File: 541.460.000n
C.H.

THE MEMPHIS DEPOT
TENNESSEE

ADMINISTRATIVE RECORD
COVER SHEET

AR File Number 681

APPENDIX N
QUALITY CONTROL SUMMARY REPORT

1 QUALITY CONTROL SUMMARY REPORT

1.1 Project Scope

Under Contract DACA87-97-D-0006, (Delivery Order 0012) the U.S. Army Engineering and Support Center, Huntsville (USAESCH) contracted UXB International, Inc. (UXB) to conduct a Chemical Warfare Materiel Investigation/Removal Action at Defense Depot, Memphis, Tennessee.

The work fell under the Base Realignment and Closure (BRAC) program. Chemical Warfare Materiel was suspected on this property currently owned by the Department of the Army and managed by Memphis Depot Caretaker Division. Activities were performed in accordance with the Comprehensive Environmental Response and Liability Act (CERCLA), National Priorities List (NPL), Environmental Protection Agency (EPA), State of Tennessee, and the National Contingency Plan. All work was conducted in compliance with the substantive requirements of all federal and state applicable, relevant, and appropriate requirements (ARAR). The provision of 29 CFR 1910.120 applied. No federal, state, or local permits were required for any action taken on-site.

1.2 Project Technical Approach

The technical approach varied for each of the three investigation sites – Site 1, Site 24-A, and Site 24-B -- to accommodate site-specific targets, chemical of concerns suspected at each site, and environmental conditions.

1.2.1 Site 1

Site-1 was a suspected burial site for CAIS vials. A soil sifter was employed to ensure capture of small glass vials that may otherwise have been missed using standard excavation techniques. Excavation of the site was performed to a depth of 10-feet.

1.2.2 Site 24-A

Site 24-A was the burial pit for 29 German chemical warfare bomb casings. Geophysical surveys determined the location of this site. Excavation locations were directed to locations known to contain high magnetic signatures. Once the bomb casings were recovered, migration of the contamination was revealed through the presence of mustard degradation by-products.

1.2.3 Site 24-B

Site 24-B, (referred to as the chlorate of lime pit in other reference materials), was the neutralization pit for mustard agent drained from the 29 German chemical warfare bombs. Geoprobe core sampling was employed to locate soil containing known mustard degradation by-products (1,4-thioxane, 1,4-dithiane, and thiodyglycol (TDG)) resulting from a mustard decontamination process. This proved most cost efficient and significantly reduced project costs. The third core sample collected was positive for mustard degradation by-products. Excavation began at this sampling location. Excavation continued until the pit boundary was excavated and sample reports proved the soil to be free of mustard agent and mustard degradation by-products.

1.3 Sampling Procedures

This section describes the sampling procedures that were implemented at all three sites.

1.3.1.1 Soil/Aqueous Sampling Procedures

The ECBC Mobile Environmental Analytical Platform (MEAP) performed all CWM sampling. This on-site laboratory was a self-contained laboratory capable of providing all laboratory functions necessary to analyze soil, water, and debris samples for CWM chemicals.

ECBC laboratory personnel analyzed samples from investigative derived wastewater, soil, and debris for CWM.

Soil and water contaminated with CWM were packaged, manifested, labeled, and shipped for disposal in accordance with the Transportation and Disposal Plan (T & D Plan).
Soil and water samples proven free of CWM contamination were shipped to an independent laboratory HTRW compliance sampling.

Sample analysis revealed all debris to be from CWM. Debris removed from pits known to have contained CWM at any given time were treated as 3X material.

1.3.1.2 Soil and Aqueous Sampling for CWM

The determination if waste was contaminated with CWM remained a critical task requiring indisputable record keeping and linking of staged soil/water to their respective composite samples. The ECBC laboratory technicians performed all CWM sampling on-site. No HTRW sampling was permitted for soil containing CWM. CWM-contaminated waste was containerized per DOT shipment regulations and shipped off-site for treatment. The following paragraphs describe the processes used to sample waste streams for CWM.

1.3.1.2.1 Soil Samples

The intent of CWM sampling was to properly profile the waste characteristics of the excavated soil and aqueous solutions to ensure appropriate disposition of soil/debris/water. Testing analysis indicated low-level CWM contamination areas. The results ensured that soils and aqueous samples could be safely shipped to off-site laboratories for further Hazardous, Toxic, and Radioactive Waste (HTRW) analyses. All soil samples were analyzed for the presence of the site-specific CWM of concern. If the soil analysis detected the presence of CWM, no further CWM testing was performed, as this soil was classified as CWM contaminated soil. Soils that did not contain CWM were further tested for 1,4-dithiane, and 1,4-thioxane (1,4-oxathiane). Soil found to contain 1,4-dithiane or 1,4-thioxane were tested for Thiodyglycol (TDG).

UXB determined the soil-sampling locations and collected soil samples according to the procedures established in the USAESCH-approved work plan. UXB double bagged the samples, prepared a Chain of Custody, assigned with a unique identification number for each sample, and passed custody of the samples to the ECBC site representative. The double-bagged soil samples were analyzed by the MINICAMS, in accordance with Soil Headspace Procedures defined in the Site Safety Submission, ECBC Air Monitoring Plan, (Section 3.3.4). Once cleared, samples were transported to the on-site Mobil Environmental Analytical Platform (MEAP) for soil extraction testing.

