-9: Participants in Training Workshop. Co-instructor, Dr. Bill Arnold is Front Center

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5. Introducing Iraqis to Modern Decommissioning and Waste Management Practices

5.1 Waste Management Symposium‘07

Sandia hosted two weeks of training and tours to introduce GOI scientists to modern practices for management and disposal of radioactive waste. A total of six representatives were nominated from MoST and IRSRA. Because three of the Iraqis could not get Visas to the U.S. in time for the trip, only three Iraqis were able to participate. The goals of the training and tours were to:

- Identify sources of information for use by Iraqis scientists
- Expose scientists to modern radioactive waste management practices
- Expose scientists to modern equipment
- Observe operating disposal facilities,
- Make waste management work real and interesting, and
- Create professional relationships for Iraqis with U.S. & international waste management experts.

This section overviews the first week of activities, in which GOI representatives participated in the world's largest radioactive waste symposium. Waste Management Symposium 2007 (WM’07) is the largest waste management conference in the world, with over 2,200 attendees from 30+ countries. There were over 600 scientific and policy presentations at WM’07, addressing some 80 topical areas, including:

- Decommissioning & Decontamination of Nuclear (non-power) Facilities
- Innovations in LLW management
- Programmatic and Regulatory Issues in Management for LLW
- Worldwide Waste Management and Regulatory Crosscutting Programs, and
- Perspectives and Practices in Packaging and Transportation.

Sandia presented a paper on the Iraq NDs Program at the opening day of this Symposium (Cochran, et al., 2007). Sandia also presented a second paper on the possible use of intermediate-depth boreholes for disposal of the U.S.’s Greater-Than-Class C LLW (Tonkay, D.W., et al., 2007). Greater-Than-Class C is the most “dangerous” class of LLW in the U.S. and there are no licensed facilities in the U.S. for disposal of this class of LLW.

In addition, over 100 vendors of equipment for decommissioning and waste management had exhibits at WM’07 (Figure 5-1). These exhibits allowed GOI representatives the hands-on experience of examining equipment and talking to vendors and gathering information to take back to Iraq (Figures 5-2 to 5-4).

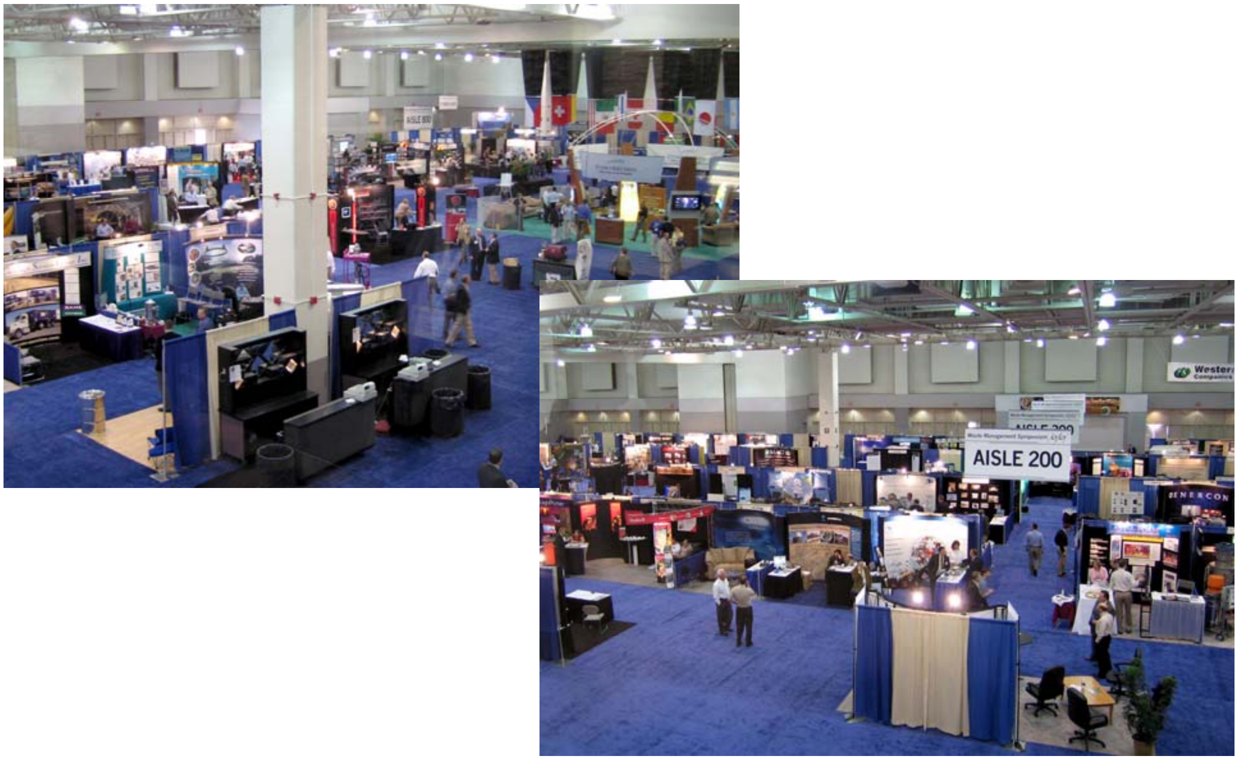

Figure 5-1: Venders Hall with over 100 Vendors of Equipment for Managing Radioactive and Hazardous Waste

Figure 5-2: GOI representatives Look at One Cubic Meter "Burrito Wrap" for Waste Transport and Disposal

Figure 5-3: Roll-off for Waste Storage and Disposal

Figure 5-4: Iraq NDs Representatives Examine Brokk Decommissioning Equipment

During the last evening of the Symposium, Sandia provided one-on-one training in the fundamentals of U.S. laws governing the disposal of LLW and the fundamental of writing a project management plan (Figure 5-5).

Figure 5-5: One-on-one Training

5.2 Tour of Operating U.S. LLW Disposal Facilities

<u>Introduction</u>

Sandia led Iraqi scientists through two operating radioactive waste disposal facilities *with climatic and geohydrologic conditions similar to those in some parts of Iraq*; to introduce GOI representatives to modern radioactive waste management practices and equipment. The first site visited was the U.S. DOE's Nevada Test Site (NTS) and the second site visited was a radioactive waste disposal facility operated by Energy*Solutions* Inc, located near Clive, Utah.

U.S. DOE's Radioactive Waste Disposal Facility at the Nevada Test Site

The NTS and adjacent Air Force Base cover 14,000 km^2 (5,500 $mile^2$) of government controlled land in south central Nevada. The photograph in Figure 5-6 shows the tour group, and the aridity and remoteness of the NTS.

Figure 5-6: Iraq NDs Program Representatives Entering the NTS
Lead Author is Second from Left Side

The NTS contains the U.S. DOE's largest facility for disposal of off-site radioactive wastes. The facility is not open to public. The security at the NTS required significant coordination and support from the U.S. DOE's Nevada Field Office. Recording devices not allowed beyond gate to the NTS and the photographs presented here are scanned from NTS brochures.

At NTS, the Iraqis learned about disposal of radioactive wastes in 4-m deep trenches and in 36-m deep augered shafts, known as greater confinement disposal (GCD) boreholes. The lead author of this report had led a 10-year study of the ability of the GCD boreholes to isolate long-lived transuranic wastes (Cochran, et al., 2001).

On the NTS, the group toured the Area 5 Radioactive Waste Management Site (A5 RWMS), which is DOE-licensed for disposal of almost all types of DOE-titled LLW, including very high-specific activity LLW. The A5 RWMS covers 65 hectares (160 acres), and over 370,000 cubic meters of radioactive wastes have been disposed there. The sites mission it to receive and dispose of waste; on-site treatment of waste is not available. Figure 5-7 is a photograph of the disposal of containerized LLW in an unlined trench at the NTS and Figure 5-8 shows the remote disposal of very high specific activity LLW in a 36 m deep borehole.

Figure 5-7: Placing Wastes in an Unlined Trench at the NTS

Figure 5-8: Historic, Remote Disposal of Reactor Fuel Rods in 36-m Deep, 3-m in Diameter GCD Boreholes (Spend Nuclear Fuel was Removed Prior to Disposal)

The site has been studied extensively over the past 20 years and long-term safety is provided by:

- The remoteness and the government ownership of the land
- The great depth to groundwater (235 m or 775 ft)
- The low precipitation rate of 130 mm or 3.3 inches per year, and
- The very high evaporation rates

Because of the thickness of the vadose zone, the aridity and the lack of fast-flow paths in the gravelly sand, rain water and snow melt never infiltrate to groundwater 235 m below the surface.

Energy*Solutions* Radioactive Waste Disposal Facility in Clive, Utah

The Energy*Solutions* facility near Clive, Utah, is one of three commercial facilities in the U.S. licensed for disposal of LLW. Figure 5-9 is an aerial view of the facility. The facility is privately operated and frequently gives public tours. Figure 5-10 is a photograph of the NDs Program tour of the facility. There is significant regulatory oversight of the facility, and the regulators include: Utah's Tooele County Health Department; Utah's Division of Radiation Control; Utah's Division of Solid and Hazardous Waste; Utah's Division of Air Quality; Utah's Division of Water Quality; the U.S. NRC and the U.S. EPA.

