RAS 14508

Army Anagnostopoulos Exh. # 1-G

[Originally Attached As EXHIBIT HWA # 8 to Witness Anagostopoulos' pre-filed testimony]

Health Risk Assessment Consultation No. 26-MF-7555-00D, Depleted Uranium - Human Exposure Assessment and Health Risk Characterization in Support of the Environmental Exposure Report "Depleted Uranium in the Gulf" of the Office of the Special Assistant to the Secretary of Defense for Gulf War Illnesses, Medical Readiness and Military Deployments (OSWAGI), U.S. Army Center for Health Promotion and Preventative Medicine, September 15, 2000. (Section 5.2, Camp Doha)

EXECUTIVE SUMMARY

1.0 Purpose

The Department of Defense (DOD) Office of the Special Assistant for Gulf War Illnesses (OSAGWI), now known as the Office of the Special Assistant to the Secretary of Defense for Gulf War Illnesses, Medical Readiness and Military Deployments, directed the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) to conduct a human exposure assessment and health risk characterization for military personnel potentially exposed to depleted uranium (DU) during service in Southwest Asia (see Memorandum, OSAGWI, 30 January 1998, subject: *Request for Assistance with Depleted Uranium (DU) Risk Assessment*).

In response to this tasking, this report provides the following:

- A review and evaluation of the existing DU munition test data.
- Identification of data gaps.
- Assessments of human exposures and qualitative health risk characterizations for each of the three OSAGWI DU exposure levels.
- Recommendations to fill data gaps by conducting further testing that will allow better health risk estimates.

inductively-coupled plasma-mass spectrometry out to almost 10 years post-exposure. The VA has been monitoring a group of Level I personnel since 1994. In McDiarmid, et al., (2000), it was reported that the results of a 1997 measurement found elevated levels of uranium only in personnel with embedded DU fragments. This work provides an indication that the estimates for inhalation exposure for all Level I personnel are in fact upper bound.

The upper-bound exposure and intake of DU from secondary ingestion (hand-to-mouth) for a single perforation is estimated to be 24 mg and the resultant radiation dose is 0.0006 rem. For two perforations the intake of DU and the radiation dose could be within a factor of 2 to 5 times greater. (See Part IV and Appendix F.) The lower-bound exposure and intake for a single perforation is estimated to be about 50 percent of the upper-bound value.

5.2 OSAGWI Level II and III Scenarios

Level II. The upper-bound exposure and intake of DU from inhalation and indirect ingestion for a single perforation is estimated to be 0.025 mg and the resultant radiation CEDE is 0.0004 rem for a 1-hour exposure in a vehicle.

For Level II personnel who may have entered vehicles perforated by two DU rounds, the secondary intake of DU and the radiation dose (CEDE) could be 2 to 5 times greater as discussed in Part V. Two perforations could result in an upper-bound intake of 0.05 mg (0.025 mg * 2) to 0.125 mg (0.025 mg * 5). The upper-bound dose for two perforations would be less than 0.1 rem (0.0004 rem * 5) which is well below the current NRC and OSHA radiation safety standards.

The upper-bound intake of 0.025 mg would result in a concentration of DU in the kidney of 0.00067 μg DU/g of kidney. This value is below the ICRP chemical toxicity guidelines of 3 μg DU/g of kidney. Scaling for two perforations will result in an intake of 0.125 mg. The resulting concentration of DU in the kidney would be 0.0035 μg DU/g of kidney. This 0.0035 μg DU/g of kidney is below the guideline of 3 μg DU/g of kidney. (See Part V.)

Level III. The upper-bound exposure and intake of DU from inhalation and indirect ingestion for a single perforation is estimated to be 0.057 mg, and the resultant radiation CEDE is 0.0001 rem for a 1-hour exposure in a vehicle.

For Level III personnel who may have entered vehicles perforated by two DU rounds or exposed to smoke from these vehicles, the intake of DU and the radiation dose (CEDE) could be 2 to 5 times greater as discussed in Part V. Two perforations could result in an upper-bound intake of 0.0114 mg (0.0057 mg * 2) to 0.029 mg (0.0057 mg * 5). The upper-bound dose for two perforations would be less than 0.1 rem (0.0004 rem * 5) which is well below the current NRC and OSHA radiation safety standards.