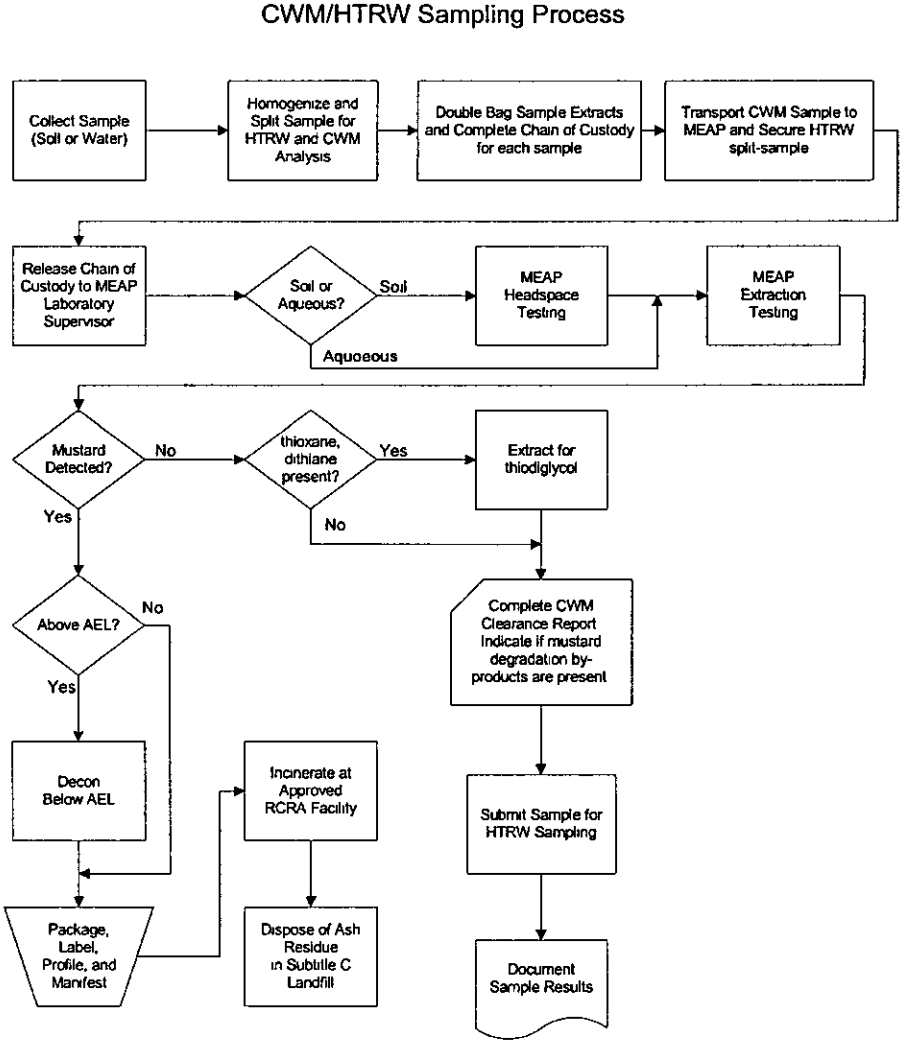
1.3.1.2.2 Aqueous Samples

UXB collected aqueous samples from all investigative derived wastewater (IDW) -- wastewater generated through decontamination procedures, rainwater that may migrate into the excavation pit, and from washing vehicles used inside the vapor containment structure (VCS). Aqueous samples were extracted in a similar matter to the procedure for soils. Samples were injected into a Hewlett-Packard Gas Chromatograph/Mass Spectrometer for analysis. If the initial analysis detected the presence of CWM, no further CWM testing was performed. If CWM was not present, the extract was tested for 1,4-dithiane, or 1,4-thioxane. The presence of either of these compounds required a subsequent extraction of the sample for TDG. If the initial analysis did not detect the presence of 1,4-dithiane or 1,4-thioxane, then the TDG extraction was not conducted.

1.3.1.2.3 Sampling Process

Refer to Figure 1 for flow-process used for CWM/HTRW Sampling.

Figure 1: Sampling Process Flow Diagram



1.3.1.3 Soil and Aqueous Sampling for HTRW

A sample was collected for analysis from each 20 cubic yards of soil excavated. The laboratory tested for reactivity, corrosivity, and ignitability on un-extracted waste samples, and an arsenic count was performed using the Toxicity Characteristic Leaching Procedure (TCLP). A water sample was also collected for each 500 gallons of Investigative Derived Waste (IDW) water generated. These samples are analyzed for Target Compounds List (TCL) volatiles, TCL semi-volatiles & pyridine, TCL pesticides, TCL PCBs, herbicides (2 compounds), Target Analytes List (TAL) metals, cyanide, sulfide, pH, and flashpoint. Severn-Trent and ETC (independent testing laboratories) performed HTRW sample analysis.

1.4 Summary of Daily Quality Control Reports

Daily Quality Control Reports were produced on the site, which covered several activities. These included safety related, maintenance related and personnel related aspects of the effort, and were inspected on a daily, weekly or monthly basis depending on the operation audited. In general, there were no quality failures noted on the daily QC reports. (Appendix L)

1.5 Analytical Procedures

Refer to Table 1, which shows the testing constituents and the laboratory methods to detect the constituents.

Table 1: HTRW Testing Protocols

IDW Water	
Constituent	*Analytical Method*
Cyanide	9012A
Flash Point	1010
Sulfide	371.1
pH – aqueous	9040
Mercury	7470A
Metals ICP- total	6010B
Metals ICP – trace total	6010B
Herbicides	8151A
TCL Pesticides	8082
TCL Pesticides	8081A
TCL BNA & Pyridine	8270C
TCL VOA	8260B
Solids	
Constituent	*Analytical Method*
TCL VOA	8260B
TCL BNA	8270C
TCL Pesticides	8081A
TCL PCBs	8082
TAL Metals ICP Trace	6010B
Mercury	7471A
Cyanide	9012A

TCLP	
Constituent	*Analytical Method*
TCLP Volatile	8260B
TCLP Semi-volatiles	8270C
TCLP Pesticides	8081A
TCLP Herbicides	8151A
TCLP ICP Metals	6010B
TCLP Mercury	7470A
Arsenic	6010A

1.6 Data Presentation (including Analysis and Validation)

1.6.1 Presentation

Summary reports for the analytical data on all of the samples taken from the Dunn field sites are included as Appendix H. Detailed data including Level IV reports are included on the CDs included with the report.

1.6.2 Analysis

All samples were pre-screened by ECBC before release to UXB for shipping to an outside analytical laboratory. Samples found to contain CWM or CWM degradation products were not analyzed by an outside laboratory due to safety and health concerns for the laboratory workers. Samples found to be free of CWM and Degradation products were sent to one of two outside labs for analysis. Each laboratory was responsible for analysis, QC and reporting for each sample. In addition, the UXB project chemist reviewed each sample report and associated QC documentation for Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) requirements

In general, the samples from the three areas which did not contain any CWM or degradation products were not contaminated with any material which was out of the ordinary or which required any material to be disposed of as hazardous waste. Exceptions were investigative derived waste (IDW) containing rinse water from equipment and PPE decontamination operations. These materials frequently contained chloroform, probably from the HTH added to the water to enable it to be used as a decontamination fluid. In one case the IDW Water required disposal as a listed hazardous waste (D022) due to chloroform contamination. The HTH also produced problems for the analytical laboratory performing the analysis of the samples. These problems manifested themselves as Quality Control failures of a sufficient magnitude as to render the analysis useless for the determination of acceptability. The IDW Water samples in several cases actually caused damage to the instrumentation used for analysis. For this reason, in several cases the IDW water from the site was disposed of as non-hazardous waste even though in principal it could have been disposed of in the Memphis sanitary sewer system.

The only other area of the chemical analysis results, which caused concern, was the consistent appearance of Arsenic in the soil. The level of Arsenic was consistent with the known naturally occurring Arsenic levels of the site soils, and did not appear to be the result of CWM contamination. In any event, the extractable Arsenic (by TCLP) was not detectable in most cases.

1.6.3 Data Validation

All samples that were submitted to a contract laboratory were validated by that laboratory according to SW 846 requirements. In addition, the UXB project chemist validated all of these samples.

1.6.4 QC Activities

The UXB project chemist reviewed each sample report and associated QC documentation for Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) requirements. There were quality failures as can be expected in analysis of this complexity. In general most of the quality failures were of a minor nature, such as high recoveries of surrogates in MS/MSD samples where there were no associated analyites detected in the corresponding samples. There were other, more serious quality failures which caused some samples to be rejected.