Figure 5-9: Aerial view of EnergySolutions Clive, Utah facility showing scale of operations. Note two closed cells in center and active cell in upper right

Figure 5-10: Group Photograph

The Energy*Solutions*' facilities are licensed for the "least hazardous" class of LLW, called Class A LLW. Class A LLW decays to safe levels for an inadvertent human intruder in 100 years. Limiting the inventory is one way of achieving long-term safety. At this site, wastes are placed in *aboveground* cells, similar to the cells built in the U.S. for disposal of uranium mill tailings. Figure 5-11 shows the placement of vey large pieces of LLW in a disposal cell.

The facility employs about 270 people and has the on-site treatment capabilities include: Macro-Encapsulation; Liquid Solidification; Thermal Desorption; Stabilization; and Shredding.

The site has been studied extensively and long-term safety is provided by:

- Limiting the inventory to Class A, the least hazardous class of LLW
- Groundwater at 10 m deep, but more saline than sea water (not drinkable)
- 200 mm (5 inches) precipitation per year & high evaporation rates, and
- Remoteness of the location.

<u>Summary</u>

Iraqi scientists toured two operating radioactive waste disposal facilities with climatic and geohydrologic conditions similar to those in some parts of Iraq; exposing GOI representatives to modern radioactive waste management practices and equipment. The facilities both provide long-term safety, by very different means. A detailed discussion is beyond the scope of this summary report, but the NTS allows disposal of very high activity LLW because of the remoteness of the site and the important fact that there is no pathway to groundwater. On the other hand, groundwater is near the surface at Clive, Utah, but undrinkable (more saline than seawater) and the facility places strict limits on what can be disposed.

Figure 5-11: Inside a Disposal Cell, Placing Backfill around Waste too Large to Shred

Participation in WM'07 an touring operating LLW disposal facilities was especially valuable for Iraqi professionals that have been isolated from their peers for many years. Seeing these operating LLW disposal facilities, in settings similar to those in some parts of Iraq helps make tangible the possibility of a licensed LLW disposal facility in Iraq.

5.3 International Conference ICEM'07

With support from the IAEA and Sandia, Dr. Al-Atia (former Chairman of IRSRA[1]) presented a paper and a poster on the characterization and cleanup of the nuclear facilities in Iraq at the International Conference on Environmental Remediation and Radioactive Waste Management (ICEM'07).

Sandia organized and funded Dr. Al-Atiya participation in the Conference. Sandia helped edit the final paper and drafted the poster. Figure 5-12 presents a copy of the poster presented by Dr. Al-Atia. Participation in ICEM'07 provided Dr. Al-Atia with the week-long opportunity to work with his peers, discuss lessons-learned, and meet vendors. This experience is especially valuable for Iraqi professionals that have been isolated from their peers for many years.

After the conference, the U.S. DOS representative presented an overview of the NDs Program to the European Commission's Nuclear Assistance Office and Dr. Al-Atia represented Iraq at the IAEA Board of Governors Meeting.

[1] Tragically, Dr. Al-Atia was assassinated in November, 2007

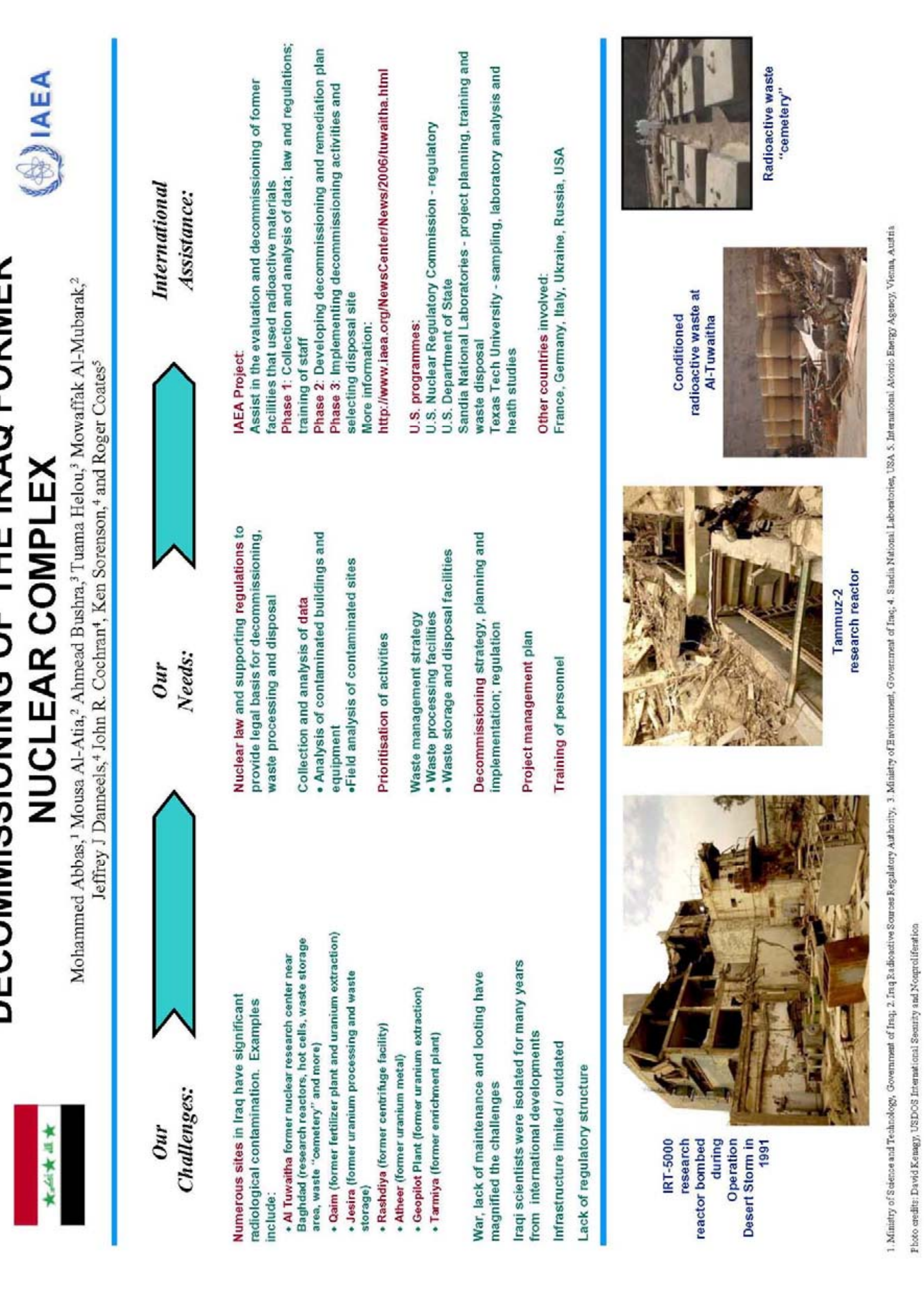

Figure 5-12: Iraqi Poster Presented at ICEM'07

5.4 Avignon International Decommissioning Conference

In support of the Iraq NDs Program, and in collaboration with the IAEA, Sandia supported a GOI representative making a presentation at the International Decommissioning Challenges Conference in Avignon, France 29 September to 1 October, 2008. The IAEA and Sandia had helped write the technical paper for the conference and had helped prepare the GOI presentation. The general quality of the presentations at the Conference was outstanding, as the French are spending billions of Euros each year on 30+ decommissioning projects.

Adnan Jarjies made the presentation on behalf of the GOI. His presentation, with photographs of the destroyed and looted nuclear facilities in Iraq, was in contrast to the tidy, and very well funded decommissioning activities in France, Japan, and other countries. Adnan was supported by Dr. Abbas from Iraq, Mark Hannan of the IAEA and John Cochran. Jarjies was asked two questions after his talk. First, are the Iraqis working on a disposal facility for the decommissioning wastes? (Answer, yes, but the top priority is to develop an interim rad waste storage facility), and second, after decommissioning LAMA, will the Iraqis then begin decommissioning their top priority facilities? (No, there will be more capacity-building by decommissioning the GeoPilot Plant). On behalf of the Agency, Mark told the audience that the Iraqis needed assistance and asked companies/countries to approach Jarjies.

Highlights of the information presented included:

- OECD / NEA has reviewed decommissioning activities in Europe and found that dismantling costs 25 – 30% total budget, waste management costs 17 – 43% of total budget and project management costs 5 – 13% of total budget.
- Difficult to apply experience from one decommissioning project to another – because each facility is unique (e.g. Pu enrichment facility vs. a research reactor vs. an early 1960s commercial NPP).
- In France, Japan, US and UK many key decommissioning activities are contracted to specialist firms – in some cases, the government only "manages" the work and all the hand-on decommissioning is conducted by contractors.
- An Areva representative made several points:
    - it is important to demonstrate "nuclear reversibility" (decommissioning to a green field), in selling future nuclear power plants
    - waste management cost ~ 30% of total
    - France has "administrative LLW" – LLW that is designated by policy and not by characterization
    - Constraints in decommissioning include: skills, waste management and safety
- France divides rad waste into VLLW, LLW, Intermediate-level waste (ILW) and HLW, and the French further subdivide LLW and ILW into long-lived and short-lived (e.g. short-lived LLW and long-lived ILW) with 30 year half-life being the boundary between short and long-lived.