The upper-bound intake of 0.0057 mg would result in a concentration of DU in the kidney of 0.00026 μg DU/g of kidney. This value is below the ICRP chemical toxicity guidelines of 3 μg DU/g of kidney. Scaling for two perforations will result in an intake of 0.029 mg. The resulting concentration of DU in the kidney would be 0.0013 μg DU/g of kidney. This 0.0013 μg DU/g of kidney is below the guideline of 3 μg DU/g of kidney. (See Part V.)

Camp Doha Exposure Scenarios. The Camp Doha scenarios in Level II and Level III are addressed in Appendix C. This Pacific Northwest National Laboratory study estimated the exposures to DU for residents and recovery workers at Camp Doha, Kuwait, following the July 1991 fire. People who were exposed to airborne concentrations from the fire (Level III) were estimated to have received negligible chemical doses. The upper-bound concentration in the kidney was estimated to be 1.8×10^{-8} μg DU/g of kidney for people assembled in the United Nations Compound at the base and about 2.8×10^{-7} μg DU/g of kidney for a person who was located in the area of highest air concentration. Estimated chemical doses for recovery workers (Level II) who spent extensive time in the contaminated areas of the North Compound after the fire range from 3.3×10^{-3} μg DU/g of kidney to 9.5×10^{-2} μg DU/g of kidney, depending on which type of activity they were involved in. People exposed to airborne concentrations from the fire were estimated to have received negligible radiation doses: about 0.000000062 rem for people assembled in the United Nations Compound at the base and about 0.000003 rem for a person who may have been located in the area of highest air concentration. Estimated doses for recovery workers who spent time in the contaminated areas of the North Compound after the fire range from 0.001 rem to 0.065 rem, depending on which type of activity they were involved. A summary of exposures, intakes, and radiation dose (CEDE) for Levels I, II, and III OSAGWI Exposure Scenarios is found in Executive Summary Tables 1 and 3. The range of DU exposures for chemical toxicity for Levels I, II, and III Exposure Scenarios is found in Executive Summary Tables 2 and 4.

The tables within this Executive Summary are meant to present a bounding of potential DU exposure for Gulf War veterans, who can then identify themselves as being included in a specific OSAGWI Gulf War scenario(s). By identifying with a particular scenario(s) (such as Explosive Ordnance Disposal (EOD) personnel), they can estimate the range in values of a potential DU intake and a characterization of health risk. This assessment may satisfy the veterans' interests or may encourage them to request further evaluation by the VA or the DOD Comprehensive Clinical Evaluation Program.

Executive Summary Table 1. Ranges of DU Intakes by Inhalation and Indirect Ingestion, Level I Scenarios

Exposure Scenario	Total Estimated DU Intake Range (mg) in a vehicle[1]	Insoluble DU Intake Range (mg) in a vehicle	Radiation Dose Range (rem) in a vehicle[2]	Possibility Radiation Exposure Limit Exceeded[3]	Radiation Risk (Total Detriment)[4]	Soluble DU Intake Range (mg) in a vehicle		Chemical Toxicity Risk
Individual inside a tank at time of impact or perforation by a single DU round and First Responders	9 (LB) to 79 (UB)[6]	7 (LB) to 66 (UB)	0.2 (LB) to 1.6 (UB)	NO	1:7,000 to 1:900	2 (LB) to 13 (UB)	Yes[7]	No
Individual inside a tank at time of impact by a single round, but did not penetrate the turret compartment	0.042	0.035	0.001	NO	1:1,000,000	0.007	No	No
Individual inside a tank after perforation by a single round receiving secondary ingestion	12 (LB) to 24 (UB)	10 (LB) to 20 (UB)	0.0003 (LB) to 0.0006 (UB)	NO	1:4,600,000 to 1:2,300,000	2 (LB) to 4 (UB)	No	No