Four sample reports were incomplete, despite the required analysis being requested on the chain of custody form. These samples were rejected. As the allowable hold times on the samples had expired, they could not be reanalyzed. Fortunately the soil that these samples represented was still available and was re-sampled for analysis. The four sample reports were resubmitted and approved.

Several IDW water samples (Discussed above) were also rejected for QC failures. Due to the nature of the matrix, the analysis was incapable of being completed satisfactorily.

Two samples arrived at the laboratory with temperatures higher than allowed (+4 C). These samples were rejected.

1.6.5 Duplicate Samples

Sample DF/24-B/1066/GRAB/002 was a blind duplicate of sample DF/24-B/1066/SDC/014 and DF/24-B/1074/SDC/020 was a blind duplicate of sample DF/24-B/1074/GRAB/023. The UXB Project chemist compared the analysis for these two sample sets and found one discrepancy greater than 50%. This was in the TCLP analysis for lead, where the value for DF/24-B/1066/SDC/014 was 0.239 mg/L (detection limit 0.100 mg/L) and the value for DF/24-B/1066/GRAB/002 was ND (detection limit 0.100 mg/L). 50% of 0.239 is 0.1195 and this is 0.0195 greater than the limit of 0.100 (The detection limit value was used in this case for comparison). As these values were far below the limits set by the EPA (5.0 mg/L), This discrepancy was inconsequential.

1.6.6 Conclusions and Recommendations

The data generated by the contract laboratories fairly represented the actual conditions extant at the three Dunn Field Sites during the remedial action. Minor QC failures did not materially affect the results of the analysis and were not factors influencing the decisions as to disposition of any materials. The only exception to this was the aforementioned IDW water samples, which could not be satisfactorily analyzed. It is recommended that this data be utilized.

Appendix O

CH2MHILL Report

StationID	CWM-1	CWM-1	CWM-1	CWM-24	CWM-24	CWM-24	CWM-24	CWM-24	CWM-24
SiteID	Site 01	Site 01	Site 01	Site 24A	Site 24A	Site 24A	Site 24B	Site 24B	Site 24B
Sample Type	Floor Sample	Floor Sample	Floor Sample	Floor Sample	Sidewall Sample	Sidewall Sample	Floor Sample	Floor Sample	Sidewall Sample
SampleID	DFCWM001FD1	DFCWM001FS001	DFCWM001FS002	DFCWM24AFS001	DFCWM24ASW001	DFCWM24ASW002	DFCWM24BFS01	DFCWM24BFS02	DFCWM24BSS01
Date Collected	6/21/00	6/21/00	6/21/00	10/30/00	11/14/00	11/14/00	3/9/01	3/9/01	3/9/01
Time Collected	12 55 PM		1 05 PM	4 50 PM	3 00 PM	3 15 PM	10 15 AM	10 30 AM	10 00 AM
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Type	Duplicate of FS001	N	N	N	N	N	N	N	N

Parameters	Units									
TAL Metals										
ALUMINUM	MG/KG	10500 =	12700 =	10200 =	7880 =	11200 =	11200 =	9900 =	7100 =	12700 =
ANTIMONY	MG/KG	2 6 J	4 3 J	3 3 J	2 U	1 9 UJ	1 8 UJ	2 U	2 U	2 U
ARSENIC	MG/KG	7 2 J	7 7 J	9 J	14 7 =	10 3 J	14 7 =	6 8 J	6 9 J	14 J
BARIUM	MG/KG	114 =	124 =	146 =	125 =	209 =	98 4 =	63 2 =	73 7 =	123 =
BERYLLIUM	MG/KG	0 5 J	0 59 J	0 52 J	0 48 J	0 7 J	0 47 J	0 28 J	0 5 J	0 47 J
CADMIUM	MG/KG	0 3 J	0 38 J	0 37 J	0 23 J	0 17 J	0 22 J	0 17 U	0 27 U	0 38 U
CALCIUM	MG/KG	3900 =	3490 =	13000 =	1960 =	1420 J	1070 J	940 J	1440 =	859 J
CHROMIUM, TOTAL	MG/KG	16 1 J	18 9 J	14 5 J	11 6 =	10 8 J	13 9 J	13 3 =	11 3 =	60 6 =
COBALT	MG/KG	7 7 J	8 J	6 8 J	7 3 J	11 4 J	6 6 J	5 3 J	7 4 J	5 3 J
COPPER	MG/KG	17 3 =	18 3 =	21 4 =	18 1 =	20 1 =	20 5 =	14 8 =	16 1 =	20 2 =
IRON	MG/KG	20000 =	22100 =	18500 =	20800 =	21500 =	22900 =	19100 =	15900 =	24000 =
LEAD	MG/KG	13 8 =	11 2 =	22 8 =	20 =	15 =	29 1 =	16 6 =	17 7 =	30 2 =
MAGNESIUM	MG/KG	2930 =	3280 =	2640 =	2040 =	2550 =	1950 =	2080 =	1860 =	2470 =
MANGANESE	MG/KG	517 =	548 =	466 =	421 =	975 =	456 =	394 =	456 =	226 =
MERCURY	MG/KG	0 03 U	0 03 U	0 03 J	0 04 J	0 02 U	0 05 J	0 01 U	0 03 J	0 05 J
NICKEL	MG/KG	20 =	20 3 =	19 =	17 6 =	21 1 =	17 2 =	16 8 =	16 7 =	19 3 =
POTASSIUM	MG/KG	1010 J	1530 J	845 J	681 J	818 J	771 J	811 J	526 J	1240 J
SELENIUM	MG/KG	0 44 UJ	0 44 UJ	0 42 UJ	0 45 U	0 45 U	0 42 U	0 09 U	0 09 U	0 09 U
SILVER	MG/KG	0 38 U	0 38 U	0 36 U	0 4 U	0 39 U	0 36 U	0 25 U	0 25 U	0 25 U
SODIUM	MG/KG	72 7 J	97 9 J	73 4 J	55 6 J	63 J	41 J	58 2 J	83 2 J	218 J
THALLIUM	MG/KG	0 26 U	0 39 U	0 24 U	0 27 J	0 34 U	0 51 U	0 21 J	0 18 J	0 42 J
VANADIUM	MG/KG	26 9 =	33 6 =	23 7 =	22 9 =	24 6 =	23 9 =	24 3 =	19 4 =	28 3 =
ZINC	MG/KG	56 7 =	61 6 =	56 2 =	62 3 =	64 5 =	57 =	47 2 =	52 9 =	249 =
TCL PCBs										
PCB-1016 (AROCHLOR 1016)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
PCB-1221 (AROCHLOR 1221)	UG/KG	85 U	85 U	80 U	85 U	83 U	81 U	1600 U	1700 U	1700 U
PCB-1232 (AROCHLOR 1232)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
PCB-1242 (AROCHLOR 1242)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
PCB-1248 (AROCHLOR 1248)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
PCB-1254 (AROCHLOR 1254)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
PCB-1260 (AROCHLOR 1260)	UG/KG	42 U	42 U	39 U	42 U	41 U	40 U	810 U	820 U	840 U
s DECACHLOROBIPHENYL	%	88 =	89 =	91 =	86 =	83 =	85 =	128 =	133 =	111 =
TCL Pesticides										
ALDRIN	UG/KG	2 2 U	2 2 U	2 U	0 91 J	2 1 U	2 U	21 UR	21 UR	22 UR
ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	140 J	22 UR
ALPHA ENDOSULFAN (ENDOSULFAN I)	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	14 J	22 UR
ALPHA-CHLORDANE	UG/KG	2 2 U	2 2 U	2 U	0 35 J	0 21 J	17 =	21 J	21 UR	22 UR
BETA BHC (BETA HEXACHLOROCYCLOHEXANE)	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	21 UR	22 UR
BETA ENDOSULFAN (ENDOSULFAN II)	UG/KG	4 2 U	4 2 U	3 9 U	4 2 U	4 1 U	4 U	41 UR	41 UR	42 UR
DELTA BHC (DELTA HEXACHLOROCYCLOHEXANE)	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	21 UR	22 UR
DIELDRIN	UG/KG	0 74 J	4 2 U	12 J	4 2 U	4 1 U	4 U	31 J	41 UR	42 UR
ENDOSULFAN SULFATE	UG/KG	4 2 U	4 2 U	3 9 U	4 2 U	4 1 UJ	4 UJ	41 J	41 UR	42 UR
ENDRIN	UG/KG	4 2 U	4 2 U	3 9 U	4 2 U	4 1 U	4 U	41 UR	41 UR	42 UR
ENDRIN ALDEHYDE	UG/KG	4 2 U	4 2 U	3 9 U	4 2 UJ	4 1 UJ	4 UJ	41 J	41 UR	42 UR
ENDRIN KETONE	UG/KG	4 2 U	4 2 U	3 9 U	1 3 J	4 1 U	4 U	41 J	41 UR	42 UR
GAMMA BHC (LINDANE)	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	33 J	22 UR
GAMMA-CHLORDANE	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	19 =	21 J	21 UR	22 UR
HEPTACHLOR	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	1 7 J	21 UR	21 UR	22 UR
HEPTACHLOR EPOXIDE	UG/KG	2 2 U	2 2 U	2 U	2 2 U	2 1 U	2 U	21 UR	21 UR	22 UR
METHOXYCHLOR	UG/KG	22 U	22 U	1 5 J	22 U	21 U	20 U	210 J	210 UR	220 UR
p p-DDD	UG/KG	4 2 U	4 2 U	2 8 J	4 2 U	4 1 U	4 U	9 3 J	41 UR	120 J
p,p'-DDE	UG/KG	0 64 J	4 2 U	12 =	0 95 J	4 1 U	1 2 J	15 J	41 UR	42 UR
p,p'-DDT	UG/KG	4 2 U	4 2 U	14 J	4 2 UJ	4 1 U	2 4 J	41 J	41 UR	42 UR
TOXAPHENE	UG/KG	220 U	220 U	200 U	220 UJ	210 U	200 U	2100 J	2100 UR	2200 UR