- The waste producer is responsible for characterization, conditioning, storage and transport and the disposal facility is responsible for setting the waste acceptance criteria and actual disposal.
- The Czech Republic cleaned up a 4.5 m^3 rad waste tank, using an evaporator (heater) to evaporate the liquids, then built a temporary building over the tank and excavated the tank.
- The Japanese have found that recycling metals is not very cost effective.
- In France the public is interested in the decommissioning strategy and the end-state.
- Many presenters talked about the importance of "knowledge retention."
- Strasbourg University research reactor – they found you can not cut iron-charged concrete with a conventional diamond blade saw.

Figure 3-13: Iraq NDs participants in International Decommissioning Conference, Mark Hannan of the IAEA is the Center Person

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6. Support of IAEA Technical Meetings

6.1 Introduction

The IAEA's Waste Safety Section is leading the IAEA's support of the GOI's nuclear facility dismantlement and waste management work. The Waste Safety Section is under the Department of Nuclear Safety & Security, which is under the Division of Radiation, Transport & Waste Safety. The Waste Safety Section was supported by other organizations within the Agency, including the Waste Technology Section and the IAEA's Technical Cooperation Division for Asia and the Pacific. The IAEA points of contact have been Mr. Ernst Warnecke, Mr. Roger Coates and Mr. Mark Hannan.

Sandia representatives participated in two of the IAEA's Technical Meetings (TMs) and co-hosted, but did not participate in a third meeting. The third meeting is described in Section 4.9 "Practical Concepts for Safe Disposal of Radioactive Waste in Arid Settings Training." Appendix F provides an example of a typical agenda of an IAEA Technical Meeting. The IAEA website for the Iraq NDs Program work is http://www-ns.iaea.org/projects/iraq/

6.2 Technical Meeting of 13 - 17 November, 2006

Sandia provided technical support to the IAEA's Working Group 3 TM of 13 - 17 November 2006 at the Agency's headquarters in Vienna. Working Group 3 addressed regulation and strategy. A number of presentations related to the development of regulations were made at this meeting by the IAEA, and by Iraqi representatives of the RPC and IRSRA. Figure 6-1 shows many members of the Working Group 3 at a dinner.

Sandia contributed to the general discussions and made a specific presentation on the value of developing a project management plan for the decommissioning work. Sandia also volunteered to write the first draft of a law governing the disposal of radioactive waste in Iraq. Appendix G provides the first 2 pages of the draft regulation prepared by Sandia and based on the U.S. NRC's 10 CFR 61. The U.S. NRC finalized the draft, which was shared with the Iraqis and the IAEA.

6.3 Technical Meeting of 21 - 25 April, 2008

From 21 to 25 April, 2008 Sandia participated in the IAEA-led Technical Meeting (TM) on the Decommissioning of Iraq's former nuclear complex: characterization data collection and the decommissioning plan. The TM addressed a broad range of topics related to the commencement of on-the-ground decommissioning of the Tuwaitha Nuclear Complex in Iraq by 1 July, 2008. MoST presented the PMP for the Phase 1 LAMA Decommissioning that was jointly drafted with Sandia during the PMP Workshop the week of 14-17 April. Sandia provided a presentation and a Conceptual Design for a Waste Sorting and Storage Facility in Iraq.

Figure 4-1: Many Members of IAEA's Working Group 3.
Mr. Kenagy is the fourth person from the left.

7. Iraqi Progress in Decommissioning Al Tuwaitha

A special ceremony was held at the Iraq Parliamentary Building, Baghdad on 7 July 2008 to announce the beginning of the on-the-ground nuclear dismantlement in Iraq. The ceremony was attended by the Minister of MoST and the Minister of MoENV, as well as representatives of both ministries and representatives of TTU and the USG.

A 24 July, 2008 presentation by Adnan Jarjies, leader of MoST's IDP highlighted some of the details of the LAMA Phase 1 progress. This progress includes the completion of many key planning documents. These documents include: the final draft of QA plan for LAMA stage 1; the final draft of LAMA stage 1 PMP, and the submission of LAMA PMP to the MoENV for regulatory consideration.

Some of the field work that was completed included the installation of a perimeter fence, the installation of three portable buildings, the completion of the unexploded ordinance survey and the designation of seven survey teams. A 250-m long perimeter fence was installed along the north and west side of LAMA Facility using about 200 pieces of isosceles triangle concrete (see Figure 7-1). Three portable buildings were installed with water and electricity. The portable buildings will be used for offices, instrument storage and showers (see Figure 7-2).

Workers have been provided with radiation protection that includes: electronic pocket dosimeter, film badges (supplied by the RPC), and complete sets of protective clothing. Seven teams were established to do the Stage 1 decommissioning: (1) background measurements team, (2) radiation protection team (3-6) four survey teams; 2 teams making exposure measurements and 2 teams making contamination measurements, and (7) a sampling team. Figure 7-3 is a photograph of a survey team with the LAMA facility in the background.

In 2006, the GOI had almost no plans, no procedures, no teams and *no infrastructure* to initiate on-the-ground decommissioning at Al Tuwaitha. The ceremony of 7 July 2008 marked the great progress made by the GOI, with support from the international community, the IAEA and the Iraq NDs Program.

Figure 7-1: Perimeter Fence Installed for LAMA Phase 1 Dismantlement

Figure 7-2: One of the Portable Buildings Installed for the LAMA Stage 1 Work

Figure 7-3: Survey Team with the LAMA Facility in the Background.

8. Summary and Conclusions

The photographs in Figures 2-1, 2-2 and 2-3, and the information presented in Appendix A attest to the significant safety and radioactive waste hazards posed by the nuclear facilities in Al Tuwaitha, 18 km southeast of downtown Baghdad. Unfortunately, Iraq has lacked the infrastructure needed to decommission its nuclear facilities and manage its radioactive wastes.

The U.S. DOS initiated the Iraq NDs Program to provide international expert advice, training and capacity building to Iraq's former nuclear scientists so the GOI can execute nuclear facility dismantlement and waste management in accordance with international standards. Implementation of the Iraq NDs Program will also build human capacity so that the GOI can manage other environmental cleanups in their country.

Sandia is a part of the DOS's team implementing the Iraq NDs Program. This report documents Sandia's support of the NDs Program which has developed into three principal work streams:

(1) Training and technical consultation
(2) Introducing Iraqis to modern decommissioning and waste management practices, and
(3) Supporting the IAEA, as they assist the GOI.

In implementing the first work stream, <u>training and technical consultation,</u> Sandia:

- Provided electronic copies of Sandia's *Radiological Worker II Training Materials* to the GOI.
- Made sustentative recommendations to MoST for improvement of MoST's *LAMA Quality Assurance Project Plan.*
- Provided *Project Management Plan Training* and helped the MoST write a PMP for the Stage 1 Decommissioning of LAMA.
- Provided a *Conceptual Design of a Sort and Store Facility for Radioactive Waste,* based on the sort and store facilities at Sandia and tailored to the situation at Al Tuwaitha.
- Trained RPC trainers (train-the-trainer) in how to teach U.S. DOE-style *Radiological Worker II classes.* The training, coupled with the electronic copies of Sandia's Radiological Worker II Training Materials, gives the GOI a long-term resource for training their workers in safe radiological work practices.
- Provided very detailed, experience-based advice on *Considerations for Purchase and Use of Radiation Protection Equipment* for the decommissioning work at Al Tuwaitha.
- Provided a four day training class to MoENV and MoENV's RPC on *Monitoring Groundwater at Liquid Radioactive Waste Tanks.*
- Provided a three day training workshop on *Practical Concepts for Safe Disposal of Radioactive Waste in Arid Settings* in Amman, Jordan.

In implementing the second work stream, <u>introducing Iraqis to modern decommissioning and waste management practices</u>, Sandia:

- Hosted GOI representatives at the WM'07 Symposium, with over 600 scientific and policy presentations and exhibits by over 100 vendors. Sandia made a presentation on the Iraq NDs Program on the opening day of the Symposium.
- Led Iraqi scientists through two operating U.S. radioactive waste disposal facilities with climatic and geohydrologic conditions similar to those in some parts of Iraq. Seeing these operating LLW disposal facilities, in settings similar to those in some parts of Iraq, helps make tangible the possibility of a licensed LLW disposal facility in Iraq.
- With support from the IAEA, Sandia helped the Chairman of IRSRA presented a paper and a poster on the characterization and cleanup of the nuclear facilities in Iraq at the International Conference ICEM'07.
- In collaboration with the IAEA, supported a GOI representative making a presentation at the International Decommissioning Challenges Conference in Avignon, France in the fall of 2008.

In implementing the third work stream, support of IAEA Technical Meetings, Sandia:

- Provided technical support to the IAEA's Working Group 3 TM of 13 - 17 November 2006.
- Participated in the IAEA's TM of 21 - 25 April, 2008 on the decommissioning of Iraq's former nuclear complex.

In 2006, the GOI had almost no plans, no procedures, no teams and *no infrastructure* to initiate on-the-ground decommissioning at Al Tuwaitha. Two years later, in July 2008 the GOI began the on-the-ground dismantlement of the LAMA facility at Al Tuwaitha. This fieldwork marked the great progress made by the GOI, with support by the international community, the IAEA and the Iraq NDs Program.