[1] No credit for personal protective equipment (PPE), such as respirators or military protective masks, was given for the calculations in this table.
[2] The CEDE dose for a 2-minute exposure spent in the vehicle. (Based on a 5-micrometer (μm) aerosol.)
[3] Internal radiation dose is expressed in terms of CEDE. Radiation standard equals 5 rem per year [Title 10, Code of Federal Regulations, Parts 20.21201 (a) and (b)].
[4] Radiation Risk is expressed in total detriment (7.3×10^{-4}/rem).
[5] Chemical Toxicity Standard: 40 mg of inhaled soluble uranium is threshold for permanent renal damage; 8 mg of inhaled soluble uranium is threshold for transient renal injury (National Defense Research Institute, 1999, and American National Standards Institute, 1995).
[6] (UB) – Upper bound of range is Assumption 1 median value for a single perforation; (LB) – Lower bound of range is Assumption 2 median value for a single perforation. For two perforations, the intake and dose can be scaled to a factor of 1.5 to 3. The UB and LB are based on a 5 μm activity median aerodynamic diameter (AMAD) particle-size distribution.
[7] Exceeding a guideline does not mean that adverse health effects will result (see Part IV).

Executive Summary Table 2. Ranges of DU Exposures for Chemical Toxicity Consideration, Level I Scenarios

Exposure Scenario	Total Estimated DU Intake Range (mg) in a vehicle[1]	Calculated Kidney Concentration (µg DU/g of tissue)	Possibility Chemical Exposure Guideline Exceeded[2]	Estimated Air Concentration[3] (mg/m^3)	Possibility Chemical Exposure Guideline Exceeded[4]
Individual inside a tank at time of impact or perforation by a single DU round	9 (LB) to 79 (UB)[5]	0.2 (LB)	NO	270 to 2,400	YES
		1.5 (UB)	NO		

[1] No credit for PPE, such as respirators or military protective masks, was given for the calculations in this table.
[2] Toxicity Guideline: 3.0 µg uranium per gram (U/g) of kidney tissue is the derived guideline (Spoor and Hursh., 1973).
[3] Air concentration guidelines used for comparisons are Department of Energy (DOE) temporary emergency exposure limits (TEELs) (0.5 mg/m^3 – 10 mg/m^3) and American Conference of Governmental Industrial Hygienists short-term exposure limits (STELs) (0.60 mg/m^3) (Craig 1998 and ACGIH 2000).
[4] (UB) - Upper Bound of range is Assumption 1 median value for a single perforation; (LB) - Lower Bound of range is Assumption 2 median value for a single perforation. For two perforations, the intake and dose can be scaled to a factor of 1.5 to 3. The UB and LB are based on a 5 µm AMAD particle size distribution.
[5] Exceeding a guideline does not imply that adverse health effects will result (see Part IV).

Executive Summary Table 3. Ranges of DU Intakes by Inhalation and Indirect Ingestion, Levels II and III Scenarios

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle [See Note 1]	Insoluble DU Intake Range (mg/hr) in a vehicle	Radiation Dose Range (rem/hr) in a vehicle (See Note 2)	Possibility Radiation Exposure Limit Exceeded [See Note 3]	Radiation Risk	Soluble DU Intake Range (mg/hr) in a vehicle	Possibility Chemical Exposure Limit Exceeded [See Note 4]	Chemical Risk	Discussion In Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Notes 5 & 6]
Level II										
Explosive Ordnance Disposal (EOD) and other unit personnel who downloaded equipment and munitions from DU-contaminated vehicles/systems	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.1	Appendix S
Radiation Control (RADCON) team members	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.2	Appendix S
Battle Damage Assessment Team (BDAT) members who examined U.S. combat vehicles damaged and destroyed by DU	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.3	Appendix S
Logistics Assistance Representatives (LARs) who inspected DU-contaminated vehicles/systems to determine reparability	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.4	Appendix S

Executive Summary Table 3. Ranges of DU Intakes by Inhalation and Indirect Ingestion, Levels II and III Scénarios (con"t)