s	2 4 5 6-TETRACHLORO-META-XYLENE	%	82 =	89 =	95 =	71 =	88 =	88 =	96 =	0 =	0 =
s	DECACHLOROBIPHENYL	%	75 =	79 =	88 =	68 =	76 =	74 =	0 =	0 =	99 =
TCL SVOCs											
	1,2,4-TRICHLOROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	230 J	98 J	840 U
	1 2-DICHLOROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	910 =	280 J
	1,3-DICHLOROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	1,4-DICHLOROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	670 J
	2,2'-OXYBIS(1-CHLORO)PROPANE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	2,4,5-TRICHLOROPHENOL	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 UJ	2100 U
	2,4,6-TRICHLOROPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	3000 =	520 J	840 U
	2 4-DICHLOROPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	2,4-DIMETHYLPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	660 J
	2,4-DINITROPHENOL	UG/KG	1000 UJ	1000 UJ	990 UJ	2100 U	2000 U	2000 U	2000 U	2100 UJ	2100 U
	2 4-DINITROTOLUENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	2,6-DINITROTOLUENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	2-CHLORONAPHTHALENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	2-CHLOROPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 UJ	840 U
	2-METHYLNAPHTHALENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	140 J	400 J
	2-METHYLPHENOL (o-CRESOL)	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 UJ	840 U
	2-NITROANILINE	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 U	2100 U
	2-NITROPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	3 3'-DICHLOROBENZIDINE	UG/KG	420 U	420 U	390 U	840 U	1600 U	1600 U	1600 U	1600 U	1700 U
	3-NITROANILINE	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 U	2100 U
	4,6-DINITRO-2-METHYLPHENOL	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 U	2100 U
	4-BROMOPHENYL PHENYL ETHER	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	4-CHLORO-3-METHYLPHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	4-CHLOROANILINE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	4-CHLOROPHENYL PHENYL ETHER	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	4-METHYLPHENOL (p-CRESOL)	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 UJ	840 U
	4-NITROANILINE	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 U	2100 U
	4-NITROPHENOL	UG/KG	1000 U	1000 U	990 U	2100 U	2000 U	2000 U	2000 U	2100 UJ	2100 U
	ACENAPHTHENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	ACENAPHTHYLENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	ANTHRACENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	BENZO(a)ANTHRACENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	BENZO(a)PYRENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	BENZO(b)FLUORANTHENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	63 J	820 U	840 U
	BENZO(g h i)PERYLENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	BENZO(k)FLUORANTHENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	BENZYL BUTYL PHTHALATE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	bis(2-CHLOROETHOXY) METHANE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	bis(2-CHLOROETHYL) ETHER (2-CHLOROETHYL ETHER)	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	bis(2-ETHYLHEXYL) PHTHALATE	UG/KG	110 U	110 U	110 J	840 U	810 U	800 U	810 U	820 U	840 U
	CARBAZOLE	UG/KG	420 U	420 U	390 U	840 U			810 U	820 U	840 U
	CHRYSENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	50 J	820 U	840 U
	DI-n-BUTYL PHTHALATE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	150 J	6300 =
	DI-n-OCTYLPHTHALATE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	DIBENZ(a,h)ANTHRACENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	DIBENZOFURAN	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	DIETHYL PHTHALATE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	82 J	160 J
	DIMETHYL PHTHALATE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	FLUORANTHENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	120 J	73 J	86 J
	FLUORENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	HEXACHLOROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	870 =	160 J	840 U
	HEXACHLOROBUTADIENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	HEXACHLOROCYCLOPENTADIENE	UG/KG	420 U	420 U	390 U	840 U	810 UJ	800 UJ	810 U	820 U	840 U
	HEXACHLOROETHANE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	INDENO(1,2,3-c,d)PYRENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	ISOPHORONE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	N-NITROSODI-n-PROPYLAMINE	UG/KG	420 U	420 U	390 U	840 U	810 UJ	800 UJ	810 U	820 U	840 U
	N-NITROSODIPHENYLAMINE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	NAPHTHALENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	73 J	1000 =
	NITROBENZENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	840 U
	PENTACHLOROPHENOL	UG/KG	210 U	210 U	200 U	420 U	410 U	400 U	3200 =	570 J	420 U

	PHENANTHRENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 U	68 J
	PHENOL	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	810 U	820 UJ	840 U
	PYRENE	UG/KG	420 U	420 U	390 U	840 U	810 U	800 U	100 J	820 U	70 J
s	2,4,6-TRIBROMOPHENOL	%	83 =	77 =	84 =	85 =	87 =	84 =	101 =	3 =	96 =
s	2-FLUOROBIPHENYL	%	95 =	82 =	92 =	89 =	97 =	96 =	94 =	86 =	81 =
s	2-FLUOROPHENOL	%	92 =	82 =	88 =	92 =	77 =	91 =	103 =	10 =	95 =
s	NITROBENZENE-D5	%	83 =	67 =	79 =	77 =	82 =	89 =	85 =	77 =	73 =
s	PHENOL-D5	%	85 =	71 =	75 =	85 =	89 =	87 =	98 =	0 =	83 =
s	TERPHENYL-D14	%	94 =	86 =	93 =	94 =	93 =	96 =	101 =	105 =	94 =
	TCL VOCs										
	1 1 1-TRICHLOROETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1 1 2 2-TETRACHLOROETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1,1,2-TRICHLOROETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1,1-DICHLOROETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1,1-DICHLOROETHENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1,2-DICHLOROETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	1,2-DICHLOROPROPANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	2-HEXANONE	UG/KG	13 U	13 U	12 U	32 U	31 U	30 U	12 U	12 UJ	13 U
	ACETONE	UG/KG	23 J	21 J	30 J	32 U	27 J	28 =	12 UJ	24 UJ	90 J
	BENZENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	1 J	190 J
	BROMODICHLOROMETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	BROMOFORM	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	BROMOMETHANE	UG/KG	13 U	13 U	12 U	6 UJ	6 UJ	6 UJ	12 U	12 UJ	13 U
	CARBON DISULFIDE	UG/KG	13 U	13 U	2 J	6 U	6 U	6 U	12 U	12 UJ	1 J
	CARBON TETRACHLORIDE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	CHLOROBENZENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 =
	CHLOROETHANE	UG/KG	13 UJ	13 UJ	12 UJ	6 UJ	6 UJ	6 UJ	12 U	12 UJ	13 U
	CHLOROFORM	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 =	110 J	13 U
	CHLOROMETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	cis-1,2-DICHLOROETHYLENE	UG/KG				6 U	6 U	6 U			
	cis-1,3-DICHLOROPROPENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	DIBROMOCHLOROMETHANE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	ETHYLBENZENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	1 J	170 J
	M P-XYLENE (SUM OF ISOMERS)	UG/KG				32 U	31 U	30 U			
	METHYL ETHYL KETONE (2-BUTANONE)	UG/KG	6 J	6 J	7 J	32 U	6 J	6 J	12 U	12 UJ	16 =
	METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	UG/KG	13 U	13 U	12 U	32 U	31 U	30 U	12 U	12 UJ	13 U
	METHYLENE CHLORIDE	UG/KG	13 U	13 U	12 U	6 U	1 J	1 J	12 U	0 9 J	13 U
	O-XYLENE (1 2-DIMETHYLBENZENE)	UG/KG				6 U	6 U	6 U			
	STYRENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	TETRACHLOROETHYLENE(PCE)	UG/KG	13 U	13 U	3 J	6 U	6 U	6 U	12 U	12 UJ	13 U
	TOLUENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	40 =
	TOTAL 1,2-DICHLOROETHENE	UG/KG	13 U	13 U	12 U				12 U	12 UJ	13 U
	trans-1 2-DICHLOROETHENE	UG/KG				6 U	6 U	6 U			
	trans-1,3-DICHLOROPROPENE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	TRICHLOROETHYLENE (TCE)	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	VINYL CHLORIDE	UG/KG	13 U	13 U	12 U	6 U	6 U	6 U	12 U	12 UJ	13 U
	XYLENES, TOTAL	UG/KG	13 U	13 U	12 U				3 J	14 J	1200 =
s	1-BROMO-4-FLUOROBENZENE (4-BROMOFLUOROBENZENE)	%	102 =	106 =	99 =	70 =	102 =	91 =	105 =	82 =	105 =
s	DIBROMOFLUOROMETHANE	%	102 =	104 =	100 =	88 =	108 =	105 =	107 =	95 =	114 =
s	TOLUENE-D8	%	98 =	101 =	98 =	81 =	103 =	95 =	100 =	64 =	105 =

MG/KG - milligrams per kilogram
UG/KG - micrograms per kilogram
'U' - not detected
'=' - detected concentration
'J' - estimated value
'R' - rejected value
s - surrogate
% - surrogate recoveries

Appendix P

H DegBP Hazard Analysis

MCHB-TS-EHR (40)

MEMORANDUM FOR Remedial Program Manager, Memphis Depot, Memphis, Tennessee, ATTN: Mr. Clyde Hunt

SUBJECT: Health Risk Assessment of Exposure to three Mustard degradation products in soils at Dunn Field, Memphis Depot.

1. References. See Appendix A.

2. Authority. Electronic Mail Request from The Defense Logistics Agency (DLA), Mr. Clyde Hunt, August 13, 2001.

3. Risk Characterization.

3.1 Introduction.

The history of chemical weapon munitions (CWM) disposal at Dunn Field began in July 1946 when 29 mustard-filled German bomb casings were destroyed and buried. These bomb casings were part of a railroad shipment en route from Mobile, Alabama to Pine Bluff, Arkansas. Prior to reaching Pine Bluff, three railcars were identified as containing leaking bomb casings and these cars were transferred to the Memphis Depot for proper handling. As the bomb casings were unloaded from the railcars, those found to be leaking were deposited in a pit in Dunn Field, site 24-B, containing a lime slurry. It is thought that the chloride lime slurry neutralized the mustard agent rendering it no longer harmful as a blistering agent. The drained bomb casings were then destroyed by detonation and buried at site 24-A in a shallow trench. A total of twenty-four 500 kilogram, and five 250 kilogram bombs were destroyed.

During remediation of site 24-A, 25 empty 500-kg FLAM C 500 Bomb Casings and 4 empty 250-kg KC 250 German Bomb Casings were found and removed. No mustard agent was detected in soils at site 24-A. However , low levels of mustard degradation by-products were found in surrounding soil.

The sites at Dunn field where concentrations of the mustard degradation by-products were detected in soil independent of mustard were, site 24-A, and site 24-B. Of these locations, only site 24-A had soils with detectable concentrations of mustard degradation by-products that were not destroyed via incineration.