The Iraq NDs Program will require U.S. / international support for 2-3 more years after which GOI will be able to continue almost independently. The exceptions are decommissioning and disposal of problematic wastes (e.g., irradiated reactors and fission product waste) for which Iraq will require additional training. The GOI budgeted $10 M for NDs work during 2008. The GOI expenditure is expected to increase as project management capacity and experience grow and more complex facilities are dismantled.

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10. Appendices

Appendix A - IAEA Overview of Status of Nuclear Facilities at Al Tuwaitha

STATUS OF NUCLEAR FACILITIES IN IRAQ

Consolidated Data – Roger Coates / G Healey

Version November 2007

Based on document "Final Version – 24 November 2006 – G. Healey"

Introduction

This document is intended to describe the status of facilities in Iraq that were involved with handling nuclear materials, how waste materials were produced and what happened to them, where contaminated materials are located and how they became contaminated. Further, note is made of what data is or is not available about the facilities from a decommissioning / contamination point of view. The information given is, essentially, from memory and review of a few documents, thus, the accuracy is not guaranteed. However, the current version of this document has been subject to review by Iraqi experts and represents the best current overview of the Iraqi nuclear facilities.

1. Al-Tuwaitha

Tuwaitha was virtually a "one-stop-shop" for the Iraqi nuclear program. Very basically, activities at Tuwaitha could be considered as two parts, radioisotope/irradiation activities and U conversion activities.

Relevant buildings are listed in numerical order.

1.1 Building 9 Radiochemistry Laboratory

- Italian-supplied equipment and labs
- Building 9 housed hot cells where reprocessing and chemical extraction activities (mixer-settlers) for Pu (and other nuclides including Po) extraction were conducted
- the hot cell area was heavily damaged but the glove box line for Pu work survived
- concrete was poured inside some of these glove boxes by IAEA inspectors to make them unusable
- areas outside the glove boxes are contaminated, but not heavily
- the internals of the glove boxes will have Pu contamination
- there is a 5 m3 tank believed to be full of High Level Liquid Waste from the reprocessing facility. The access to the tank is very difficult.
- it is possible that there may be buried contamination at the opposite end of the building from the hot cells (a suspicion from the Inspection Team).
- some years ago, there existed an underground storage tank outside at the rear of the extraction area. It gave high radiation readings. There will be piping connection from the extraction area to

the tank. A brief attempt to locate this tank in June 2003 failed, but efforts should be made to locate it.
- estimated currently 55 te solid waste and 5 m3 High Level Liquid Waste

1.2 Building 13 IRT 5000
- Russian-supplied pool-type research reactor: went critical in 1967 as IRT 2000 (upgraded 1978 to IRT 5000)
- used for isotope production and neutron source
- still exists in heavily damaged condition
- physically dangerous area
- heavy contamination in foundation/basement structures and remaining equipment, plus activation of the core structure and surrounding shielding
- estimated currently 85 te solid waste and 55 m3 liquid waste
- there is a liquid waste tank outside the building containing small quantity of radioactive liquid waste

1.3 Building 15A Italian Radioisotope Production [Isotope Production No 2]
- Bldg 15A totally destroyed during 1991 war and later completed by Iraq. Currently only two hot cells standing
- Italian-supplied facility
- There is tank located near to the building for liquid waste (contents unknown)
- Radioisotopes were transferred by cask from the building

1.4 Building 15B Russian Radioisotope Production [Isotope Production No 1]
- Russian supplied facility: sometimes referred to as the Russian Isotope Production Building
- purpose was to produce medical isotopes from irradiations in IRT
- Liquid wastes was sent initially to a tank which is outside the building
- underground transfer system between IRT and Bldg 15B
-underground systems still in place
- informal surveys showed no surface contamination [but may be some spotty contamination around the adjacent Building 14]
- underground situation is unknown

1.5 Building 22 LAMA
- French-supplied facility
- building still exists but in heavily damaged condition
- never used for intended purpose; thus very little nuclear material ever processed (see below).
- a processing line was installed to extract enriched U but only did one test using one unirradiated natural U batch. There are some references to previous Li alloy processing, so H3 contamination may also be possible.
- contents of concrete hot cells were totally removed by Iraqi authorities and the concrete hot cells were decontaminated
- other hot cells in LAMA were dismantled and it is reported that no contamination was found on lead recovered from these cells (lead was sent offsite under IAEA supervision for battery manufacture). There was some contamination on lead and it was decontaminated
- any residual contamination in LAMA is believed to be minor

- Image 077 shows the LAMA concrete hot cells

1.6 Building 24 Tamuz 2

- French-supplied pool-type research reactor went critical in 1980: 500kW thermal
- ruins still exist and are in danger of collapse: physically dangerous area
- light contamination and heavy activation in foundation/basement structures and remaining equipment
- estimated currently 50 te solid waste and 35 m3 liquid waste
- links to Tammuz 1 reactor via water channel; Channel 3 goes from Tammuz 2 to Channel 2 which links to two Hot Cells (contaminated). Channel 1 links Channel 2 to Tammuz 1 but was isolated and should be clean.
- [NB Tammuz 1 reactor destroyed in 1981 prior to fuel load: not generally part of this decommissioning project since clean, except for possibility of contaminated resins used for cleaning water from water channels and Tammuz-2 reactor pool]
- *Image 076 – ruins of Tamuz 2 1991 to present*

1.7 Building 35 Radioactive Waste Treatment Station [RWTS]

- French-supplied facility (circa 1981)
- building still exists and has been repaired to some extent.
- diluted high level liquid wastes present in tanks (2?) in shielded room
- low level wastes present in tanks (3 at least?) in separate room
- diluted high level liquid waste tank present in a sub-floor room
- types of isotopes and quantities stored in the waste tanks is not defined/known fission product and actinide

  [Iraq preliminary data suggests the following:

    1.25 m3 tank containing 0.25 m3 H/MLW (3 Ci total, ie 0.4MBq/ml)
    10 m3 tank full M(?)LW (1500Bq/ml)
    5 m3 tank full LLW (900Bq/ml)
    2 m3 tank full LLW (900Bq/ml)
    1 m3 tank full LLW ex-laundry (?Bq/ml)
    1 m3 tank containing 30 litres LLW ex-laundry (100Bq/ml)

  This information needs to be correlated with the above provisional data on tanks]
- considerable piping, all contaminated, associated with tank storage
- [Note: how did liquors arrive at RWTS? Pipework existed between facilities in the French Complex – RWTS, Tammuz 1 and 2, LWB (clean) and LAMA.
- RWTS had facilities for compacting and bituminizing rad waste
- estimated currently 50 te solid waste and 25 m3 of medium and low active liquid waste
- surface contamination exists is spotty areas in surrounding ground areas. Mainly U compounds associated with contaminated equipment storage

Images

- *049 – high level liquid waste tank behind shielded door*
- *050 – possible high level liquid waste tank*
- *051 – low level liquid waste tank*
- *052, 053 – liquid waste pump stand and related piping (pump missing)*
- *054 – concrete containers for bituminized and compacted rad waste outside RWTS, circa 1994*

1.8 Building 36 Solid Waste Storage Silo [Monolat] -

- French-supplied silo facility
- still exist in good condition
- little known of the contents (no documents): some waste may have come from the Italian B73 complex.
- some storage of low-level solid wastes

1.9 Building 39 RWTS Warehouse/ Waste Store

- warehouse contains a vast assortment of solid waste including contaminated equipment
- large number of concrete containers, many housing bituminized waste
- high radiation levels with some concrete containers
- large number (1000+) metal drums, many holding contaminated contents (estimated 1200 drums containing around 250 te contaminated sludge, at least some of which came from the B73 complex)
- some drums contain U compound residues
- numerous empty contaminated drums
- some drums contain medical isotope waste
- in June 2003, medical wastes were littering the floor inside in front of the access gate
- contaminated equipment contains U_3O_8, yellowcake, UO_3
- practically every item in the building is contaminated to some extent
- the building floor is heavily contaminated
- estimated currently 8 te solid waste (destroyed equipment, mainly U contamination), plus bituminized waste and drummed sludge

Images

- *055 – front view of warehouse circa 1994 (in much tidier condition than at present). Note liquid waste transfer truck on left (still present)*
- *056 – interior photo of warehouse*
- *057, 058 – interior of warehouse showing large number of waste drums*
- *059 - shows contaminated equipment items, a U_3O_8-UO_2 reduction kiln to the left, a rotary calciner in mid view, both ex building 73*
- *060, 061, 062 – additional views of warehouse contents, drums, equipment, concrete canisters. Views are some years ago, situation today is worse*
- *063 – outside front of warehouse showing liquid waste transfer truck, concrete canisters and filter banks, circa 1994.*

1.10 Contaminated ground areas surrounding Building 39

- outside the building is a liquid waste transfer truck – it is contaminated and some liquid is still probably present in the tanks.
- Miscellaneous waste in the surrounding area is currently estimated at 50-60 te yellow barrels of contaminated soil from Al-Jesira, plus around 50 te of scattered metallic waste.

