APPENDIX T – Example OSAGWI Level III Combination Exposure Scenarios from the Gulf War

T.1 Introduction

In examining the DU intakes and internal doses from the OSAGWI Level II and Level III exposure scenarios (see Tables 47 and 48 in Part V), a Gulf War soldier might indicate that he experienced all of the Level III scenarios.

A sample exposure scenario combining many of the OSAGWI exposure scenarios is provided to demonstrate how a generalized exposure assessment can be tailored to a soldier's own experiences in Southwest Asia.

T.2 Scenario

One soldier describes his experience this way:

"While in the Persian Gulf I was assigned to the 9th ACR as a Cavalry Scout. During the ground war I passed by one Abrams Heavy tank that was on fire. I entered 7 Iraqi vehicles that may have been contaminated with DU from large caliber rounds. I estimate that I spent an average of 7 minutes per vehicle. I also passed by 3 Iraqi tanks that may have been struck by large caliber DU munitions. During the entry into one of the Iraqi tanks, my hands were extremely smudged and I did not have a chance to wash them for two days. Did I contaminate my hands with DU?

What kind of exposure did I receive from the DU and what are my risks from this exposure? In other words, What are the best estimates of DU intake into my body, the radiation dose to my lungs and whole body, and the toxicological risks to my kidney?"

T.3 Assessment

Using the information from Table 47 and Sections 5.2, 5.3, and 5.3.2, estimated DU intakes can be calculated for this soldier:

- **Exposure to Smoke From a Burning Abrams Tank (Section 5.3.1)**

  - As a Cavalry Scout, if it took you 20 minutes to walk through the smoke plume of a burning Abrams tank, uploaded with DU munitions, at a distance of 100 meters from the burning tank, you may have received an inhalation and indirect ingestion intake of 0.00093 mg of DU. The calculation is as follows:

(0.0028 mg/hr/vehicle)*(1 hr/60 min)*(20 min)*(1 vehicle) =

0.00093 mg [that is, 0.000865 mg insoluble (93%) DU and 0.000065 mg soluble (7%) DU]

Considering the fraction of 5 μm AMAD DU particles that are transferred to the blood, the amount of DU that passes through your kidney from an intake of 0.000865 mg (insoluble) and

0.000065 mg (soluble) is calculated as follows (see Appendix J for a more detailed discussion of DU biokinetics):

(0.000065 mg) * (0.0642) + (0.000865 mg) * (0.0034) = 0.000007 mg

To determine the concentration of DU in the kidney, this value is multiplied by 1000 then divided by the default kidney weight of 310 grams:

μg DU/g of kidney tissue = (0.000007 mg) * (1000 μg/mg)/310 grams

= 0.000023 μg DU/g of kidney tissue

- Your corresponding radiation dose (CEDE) as a Scout, associated with an intake of 0.00093 mg, would be:

(0.00007 rem/hr/vehicle)*(1 hr/60 min)*(20 min) = 0.000023 rem

- Your lung dose can be calculated by taking the CEDE of 0.00017 rem and dividing the CEDE by the ICRP-26 tissue weighting factor for the lung, 0.12, to obtain the following CDE:

(0.000023 rem)/(0.12) = 0.00019 rem [lung]

- **Entry Into Iraqi DU-Contaminated Vehicles (Section 5.3.2)**

  - As a Cavalry Scout, if you entered 7 Iraqi vehicles destroyed by DU munitions and spent 7 minutes per vehicle, then you may have received an inhalation and indirect ingestion intake of 0.0047 mg of DU. The calculation is as follows:

(0.0057 mg/hr/vehicle)*(1 hr/60 min)*(7 min)*(7 vehicles) =

0.0047 mg [that is, 0.0039 mg insoluble DU and 0.00080 mg soluble DU]

Considering the fraction of 5 μm AMAD DU particles that are transferred to the blood, the amount of DU that passes through your kidney from an intake of 0.0008 mg (soluble) and 0.0039 mg (insoluble) is calculated as follows (see Appendix J for a more detailed discussion of DU biokinetics):

(0.0039 mg) * (0.0034) + (0.0008 mg) * (0.0642) = 0.000065 mg

To determine the concentration of DU in the kidney, this value is multiplied by 1000 then divided by the default kidney weight of 310 grams:

μg DU/g of kidney tissue = (0.000065 mg) * (1000 μg/mg)/310 grams

= 0.00021 μg DU/g of kidney tissue

- Your corresponding radiation dose (CEDE) associated with an inhalation and indirect ingestion intake of 0.0047 mg would be:

(0.0001 rem/hr/vehicle)*(1 hr/60 min)*(7 min)*(7 vehicles) =

0.00008 rem.

- Your lung dose can be calculated by taking the CEDE of 0.00008 rem and dividing it by the ICRP-26 tissue weighting factor for the lung, 0.12, to obtain the following CDE:

(0.00008 rem)/(0.12) = 0.0007 rem [lung]

- **Entry Into Iraqi DU-Contaminated Vehicle With Scout Contaminating His Hands (Section 5.3.1)**

  - You indicated that your hands were heavily smudged and you suspected that they were potentially contaminated after entering a damaged Iraqi vehicle. By contaminating your hands with DU, you may have been exposed to DU by secondary ingestion via hand-to-mouth transfer.
  - Surface contamination data reported from a developer's munitions test involving a DU munition interacting with a DU armored Abrams tank was used to estimate an intake via hand-to-mouth transfer. This is most likely an overestimation of hand-to-mouth transfer, because Iraqi armor does not contain DU.

- Moreover, absorption of uranium oxides into the blood via the GI tract is very inefficient. The transfer coefficient from the GI tract to blood for insoluble uranium oxides is 0.002 (ICRP-71). The transfer coefficient from the GI tract to blood for soluble uranium oxides is 0.02 (ICRP-71). Since you were not able to wash your hands for two days after your hands were contaminated with DU, it is assumed DU on your hands was ingested.
- Therefore, the total intake from secondary ingestion that you may have received from entering an Iraqi vehicle is 0.057 mg (0.047 mg insoluble and 0.01 mg soluble DU).

- The calculations are as follow:

(0.057 mg per event)*(1 event) =0.057 mg total DU

(available for ingestion via hand-to-mouth)

The absorbed fraction (the amount of DU that passes through your kidney) of the soluble DU ingested would be:

(0.01 mg)*(1 event)*(GI transfer coefficient 0.02) = 0.0002 mg DU [soluble]

This is equivalent to 0.0005 μg DU/g of kidney tissue.

The absorbed fraction (the amount of DU that passes through your kidney) of the insoluble DU ingested would be:

(0.047 mg)*(1 event)*(GI transfer coefficient 0.002) =

0.00009 mg DU [insoluble]

This is equivalent to 0.0003 μg DU/g of kidney tissue.

The total amount of DU that passes through your kidney is calculated as follows:

(0.00002 mg + 0.00009 mg) = 0.00029 mg.

The total DU concentration in the kidney is calculated as follows:

(insoluble) 0.0003 μg DU/g of kidney tissue + (soluble) 0.0006 μg DU/g of kidney tissue =

0.0009 μg DU/g of kidney tissue.

- The corresponding radiation dose (CEDE) associated with a secondary ingestion (hand-to-mouth) intake of 0.057 mg would be 0.000002 rem.
- You would not have a lung dose from secondary ingestion.

- **Exposure to Smoke From DU-Perforated Iraqi Equipment (Section 5.2)**

  - As a Cavalry Scout, if you took 10 minutes each time as you passed (by walking) through the smoke, at a distance of 80 meters from 3 burning Iraqi vehicles destroyed by DU munitions, you may have received an inhalation and indirect ingestion intake of DU estimated to be 0.0022 mg. The calculation is as follows:

(0.0044 mg/vehicle hr) * (1 hr/60 min) * (10 min) *(3 vehicles) = 0.0022 mg

[that is, 0.00183 mg insoluble DU and 0.00037 mg soluble DU]

Considering the fraction of 5 μm AMAD DU particles that are transferred to the blood, the amount of DU that passes through your kidney from an intake of 0.00183 mg (insoluble) and 0.00037 mg (soluble) is calculated as follows (see Appendix J for a more detailed discussion of DU biokinetics):

(0.00037 mg) * (0.0642) + (0.00183 mg) * (0.0034) = 0.00003 mg

To determine the concentration of DU in the kidney, this value is multiplied by 1000 then divided by the default kidney weight of 310 grams:

μg DU/g of kidney tissue = (0.00003 mg) * (1000 μg/mg)/310 grams

= 0.0001 μg DU/g of kidney tissue

- The corresponding radiation dose (CEDE) associated with an inhalation and indirect ingestion intake of 0.0022 mg would be:

(0.00001 rem/hr/vehicle)*(1 hr/60 min)*(10 min)*(3 vehicles) = 0.000005 rem

- Your lung dose can be calculated by taking the CEDE of 0.000005 rem and dividing it by the ICRP-26 tissue weighting factor for the lung, 0.12, to obtain the following CDE:

(0.000005 rem)/(0.12) = 0.00042 rem [lung]

Your Estimated Total DU Intake: This total DU intake is based on the four previously discussed examples of possible exposure during the Gulf War. You would have inhaled and directly ingested a total of 0.0078 mg of DU (0.0012 mg soluble and 0.0066 mg insoluble). You would have transferred via hand-to-mouth a total of 0.057 mg of DU (0.047 mg soluble DU and 0.01 mg insoluble DU).