Samples collected and analyzed during the remediation of soils at Dunn Field, Memphis Depot, detected low levels of the chemical warfare agent mustard HD and its degradation products 1,4 Oxathiane, 1,4-Dithiane, and Thiodiglycol. All soils, which contained mustard, were consolidated and transferred to Kleen-Harbor Waste Treatment Facility in Kimball, NE for incineration. The soils that did not have detectable concentrations of mustard, but did have detectable concentrations of heavy metals were sent to Pollution Controls Industries for stabilization. Once the soils sent to the Pollution Control Industries were stabilized, they were disposed of in BFI North Landfill, Millington Tennessee.

The sample data supplied to us for evaluation was delivered via a fax transmission dated 17 August 2001. These data were in the form of an SBCCOM Monitoring branch Laboratory clearance report for site 24-A only, and had dates of 27 and 28 September, 2000, 27 and 28 October, 2000, and 30 October, 2000. Also included in the fax were section three, four and five from the UXB International Inc. (UXB) transportation and disposal plan for the Memphis Depot, Dunn Field.

3.2 Health Risk Assessment Methodology. The health risk assessment (HRA) methodology can be broken down into four main steps: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization. An uncertainty analysis is also an important component for making risk management decisions. In general, the daily chemical intake level is estimated for the receptors of concern based on daily habits and other site-specific information. Next, the average daily intake is compared to chemical-specific toxicological values (either a reference dose for noncancer effects, or a cancer slope factor for carcinogenesis) to determine whether or not adverse health effects would be expected from the estimated level of exposure. Noncancer effects are compared to a benchmark level of 1 and the estimated lifetime cancer risk compared to a range from 10^{-4} to 10^{-6}. Guidance developed by the U.S. Environmental Protection Agency (USEPA) was used to conduct this HRA [2]. As instructed, the above process was applied to the soil concentrations of the analytes of concern detected during soil characterization conducted at site 24-A.

3.3 Data Collection/Data Evaluation. UXB conducted soil sampling with confirmation sampling by CH2M Hill. The UXB determined the sampling location according to their procedures set in the UXB work plan, which dictates that one sample is collected for every 20 cubic yards of soil excavated. The samples were screened and shipped to the Edgewood Chemical and Biological Command facility in Edgewood Maryland for analytical testing for the three mustard degradation products. See table 3-1 below for the analytes of concern, their respective analytical procedures and detection limits. The data were evaluated by first calculating the average soil concentration for each analyte, and estimating an intake/dose, based on a construction worker scenario. Second, the single highest soil concentration for each analyte was then used to evaluate intake/dose, in exactly the same manner as the averaged value was to demonstrate a worst-case intake/dose. A value of one half of the analytical detection limit was used when an analyte was not detected.

Table 3-1 Analytes of Concern and Analytical Detection Limits

ANALYTE	Method of Analysis	Detection Limit Soil Matrix (ppb)
1,4-Dithiane	1	200
1,4-Thioxane	1	200
Thiodiglycol	2	250

1: "Application of Gas Chromatography/Mass Spectroscopy (GC/MS) for the detection of military agents and mustard and mustard breakdown products 1,4 Dithiane and 1,4 Oxathiane in water and soil"

2: "Application of Gas Chromatography/Mass Spectroscopy (GC/MS) for the detection of military agent breakdown products Thiodiglycol in soil and water"

3.4 Exposure Assessment. Since no residential areas exist at Dunn Field, only a worker scenario was evaluated at this location. The worker was evaluated for exposure to mustard degradation products via incidental soil ingestion, and dermal absorption of soil only. The exposure duration for the worker was assumed to be 25 years, which is the USEPA recommended exposure duration for occupational scenarios.

USEPA's standard intake equations were used to estimate intake from the different exposure pathways [2]. They are as follows:

Equation 1: Incidental Ingestion of mustard degradation products in soils from hand to mouth ingestion:

$$Intake\ (mg/kg-day) = \frac{C_s \cdot IR \cdot EF \cdot ED}{CF \cdot BW \cdot AT}$$

Where:

Cs = chemical concentration in soil (mg/kg)
IR = ingestion rate (mg/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = mass conversion factor for soil (1000000 mg/kg)
BW = body weight (kg)
AT = averaging time (days)

Equation 2: Dermal absorption from incidental contact with soil:

$$Absorbed\ Dose\ (mg/kg-day) = \frac{C_s \cdot SA \cdot SL \cdot ET \cdot EF \cdot ED}{CF \cdot BW \cdot AT}$$

Where:

C_s = chemical concentration in soil (mg/kg)
SA = Exposed skin surface area (cm^2)
SL = Soil Loading (mg/cm^2)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = mass conversion factor for soil (1000000 mg/kg)
BW = body weight (kg)
AT = averaging time (days)

The concentration in air from volatilization and re-suspension is not considered to impact the total exposure for this analysis [2] and so was not incorporated into the total intake/dose scenario.

Various parameters were needed to estimate intake from the different exposure pathways. Site-specific data were used whenever the information was available. Table 1 provides the exposure parameters used in this assessment.

Table 3-2, Parameters Used to Estimate Intake

Parameter	Exposure Scenario	Parameter Value	Source
DERMAL ABSORPTION			
Soil Loading	Construction worker	0.24 mg/cm^2	[4] construction worker
Dermal surface area available for absorption - construction	Construction worker	1980 (cm^2)	[4] construction worker
Fraction of Available Dermal Area that Contacts the Surface.	Construction worker	0.25 (unitless)	[4] construction worker
Exposure Time	Construction worker	8 hours per day	

Parameter	Exposure Scenario	Parameter Value	Source
INGESTION			
Soil Intake	Outdoor Worker	480 mg/day	[4]
ALL EXPOSURE PATHWAYS			
BW (kg)		Worker and adult resident	71.8 kg
AT (days)	Worker	Noncancer:9125 (days)	[6]
EF (days/year)	Worker	250	5 days a week minus 30 days leave and other days such as holidays [2]
ED (years)	Worker	25	Worker Employment Period. [2]

3.5 Toxicity Evaluation. In the data evaluation process, the Program Manager, Memphis Depot Remdial Projects, requested of the USACHPPM that we evaluate only three of the mustard degradation products, thiodiglycol, 1,4-Thioxane, and 1,4-Dithiane. The USACHPPM Health Effects Research Program analyzed the three compounds and submitted the following conclusions based on their analysis.

Thiodiglycol

CAS No.: 111-48-8
MW: 122.2
Synonym: 2,2'-Thiodiethanol
RfDo: 5 E-01 mg/kg/day (USA CHPPM proposed)
RfDi: 5 E-01 mg/kg/day (USA CHPPM HERP)

Thiodiglycol (2,2'-thiodiethanol, TD) is a hydrolytic degradation product of sulfur mustard. It is resistant to hydrolysis and photolysis, and has been shown to be present in the ground and surface water at several military installations.