1.11 Building 40 Russian Silos

- still present but in decayed state. Roof structure might be unsafe
- used for both solid (98 wells/silos) and liquid waste
- liquid wastes evaporated to solid many years ago

- former liquid waste tank still shows high activity: some waste probably originated from the IRT upgrade but the origin of the higher activity waste is unknown.
- contents of the silos and liquid tank are unknown
    98 wells/silos contained about 20-30 te solid waste from IRT (including upgrade) 1967-90
    70-80 te solid waste added around 1991 from unknown origin
- known leakage to ground after nearby bomb explosion - further information on ground contamination would be desirable.
- surrounding ground areas show spotty contamination
- there were unconfirmed rumours of buried contaminated items in the surroundings

1.12 Building 64 Uranium Metal Production
- made around 10 kg of UF4
- all equipment was removed and building cleaned (as part of concealment activity)
- now down to concrete base level
- Decommissioning may not be required – just confirmation of no activity in the area.

1.13 Building 73A Fuel Fabrication and Building 73B U Purification (including 73.4 Waste Pit)
- Italian-supplied facility (part of B73 Italian complex)
- a conversion plant that purified yellowcake to produce UO3, U3O8, UO2, UF4 and U metal.
- plant was heavily damaged during the 1991 war and today, only a steel skeleton remains.
- spotty surface contamination can be found in the surroundings originating from the movement of contaminated equipment etc.
- there remains some sub-floor piping in the ruin which contains U compound. This is the piping that connected the purification equipment to a small waste storage area.
- Building73B: U Purification (Technological Hall) – joined to Building 73A: may have sub-floor pipework connections- the open areas between Building 73 and the Berm were used in the past as a vast scrapyard of damaged equipment. Spotty surface contamination could be found in this area and some buried contaminated item might still exist. Care should be taken in this area because acid waste, particularly HF acid was buried - currently estimated 10 te solid waste
- treat B73 and the adjacent open area as a single facility for planning purposes: essentially a common open area.
- *Image 045 shows the skeleton ruins of Building 73 A (to the left) and 73B, in mid view.*

Building 73B Waste Pit [B73.4]
- located nearby Building 73
- consists of a concrete pit housing two stainless steel tanks
- one tank contained inactive liquid waste
-one tank housed liquid uranium bearing waste as a sludge
- most of the sludge tank contents were removed in 1998, probably to the B39 Warehouse
- the bottom of the pit still contains a thin sludge (unless it has by now dried out): this remaining sludge was estimated to contain about 150 kg U as U oxides.
- there is spotty surface contamination in the pit area
- two truck body containers used in the 1998 recovery operations are contaminated

Images
- *046 – general view of the building 73 waste pit*

- 047, 048 – views showing storage tank in the active waste pit.
Note that sludge present in bottom of pit below tank

1.14 Buildings 73 C and D Other Italian Complex

- B73C: Utilities Facility - possible spotty surface contamination due to cross contamination
- B73D: Fuel Element Thermal Test : had a rig to heat fuel elements (may not have used real fuel)

This group will be considered as a single facility for this project

1.15 Building 85 Technology Hall (Uranium Tetrachloride Preparation and Purification Labs)

- principally the home of UCl_4 development and production
- also housed waste recovery activities
- building damaged during 1991 war and then raised to the ground by Iraqi authorities - site then buried by rubble and soil
- uranium compounds almost certainly were buried in the foundation structures
- material balance calculations by the Action Team indicate that any buried quantity of U would be quite small, possibly less than 100 kg (use as pessimistic assumption).
- surface contamination was never found in the Building 85 area.
- *images 043 and 044 show site circa 1993/4 and little changed today except for some flattening and more vegetation*

1.16 Building 155?? Po 210 Production

- Referred to as Building 155 on some lists, but this notation not known to Iraqi staff
- Building purpose and activity to be determined, but listed as a Po210 facility. Not clear whether this building was active (to be confirmed)
- Building may have been severely damaged
- Note that Building 66 Physics Lab was intended for Po work but did not go active

1.17 OUT-1 Burial/Concealment Location

- OUT-1 is located outside the berm, adjacent to the perimeter road, on the West side of Tuwaitha. It was a concealment location used for uranium compounds evacuated from Building 85 (possibly up to 100 kg U).
- numerous small containers of solvent extraction fluid and uranyl nitrate plus small containers and vials of U compounds were placed in concrete containers and buried beside the road.
- additionally, about 40 plastic containers of uranyl nitrate were buried in scattered fashion in the adjacent marsh area
- examination confirmed the presence of plastic containers and yellow staining of soil in the marsh area, but no liquid contents were found. Most of the containers probably broke open when they were being covered over.
- snakes might be present in this area (one found during original examination)

1.18 Scrapyard(s) and Burial Sites

- Further information required: numerous scrap areas around the site (including eg around the Italian area)

- Miscellaneous scrap areas and burial sites will be considered as one facility for the project
- contaminated scrap was looted during 2003 events- contaminated equipment and probably waste materials were buried at Tuwaitha. A ground area near the Tuwaitha Fire Station was heavily used for this purpose
- EMIS equipment was buried at several locations. The extent of contamination is not known. Information about burial activities exists in AT reports, but there will be no information about quantities of nuclear material.
- listed here as a general reminder that all ground areas on Tuwaitha have the potential to have had previous usage for disposal/burial or miscellaneous temporary storage

Amended
International Atomic Energy Agency
November 2007

Related Document: "Relating to Al Jesira and Adaya Dump Situation" GJ Healey (November 2006)

Appendix B – Summary of Spending FY's 2007, 2008 and 2009

Costed FY07 Activities

Total funding going into FY07: $388 K

Sandia work	Cost $ K	Breakdown $ K
Support IAEA TM 13-17 November, 2006	42	Travel 8 Labor 34
Write draft LLW disposal regulation for Iraq	14	Labor 14
Planning Meeting DOS and TTU in Washington DC January 2007	4	Travel 1 Labor 3
Prepare WM'07 paper	10	Labor 10
Bring Iraqis to WM'07, tour LLW disposal facilities in Nevada and Utah	83	Labor 42 Travel 4 Iraqi travel 37
Assist IRSRA with paper and poster and send IRSRA to ICEM'07	23	Labor 16 Iraqi travel 7
25. Project Management	31	Labor 31
TOTAL Sandia FY07 costs	$207 K	
TTU invoices paid in FY07	$42 K	
Total FY07 activities costed @ Sandia	**$249 K**	

Costed FY08 Activities

Total funding going into FY08: $1,061 K
Comprised of $139 K FY07 carryover + $922 K FY08/09 new funding

Sandia work	Cost $ K	Breakdown $ K
Planning meeting Lubbock Jan 2008	7	Travel 2 Labor 5
2. Workshop; drafting PMP for LAMA dismantlement and participation in IAEA April meeting	82	Travel 18 Labor 37 Iraqi travel 27
3. Provide Rad Worker II training materials to Iraqis	5	Labor 5
4. Provide Rad Worker II train-the-trainer training in Amman (budget for Iraqi travel $23K converted to more SNL hours and 2^{nd} trainer)	72	Labor 36 Travel 36
6. Assist design work areas and signage	2	Labor 2
8&9. Temporary rad waste accumulation area ~~& interim waste categorization system & participation in IAEA July meeting~~	7	Labor 7
13. Assist in design of waste sorting and staging area (partly accelerated for April meeting)	10	Labor 10
20. Submit Technical Paper to International Decommissioning Conference Avignon and air ticket	21	Labor 14 Travel 5 Registration 2.3
~~22. Workshop~~ Support on Quality Manual for LAMA Dismantlement	16	Labor 15.5
23 & 23A. US EPA Workshop for MoEN on env monitoring & Workshop at Sandia on monitoring groundwater / underground rad waste tanks	77 (budgeted 57)	Labor 42 Iraqis travel 35
25. Project Management	22	Labor 22
TOTAL Sandia FY08 costs	$321 K	
TTU invoices paid in FY08	$360 K	
Total FY08 activities costed @ Sandia	**$681 K**	

Costed FY09 Activities

Total funds going into FY09: $380 K carryover from FY08

Sandia work	Cost $ K	Breakdown $ K
20.Support MoST Presentation Technical Paper International Conference Avignon	15	Labor 11 Travel 4
Provide information on steel roll-offs for waste storage	3	Labor 3
16. Training Workshop on Disposal of Difficult Rad Waste, Amman Jordan ~~and participation in IAEA November meeting~~	85	Labor 55 Travel 13 Rent meeting facilities: 17
25. Project Management	16	Labor 16
26. Close-out Report with photos summarizing SNL support of Iraq NDs Project	26	Labor & printing 26
TOTAL Sandia FY09 costs	$145 K	
TTU invoices paid in FY09 (assumes TTU bills the remaining balance)	$235 K	
Total FY09 activities costed @ Sandia	**$380 K**	

Appendix C - Radiation Protection Equipment Considerations

This document is intended to provide an overview of considerations for purchase and use of radiation protection equipment for remediation of the LAMA facility located at Al-Tuwaitha. It is important to note that this document does not constitute the endorsement of any particular equipment manufacturers; rather it represents the collective opinion of the authors based upon equipment familiarity.

A comprehensive considerations list could not be constructed without a valid project management plan or without being privy to the actual conditions in the field, particularly the current or anticipated infrastructure; however, this document will hopefully provide some insight into typical considerations for a project of this nature.