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle [See Note 1]	Insoluble DU Intake Range (mg/hr) in a vehicle	Radiation Dose Range (rem/hr) in a vehicle (See Note 2)	Possibility Radiation Exposure Limit Exceeded [See Note 3]	Radiation Risk	Soluble DU Intake Range (mg/hr) in a vehicle	Possibility Chemical Exposure Limit Exceeded [See Note 4]	Chemical Risk	Discussion In Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Notes 5 & 6]
Unit maintenance personnel who performed maintenance on or in DU-contaminated vehicles/systems	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.5	Appendix S
144th Service and Supply Co. personnel who processed damaged equipment, including some with DU contamination	0.00078 (LB) to 0.025 (UB)	0.00065 to 0.023	0.00001 to 0.0005	No	Acceptable	0.00013 to 0.002	No	Acceptable	5.2 and 5.2.6	Appendix S
Personnel exposed to DU contamination during cleanup operations at Camp Doha's North Compound	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	5.2, 5.2.7, and App S	—
Level III										
Personnel exposed to smoke from burning DU rounds at Camp Doha	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	5.2.7 and App S	—
Personnel exposed to smoke from burning Abrams tanks	0.0000039 (LB) to 0.0028 (UB)	0.0000036 to 0.0026	0.0000001 to 0.00007	No	Acceptable	0.0000003 to 0.0002	No	Acceptable	5.2 and 5.3.1	5.2 and 5.3.1

Executive Summary Table 3. Ranges of DU Intakes by Inhalation and Indirect Ingestion, Levels II and III Scénarios (con"t)

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle [See Note 1]	Insoluble DU Intake Range (mg/hr) in a vehicle	Radiation Dose Range (rem/hr) in a vehicle (See Note 2)	Possibility Radiation Exposure Limit Exceeded [See Note 3]	Radiation Risk	Soluble DU Intake Range (mg/hr) in a vehicle	Possibility Chemical Exposure Limit Exceeded [See Note 4]	Chemical Risk	Discussion In Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Notes 5 & 6]
Personnel who entered DU-contaminated Iraqi vehicles/ equipment	0.00078 (LB) to 0.0057 (UB)	0.00065 to 0.0047	0.00001 to 0.0001	No	Acceptable	0.00013 to 0.001	No	Acceptable	5.2 and 5.3.2	5.2 and 5.3.2
Personnel exposed to smoke from DU-perforated Iraqi vehicles/ equipment	0.000063 (LB) to 0.0044 (UB)	0.000052 to 0.0037	0.000001 to 0.00007	No	Acceptable	0.000011 to 0.00075	No	Acceptable	5.2 and 5.3.3	5.2 and 5.3.3

Note 1. No credit for PPE, such as respirators or military protective masks, was given for the calculations in this report. UB) - Upper Bound of range; (LB) - Lower Bound of range. The UB and LB are based on a 5 μm AMAD particle size distribution.

Note 2: CEDE dose for each hour spent in the vehicle.

Note 3. Internal radiation dose is expressed in terms of CEDE which is based on a 5 μm AMAD particle size distribution. Radiation Standard: 5 rem per year (10 CFR).

Note 4. Chemical Toxicity Standard: 40 mg of soluble uranium as threshold for permanent renal damage; 8 mg of soluble uranium as threshold for transient renal injury (National Defense Research Institute, 1999, and ANSI, 1995).

Note 5. Examples developed from OSAGWI interview data (see Appendix S for dose assessments).

Note 6. Assessment of secondary ingestion (hand-to-mouth) intakes has been considered and is included in Part V.

Note 7. Analysis of Camp Doha scenarios (Level II and Level III) is provided in Appendix C.