Based on results from a 14-day oral toxicity study, dosage levels in the subchronic study were set at 0 (negative control), 50, 500 and 5000 mg/kg/day. Thiodiglycol was not lethal to rats, nor did it produce overt signs of toxicity at any of these doses. Toxic effects included decreased weight gain, changes in urine, and increased kidney weights. Based on these results, the no observable adverse effects level (NOAEL) for TD (2,2'-thiodiethanol) was determined to be 500 mg/kg/day.

The (NOAEL) was used to derive an oral reference dose of 5 E-1 mg/kg/day for Thiodiglycol (TDG). Because the effects noted were systemic, this value can be extrapolated to an inhalation reference dose of 5 E-1 mg/kg/day (1.75 E+0 mg/m^3).

1,4-Dithiane

CAS No.:	505-29-3
MW:	120
Synonym:	Diethylene disulfide
RfDo:	1E-02 mg/kg/day (IRIS)
RfDi:	1E-02 mg/kg/day (EPA Region 9)

The oral reference dose (RfD) is based on a study in which rats were dosed for 90-day with 0, 105, 210, or 420 mg 1,4-dithiane /kg-day suspended in sesame seed oil (Schieferstein et al., 1988). The lowest observable adverse effects level (LOAEL) for this study is 105 mg/kg-day based upon the occurrence of nasal lesions in female rats. A NOAEL could not be determined because effects were observed at the lowest dose tested.
No inhalation data are available for 1,4-dithiane. However, the oral RfD can be extrapolated to an inhalation RfD based on the systemic effects noted following oral administration of the compound. The inhalation RfD is 1 E-02 mg/kg/day (RfC [reference concentration] = 3.5 E-02 mg/m^3).
The EPA has assigned 1,4-dithiane a carcinogenicity classification of D; not classifiable as to human carcinogenicity. This is based on the lack of data in humans and animals.

1,4-Oxathiane

CAS No.:	15980-15-1
MW:	104.18
Synonym:	1,4-Thioxane, Oxathiane
RfDo:	6.7 E-3 mg/kg/day (USA CHPPM HERP)
RfDi:	6.7 E-3 mg/kg/day (USA CHPPM HERP)

1,4-Oxathiane is a breakdown product of mustard (HD). There are no chronic toxicity data available for this compound. The rat 4-hr LCLo via inhalation is 4000 ppm; the rat oral LD50 is 2830 mg/kg. Using the lower bound of the 95% CI, USA CHPPM Health Effects Research Program proposed an oral RfD of 6.7 E-3 mg/kg/day.

No inhalation data are available for 1,4-oxathiane. However, based on its structural similarity to 1,4-dithiane, it is expected that its effects would be systemic. Therefore, the oral RfD can be extrapolated to an inhalation RfD. The inhalation RfD is 6.7 E-3 mg/kg/day (RfC = 2.3 E-2 mg/m^3).

Surrogate data were used to evaluate dermal effects since toxicity data for this pathway is not readily available. Dermal RfDs were estimated by extrapolating from the oral RfD and assuming a 100% gastrointestinal absorption value [2]. Table 3-3 contains the noncarcinogenic

toxicity data used in this assessment.

Table 3-3, Summary of Toxicological Values

PAH	RfD_{oral} (mg/kg/day)	Source	$RfD_{inhalation}$ (mg/kg/day)[1]	Source	RfD_{dermal} (mg/kg/day)	Source
Thiodiglycol	5.0E-01	USACHPPM proposed	5.0E-01	USACHPPM HERP	5.0E-01	Extrapolated [2]
1,4 Dithiane	1.0E-02	IRIS	1.0E-02	USACHPPM HERP	1.0E-02	Extrapolated [2]
1,4 Oxathiane	6.7E-03	USACHPPM HERP	6.7E-03	USACHPPM HERP	6.7E-03	Extrapolated [2]

[1] Converted from mg/m^3 using a standard body weight of 70 kg and inhalation rate of 20 m^3/day

3.6 Risk Characterization. Risk evaluation for noncarcinogenic effects from chronic exposure (defined by USEPA as >7 years) involves calculating a hazard quotient (HQ) which is the ratio of the daily intake and the RfD of the compound of concern:

Equation 2:

$$HQ = \frac{Dose}{RfD}$$

Where:

Dose = chemical intake calculated from Equations 1-2 (mg/kg-day)
RfD = chemical-specific reference dose (mg/kg-day)

After each chemical-specific HQ was calculated, the HQs were summed to obtain a hazard index (HI). A hazard index of 1 or less is considered acceptable. Since toxicity of chemicals vary by route of exposure, different HIs were evaluated for different exposure pathways (i.e., one for ingestion, and one for dermal absorption). Table 3-4 summarizes the estimated HIs estimated using the maximum detected concentrations for each exposure scenario.

Table 3-4, Estimated Hazard Indices Using average Concentrations

Route of Exposure		Worker Scenario		
		Thiodiglycol	1,4 Dithiane	1,4 Oxathiane
Average Concn. (mg/kg)		1.98	1.98	1.98
Ingestion		0.0001	0.0007	0.00006
Inhalation		NA	NA	NA
Dermal Absorption		0.00003	0.0002	0.00001
Sum HQ		0.00013	0.0009	0.00007

Table 3-5 Estimated Hazard Indices Using Single Maximum Concentration

Route of Exposure		Worker Scenario		
		Thiodiglycol	1,4 Dithiane	1,4 Oxathiane
Single Max Concn. (mg/kg)		25.5	28.4	25.3
Ingestion		0.002	0.003	0.00008
Inhalation		NA	NA	NA
Dermal Absorption		0.0004	0.0006	0.003
Sum HQ = HI		0.0024	0.0036	0.00308

The results show that all estimated HIs are all well below the target level of 1 for Dunn Field, site 24-A. Since these estimates were made using conservative assumptions, such as using the maximum concentration, it is expected that the HIs will be much lower than the current estimates.

Little acute toxicity data are available to quantify potential adverse health effects from acute exposure. Generally, concerns with acute toxicity are associated with short-term exposure to high concentrations. Even when the maximum concentrations were used with chronic toxicity data, the estimated HIs for the construction worker exposure scenario was less than 1.

3.7 Uncertainty in the Assessment. Since not all information is readily available, professional judgment was used to derive various exposure parameters which introduces uncertainty. For example, workers were assumed to shower every day whether they are at work or at home, so the surface loading is expected to occur daily. In addition, the use of models to estimate concentrations introduces uncertainty, as models may not be applicable for all scenarios. Table 4 summarizes the major uncertainties and their effects on the final health risk estimates.