After review of the existing Project Commercial Offer it appears that:

1) Some of the equipment listed could be phased in later
2) Special considerations exist for some of the equipment listed
3) Additional necessary equipment should be added to the list, and
4) Additional equipment may be needed, depending upon the results of the site characterization.

1. EQUIPMENT LISTED THAT COULD BE PHASED IN LATER

A. Canberra Argo-3 - Personnel contamination monitoring (Section 3 on list):

The Canberra Argo-3 will require:

- o a highly regulated power supply (proportional detectors)
- o a ready supply of P-10 gas
- o a low background counting area
- o routine maintenance and testing
- o a trained operator (preferably two) with the necessary maintenance equipment

It might be more appropriate to obtain and use hand-held friskers for personnel contamination monitoring, and phase in automated personnel contamination monitoring (such as the Canberra Argo-3 shown above or the Thermo PCM-2 shown on the left) as the remediation effort progresses and as infrastructures are put into place.

Hand-held friskers will be needed for other monitoring needs (equipment, material, vehicles, etc.). These same friskers can be used for personnel contamination monitoring. Radiological worker training includes basic personnel monitoring with a handheld frisker.

The Argo-3 with listed equipment can be purchased from Canberra for about **$69,700 USD**, which includes export costs.

B. *2250G2K ABACOS 2000, ASA-100 FASTSCAN - In-Vivo Activity Measurement (Section 4 on list)*

Lower cost alternatives are available for determining internal disposition. Internal contamination from many of the contaminants can be assessed by in-vitro sampling (urine or other).

An internal monitoring program will be necessary to provide the preferred monitoring. Considering that the potential for internal deposition from the LAMA remediation is reportedly low, it may be better to obtain and install the Fastscan at a later date.

Note that a shower facility and additional clothing (usually paper suit) will be needed to support operation.

<u>Questions:</u> Are in-vivo measurements available anyplace else in Iraq or a surrounding country? Will the current infrastructure support setup and reliable operation of the Fastscan? Would it be possible to install high purity germanium detectors (HpGe) rather than the sodium iodide (NaI) detectors listed (HpGe has a higher resolution than NaI but requires a supply of liquid nitrogen)?

The Fastscan with listed equipment can be purchased from Canberra for about **$118,500 USD**, which includes export costs.

2. SPECIAL CONSIDERATIONS FOR SOME OF THE EQUIPMENT LISTED

A. Kinetic Phosphorescence Analyzer (KPA) and other Uranium Assay Equipment (Sections 5 and 6 on list)

KPA is a proven technique for rapid, precise and accurate determination of uranium in aqueous solutions; however, Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) is the method of choice for determination of low level concentrations of uranium in urine in view of its speed and simplicity compared with more conventional methods of analysis.

Perhaps ICP-MS is something that may be phased in at a later date depending on budgetary constraints.

B. Clothing Inventory (Section 7 on list)

One of the primary considerations in clothing protective selection = potential for heat stress and/or heat stroke.

Tyvek® Suits - Tyvek® is acceptable; however, other choices (that may prove cooler for the user) are available for heat stress considerations. Recommend purchasing no more than one order cycle supply initially to determine adequacy and supply chain quality.

Gloves – Contaminants adhere to cotton and tritium easily permeates cotton. Latex is easily damaged, tritium also permeates. Consider thin nitrile gloves. Purchase 50 gloves/box, 10 boxes/case, at least 4 cases to start depending on supply cycle. Use masking or vinyl tape to fasten gloves to coveralls. Wear multiple pair to prevent spread of contamination and personnel contamination. Purchase leather gloves and issue for work where physical hazards exist. Leather gloves may become highly contaminated and will need to be disposed of accordingly. Survey prior to reuse. Establish contamination thresholds allowing reuse – dependent on contamination levels in the work area.

Footwear – Expect puncture hazards. Therefore, consider providing leather, steel toed, reinforced sole safety shoes for the work crews. Inventory and issue by name. Survey (frisk) daily prior to exit from radiological work areas. Wear plastic shoe/boot covers in areas where contamination is known to exist. Wear low cut rubber overshoes where water or slip hazard exists. Substitute safety footwear and shoe covers with rubber "safety" boots only when necessary. Decontamination and survey will be required prior to reuse.

C. Respiratory Protective Equipment (Section 8 on list)

Use of respiratory protection equipment for protection against airborne radioactive contamination should be minimized to the maximum extent practical; however, it is prudent to have respiratory protection equipment readily available. A characterization of respiratory hazards should be conducted to determine the most appropriate type(s) of respirators to use [e.g., filtering facepiece vs. tight-fitting elastomeric respirator (full-face or half-mask)]. Bear in mind that use of respiratory protection in conjunction with protective clothing in a high temperature work environment will aggravate problems with heat stress. Individuals selected for wearing respiratory protection equipment in this environment should be medically screened and trained/qualified in advance. If tight-fitting respirators are to be used, users should be fit-tested (preferably quantitatively) to determine most appropriate model and size of respirator(s) to use.

D. Protective Eyewear (Section 9 on list)

Protective eyewear should be in the form of ANSI approved safety glasses. Minimize use of safety goggles due to fogging. Full face reusable face shields should be used when additional hazards exist. Clean face shields and survey prior to reuse. Use anti-fog cleaner or specially coated eyewear to prevent fogging.

E. Electronic Pocket Dosimeters (Section 10 on list)

RAE Worker EPD – probably a decent dosimeter - overpriced. Should be worn in a plastic bag taped to the outside of protective clothing close, but not directly over, whole-body dosimetry (which is usually a Thermoluminescent Dosimeter, or "TLD").

RAE Environmental EPDs – probably don't need these. Should be able to drop these from the list.

RAE Dosimeter Reader and Software Kit – not necessary unless electronic access control will be the norm. Use hardcopy records in work control system to track dose in the field using EPDs. Make sure EPDs purchased are capable of stand-alone operation.

3. ADDITIONAL <u>NECESSARY</u> EQUIPMENT THAT SHOULD BE ADDED TO LIST

A. Instruments

1) <u>Dose Rate Instruments</u> – survey instruments capable of measuring gamma and beta radiation and at least one instrument capable of detecting neutron radiation.

- Low range gamma dose rate instruments – at least one, preferably two low range instruments to measure perimeter gamma dose rates and verify acceptable radiation levels in normally occupied spaces. Usually a NaI scintillation detector. $1000.00 – $2000.00 each. Example = Bicron microrem (also available in micro-sievert models)

- Medium range gamma and beta dose rate instruments – the "work-horse" of field survey instruments used to measure work area gamma and beta dose rates. Open air ion-chamber. At least 4-5 to start. Should be $850.00 to $1500.00 each. Example = Eberline RO-20

2) Contamination Monitoring Equipment – survey instruments (friskers) capable of detecting and measuring beta and alpha contamination. At least five instruments to start. Additional instruments as the project expands. Should be $750.00 to $3500.00 each depending on capabilities, model and setup.
Example = Eberline E600 fitted with 380 A/B probe

3) Personal Dosimeters – Individually issued Thermoluminescent Dosimeters (TLDs) will provide whole body dose of record for occupationally exposed workers. EPDs will provide real time running estimate of whole body dose received; however, not considered a dose of “record”. Reading / processing services may be contracted out to a 3rd party contractor. It may be better to obtain and provide dosimetry processing services in-country.

4) Counter – Multichannel Scaler – inexpensive version of swipe counter, which is setup at control points to analyze smear samples for personnel protection, material release, etc. At least two to begin, with more added as necessary to support field operations.
Example = Ludlum Model 2929 or Model 3030

5) Personal Air Samplers / Monitors – A battery powered personal air sampler such as a “Lapel” air sampler may be a suitable temporary alternative to area air sampling, which is dependent on available power supply.

Additional air sampling / air monitoring equipment should be added as soon as a reliable power supply becomes available.

B. Miscellaneous Equipment

1) Portable lighting
2) Tents / building with air conditioning for heat stress cool down areas
3) Uninterruptible power supplies (UPS) for critical equipment
4) Personnel shower / decontamination facility
5) Radiological (yellow and magenta) rope / ribbon
6) Stanchions
7) Waste bags / containers
8) Radiological tags / labels
9) Swipes (smears)
10) Sampling equipment / media for air, soil, H_2O
11) Small ziplock bags for EPDs
12) Masking, vinyl, and duct tape
13) Hearing protection
14) Hard hats? (probably)
15) Heat stress monitoring equipment – WBGT, blood pressure, temperature, weight, monitoring log
16) Modesty garments (optional)
17) Fluids
18) Hot work PC's – flame retardant for hot work – Tyvek® burns
19) Decontamination material – paper towels, soap, water, brushes, shovels, power sprayer

4. ADDITIONAL EQUIPMENT POSSIBLY NEEDED DEPENDING ON CHARACTERIZATION AND SCALE OF OPERATION

(In addition to equipment listed in section 1 of this document)

A. Additional Field Use Instruments

1) High Range Gamma Dose Rate Instrument(s) – such as Telescopic instruments (Example = Teletector) which goes up to 1000 Roentgen/hr (G-M type detector). A high range, remote readout, waterproof instrument such as the Eberline RO-7 may be needed depending on the radiological hazards encountered. Note: High probability that Teletector type instrument will be needed at some point

2) Neutron Dose Rate Instrument(s) – A neutron radiation dose rate instrument may be needed to establish neutron dose rates in the event that a neutron-emitting source is detected during remediation. Example = Eberline E600 with Neutron Detector (Remball).