Executive Summary Table 4. Ranges of DU Intakes by Inhalation and Indirect Ingestion and Chemical Guidelines, Levels II and III Scenarios

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle[1]	Calculated Kidney Concentration (μg DU/g of tissue)	Possibility Kidney Concentration Guideline Exceeded[2]	**Air Concentration** (mg/m^3)	Possibility Air Concentration Guideline Exceeded[3]	Discussion in Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Notes 5 & 6]
Explosive Ordnance Disposal (EOD) and other unit personnel who downloaded equipment and munitions from DU-contaminated vehicles/systems	0.00078 (LB)[4] to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.1	Appendix S
Radiation Control (RADCON) Team members	0.00078 (LB) to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.2	Appendix S
Battle Damage Assessment Team (BDAT) members who examined U.S. combat vehicles damaged and destroyed by DU	0.00078 (LB) to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.3	Appendix S
Logistics Assistance Representatives (LARs) who inspected DU-contaminated vehicles/systems to determine reparability	0.00078 (LB) to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.4	Appendix S
Unit maintenance personnel who performed maintenance on or in DU-contaminated vehicles/systems	0.00078 (LB) to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.5	Appendix S

Executive Summary Table 4. Ranges of DU Intakes by Inhalation and Indirect Ingestion and Chemical Guidelines, Levels II and III Scenarios (con't.)

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle[1]	Calculated Kidney Concentration (µg DU/g of tissue	Possibility Kidney Concentration Guideline Exceeded[2]	**Air Concentration** (mg/m^3)	Possibility Air Concentration Guideline Exceeded[3]	Discussion in Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Note 5 & 6]
144th Service and Supply Co. personnel who processed damaged equipment, including some with DU contamination	0.00078 (LB) to 0.025 (UB)	0.000032 to 0.00067	No	2.6×10^{-4} to 8.4×10^{-3}	No	5.2 and 5.2.6	Appendix S
Personnel exposed to DU contamination during cleanup operations at Camp Doha's North Compound	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	5.2.7 and App C	Appendix S
Level III							
Personnel exposed to smoke from burning DU rounds at Camp Doha	[See Note 7] —	[See Note 7]	[See Note 7]	[See Note 7]	[See Note 7]	5.2.7 and App C	—
Personnel exposed to smoke from burning Abrams tanks	0.0000039 (LB) to 0.0028 (UB)	0.0000001 to 0.00007	No	1.3×10^{-6} to 9.3×10^{-4}	No	5.2 and 5.3.1	5.2 and 5.3.1
Personnel who entered DU-contaminated Iraqi vehicles/equipment.	0.00078 (LB) to 0.0057 (UB)	0.000033 to 0.00026	No	2.6×10^{-4} to 1.9×10^{-3}	No	5.2 and 5.3.2	5.2 and 5.3.2

Executive Summary Table 4. Ranges of DU Intakes by Inhalation and Indirect Ingestion and Chemical Guidelines, Levels II and III Scenarios (con't.)

Exposure Classification: Levels and Scenarios	Total DU Intake Range (mg/hr) in a vehicle[1]	Calculated Kidney Concentration (µg DU/g tissue)	Possibility Kidney Concentration Guideline Exceeded[2]	**Air Concentration** (mg/m^3)	Possibility Air Concentration Guideline Exceeded[3]	Discussion in Sections of Part V	**Scenario Example:** Estimated Total DU Intake (mg) [See Note 5 & 6]
Personnel exposed to smoke from DU-perforated Iraqi vehicles/equipment	0.000063 (LB) to 0.0044 (UB)	0.000003 to 0.0002	No	0.021×10^{-3} to 1.48×10^{-1}	No	5.2 and 5.3.3	5.2 and 5.3.3

Notes:
[1] No credit for PPE, such as respirators or military protective masks, was given for the calculations in this report.
[2] Toxicity Guideline: 3.0 µg U/g tissue (Spoor and Hursh, 1973)
[3] Air concentration guidelines used for comparisons are DOE TEELs (0.5 mg/m^3 – 10 mg/m^3) and ACGIH STEL (0.60 mg/m^3).
[4] (UB) - Upper Bound of range; (LB) - Lower Bound of range. The UB and LB are based on a 5 µm AMAD particle size distribution.
Note 5. Examples developed from OSAGWI interview data (See Appendix S for dose assessments.)
Note 6. Assessment of secondary ingestion (hand-to-mouth) intakes has been considered and is included in Part V.
Note 7. Analysis of Camp Doha Scenarios (Level II and Level III) is provided in Appendix C.