Your Estimated Total Radiation Dose: This total radiation dose is based on the four previously discussed examples of possible exposure during the Gulf War. The total CEDE is equal to 0.00016 rem and the sum total CEDE (lung dose) is equal to 0.0013 rem.

Your Health Risk: Applying the fraction of 5 μm DU particles that are transferred to blood after inhalation and indirect ingestion, the total amount of DU that passed through your kidney via the inhalation and indirect ingestion pathway was calculated to be:

0.00003 mg + 0.00025 mg + 0.000007 mg = 0.0003 mg

To determine the concentration of DU in the kidney, this value is multiplied by 1000 then divided by the default kidney weight of 310 grams:

μg DU/g of kidney tissue	=	(0.0003 mg) * (1000 μg/mg) / 310 grams
	=	0.001 μg DU/g of kidney tissue

- Applying the GI transfer coefficient for soluble DU (0.02) to a secondary ingestion intake of 0.01 mg, the amount of soluble DU that enters the bloodstream and is excreted in the urine after passing through the kidneys would be less than or equal to 0.0002 mg.
- Applying the GI transfer coefficient for insoluble DU (0.002) to a secondary ingestion intake of 0.047 mg, the amount of insoluble DU that enters the bloodstream and is excreted in the urine after passing through the kidneys would be less than or equal to 0.00009 mg. In addition, of the total amount of DU that is inhaled (0.0078 mg), less than 1 percent (0.000078 mg) makes its way to the kidney, National Defense Research Institute, (1999).
- The concentration of DU in the kidney from inhalation (0.001 μg DU/g of kidney tissue) and from secondary ingestion (0.00029 μg DU/g of kidney tissue) is below the suggested

levels that could result in either transient or permanent kidney damage. As a result of your intake of soluble DU, you would not experience any observable, adverse health effects.

- Your radiation dose was determined by considering your total DU intake, both the insoluble and soluble fractions.
- Your total internal radiation dose (CEDE) of 0.00016 rem and your lung dose (CDE) of 0.0013 rem are well below the suggested levels in national and international radiation safety standards. As a result of your radiation exposure, you would not experience any observable, adverse health effects. In fact, the NCRP-91 recommended that an annual effective dose of 0.001rem be considered a negligible individual dose (NID). Your 50-year dose (CEDE) of 0.00016 rem is a factor of 10 less than the recommended NID. This corresponds to a 1 in 16,500.000 [$1/(5 \times 10^{-4}/\text{rem} * 1.6 \times 10^{-4}$ rem)] chance of getting fatal cancer in your lifetime from a 50-year dose of 0.00016 rem (NCRP-115).

Your exposure assessment based on the scenario presented in this Appendix is summarized in Table T-1.

Table T-1. Example, DU Intakes Via Inhalation, Indirect Ingestion, and Secondary Ingestion, Level III Scenarios Soldier's Combined Exposure Assessment Summary

Route of Exposure	Scenario	Total DU Intake (mg) [µg DU/g of kidney][1]	Insoluble DU Intake (mg)	Radiation Dose (rem)	Possibility Radiation Exposure Limit Exceeded	Radiation Risk	Soluble DU Intake (mg)	Possibility Chemical Exposure Limit Exceeded	Chemical Toxicity Risk	Discussion in Section Number
Inhalation & Indirect Ingestion	Scout exposed to smoke from burning Abrams tanks	0.00093 [0.000023]	0.000865	0.000023* (0.00019**)	No	Acceptable	0.000065	No	Acceptable	5.3.1
Inhalation & Indirect Ingestion	Scout who entered DU-contaminated equipment	0.0047 [0.00021]	0.0039	0.00008* (0.0007**)	No	Acceptable	0.00080	No	Acceptable	5.3.2
Secondary Ingestion (Hand-to-Mouth)	Scout who entered DU-contaminated equipment and contaminated their hands	0.057 [0.0009]	0.047	0.000002*	No	Acceptable	0.01	No	Acceptable	5.3
Inhalation & Indirect Ingestion	Scout exposed to smoke from DU-perforated Iraqi equipment	0.0022 [0.0001]	0.00183	0.00005* (0.0004**)	No	Acceptable	0.00037	No	Acceptable	5.3
---	Total	0.065 [0.0012]	0.054	0.00016* (0.0013**)	No No	Acceptable	0.012	No	Acceptable	---

[1]µg DU/g of kidney calculated based on DU passing through kidney. ANSI limit is 3 µg U/g of kidney; *CEDE dose; **CDE dose (Lung)