3) Gamma Exit/Entrance Monitor – easier to maintain and operate that traditional PCMs (plastic scintillators vs. gas flow proportional detection). Placed at the site exit. Example is the Canberra GEM 5.

4) Small Article and Tool Monitor – used to speed processing time for release of small items. Plastic scintillation detectors are used. Example is the Thermo Eberline Model SAM-12.

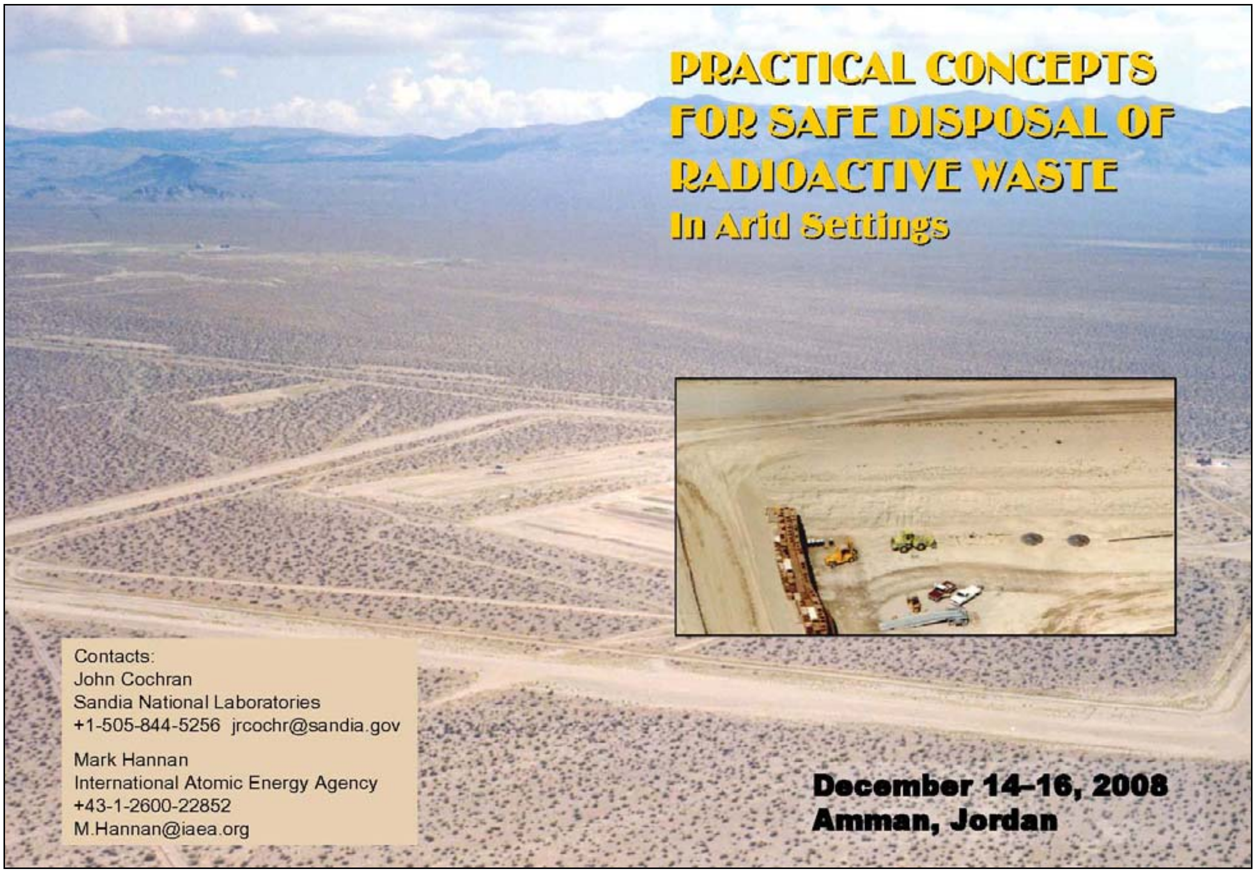
B. Additional Laboratory Instruments

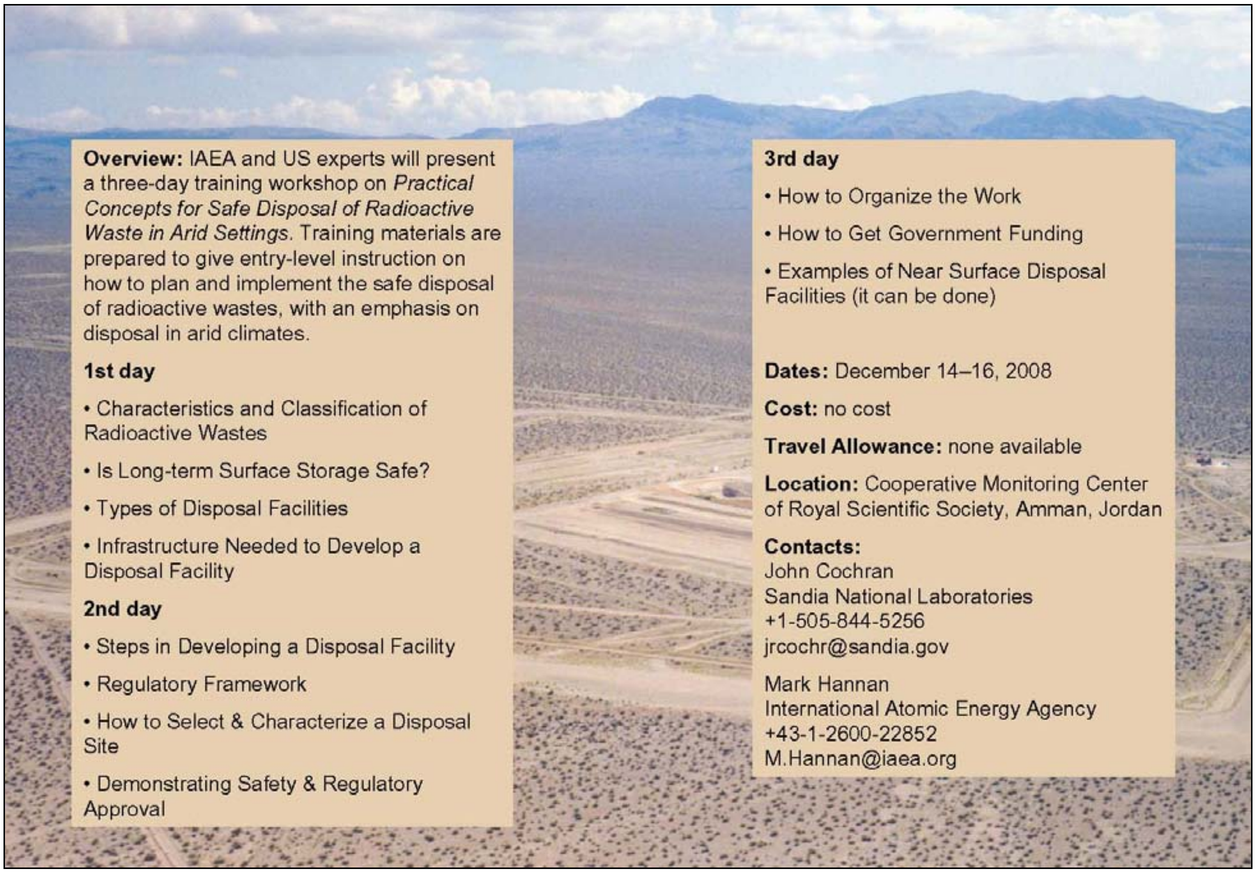
1) Liquid Scintillation Counter (LSC) – needed if tritium is determined to be contamination source. Used to count tritium smear samples, air samples, and urine samples (bioassay). Tritium can not be measured with conventional counting instruments. Tritium was mentioned in the LAMA paperwork.

2) Automated Alpha/Beta Sample Counting Instrument – a higher volume automated sample (smear and air) counting instrument will speed processing of samples. Example is the Tennelec, Model LB 5100.

3) High Purity Germanium Gamma Spectroscopy System –determines isotope(s) and activity concentration of radioactive samples. Used to analyze bioassay samples, smear and air samples, and soil samples.

Appendix D - Brochure for Training on Practical Concepts for Safe Disposal of LLW in Arid Setting




Overview: IAEA and US experts will present a three-day training workshop on *Practical Concepts for Safe Disposal of Radioactive Waste in Arid Settings*. Training materials are prepared to give entry-level instruction on how to plan and implement the safe disposal of radioactive wastes, with an emphasis on disposal in arid climates.
1st day
• Characteristics and Classification of Radioactive Wastes
• Is Long-term Surface Storage Safe?
• Types of Disposal Facilities
• Infrastructure Needed to Develop a Disposal Facility
2nd day
• Steps in Developing a Disposal Facility
• Regulatory Framework
• How to Select & Characterize a Disposal Site
• Demonstrating Safety & Regulatory Approval
3rd day
• How to Organize the Work
• How to Get Government Funding
• Examples of Near Surface Disposal Facilities (it can be done)
Dates: December 14–16, 2008
Cost: no cost
Travel Allowance: none available
Location: Cooperative Monitoring Center of Royal Scientific Society, Amman, Jordan
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Appendix E - Letter to IAEA's Technical Cooperation

Sandia National Laboratories
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Internet: jrcochr@Sandia.gov

May 7, 2008

Peter Salema
Director,
Division for Asia and the Pacific (TCAP)
Department of Technical Cooperation
International Atomic Energy Agency
Vienna, Austria

Dear Mr. Salema,

Our Laboratory would like to explore the possibility of IAEA collaboration in expanding an existing four-day training course on Disposal of Difficult Radioactive Wastes in Iraq.

To provide a short background, we have been contracted by the U.S. Department of State to provide support to the Iraq Nuclear Facility Dismantlement and Disposal Program (the Iraq NDs Program). The Iraq NDs Program provides expert advice, training and equipment to Iraq, so the Government of Iraq can cleanup its radioactively contaminated sites and safely dispose of its radioactive wastes. The project is organized in association with the IAEA and has participation of several countries. A link to the IAEA Iraq NDs website follows: http://www-ns.iaea.org/projects/iraq/

As a part of the NDs Program, the Department of State has provided us with scope to present a training course on Disposal of Difficult Radioactive Wastes in Iraq, with emphasis on disposal in boreholes. Because of limited funds, the baseline is for our Laboratory to teach this course this fall to a small number of Iraqis who will already be in Vienna for meetings with the IAEA.

We would like to explore the option of collaborating with IAEA TCAP to expand this training course to a more regional training course with a target audience of professionals and managers from neighboring, Arab-speaking countries. Such a regional training course could be held in Amman, Jordan and the course would benefit greatly from the support of experts from the Division of Radiation, Transport and Waste Safety, and the Division of Nuclear Fuel Cycle and Waste Technology.

The advantages of such a collaborative regional training course include: the opportunity to leverage an existing effort already funded outside of the Agency; the opportunity to target Arab-speaking Gulf countries; the opportunity to help multiple MSs with a single Agency effort, and the opportunity to promote cooperation between MSs and the areas of waste management and waste disposal. If you feel such a proposal is worthy of further discussions, please feel free to contact me at (505) 844-5256 or jrcochr@Sandia.gov.

With my best regards,

John R. Cochran
Principal Investigator
Organization 6765
Sandia National Laboratories

cc: W. David Kenagy, U.S. Department of State
Jeff Danneels, SNL, Org 6760, MS 0719

d).

Appendix F - Sample IAEA Meeting Agenda, 14-17 December, 2008

Agenda - IAEA Concurrent Meetings on Evaluation and Decommissioning of Former Facilities that used Radioactive Material in Iraq

14th -17th December 2008 (0900hrs to 1600hrs daily):
Cooperative Monitoring Centre in Amman, Jordan

(Note: CS-173 Project to assist the Government of Iraq in the Evaluation and Decommissioning of Former Facilities that used Radioactive Material in Iraq (practical implementation of previous IAEA Waste Strategy meetings) will be primarily delivered by Sandia Laboratories under the title *"Workshop on Safe Disposal of Radioactive Waste in Arid Settings")(See separate Agenda, same venue and week)*

1) Welcome and general introductions *[Messrs Hannan/Cochran*]

2) Overview of national situation in Iraq *[Mr Jarjies]*

3) Legal and Governmental infrastructure in Iraq [*Mr Jarjies]*

4) Regulation generally (passing of laws etc) *[Iraq]*
   a. update from Iraq on
      i. Regulations
         1. progress on Transport regulations
         2. progress on Security regulations
      ii. new Nuclear Law
      iii. use of draft regulations on LAMA
      iv. interface between all regulators and operators
      v. Waste Management Policy and Strategy

5) Progress in Decommissioning Programme of Iraq Destroyed Nuclear Facilities and Sites (encompassing the prioritization report, overall length of programme, and expected resource requirements) *[Mr Jarjies]*

6) Radiological Characterization of LAMA Stage-1 Decommissioning *[Mr Al-Bakhat]*

7) Statistical Analysis of Radiological Characterization *[Mr. Al-Tameemi]*

8) Development of Project Plan to Address Scrap Material at Al-Tuwaitha *[Mr. Zaboon]*
9) Biological Dosimetry and Haematological Analysis for Workers at Al- Tuwaitha *[Ms. Mutter]*
10) PMP of LAMA Stage-2 Decommissioning *[Mr. Baiee]*
11) LAMA Unsafe Structure Dismantling Plan *[Mr. Jassim]*
12) Development of Oversight and Contingency Plan for Radioactive Liquid Waste Tanks at Al- Tuwaitha

    [Mr. Zaboon]
13) PMP for Decommissioning of the Geo Pilot Plant *[Mr.Waheeb]*
14) Proposal for Establishing Radioecology Laboratory in Iraq (tie in to Pripyat learning)

    [Mr. Mahmoud]
15) Securing additional resources *[Iraq]*
    a. Review of the international support already received
    b. Fresh support identified e.g. after Avignon and Buenos Aires Conferences (include also progress on obtaining funds from Non-US sources (e.g. following on from the IAEA Vienna General Conference) and from elsewhere in Iraq
    c. Procurement
        i. TC Prime
16) Training update *[Iraq with support from Hannan]*
    a. Iraq training/US training/IAEA training
    b. Training needs
17) Establishing uranium monitoring facilities in Iraq *[Iraq]*
18) Review of material received for Website (Note: US and IAEA contributions are available) *[Hannan]*
19) Review of forward plan (especially November 2008 Technical Meeting) *[Hannan]*
    a. Joint mission to Australia
    b. Schedule of meetings
20) Any other business and close of meeting *[Hannan]*

Mark Hannan
IAEA

Appendix G - First Two Pages of a Draft Regulation for Land Disposal of Radioactive Waste in Iraq

DRAFT - Regulations for land disposal of radioactive waste in Iraq
John Cochran, rev. 1, 25 January 2007

§ 1 Purpose and scope.

(a) These regulations establish the procedures and criteria for land disposal of radioactive wastes.

§ 2 Definitions.

Buffer zone is a portion of the disposal site that is controlled by the licensee and that lays under the disposal units and between the disposal units and the boundary of the site.

Disposal means emplacement of radioactive wastes in a licensed disposal facility with no intent of retrieval.

Disposal site means that portion of a land disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone.

Disposal unit means a discrete portion of the disposal site into which waste is placed for disposal. For near-surface disposal the unit is usually a trench.

Engineered barrier means a man-made structure or device that is intended to improve the land disposal facility's ability to meet the performance objectives. An engineered barrier may be constructed of natural or man-made materials.

Explosive material means any chemical compound, mixture, or device, which produces a substantial instantaneous release of gas and heat spontaneously or by contact with sparks or flame.

Inadvertent intruder means a person who might occupy the disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which the person might be unknowingly

Land disposal facility means the land, building, and structures, and equipment which are intended to be used for the disposal of radioactive wastes.

Monitoring means observing and making measurements to provide data to evaluate the performance and characteristics of the disposal site.

Near-surface disposal facility means a land disposal facility in which radioactive waste is disposed of in or within the upper 30 meters of the earth's surface.

Pyrophoric liquid means any liquid that ignites spontaneously in dry or moist air at or below 130F (54.5C). A *pyrophoric solid* is any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires.

Site closure and *stabilization* means those actions that are taken upon completion of operations that prepare the disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing active maintenance.

Surveillance means observation of the disposal site for purposes of visual detection of need for maintenance, custodial care or evidence of intrusion.

§ 3 License required.

(a) No organization may dispose of radioactive waste unless authorized by a license issued by the regulatory authority. (b) A license must be applied for and obtained before commencing construction of a land disposal facility.

§ 4 Concepts.

(a) The disposal facility.

> (1) These regulations apply to land disposal of radioactive waste. These regulations contain procedural requirements and performance objectives applicable to any method of land disposal. They contain specific technical requirements for near-surface disposal of radioactive waste, which involves disposal in the uppermost portion of the earth, approximately 30 meters.
>
> (2) The disposal site is that portion of the facility which is used for disposal of waste and consists of disposal units and a buffer zone. For near-surface disposal, the disposal unit is usually a trench. A buffer zone is a portion of the disposal site that is controlled by the licensee and that lies under the site and between the boundary of the disposal site and any disposal unit. It provides controlled space to establish monitoring locations.

(b) Key Performance Objectives for Disposal of Radioactive Waste.

(1) Disposal of radioactive waste in near-surface disposal facilities has the following four safety objectives: 1) protection of the general population from releases of radioactivity, 2) protection of individuals from inadvertent intrusion, and 3) protection of individuals during operations. A fourth objective is to ensure stability of the site after closure.

Distribution List:

5	W. Dave Kenagy US Department of State, ISN/NESS Room 3320 Washington DC, 29520	
2	Dr. Ronald K. Chesser, Director Center for Environmental Radiation Studies Texas Tech University Lubbock, Texas 79409-3131	
5	MS0719	John Cochran, 6765
1	MS0719	Jeff Danneels, 6761
1	MS0719	David Miller, 6765
1	MS 0899	Technical Library, 9536 (electronic copy)