Table 3-6, Types of Uncertainty

Issue	Uncertainty	Direction of Effect
Exposure Assessment		
Assuming exposure to maximum detected concentrations for the entire exposure duration	The exposure point concentration over the exposure duration is likely to be lower than the maximum detected concentration. The maximum concentration is only a one time event.	Overestimates
Activity patterns	Everyone has different activity patterns (e.g., number times wash times). Although a wide range may be available for certain parameters, an attempt was made to combine upper bound and central tendency values to estimate potential health risks.	Varies (but will overestimate average population exposure if upper bound values are used)
Intake rate/dose	Similar to the activity patterns, intake rates such as the ingestion rate can vary from person to person. An attempt was made to include those intake rates that are applicable to the expose scenario.	Varies
Use of a model to estimate dermal exposure.	Models can either be theoretical or empirical. Theoretical models are generally more conservative because usually, the environmental loss processes are not considered. Empirical models, even though lab-based, may not represent field conditions (subject to environmental factors) and may also not be appropriate for all Substances of Potential Concern.	Varies
Using ½detection limit for non-detects.	Using ½detection limit value for samples with no detectable concentrations in soil is designed to include concentrations of an analyte, which may be present in soil, but are below the analytical detection limits.	Overestimates
Toxicity Assessment		
Route to route	To fill in data gap, it is common to conduct	Varies

Issue	Uncertainty	Direction of Effect
extrapolation of toxicity data	route-to-route extrapolation as was done for the dermal RfDs. Since absorption of a chemical varies by route of exposure, route-to-route extrapolation introduces uncertainty to a value that was not derived from laboratory or human data.	
Modifying and uncertainty factors for toxicity data	Modifying factors and uncertainty factors of varying degree are typically applied to toxicological values. These factors are used to conservatively account for extrapolating from animal studies for human health evaluation.	Overestimates

4. Conclusions. Risk calculations based on USEPA methodology produced HIs of less than 1 for workers. Based on standard EPA methodology, an HI of less than 1 indicates that systemic health effects would not be expected in receptors exposed to the levels of mustard degradation by-products evaluated in the HRA. Cancer risk was not evaluated because the mustard degradation products are not classified as probable human carcinogens. Based on the results of this assessment, it can be concluded that the soil concentrations at Dunn Field, site 24-A would not be expected to produce an adverse health effect to occupational workers with exposures as defined in this report.

5. The Occupational and Environmental Medicine Program, has reviewed this memorandum and concurs with the conclusions. The point of contact for this matter is Mr. James Mullikin, Environmental Health Risk Assessment. Questions or concerns should be directed to Mr. Mullikin at commercial (410) 436-5205, DSN 584-5205, or electronic mail james.mullikin@apg.amedd.army.mil.

FOR THE COMMANDER:

Encl

Program Manager, Environmental Health
Risk Assessment

CF:

APPENDIX A

1. Electronic mail transmission from DLA (Mr. Clyde Hunt) 13 August 2001.

2. USEPA (1989). *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A).* Prepared by the Office of Emergency and Remedial Response. EPA/540/1-89/002.

3. USEPA (1991). *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors".* OSWER Directive 9285.6-03.

4. USEPA (1997). *Exposure Factors Handbook, Volumes I-III.* Office of Research and Development, Washington, D.C. EPA/600/P-95/002F.

5. USEPA (1992). *Dermal Exposure Assessment: Principles and Applications.* Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-91/011B.

6. McKone, M.E., and Bogen, K.T. (1991). *Predicting the Uncertainties in Risk Assessment.* Environ. Sci. Technol., 25(10), 1674-1681.

7. Angerhofer, RA, Michie, MW & Leach, GJ (1998). US Army CHPPM Report from Toxicological Study No. 85-7415-97-05-01, Phase I, Subchronic Oral Toxicity of Thiodiglycol in Rats, May – December 1997.

8. Schieferstein, G.J., W.G. Sheldon, S.A. Cantrell and G. Reddy. 1988.Subchronic toxicity study of 1,4-dithiane in the rat. Fund. Appl. Toxicol. 11: 703-714.

9. US Army CHPPM (1997). In Vitro Chromosome Aberrations Study in Chinese Hamster Ovary (CHO) Cells. Test Substance: Thiodiglycol.

10. US Army CHPPM (1998). Mouse Lymphoma Mammalian Mutagenesis Assay. Test Substance: Thiodiglycol.

11. Vodela, JK, Angerhofer, RA, Michie, MW, Leach, GJ & Reddy, G (in press). Effect of Thiodiglycol (2,2'thiodiethanol) on Glutathione Antioxidant System in Rat Erythrocytes. Environmental and Nutritional Interactions.

Appendix Q

PCI Soil Table

PCI Soil Data Table

Memphis Depot, Dunn Field

Item No.	Profile	Manifest	Date	Quantity (Cubic YDS)	CWA Present	Mustard Degradation By-Products	HTW Constituent	Treatment	Disposition	Chemical Composition
1	203864	1706	26-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM
2	203864	1707	27-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM
3	203864	1708A	27-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM
4	203864	1709	30-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM
5	203864	1710	30-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM

Item No.	Profile	Manifest	Date	Quantity (Cubic YDS)	CWA Present	Mustard Degradation By-Products	HTW Constituent	Treatment	Disposition	Chemical Composition
6	203864	1711	31-Oct-00	20	No	No	Lead w/ Arsenic	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt 99-100% Glass < 1% Sodium Hydroxide <1% Arsenic: 0-60 PPM Lead: 5-80 PPM
7	206154	12600B	7-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
8	206154	12601	7-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
9	206154	12700	8-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
10	206154	12121	12-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
11	206154	12122	12-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
12	206154	12120	12-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
13	206154	12123	15-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting. 1-2%
14	206154	12701	15-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%

Item No.	Profile	Manifest	Date	Quantity (Cubic YDS)	CWA Present	Mustard Degradation By-Products	HTW Constituent	Treatment	Disposition	Chemical Composition
15	206154	12141	15-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
16	206154	12140C	22-Dec-00	20	No	No	None	None	BWI Landfill - Subtitle D, Millington, TN	Soil/Dirt: 98-100% Air Filters & Duct Work: 1-2% (Shreddable) Plastic Sheeting: 1-2%
17	209401	02061A	18-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
18	209401	2062	19-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol. ND Air Filters & Duct Work: 0 - 1%
19	209401	2063	22-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
20	209401	2064	22-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
21	209401	2065	22-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%

Item No.	Profile	Manifest	Date	Quantity (Cubic YDS)	CWA Present	Mustard Degradation By-Products	HTW Constituent	Treatment	Disposition	Chemical Composition
22	209401	2066	22-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
23	209401	2068	23-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
24	209401	2069	23-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
25	209401	2070	23-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
26	209401	2071	24-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
27	209401	2072	24-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%

Item No.	Profile	Manifest	Date	Quantity (Cubic YDS)	CWA Present	Mustard Degradation By-Products	HTW Constituent	Treatment	Disposition	Chemical Composition
28	209401	2073	24-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
29	209401	2074	24-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane. 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol. ND Air Filters & Duct Work: 0 - 1%
30	209401	2075	25-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane. ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
31	209401	2099	25-Jan-01	20	No	Yes	None	Stabilization/ Fixation	BWI Landfill - Subtitle D, Millington, TN	Soil 99-100% 1,4 Thioxane: 20 PPB-850 PPB 1,4 Dithiane: ND - 210 PPB Thiodiglycol: ND Air Filters & Duct Work: 0 - 1%
All other soil was transported outside the State of Tennessee.										

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE