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11901 Samuel, Garden Grove, CA 92840-2546

TABLE 31. (Continued)

Sample Code	Lab Code	Results (ppb) Methyl Esters 2,4-D	2,4,5-T
P120T700J	WL-89C	ND	Trace
Blank		ND	ND
P121T700J	WL-90C	ND	Trace
WF21T700J	WL-91C	0.28	0.47
WS21T700J	WL-92C	ND	Trace
WF22T700J	WL-93C	ND	ND
WS22T700J	WL-94C	ND	Trace
WO22T700J	WL-95C	ND	Trace
P122T700J	WL-96C	ND	Trace
WD22T708J	WL-97C	ND	Trace
WF23T700J	WL-98C	ND	Trace
WS23T700J	WL-99C	ND	ND
SE123T700J	WL-100C	29.60	29.16
P123T700J	WL-101C	ND	Trace
Blank		ND	ND
WF24T700J	WL-102C	ND	Trace
WO24T700J	WL-103C	ND	ND
WS24T700J	WL-104C	ND	Trace
WD24T708J	WL-105C	ND	Trace
P124T700J	WL-106C	ND	ND
WS25T700J	WL-107C	ND	ND
WF25T700J	WL-108C	ND	ND
SE25T700J	WL-109C	3.88	2.83
P125T700J	WL-110C	ND	ND
Blank		ND	ND
WF26T700J	WL-111C	ND	ND
WS26T700J	WL-112C	ND	ND
P126T700J	WL-113C	ND	ND
SE26T700J	WL-114C	1.42	0.89

2401

Drum Rinse Samples. The following codes are used in reporting the data given below:

D = day shift

N = night shift

The bottles were arbitrarily numbered, and were cleaned for re-use after analysis. The bottle analyses are presented in the order that the drum rinse samples were taken.

TABLE 32. ANALYTICAL DATA FOR DRUM RINSE SAMPLES

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml)	Running Average (μg/ml)
		July			
R101	DR-1	28D	23.9		23.90
R120	DR-2	28D	3.7		13.80
R119	DR-3	28D	32.8		20.13
R118	DR-4	28D	7.9		17.08
R117	DR-5	28D	29.5	19.56	19.56
R116	DR-6	28D	23.4		20.20
R115	DR-7	28D	2.5		17.67
R114	DR-8	28D	70.6		24.29
R217	DR-9	28N	18.0		23.59
R213	DR-10	28N	17.50	26.40	22.98
R209	DR-11	28N	27.0		23.35
R201	DR-13	28N	4.3		20.52
R202	DR-14	28N	45.6		24.02
R214	DR-15	28N	16.2	19.74	21.90
R206	DR-16	28N	51.3		23.74
R203	DR-17	28N	21.5		23.61
R218	DR-18	28N	25.4		23.71
R210	DR-19	28N	3.6		22.65
R207	DR-20	28N	16.3	23.62	22.33
R219	DR-21	28N	37.3		23.04
R204	DR-22	28N	4.2		22.19
R320	DR-23	29D	2.0		21.31
R319	DR-24	29D	2.0		20.50

2402

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (µg/ml) 2,4-D & 2,4,5-T	5 Drum Average (µg/ml)	Running Average (µg/ml)
R315	DR-25	29D	2.0	9.50	19.76
R316	DR-26	29D	2.0		19.08
R312	DR-27	29D	10.6		18.77
R317	DR-28	30N	43.1		19.64
R313	DR-29	30N	21.0		19.68
R306	DR-30	30N	18.8	19.10	19.65
R302	DR-31	30N	14.8		19.50
R309	DR-32	30N	2.0		18.95
R314	DR-33	30N	7.8		18.61
R308	DR-34	30N	22.5		18.73
R311	DR-35	30N	27.9	15.00	18.99
R318	DR-36	30N	4.5		18.59
R30	DR-37	30N	11.9		18.41
R211	DR-38	31D	3.3		18.01
R106	DR-39	31D	4.1		17.65
R107	DR-40	31D	2.2	5.20	17.27
R220	DR-41	31D	4.2		16.95
R109	DR-42	31D	2.0		16.59
R113	DR-43	31D	4.2		16.30
R208	DR-44	31D	2.1		15.98
R111	DR-45	31D	5.3	3.56	15.74
R107	DR-46	31D	7.2		15.56
R-S-001	DR-47	31D	14.7		15.54
R-S-002	DR-48	31D	3.8		15.29
R-S-003	DR-49	31D	10.0		15.19
R-S-004	DR-50	31D	2.0	7.54	14.92
R-S-005	DR-51	31D	0		14.63

2403

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (µg/ml) 2,4-D & 2,4,5-T	5 Drum Average (µg/ml)	Running Average (µg/ml)
R112	DR-52	31D	11.6		14.57
R102	DR-53	31D	4.6		14.38
		August			
R207	DR-54	2N	9.9		14.30
R214	DR-55	2N	15.9	8.40	14.33
R202	DR-56	2N	11.1		14.27
R217	DR-57	2N	29.1	14.53	
R205	DR-58	2N	16.5		14.57
R213	DR-59	2N	8.6		14.46
R120	DR-60	2N	8.9	14.84	14.37
R115	DR-61	2N	24.2		14.53
R201	DR-62	2N	8.4		14.43
R218	DR-63	2N	17.5		14.48
R210	DR-64	2N	6.9		14.36
R114	DR-65	2N	18.1	15.02	14.42
R204	DR-66	3D	3.4		14.25
R303	DR-67	3D	2.4		14.08
R320	DR-68	3D	2.0		13.90
R118	DR-69	3D	5.4		13.78
R113	DR-70	3D	3.6	3.36	13.63
R316	DR-71	3D	2.0		13.46
R319	DR-72	3D	24.7		13.62
R305	DR-73	3D	3.6		13.48
R310	DR-74	3D	2.2		13.33
R301	DR-75	3D	7.0	7.90	13.24
R206	DR-76	3D	2.5		13.10
R304	DR-77	3D	9.4		13.05
R203	DR-78	3N	15.1		13.08
R209	DR-79	3N	4.3		12.97

2404

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml)	Running Average (μg/ml)
R306	DR-80	3N	2.0	6.66	12.83
R116	DR-81	3N	15.9		12.87
R311	DR-82	3N	5.9		12.79
R314	DR-83	3N	2.0		12.66
R313	DR-84	3N	3.2		12.54
R211	DR-85	3N	5.2	6.44	12.46
R312	DR-86	3N	9.3		12.42
R117	DR-87	3N	5.6		12.34
R307	DR-88	3N	7.1		12.28
R308	DR-89	3N	7.1		12.22
R302	DR-90	4D	6.1	7.04	12.16
R119	DR091	4D	2.0		12.04
R315	DR-92	4D	46.0		12.41
R212	DR-93	4D	9.9		12.39
R219	DR-94	4D	6.0		12.32
R111	DR-95	4D	15.7	15.92	12.35
R112	DR-96	4D	17.3		12.41
R102	DR-97	4D	11.8		12.40
R318	DR-98	4N	23.40		12.51
R317	DR-99	4N	9.5		12.48
R319	DR-100	4N	41.8	20.76	12.77
R107	DR-101	4N	14.1		12.79
R302	DR-102	4N	57.5		13.22
R309	DR-103	4N	11.9		13.21
R306	DR-104	5D	13.0		13.11
R314	DR-105	5D	80.6	35.42	13.85
R303	DR-106	5D	21.1		13.92

2405

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml)	Running Average (μg/ml)
R113	DR-107	5D	54.4		14.30
R217	DR-108	5D	44.2		14.58
R201	DR-109	5D	11.1		14.54
R311	DR-110	5D	63.0	38.76	14.98
R207	DR-111	5D	15.0		14.98
R120	DR-112	5D	30.1		15.12
R213	DR-113	5D	56.0		15.48
R115	DR-114	5D	7.4		15.41
R208	DR-115	5D	21.8	26.06	15.47
R307	DR-116	5N	6.0		15.38
R214	DR-117	5N	54.8		15.72
R203	DR-118	5N	14.3		15.71
R116	DR-119	5N	9.9		15.66
R305	DR-120	5N	214.6	59.92	17.32
R103	DR-121	5N	19.2		17.33
R311#	RD-1	17D	70.7		17.76
R216	RD-2	17D	43.6		17.97
R209	RD-3	17D	34.5		18.11
R115	RD-4	17D	27.2		18.18
R204	RD-5	17D	11.5	37.50	18.13
R320	RD-6	17D	14.8		18.10
R217	RD-7	17N	15.6		18.08
R109	RD-8	17N	4.2		17.97
R118	RD-9	17N			17.98
R220	RD-10	17N	6.2	12.00	17.89
R114	RD-11	17N	4.7		17.79
R206	RD-12	17N	2.0		17.67
R208	RD-13	17N	7.6		17.59

#Beginning of 2nd de-drum period.

2406

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (µg/ml) 2,4-D & 2,4,5-T	5 Drum Average (µg/ml)	Running Average (µg/ml)
R214	RD-14	17N	7.1		17.52
R108	RD-15	17N	8.0	5.88	17.45
R113	RD-16	17N	4.9		17.35
R106	RD-17	17N	11.0		17.31
R119	RD-18	18D	9.2		17.25
R307	RD-19	18D	10.4		17.20
R315	RD-20	18D	8.6	8.82	17.14
R211	RD-21	18D	43.7		17.33
R107	RD-22	18D	139.4		18.19
R309	RD-23	18D	3.6		18.08
R111	RD-24	18D	16.1		18.07
R205	RD-25	18D	11.9	42.94	18.03
R101	RD-26	18D	31.7		18.12
R302	RD-27	18D	115.1		18.78
R219	RD-28	18N	13.5		18.74
R303	RD-29	18N	52.6		18.97
R212	RD-30	18N	14.4	45.46	18.94
R117	RD-31	18N	89.1		19.41
R308	RD-32	18N	5.2		19.31
R318	RD-33	18N	4.8		19.22
R102	RD-34	18N	12.2		19.17
R317	RD-35	18N	47.1	31.68	19.35
R313	RD-36	18N	38.8		19.48
R310	RD-37	18N	22.2		19.49
R115	RD-38	20D	114.2		20.09
R204	RD-39	20D	5.4		20.00
R109	RD-40	20D	79.4	52.00	20.37

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml)	Running Average (μg/ml)
R214	RD-41	20D	37.0		20.48
R206	RD-42	20N	19.9		20.47
R116	RD-43	20N	167.7		21.38
R113	RD-44	20N	34.3		21.45
R301	RD-45	20N	83.3	68.44	21.83
R305	RD-46	20N	7.2		21.74
R209	RD-47	20N	14.2		21.70
R220	RD-48	20N	28.3		21.74
R320	RD-49	20N	35.0		21.81
R208	RD-50	20N	38.5	24.64	21.91
R108	RD-51	20N	38.8		22.01
R114	RD-52	20N	30.3		22.06
R205	RD-53	20N	47.6		22.21
R111	RD-54	21D	23.8		22.22
R311	RD-55	21D	12.1	30.52	22.16
R203	RD-56	21D	16.2		22.12
R217	RD-57	21D	40.1		22.23
R315	RD-58	21D	38.5		22.32
R207	RD-59	21D	25.2		22.33
R106	RD-60	21D	10.1	26.02	22.27
R103	RD-61	21D	8.4		22.19
R314	RD-62	21D	26.3		22.21
R306	RD-63	21D	38.6		22.30
R202	RD-64	21D	6.4		22.21
R112	RD-65	21D	74.8	30.90	22.50
R303	RD-66	21D	4.8		22.40
R313	RD-67	21D	23.7		22.41
R102	RD-68	21N	2.2		22.30

2408

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml)	Running Average (μg/ml)
R317	RD-69	21N	6.2		22.22
R309	RD-70	21N	14.3	10.24	22.18
R212	RD-71	21N	14.4		22.14
R307	RD-72	21N	27.2		22.16
R319	RD-73	21N	29.1		22.20
R119	RD-74	21N	4.3		22.11
R312	RD-75	21N	4.7	15.94	22.02
R310	RD-76	21N	13.7		21.97
R216	RD077	21N	2.0		21.87
R211	RD-78	21N	12.2		21.81
R201	RD-79	22D	2.7		21.71
R214	RD-80	22D	7.5	7.62	21.65
R316	RD-81	22D	8.1		21.58
R120	RD-82	22D	2.0		21.48
R215	RD-83	22D	15.0		21.45
R101	RD-84	22D	9.3		21.39
R117	RD-85	22D	9.6	8.80	21.33
R210	RD-86	22D	4.1		21.25
R307	RD-87	22N	2.4		21.16
R209	RD-88	22N	3.9		21.08
R216	RD-89	22N	4.4		21.00
R310	RD-90	22N	26.2	8.20	21.02
R212	RD-91	22N	2.9		20.93
R319	RD-92	22N	38.7		21.02
R102	RD-93	22N	12.8		20.98
R112	RD-94	22N	2.0		20.90
R303	RD-95	22N	19.1	15.30	20.82

2409

TABLE 32. (Continued)

Bottle Code	Lab Code	Date	Total Weight (μg/ml) 2,4-D & 2,4,5-T	5 Drum Average (μg/ml	Running Average (μg/ml)
R309	RD-96	22N	47.7		21.01
R312	RD-97	22N	9.0		20.96
R107	RD-98	22D	15.4		20.93
R116	RD-99	22D	2.7	18.70	20.85

2410

Ship Samples

Wipe Samples. The following codes are used in reporting the data given below:

ND = not detected

NA = not analyzed

Trace = at or below the lower limit of quantitation

* = data reported in mg/swipe

TABLE 33. ANALYTICAL DATA FOR SHIP WIPE SAMPLES

Sample Code	Lab Code	Results (μg/swipe) Butyl Esters 2,4-D	2,4,5-T
Detection Limit for following samples		0.1	0.1
Limit of Quantiation for following samples		0.2	0.2
(DNA Owned) 31506	SW-1	42.6*	42.3*
(PACAF) 66L 1216	SW-2	25.1*	24.3*
(PACAF) 67L 440	SW-3	9.3*	9.3*
(PACAF) 67L 440	SW-4	10.3*	11.1*
(AFLC) 67 1280	SW-5	3.6*	3.6*
(AFLC) 67 1280	SW-6	13.3*	1.48*
SQ-01D-055-K	SW-7	23.0	31.2
SQ-02W-055-K	SW-8	15.5	21.3
SQ-03D-055-K	SW-9	12.5	17.4
SQ-04W-055-K	SW-10	21.2	28.1
SQ-05W-055-K	SW-11	10.6	14.6
SQ-06D-055-K	SW-12	48.9	63.9
SQ-08D-055-K	SW-13	2.4	2.4
SQ-09D-055-K	SW-14	18.1	24.3
SQ-10D-055-K	SW-15	31.5	37.2

2111

TABLE 33. (Continued)

Sample Code	Lab Code	Results (µg/swipe) Butyl Esters 2,4-D	2,4,5-T
SQ-11D-055-K	SW-16	13.8	17.6
SCR-01-055-K	SW-17	28.6*	37.1*
SCR-02-055-K	SW-18	10.0	8.8
SPR-01-055-K	SW-19	1.8*	1.8*
SPR-02-055-K	SW-20	0.11*	0.15*
SITS-1C-065-K	SW-21	4.9*	4.9*
SITS-3C-065-K	SW-22	7.9*	8.2*
SITS-5C-065-K	SW-23	54.5*	57.1*
SQ-06D-055-K	SW-12 #2	37.6	50.9
SITS-1CW-08S-K	SW-24	41.3*	44.1*
SITS-2CW-08S-K	SW-25	19.1*	20.5*
SITS-3CW-08S-K	SW-26	54.9*	57.7*
SITS-4CW-08S-K	SW-27	28.5*	30.1*
SITS-5CW-08S-K	SW-28	24.1*	25.6*
SITS-3CF-09S-K	SW-29	89.0*	92.4*
SITS-1CC-08S-K	SW-30	6.1*	5.9*
SITS-2CC-08S-K	SW-31	24.0*	25.7*
SITS-3CC-08S-K	SW-32	66.9*	70.4*
SITS-4CC-08S-K	SW-33	58.3*	61.6*
SITS-5CC-08S-K	SW-34	140.5*	145.3*
SPR-01-09S-K	SW-35	0.84*	0.89*
SPR-02-09S-K	SW-36	137.3	165.2
SPR-05-09S-K	SW-37	19.1*	19.1*
SCR-01-09S-K	SW-38	14.0	16.3
SCR-02-09S-K	SW-39	2.4*	3.0*
SCR-05-09S-K	SW-40	9.3*	12.7*
SITS-3CW-11S-K	SW-41	22.6*	23.3*
SQ-01-K	SW-42	20.1	22.3

2412

TABLE 33. (Continued)

Sample Code	Lab Code	Results (µg/swipe) Butyl Esters 2,4-D	2,4,5-T
SQ-04-K	SW-43	<1.0	<1.0
SQ-06-K	SW-44	23.3	25.7
SQ-10-K	SW-45	<1.0	<1.0
SQ-11-K	SW-46	<1.0	<1.0
SQ-13-K	SW-47	20.9	25.8
SQ-02-11S-K	SW-48	7.9	5.3
SQ-05-11S-K	SW-49	Trace	Trace
SQ-07-11S-K	SW-50	23.3	29.3
SQ-08-11S-K	SW-51	19.7	21.0
SQ-09-11S-K	SW-52	6.8	5.0
SQ-12-11S-K	SW-53	Trace	Trace

2413

Impinger, Probe, and Line Rinse Samples. The following codes were used in reporting the data given below:

ND = not detected

NA = not analyzed

Trace = at or below the lower limit of quantitation

TABLE 34. ANALYTICAL DATA FOR SHIP'S IMPINGER, PROBE, AND LINE RINSE SAMPLES

Sample Code	Lab Code	Results (µg/sample) Butyl Esters 2,4-D	2,4,5-T
Detection limit for following samples		0.1 µg/ml	0.1 µg/ml
Limit of Quantitation for following samples		0.5 µg/ml	0.5 µg/ml
HO-1-BT-H-S-B-11:15	I-1	ND	ND
HO-1-BI-H-S-B-9:29	I-2	ND	ND
HO-1-BI-H-S-B-11:40	I-3	ND	ND
HO-1-BI-H-S-B-10:08	I-4	ND	ND
HO-1-BI-F-S-B-AF	I-5	ND	ND
Benzene and Acetone Blank	I-Blank	ND	ND
Acetone, Benzene Blank	I2-Blank	ND	ND
HO-2-BI-8/13-H-S-B-1210	I-6	ND	ND
HO-3-BI-8/24-A/B-S-B	I3-Blank	ND	ND
HO-3-BI-8/28-H-S-B	I-10	ND	ND
HO-1-PR-722-H-S-B	PR-1	ND	ND
HO-1-PR-725-H-S-B(2)	PR-2	ND	ND
HO-2-PR-8/13-H-S-B	PR-3	Trace	ND
HO-3-PR-9/01-H-S-B	PR-4	ND	ND
HO-1-LR-714-H-S-B (Fuel Bkg)	LR-1	ND	ND

2414

TABLE 34. (Continued)

Sample Code	Lab Code	Results (μg/sample) Butyl Esters 2,4-D	2,4,5-t
HO-1-LR-715-H-S-B (Test 2)	LR-2	ND	ND
HO-1-LR-716-H-S-B	LR-3	ND	ND
HO-1-LR-718-S-B (Test 4)	LR-4	ND	ND
HO-1-LR-719-S-B (Test 5)	LR-5	ND	ND
HO-1-LR-719-S-B (Test 6)	LR-6		
HO-2-LR-8/13-H-S-B	LR-7	ND	ND
HO-3-LR-8/28-H-S-B	LR-8	ND	ND

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Chromosorb (Air) Samples. The following codes are used in the reporting of the data given below:

NA = not analyzed

ND = not detected

Trace = at or below lower limit of quantitation

TABLE 35. ANALYTICAL DATA FOR SHIP'S CHROMOSORB (AIR) SAMPLES

Sample Code	Lab Code	Results (µg/sample) Butyl Esters 2,4-D	2,4,5-T
Detection Limits for the following samples		0.08	0.04
Limit of Quantitation for following samples		0.4	0.4
HO-1-PM-13-P-B-8	13C	0.3	0.07
HO-1-AM-14-F-I-B-8	14C	ND	0.02
HO-1-PM-15-H-P-B-20	15C	0.39	0.15
HO-1-PM-16-H-I-B-20	16C	ND	ND
HO-1-AM-17-H-P-B-8	17C	1.18	0.43
HO-1-AM-18-H-I-B-8	18C	0.2	Trace
HO-1-PM-19-H-P-B-20	19C	1.63	0.77
HO-1-PM-20-H-I-B-20	20C	0.91	0.43
HO-1-AM-21-H-P-B-8	21C	0.58	0.18
HO-1-AM-22-H-I-B-8	22C	1.8	0.88
HO-1-PM-23-H-P-B-20	23C	1.11	0.38
HO-1-PM-24-B-I-B-20	24C	0.10	0.06
Detection Limits for the following samples		0.08	0.03
Lower Limit of Quantitation for following samples		0.2	0.1
HO-1-PM-16-H-G-B-20	59C	Trace	ND

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TABLE 35. (Continued)

Sample Code	Lab Code	Results (μg/sample) Butyl Esters 2,4-D	2,4,5-T
HO-1-PM-16-H-P-B-20	60C	0.38	0.09
HO-1-PM-16-H-C-B-20	61C	Trace	ND
HO-1-AM-18-H-G-B-8	68C	Trace	ND
HO-1-AM-18-H-P-B-8	69C	3.04	0.96
HO-1-AM-18-H-C-B-8	70C	0.06	Trace
HO-1-PM-18-H-C-B-20	71C	0.11	Trace
HO-1-PM-18-H-P-B-20	72C	Lost Sample	
HO-1-PM-18-H-G-B-20	73C	Trace	ND
HO-1-AM-16-H-C-B-8	90C	Trace	Trace
HO-1-AM-16-H-G-B-8	91C	0.09	Trace
HO-1-AM-16-H-P-B-8	92C	21.93	3.79
HO-1-AM-15-H-C-B-8	93C	Trace	Trace
HO-1-AM-15-H-G-B-8	94C	ND	ND
HO-1-AM-20-H-C-B-9	95C	Trace	Trace
HO-1-PM-20-H-G-B-20	96C	Trace	ND
HO-1-AM-22-H-G-B-8	97C	ND	ND
HO-1-PM-22-H-C-B-20	98C	Trace	ND
HO-2-AM-11-H-I-B-19	99C	24.63	13.79
HO-2-AM-12-H-P-B-19	100C	10.90	3.33
HO-2-AM-13-H-I-B-19	101C	49.55	27.69
HO-2-AM-14-H-P-B-19	102C	0.51	0.16
HO-2-AM-15-H-I-B-19	103C	1.23	0.60
HO-2-AM-6-H-P-B-19	104C	15.07	7.38
HO-2-AM-7-H-I-B-19	105C	28.52	15.63
HO-2-AM-8-H-P-B-19	106C	12.85	3.85
HO-2-AM-9-H-I-B-19	107C	2.23	1.16
HO-2-AM-10-H-P-B-10	108C	5.23	1.62
HO-2-AM-7-H-G-B-19	109C	0.40	0.11

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TABLE 35. (Continued)

Sample Code	Lab Code	Results (μg/sample) Butyl Esters 2,4-D	2,4,5-T
HO-2-AM-8-H-C-B-19	110C	Trace	Trace
HO-2-AM-9-H-G-B-19	111C	1.00	0.35
HO-2-AM-10-H-C-B-19	112C	Trace	Trace
HO-2-AM-11-H-G-B-19	113C	0.52	0.15
HO-2-AM-12-H-C-B-19	114C	Trace	Trace
HO-3-AM-25-H-I-B-07	115C	34.51	16.50
HO-3-AM-25-H-G-B-07	116C	0.42	Trace
HO-3-AM-26-H-G-B-07	117C	0.38	Trace
HO-3-AM-27-H-I-B-07	118C	55.0	25.5
HO-3-AM-27-H-G-B-07	119C	0.49	0.11
HO-3-AM-29-H-I-B-07	120C	7.20	4.40
HO-3-AM-29-H-G-B-07	121C	1.10	0.31
HO-3-AM-30-H-G-B-07	122C	0.84	0.25
HO-3-AM-31-H-G-B-07	123C	1.10	0.30
HO-3-AM-31-H-I-B-07	124C	82.8	43.2
HO-3-AM-01-H-G-B-08	125C	0.89	0.23
HO-3-AM-02-H-G-B-08	126C	55.5	29.5
Tank 5C	127C	14.50	4.10
Tank 2C	128C	4.40	0.90
Tank 3C	129C	5.20	1.10
Tank 4C	130C	25.8	3.8
Tank 1C	131C	11.1	2.9
Tank 4S	132C	5.70	1.50

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Tank Rinse Samples.

TABLE 36 . ANALYTICAL DATA FOR SHIP'S TANK RINSE SAMPLES

Sample Code	Lab Code	Results (mg/ml) Butyl Esters	
		2,4-D	2,4,5-T
RDF-03-07S-K-1930	DFR-1	83.3	84.9
RDF-04-08S-K-0200	DFR-2	88.4	90.3

Water Samples. The following codes are used in reporting the data given below:

ND = not detected

NA = not analyzed

Trace = at or below lower limit of quantitation

TABLE 37. ANALYTICAL DATA FOR SHIP'S WATER SAMPLES

Sample Code	Lab Code	Results (ppb) 2,4-D (Me)	Results (ppb) 2,4,5-T (Me)
Detection Limit for following samples		0.1	0.1
Lower Limit of Quantitation for following samples		0.2	0.2
Ship's Drinking Water (Kitchen, Lower Wing Tank, STB)	VDW-1	ND	ND
HO-2-SW-8/16-H-T-1600	VDW-3	ND	ND
Ship's Drinking Water (8/28/77 @ 1350)	VDW-4	ND	ND

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Dunnage Burn Air and Ash Samples.

TABLE 38. ANALYTICAL DATA FOR DUNNAGE BURN SAMPLES

Sample Code	Lab Code	Results (µg/sample) Butyl Esters 2,4-D	2,4,5-T
Detection Limits for the following samples		0.1	0.1
Limit of Quantitation for the following samples		0.5	0.5
SVW09S77 Background	HV-1	2.49*	2.41*
SDW09S77 Station No. 1	HV-2	1.52*	1.98*
SDW09S77 Station No. 2	HV-3	24.45	48.89
Incinerator Ash	Ash-1	3.44	1.64

*Normal background for untreated filter paper.

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PROPOSED TWO-STEP PROCEDURE

FOR CLEANING THE WASTE TANKS

OF THE M/T VULCANUS

FOLLOWING INCINERATION OF ORANGE HERBICIDE

June 8, 1977

by

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[redacted] Captain, USAF, BSC

PROJECT PACER HO

UNITED STATES AIR FORCE

GULFPORT, MISSISSIPPI

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SUMMARY

Subsequent to the three at-sea incineration burns of Orange Herbicide, a chlorinated hydrocarbon, there will be some residual left in the tanks of the M/T VULCANUS. This residual is conservatively estimated to consist of approximately 18 metric tons of Orange Herbicide containing an estimated 33 grams of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the contaminant of the herbicide. A two-step rinse procedure initially using clean Orange Herbicide (no detectable levels of TCDD) followed by diesel fuel is proposed to remove the TCDD. Calculations are presented which show that the proposed procedure will remove 99.9+% of the TCDD residual and also 94.5+% of the chlorinated hydrocarbon herbicide residual. This represents a cleaning efficiency equivalent to the 90-99.9% efficiency of the currently practiced tanker rinsing method known as "Butterworth". The proposed procedure will result in TCDD residuals comparable to those levels resulting from a Butterworth rinse. Removal of the remaining hydrocarbons can then be accomplished at any dock side facility using conventional degasification procedures in a safe and environmentally acceptable manner.

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I OBJECTIVES

The objectives of this paper are to define the magnitude of contamination of the waste holding tanks on the M/T VULCANUS, as well as the proposed methods and procedures for decontamination of these tanks following the transportation and subsequent burning of Orange Herbicide and its contaminant (2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD).

II BACKGROUND

1. USES OF PHENOXY HERBICIDES: The phenoxy herbicides 2,4-Dichlorophenoxyacetic acid (2,4-D) and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T); their salts, esters and other compounds, are well established pesticides for the control of weeds and shrubs in agriculture. In particular, as noted by Klingman and Shaw (1967[1]),the phenoxy herbicides are especially useful because; a) they are selective, they kill most broadleaf plants, but do not kill grasses or grain crops; b) they are potent, many species of weeds are controlled by less than one pound of active ingredient per acre; c) they are easy to use; d) they are only mildly to moderately toxic to man, domestic animals, or wildlife when applied as recommended; and e) they do not accumulate in the soil and they have minimal, if any, harmful effects on soil organisms. Klingman and Shaw noted that ester formulations are generally more potent, pound for pound, than salt formulations. The esters are more effective than salts for killing weeds that are growing slowly; and because these esters are oily, they are less likely to be washed off the foliage if rain falls soon after application.

2. EXTENT OF USE: The herbicides 2,4-D and 2,4,5-T were first employed by farmers and ranchers in the mid-1940's and remain the most common synthetic organic herbicides. The largest use of 2,4-D is for broadleaf weed control in corn and other grains; the major use of 2,4,5-T is to kill brush (Fox *et al.*, 1970).[2] The combined production of 2,4-D and 2,4,5-T has increased steadily from 34.6 million pounds in 1958 to 96.8 million pounds in 1968. At present, the phenoxy herbicides are the only group of herbicides used to any extent on pasture and rangeland. In 1964, the uses of 2,4,5-T were: rights-of-way - 49%; nonfarm forests - 10%; hay, pasture, and rangelands - 7%; all other farm uses - 12%; lawns and turfs - 7%; federal agencies - 6%; and other miscellaneous uses - 9%.[3] Incomplete information indicates that about nine million pounds of 2,4,5-T esters, acids, and salts were domestically used during 1970. Weeds and brush infesting pasture and rangeland are most widely controlled by 2,4-D and 2,4,5-T, respectively. In 1966, nearly 8 million acres (more than 1 percent) of pasture and rangeland were treated with phenoxy herbicides (Fox *et al.*, 1970).[2] The herbicide 2,4,5-T is a

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particularly effective tool for vegetation management on forest lands (Montgomery and Norris, 1970).[4] It is used on power line, railroad rights-of-way; but its most important use is in connection with the establishment and release of conifers on forest lands. For these purposes, 0.5 to 4 pounds of 2,4,5-T per acre were applied as low volatile esters dissolved or emulsified in diesel oil or water.

3. HISTORICAL DOCUMENTATION OF EVENTS: In April 1970, the Secretaries of Agriculture, Health, Education and Welfare, and the Interior jointly announced the suspension of certain uses of 2,4,5-T. These suspensions resulted from published studies indicating that 2,4,5-T was a teratogen. Subsequent studies revealed that the teratogenic effects had resulted from a toxic contaminant in the 2,4,5-T. The contaminant was identified as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Subsequently, the Department of Defense suspended the use of Orange Herbicide, which is a chlorinated hydrocarbon herbicide that consists of approximately 50 percent 2,4,5-T and 50 percent 2,4-D. At the time of this suspension, the Air Force had an inventory of 1.37 million gallons of Orange Herbicide in South Vietnam and 0.86 million gallons in Gulfport, Mississippi. In September 1971, the Department of Defense directed that the Orange Herbicide in South Vietnam be returned to the United States and that the entire 2.23 million gallons be disposed of in an environmentally safe and efficient manner. The 1.37 million gallons were moved from South Vietnam to Johnston Island, North Pacific for storage in April 1972. The average concentration of TCDD in the Orange Herbicide is about 2 mg/kg and the total amount of TCDD in the entire Orange stock is approximately 20 kg.

During the development of a method of disposition from 1971 to 1974. Various techniques of destruction and recovery were investigated. Destructive techniques investigated included soil biodegradation, high temperature incineration, deep well injection, burial in underground nuclear test cavities, sludge burial and microbial reduction. Techniques to recover a useful product included use, return to manufacturers, fractionation and chlorinolysis.

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Of these techniques, only high temperature incineration was sufficiently developed at that time to warrant further investigation. The other methods were rejected because of several considerations, including long lead times for development with no assurance of success and the lack of industrial interest.

In December 1974, the Air Force filed a final environmental impact statement[5] with the Council on Environmental Quality on the disposition of Orange Herbicide by destruction aboard a specially designed incineration vessel in a remote area of the Pacific Ocean, west of Johnston Island.

The Environmental Protection Agency (EPA) held a public meeting in February 1975 to consider an ocean dumping permit application submitted by the Air Force in accordance with the Marine Protection, Research and Sanctuaries Act. During this meeting, testimony was presented which indicated that techniques for chemically reprocessing the herbicide to remove unacceptable quantities of TCDD might have been developed. The EPA indicated that the option for use/reprocessing should be further explored as a means of disposition prior to destruction of the herbicide.

Subsequently, the U.S. Air Force undertook an investigation into the feasibility of reprocessing. Pilot plant studies were conducted and only partially completed in July 1976. This process, selective activated carbon adsorption of TCDD from undiluted herbicide, was shown to be technically and environmentally feasible; however, a feasible and environmentally acceptable method of safely disposing of the TCDD-laden activated carbon was not demonstrated. The U.S. Air Force concluded in February 1977 that the option of reprocessing was not feasible, timely or cost effective since a technique for the ultimate disposal of the activated carbon was not currently available or anticipated in the foreseeable future.

Consequently, the Air Force requested reconvening of the EPA public hearings on 9 March 1977. As a result of public hearings held on 7 April 1977, the US EPA issued a research permit to the U.S. Air Force and Ocean Combustion Services, B.V. (OCS). This permit authorizes the transport of the Orange Herbicide from the Naval Construction Battalion Center, Gulfport, MS to a designated site

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in the North Pacific Ocean for the purpose of at-sea incineration in accordance with the provisions of the Marine Protection, Research and Sanctuaries Act of 1972, as amended.

This permit includes a requirement for decontaminating the vessel's tanks, transfer lines, headers and other equipment in contact with Orange Herbicide following the final incineration process. In addition, the contractual agreement between the Military Sealift Command, (the DoD Charter agent for the U.S. Air Force), and Ocean Combustion Services also contains a provision for vessel decontamination. A total of three sailings will be required to incinerate the total stocks of Orange Herbicide including one loading from Gulfport, MS and two loadings from Johnston Island.

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III CHEMICAL, PHYSICAL AND TOXICOLOGICAL PROPERTIES OF ORANGE HERBICIDE

All available reference data on the general properties of Orange Herbicide are summarized and presented in Appendix A, Tables A-1 and A-2. General properties of TCDD are presented in Table A-3; the statistical analyses for the TCDD content in the Orange Herbicide stocks are discussed below. The Orange Herbicide has a very low vapor pressure, and a high flash point. It is non-corrosive to most materials, and is insoluble in water, while highly soluble in organic, non-polar solvents such as diesel fuel. The chlorine content of Orange Herbicide is approximately one-half that of the wastes previously incinerated by the M/T VULCANUS. Its caloric value is substantially higher than that of the wastes previously incinerated.

1. RESULTS OF JOHNSTON ISLAND ANALYSES: The arithmetic mean TCDD concentration was found to be 1.909 mg/kg; therefore, the total TCDD in the Orange stock at Johnston Island is estimated to be 12.66 kg. The TCDD concentrations in the 200 samples from Johnston Island did not follow a normal distribution. Of the 200 samples, 153 or 76.5% contained TCDD concentrations of 1.0 mg/kg or less. Of the 200 samples, 195 or 97.5% had TCDD concentrations of 10.0 mg/kg or less. Only 5 samples (2.5%) had TCDD concentrations larger than 10.0 mg/kg. These larger values were 13, 17, 22, 33 and 47 mg/kg. None of these values were discarded as "outliers" in computing the arithmetic mean TCDD concentration of 1.909 mg/kg.

2. RESULTS OF GULFPORT ANALYSES: The maximum concentration of TCDD was found to be 14.2 mg/kg. The average TCDD concentration was found to be 1.772 mg/kg of Orange Herbicide. The total TCDD in the Orange stock at Gulfport is estimated to be 7.26 kg. The stocks at Gulfport can be grouped into manufacturer's lots and have been studied very extensively. Two of these lots are known to have non-detectable levels of the TCDD contaminant; i.e., the TCDD concentration is less than 0.02 mg/kg of Orange. The total quantity of these two lots is approximately 140,000 gal (530 cubic meters).

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3. TCDD CONTENT OF TOTAL ORANGE HERBICIDE STOCKS: At the present time, the total Air Force inventory of Orahge Herbicide at Gulfport and Johnston Island is approximately 40,500 fifty-five gallon drums or 2.23 million gallons. The weighted average concentration of TCDD is 1.859 mg/kg. Therefore, the total amount of TCDD in the entire Air Force inventory is estimated to be 19.9 kg.

4. TOXICOLOGICAL PROPERTIES OF ORANGE HERBICIDE:

A. 2,4-D and 2,4,5-T: The relative toxicity of 2,4-D and 2,4,5-T may be characterized as "low".[5] The acute oral *LD_{50}[5] of 2,4-D acid to rats is 375 mg/kg. The acute oral LD_{50} of 2,4,5-T acid to rats is 500 mg/kg. Chronically, both 2,4-D and 2,4,5-T are of low toxicity because of the highly developed kidney function possessed by mammals tnat will rapidly eliminate 2,4-D and 2,4,5-T by active tubular secretion. The cummulative effects of 2,4-D and 2,4,5-T are minimal.[5]

B. TCDD: TCDD has been found to be the most toxic of the chlorodibenzo-p dioxins studied. The LD_{50}'s were found to be in the ug/kg range for several species of mammalian animals. TCDD was also found to be acnegenic to humans as well as being teratogenic and embryotoxic in laboratory studies utilizing laboratory mammals. Studies performed on TCDD by the Biochemical Research Laboratory, Dow Chemical Co., can be summarized as follows with the data presented as the LD_{50} in ug/kg of body weight for several species; rats 20-40; mice, males 64, females 130; guinea pig 0.6-2.0; rabbits 30; dogs 30 (Rowe et al., n.d.).[6]

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* LD_{50} - Lethal dose fifty. A calculated dose of a chemical substance which is expected to cause the death of 50% of an entire population of an experimental animal species, as determined from the exposure to the substance, by any route other than inhalation, of a significant number from that population.

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The signs of intoxication are characterized by a chronic illness and liver damage. Half of the deaths occur more than two weeks after treatment while some animals died after 48 hours. Excretion is primarily by way of feces and is very slow. The highest concentrations are found in the liver and fat with a smaller amount being found in the testes. The LD_{50} for the rabbit is about the same whether administered intraperitoneally or applied to the skin. In the eye it does not cause corneal injury but does produce thickening of the lids. It does cause severe chloracne when applied to the ears of rabbits in ug quantities. Despite the known toxicity of TCDD, with the exception of industrial accidents/incidents there have been no scientifically documented cases of human TCDD intoxication resulting from or directly attributed to the 31-year military, commercial or private use of TCDD contaminated 2,4,5-T.[3]

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IV COMMON SHIP TANK CLEANING

As mentioned previously, the research permit for the incineration of Orange Herbicide includes a requirement for decontaminating the vessel's tanks, transfer lines, headers and other equipment in contact with the herbicide following the final incineration process. This requirement is not to prevent the contamination of the next cargo, but to adequately purge the tanks of TCDD prior to the ship going into drydock in Europe to undergo inspection and repairs. This section discusses the Air Force's proposal to accomplish this cleaning.

1. COMMON PRACTICE: Common practice in the tanker industry today is to clean a vessel's tanks of residue after unloading to avoid contamination of the next cargo. This cleaning process commonly utilizes water as a solvent/rinseate. Depending upon the solubility (in water) and specific gravity of the residue being rinsed, the water rinseate may be heated or unheated and applied under low or high pressure spray. In some cases where the residue may be insoluble in water, or undesirable residue/water reactions could occur, other solvents may be used. After unloading, a vessel's tanks are commonly washed with a rotary water jet washing machine such as "Butterworth" or "Victor Pyrate".

2. THEORETICAL STUDIES: In the past some trials have been carried out to determine the amount of residue left onboard a vessel and the removal efficiency achieved by rinsing.[7,8] Unfortunately, the results of these tests have been inconclusive. However, theoretical studies have been carried out by Schuurmans and Schilder[9] to predict the amount of residue left on board. In general, the predicted volumes of residue remaining have been somewhat higher than those actually measured. Considering the many variables and uncertainties involved, however, the agreement of the theoretical estimates with actual measurements was satisfactory. Wybenga[10] indicates that in current (IMCO sponsored Dutch) studies not yet published, the residual removal efficiency for a single Butterworth cleaning ranges from 90.0 to 99.9 percent depending on a variety of controlling parameters. Schuurmans and Schilder have indicated that a single Butterworth cleaning achieves at least 99% removal efficiency.[11]

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V THEORETICAL RESIDUES AND PROPOSED TANK RINSING PROCEDURES

1. THEORETICAL RESIDUES OF ORANGE HERBICIDE LEFT ONBOARD: The Orange Herbicide residual left onboard the vessel has been estimated as 14,580 liters (18.7 metric tons) based on a conservative application of the estimating procedures developed by Schuurman and Schilder.[9] The residual TCDD is 33.3 gm. Calculations are included in Appendix B.

2. PROPOSED RINSE PROCEDURES: A two-step cleaning procedure will be used to reduce the levels of Orange Herbicide and TCDD in the vessel's tanks: See Appendix C for assumptions detailed rinsing procedures and expected cleaning efficiencies.

A. <u>First Rinse Step</u>: The first step in the procedure is the rinsing of the tanks with clean herbicide (non-detectable levels of TCDD). The clean Orange Herbicide (approximately 140,000 gallons) will be loaded at Gulfport, MS in one tank of the vessel and held in this tank until the decontaminating/rinsing procedures are carried out following the third incineration at sea. The clean herbicide will be pumped into a tank until it is full, and then pumped from that tank to another tank until all tanks have been rinsed. This herbicide will then be burned. This first step procedure will not reduce the chlorinated hydrocarbon Orange Herbicide residual in the tanks, but it will remove a substantial (see Table C-1 Appendix C) amount of the TCDD contaminant by diluting the TCDD in the residual with the large volume of clean herbicide. Using the clean Orange Herbicide as a diluent to reduce the TCDD concentration in the liquid residual should be very effective, as the TCDD-contaminated liquid residue left aboard the vessel will be completely miscible with the clean herbicide.

B. <u>Second Rinse Step</u>: The second step is the rinsing of the tanks with diesel fuel (DF-2 or equivalent) to remove an additional amount of TCDD and also a large part of the herbicide residual in the tanks. The diesel fuel will be pumped into a wing tank until the tank is full. It will then be pumped from that tank to another wing tank. Each of the wing tanks will be filled and emptied in turn. The diesel fuel will then be pumped to one of the center tanks, to a depth of about 1 meter.

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Fresh water will then be pumped into the tank to fill the tank and float the diesel fuel. According to Wybanga,[10] this water floatation procedure is a common practice. The diesel fuel will contact all surfaces (bottom, sides, and top) of the tank. The chlorinated hydrocarbon herbicide is very soluble in diesel fuel, and insoluble in water. The same water will be used to float the diesel fuel in all of the center tanks. After all of the center tanks are clean, the diesel fuel will be incinerated while the fresh water rinseate will be discharged to the ocean. The fresh water/diesel fuel floatation approach was chosen for the center tanks because of the large size of the tanks, and the cost of the quantity of diesel fuel that would be necessary to fill them. The sequence of operations necessary to complete this two-step rinse plan is included in Appendix C.

3. RESIDUE REMOVAL EFFICIENCIES: Table C-1 Appendix C presents an estimate of the amount of herbicide and TCDD residual in each tank following this two-step rinse procedure. The total quantity of herbicide and TCDD residual in the ship's tanks before the two-step rinse procedure is 18.7 metric tons of herbicide and 33.3 gm of TCDD. The two-step rinse procedure will remove more then 94.5% of the herbicide and more than 99.9% of the TCDD, leaving a total residual of 1,012.6 kg of Orange Herbicide and 28.2 mg of TCDD.

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VI CONCLUSIONS

1. Orange Herbicide is a chlorinated hydrocarbon which, with the exception of its contaminant TCDD, is not substantially different from other wastes previously incinerated by the M/T VULCANUS.

2. The contaminant TCDD has been shown to be a highly toxic compound. It is present in the Orange Herbicide at low average concentrations (less than 2.0 mg/kg).

3. The thirty-one year human experience in the handling and use of 2,4,5-T with TCDD contamination has not resulted in any known scientifically documented TCDD intoxication to humans.

4. The pre-rinse residues left onboard as calculated by an accepted theoretical technique are conservatively high.

5. Rinsing of the vessel's waste tanks is required not to prevent contamination of the next cargo, but to adequately clean the tanks of the TCDD residue prior to the ship's drydocking in Europe to undergo inspection and repairs.

6. The residual TCDD removal effected by this proposed two-step rinsing procedure is as effective as a commonly accepted rinsing practice in the industry,i.e., "Butterworth".

7. After completing this proposed rinsing procedure, a degasification using any commonly accepted tank rinsing procedure may be used to remove the remaining hydrocarbon materials safely and in an environmentally acceptable manner at any shore side dock. The rinseate could be easily loaded back aboard the VULCANUS for subsequent incineration with the next waste.

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APPENDIX A

GENERAL CHEMICAL/PHYSICAL PROPERTIES OF ORANGE HERBICIDE AND TCDD

The general chemical/physical properties of Orange Herbicide are contained in Tables A-1 and A-2. Table A-3 contains the general chemical/physical properties of TCDD.

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TABLE A-1. GENERAL CHEMICAL/PHYSICAL PROPERTIES OF ORANGE HERBICIDE

Property	Orange	Orange II
BTU Content per Pound[1]	10,017 (s=80)	
Physical State	Liquids at room temperature.	
Color	Clear, reddish brown to straw color.	
Appearance	Dark, rust-colored liquid of oily consistency.	
Solubility	Soluble in diesel fuel and organic solvents. Insoluble in water.	
Freezing Point (°C)	7 to 8	9
Flash Point	146°C (295°F)	Unknown
Specific Gravity @ 25°C	1.275 to 1.295	1.220 - 1.242
Weight (lb/gal)[2]		
Total ester	(@20°C) 10.7 (±0.08)	10.2 (±0.09)
Acid equivalent	8.6	7.6
Vapor Pressure (30°C)	~3.6 x 10^{-4} mm Hg ††	
Viscosity, centipoises @:[2]		
-17.7°C	5,000	unknown
- 6.6°C	940	unknown
0.0°C	390	unknown
10.0°C	134	unknown
23.8°C	43	67
37.7°C	24	27
Viscosity, centipoises @:[3]		
20°C	46	-
30°C	24	-
35°C	18	-
40°C	14	-
45°C	11	-
Theoretical % Weight[4]		
Carbon	49.11*	52.12†
Chlorine	29.87*	27.27†
Oxygen	16.37*	15.20†
Hydrogen	4.65**	5.41**
Free Acid (by weight)	0.5% maximum	0.5% maximum
Total Acid Equivalent (% by weight as 2,4-D)	90.0% minimum 94.0% maximum	79.9% minimum 80.0% maximum
Corrosiveness	Noncorrosive on most metals. Deleterious to some paints, natural rubber, and neoprene. Teflon, viton, polyethylene and butyl rubber are resistant.	

*Sample contained 14 ppm TCDD.
†Sample contained 3.7 ppm TCDD.
††Calculated and confirmed by EHL(M).
**Calculated by EHL(K), Kelly AFB TX as (100-ΣC,Cl,O weight percents).

1. USAF EHL(K) a, 1973.
2. U.S. Army, 1969.
3. USAF RPL, 1972 (Dept. Agr.).
4. USDA, 1972.

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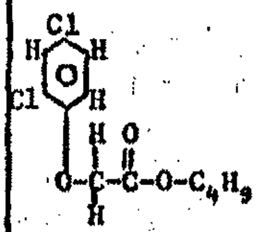
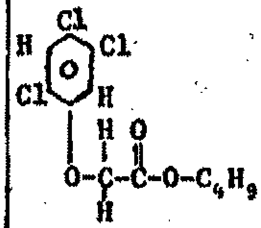
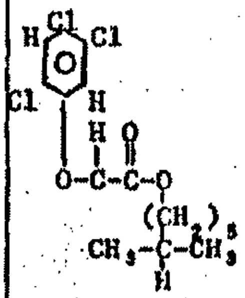
Table A-2. GENERAL CHEMICAL/PHYSICAL PROPERTIES OF INGREDIENT ESTERS OF ORANGE HERBICIDE

Property	Normal Butyl 2,4-dichloro-phenoxyacetate NB 2,4-D	Normal Butyl 2,4,5-trichloro-phenoxyacetate NB 2,4,5-T	Iso-octyl 2,4,5-trichloro-phenoxyacetate IO 2,4,5-T
Purity (ester by weight)	98.0% minimum	95% minimum	95% minimum
Appearance	Clear, reddish brown liquids		
Acid Equivalent (by weight)	79.0% minimum to 80.0% maximum	78-82%	66-69.5%
Free Acid (by weight)	0.5% maximum	0.5% maximum	0.5% maximum
Specific Gravity($20^o/20^o$)		1.316 to 1.340	1.200 to 1.220
Freezing Point (^oC)		29[1,2,3]*	-21 to -23
Molecular Weight	277.15	311.60	367.71
Molecular Elements	$C_{12}H_{14}Cl_2O_3$	$C_{12}H_{13}Cl_3O_3$	$C_{16}H_{21}Cl_3O_3$
Structural Formula			
Theoretical % Weight			
Carbon	57.99[4]*	46.23[4]†	52.24[4]
Chlorine	25.60[4]	34.14[4]†	28.94[4]
Oxygen	17.33[4]	15.41[4]†	13.06[4]
Carbon	52.01**	46.26**	52.26**
Chlorine	25.58**	34.13**	28.93**
Oxygen	17.32**	15.40**	13.05**
Hydrogen	5.09**	4.21**	5.76**
Heat of Formation[3] (cal/mole)	-152,000***	-159,000***	

*Considered by EHL(K) to have been an error in the reference.

†Same value for ester containing 0.1 ppm of 2,3,7,8-tetrachlorodibenzo-p-dioxin ("Dioxin" or TCDD).

**Calculated by EHL(K), Kelly AFB TX 78241.

***"...estimated by taking the heats of formation of similar compounds and adding/subtracting the heats of formation of similar/dissimilar groups."

3. USAF RPL, 1972.

4. U.S. Dept. Agr., 1972.

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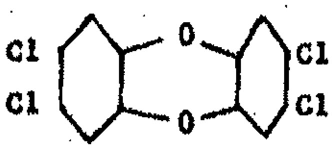
TABLE A-3. GENERAL CHEMICAL/PHYSICAL PROPERTIES OF TCDD

Property	Data	
Content in Orange or Orange II	Range 0-47 mg/kg. Estimated mean of 1.9 mg/kg with a 95% upper and lower confidence limit of 2.6 and 1.2 mg/kg, respectively.[5]	
Molecular Weight	321.97	
Structural Formula		
Theoretical % Weight		
Carbon	44.77*	45.41[4]
Chlorine	44.04*	44.61[4]
Oxygen	9.94*	9.95[4]
Hydrogen	1.25*	

*Calculated by EHL(K), Kelly AFB TX

4. U.S. Dept Agr, 1972.
5. USAF EHL(K) b, 1973.

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REFERENCES FOR APPENDIX A

1. USAF EHL (K) -- USAF Environmental Health Laboratory, Kelly AFB.a.1973. Letter regarding ARL analyses for BTU content of Gulfport Orange Herbicide stocks. (12 Oct 73).

2. U. S. Army. 1969. Herbicides used in Southeast Asia. Rept. No. SAOQ-TR-69-11078. Plant Sciences Lab, Fort Detrick, Md. (Contract #FD-2050-9-11078).

3. USAF RPL -- USAF Rocket Propulsion Lab. 1972. Contract No. FO-4611-72-C-0087

4. U. S. Dept. of Agr. 1972. Thermal decomposition of Orange herbicides. Miss. Agricultural and Forestry Experimental Station and Plant Science Research Div., USDA. Cooperative Agreement No. 12-14-100-10,673(34).

5. USAF EHL (K) -- USAF Environmental Health Laboratory, Kelly AFB. b. 1973. Statistical presentation of the results of analysis for dioxin concentrations found in Orange herbicide analyses performed by Dow Chemical Co. Unpublished data. USAF EHL (K), Kelly AFB, Texas.

APPENDIX B

RESIDUALS LEFT IN VULCANUS TANKS

The residual left in the tanks of the Vulcanus can be divided into five types of residual:

1. Residual clinging to the walls
2. Residual clinging to the ceiling
3. Residual clinging to the floor
4. Residual liquid in a pool around the suction pipe
5. Residual in the piping

The amount of residual clinging to the walls, ceiling and floor of the tank, and in the pool near the suction pipe is estimated from the procedures developed by H.J.A. Schuurmans and J.G.M. Schilder in a report, "Desk Study on Residues Left On Board Chemical Tankers After Discharge of Noxious Liquid Substances" March 1976 and prepared under contract for the Netherlands Maritime Institute (NMI). The amount of residual in the piping was calculated from the blueprint of the ship and the tank cleaning plan. The value for each type of residual and the total residual is presented in Table B-1 for each tank. The method for calculation of each type of residual is described below.

TABLE B-1

RESIDUAL LEFT IN EACH TANK

Tank #	Wall (Clingage) ℓ	Ceiling (Clingage) ℓ	Floor (Clingage) ℓ	Sump (liquid) ℓ	Piping (liquid) ℓ	Total ℓ
1C	1.2	111	129	500	672	1413
2C	1.5	132	145	500	742	1521
3C	1.1	107	105	500	765	1478
4C	1.1	111	113	500	765	1490
5C	1.2	98	94	500	765	1458
2P	0.6	48	47	300	448	844
2S	0.6	48	47	300	364	760
3P	0.5	43	36	300	448	828
3S	0.5	43	36	300	387	767
4P	0.6	55	50	300	425	831
4S	0.6	55	50	300	364	770
5P	0.5	42	35	300	448	826
5S	0.5	42	35	300	387	765
6P	0.6	41	39	300	448	829
6S (not used)	-	-	-	-	-	-
					Total	14,580

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A. Thickness of wall layer.

The procedure in the report yields the average film thickness on the walls, if the liquid is newtonian, of constant density, viscosity and surface tension, and flows in a laminar and stable manner. It is also assumed that the walls are smooth, well-wetted and almost vertical, and that the lowering velocity (the rate at which the liquid surface falls) is constant with negligible evaporation of the liquid film. The surface tension for both the herbicide and the diesel fuel are assumed equal at a value of σ = 0.04 newtons/m.

Calculations

Unloading rate u_L : The burners are fed at a rate of 24mt/hr. The tank with the smallest cross-sectional area would have the fastest rate of liquid level droppage, and the most liquid left on the walls. Tank 6P has the smallest cross-sectional area, 22.4m^2. The unloading rate is then

$$24\,\frac{mt}{hr}\;\frac{m^3}{1.275\,mt}\;\frac{1}{22.4\,m^2}\;\frac{hr}{60\,min}\;\frac{min}{60\,sec} = 2.3\times10^{-4}\,\frac{m}{sec}$$

Viscosity: μ = 46 CP @ 20° c

Surface tension: σ = 0.04 newtons/m (assumed)

Capillary number: $C_a = \frac{u_L\,\mu}{\sigma} = \left(2.3\times10^{-4}\frac{m}{sec}\right)\left(\frac{46\,cP}{0.04\,\frac{newton}{m}}\right)\left(\frac{newton\ sec}{(cP)(10^3 m^2)}\right)$

$$C_a = 2.65\times10^{-4}$$

$$\frac{\mu\,u_L}{\rho g} = (46\,cp)\left(\frac{newton\ sec}{10^3 m^2 (cP)}\right)\left(2.3\times10^{-4}\frac{m}{sec}\right)\left(\frac{m^3}{1275\,kg}\right)\left(\frac{sec^2}{9.8\,m}\right)$$

$$= 8.47\times10^{-10}\,m^2$$

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From Figure 14 of the paper, and the capillary number Ca , a value for the dimensionless parameter To is to read as 0.2. With this value and the value of $\frac{\mu u_L}{\rho g}$, the film thickness can be read from Figure 15 as $5 \mu m$. The contribution to the tanks residual from wall clingage is computed from this thickness and the wall area for each tank.

B. Thickness of Ceiling Layer.

The equation used for predicting the thickness of the ceiling layer is

$$\text{Thickness} = \sqrt{\frac{\sigma}{g\rho}} = \sqrt{\frac{0.04\ \text{newton/m}}{9.8\ \text{m/sec}^2 \quad 1275\ \text{kg/m}^3}}$$

$$= 1.83\ \text{mm}$$

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C. Thickness of the Floor Layer.

A conservative equation for the average thickness of the film layer on the floor of the tanks is given as:

$$h = \frac{2}{3}\sqrt{\frac{\mu l}{\rho g t \sin \tau}}$$

where
- h is the average film thickness
- μ is the viscosity of the liquid
- l is the length of the tank
- ρ is the density of the liquid
- t is the drain time of the tank
- τ is the trim angle of the ship

For a trim angle of 1°, a drain time of 5 minutes, the thickness is

$$\frac{h}{\sqrt{l}} = \frac{2}{3}\sqrt{\frac{46\,cp \quad newton\,sec \quad m^3 \quad sec^2 \quad min}{1000\,m^2\,(cp) \quad 1275\,kg \quad 9.8\,m \quad 60\,sec \quad 5\,min \quad \sin(1^\circ)}}$$

$$h = 5.6 \times 10^{-4}\sqrt{l}$$

$h = 2 \times 10^{-3}\,m$ for the longest tank

$h = 1.5 \times 10^{-3}\,m$ for the shortest tank

The total left in a layer on the tank floor is this average thickness times the area of the tank floor.

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D. Quantity of residual left near tank suction line.

The tanks of the Vulcanus do not have a sump. The paper presents a method for calculating this amount of liquid based on the height of the suction pipe entrance above the floor, the diameter of the suction pipe, the pumping rate, and the trim and list angles of the ship. The method assumes that pumping will be stopped when air first enters the suction line.

Two equations are involved. The first calculates the height of liquid above the tank bottom at the discharge pipe:

$$h = h_2 + \frac{\phi_p^2}{\pi^2 D_e^2 h_2^2 2g}$$

where h is the height of liquid at the suction pipe

h_2 is the height of the suction pipe above the tank floor = 3.5 cm

D_e is the diameter of the suction pipe = 0.15m

and ϕ_p is the pumping rate, m^3/sec

At an incineration rate of 24mt/hr

$$\phi_p = \frac{24\,mt}{hr} \cdot \frac{m^3}{1{,}275\,mt} \cdot \frac{hr}{60\,min} \cdot \frac{min}{60\,sec}$$

$$= 5.2 \times 10^{-3}\,m^3/sec$$

$$h = 0.035\,m + \frac{(5.2 \times 10^{-3}\,m^3/sec)^2}{2\pi^2 \left(9.8\,\frac{m}{sec^2}\right)(0.15\,m)^2 (0.035\,m)^2}$$

$$= 0.0401\,m$$

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The second calculates the volume of liquid corresponding to this liquid height:

$$V = \frac{h^3}{6 \tan \tau \tan \psi}$$

where τ is the trim angle of the ship

and ψ is the list angle of the ship.

The Vulcanus usually maintains a list angle of 6° and a trim angle of 1° during incineration. The volume left in a tank is then

$$V = \frac{(0.0401\ m)^3}{6(\tan 1°)(\tan 6°)} = 5.9 \times 10^{-3} m^3 = 5.9\ \ell$$

This calculation does not take into account the interference to tank draining offerred by the structural beams running from side to side across the width of the tanks about every 0.5m. The chief engineer of the Vulcanus estimates that under the worst possible case 500 ℓ of liquid is left in each of the 5 large tanks and about 300 ℓ of liquid in each of the 9 small tanks. These conservatively high estimates will be used in place of the theoretically calculated values as a safety factor in determining the residuals of Orange Herbicide's contaminant, TCDD, left on board the ship following the proposed rinsing procedures.

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E. Residual Left in Piping.

The residual left in the piping between tanks and in the suction and discharge lines has been calculated from the diameter and length of the pipes as measured from the ship's blueprints. For many tanks certain lines do not contribute to the residual in a tank because the rinse plan has the lines purged before the rinse fluid is pumped into the tank. Since purging liquid is incinerated directly and not permitted to contaminate the rinse fluid, it is not included in the residual. Details of the calculations are presented in Table B-2.

TABLE B-2

RESIDUALS LEFT IN PIPING

Tank #	Tank Filling Line [1]			From Previous Tank to this Tank [2]				Tota Residu
	Length m	Dia m	Vol ℓ	Previous Tank	Length m	Dia m	Vol ℓ	ℓ
1C	10.8 (P) 9.5 (S)	0.20	345 304	5C	1.3	0.15	23	672
2C	12.4 (P) 10.8 (S)	0.20	397 345	--	--	--	--	742
3C	12.4 (P) 10.8 (S)	0.20	397 345	6P	1.3	0.15	23	765
4C	12.4 (P) 10.8 (S)	0.20	397 345	3C	1.3	0.15	23	765
5C	12.4 (P) 10.8 (S)	0.20	397 345	4C	1.3	0.15	23	765
2P	13.3	0.20	425	4P	1.3	0.15	23	448
2S	11.4	0.20	364	2C	--	--	--	364
3P	13.3	0.20	425	2P	1.3	0.15	23	448
3S	11.4	0.20	364	2S	1.3	0.15	23	387
4P	13.3	0.20	425	2C	--	--	--	425
4S	11.4	0.20	364	2C	--	--	--	364
5P	13.3	0.20	425	3P	1.3	0.15	23	448
5S	11.4	0.20	364	3S	1.3	0.15	23	387
6P	13.3	0.20	425	5P	1.3	0.15	23	448
6S (not used)	--	--	--	--	--	--	--	--

NOTES:

1. The tank filling line is measured starting from the valve connecting the tank with the common feed header and ending at a point near the bottom of the tank where the line discharges into the tank. This line is assumed to be always full.

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2. This is based on the lengths of previously unpurged piping through which the rinse liquid must flow to reach the tank, according to the rinsing plan.

APPENDIX C

Calculations of Orange Herbicide and TCDD Residuals Following Two-Step Rinsing Procedure

I. OVERVIEW

The approach used in this plan for cleaning the tanks of the Vulcanus is to rinse each tank by filling it completely with clean Herbicide Orange (initial concentration of TCDD non detectable). The tanks will be rinsed consecutively. Following this rinse, each of the wing tanks will be filled consecutively with diesel fuel. Each of the center tanks will be filled with diesel fuel to a depth of about 1 meter and then water will be added to raise the diesel fuel and allow it to contact all sides and the top of the tank. Both the clean herbicide and the diesel fuel will be incinerated after the rinse procedure. The water will be discharged over the side. The detailed rinse pattern is attached (Atch 1) showing the suggested sequence of tank rinsings.

II. ASSUMPTIONS

The calculation of residuals of Orange Herbicide and TCDD following the two-step rinse procedure is based on the following assumptions:

1. The TCDD concentration in the final load of Orange Herbicide from Johnston Island is 2.0 mg/kg (2.55mg/l).

This is conservative in that the arithmetic mean concentration of these stocks is 1.909 mg/kg and will be even lower as a result of dilution by diesel fuel rinseate used for drum/equipment decontamination.

2. The TCDD concentration in the clean herbicide is 0 mg/kg.

3. The volume of clean Orange herbicide available for the first step of the rinse is 478 cubic meters.

4. The volume of diesel fuel available for the second step rinse is 150 cubic meters.

5. The volume of fresh water available for the floatation rinse procedure is 487 cubic meters.

6. The clean herbicide/residuals and the diesel fuel/residuals mix completely to attain uniform concentration.

7. The residual left in the tank by a diesel fuel rinse is the same as the residual left by a herbicide rinse. This is conservative since diesel fuel has a lower viscosity than the herbicide.

III. CALCULATIONS

Table C-1 presents the calculated amount of Orange herbicide and TCDD residual in each tank following the two-step rinse procedure. Attachment 1 presents a step by step operation plan for the third loading and rinsing of the ship's tanks. Attachment 2 presents the calculations of the residuals following the two-step rinsing procedure.

TABLE C-1 TANK RESIDUALS

TANK #	INITIAL HERB-ICIDE RESIDUAL (kg)	INITIAL TCDD RESIDUAL (gm)	TCDD RESIDUAL AFTER HERBI-CIDE RINSE (gm)	TCDD RESIDUAL AFTER 2ND RINSE (gm)	HERBICIDE RESIDUAL AFTER 2ND RINSE (kg)
1C	1802	3.60	0.100	0.00522	168.4
2C	1939	0.00	0.024	0.00254	121.5
3C	1884	3.77	0.077	0.00472	133.9
4C	1900	3.80	0.082	0.00386	149.7
5C	1859	3.72	0.093	0.00674	173.1
2P	1076	2.15	0.028	0.00063	33.9
2S	969	1.94	0.015	0.00014	10.7
3P	1056	2.11	0.028	0.00079	39.4
3S	978	1.96	0.016	0.00024	17.1
4P	1060	2.12	0.025	0.00044	26.6
4S	982	1.96	0.010	0.00029	19.9
5P	1053	2.11	0.040	0.00101	44.8
5S	975	1.95	0.016	0.00034	22.7
6P	1057	2.11	0.043	0.00127	50.9
6S (Not Used)	----	----	-----	-------	-----
TOTALS	18590	33.30	0.597	0.02823	1012.6
% REMOVAL	----	----	98.207%	99.915%	94.553%

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Attachment 1 to Appendix C

Third Burn Operations Plan

Combined Clean Orange Herbicide Followed

By Clean Diesel Fuel Rinse

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TABLE C-2 COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION LINE	DISC LINE	SHIP LIST	TERM WHEN	REMARKS
1. Load HO per figure 1, with tank 1C filled last	----	----	----	All J.I. stocks loaded	
2. Pump from 2C to 1C	S	S	P	2 m^3 transferred	Purge S suction and discharge lines
3. Pump from 2C to 4S	S	S	P	4S full	
4. Pump from 4S to 2C	S	S	P	4S empty	4S rinsed
5. Load clean diesel into 4S	----	S	P	2 m^3 loaded	
6. Pump from 4S into 1C	S	S	P	4S empty	Purge lines
7. Load clean diesel into 4S	----	S	P	4S full	
8. Move to burn site			----		
9. Incinerate 2S, 3S, 5S	S	S	P	All burned	
Steps 10 and 11-24 are simultaneous					
10. Incinerate partly 2P, 3P, 4P, 5P, 6P, 3C, 4C, 5C, (stop when step 22 reached)	P	P	P	Leave 1 m in each tank	
11. Pump from 2C to 1C	S	S	P	2 m^3 transferred	Purge S suction and discharge lines
12. Pump from 2C to 2S	S	S	P	2S full	

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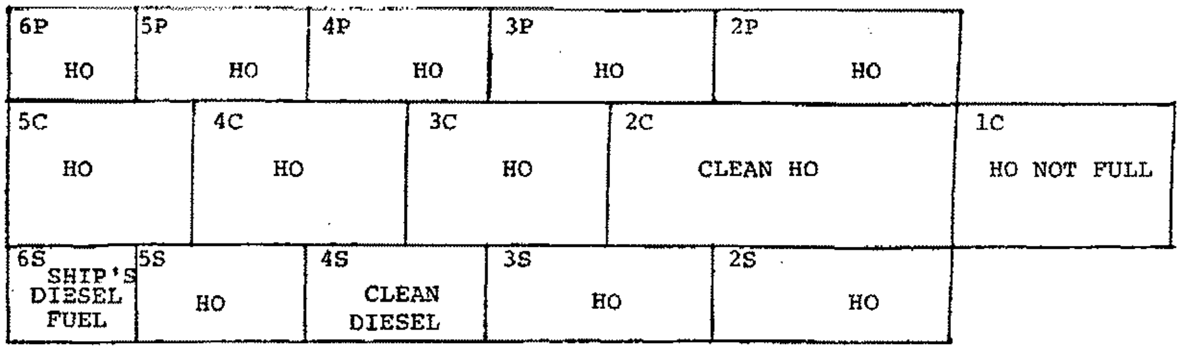

FIGURE 1. LOADING DIAGRAM FOR THIRD BURN

COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION LINE	DISC LINE	SHIP LIST	TERM WHEN	REMARKS
13. Pump from 2C to 3S	S	S	P	3S full	
14. Pump from 2C to 5S	S	S	P	5S full	
15. Pump from 2S to 2C	S	S	P	2S empty	2S rinsed
16. Pump from 3S to 2C	S	S	P	3S empty	3S rinsed
17. Pump from 5S to 2C	S	S	P	5S empty	5S rinsed
18. Pump from 4S to 1C	S	S	P	2 m^3 transferred	Purge S suction and discharge lines
19. Pump from 4S to 2S	S	S	P	2S full	
20. Pump from 2S to 3S	S	S	P	3S full	
21. Pump from 2S to 5S	S	S	P	2S empty	2S clean
22. Pump from 3S to 5S	S	S	P	5S full	
23. Pump from 3S to 4S	S	S	P	3S empty	3S clean
24. Pump from 5S to 4S	S	S	P	5S empty	5S clean
25. Finish Burning 2P, 3P, 4P, 5P, 6P	P	P	S	All burned	
Steps 26 and 27-40 are simultaneous					
26. Incinerate 3C, 4C, 5C, 1C	S	S	S	All burned	

COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION LINE	DISC LINE	SHIP LIST	TERM WHEN	REMARKS
27. Pump from 2C to 1C	P	P	S	2 m^3 transferred	Purge P suction and discharge line
28. Pump from 2C to 3C, 4C, 5C	P	P	S	2 m^3 total transferred	Purge P discharge lines to tanks
29. Pump from 2C to 4P	P	P	S	4P full	
30. Pump from 2C to 2P	P	P	S	2P full	
31. Pump from 2C to 3P	P	P	S	3P full	
32. Pump from 4P to 5P	P	P	S	5P full	
33. Pump from 4P to 6P	P	P	S	4P empty	4P rinsed
34. Pump from 3P to 6P	P	P	S	6P full	
35. Pump from 3P to 3C (when empty)	P	P	S	3P empty	3P rinsed
36. Pump from 2P to 3C	P	P	S	2P empty	2P rinsed
37. Pump from 5P to 3C	P	P	S	5P empty	5P rinsed
38. Pump from 6P to 3C	P	P	S	6P empty	6P rinsed
39. Pump from 2C to 3C	P	P	S	3C full	
40. Pump from 3C to 4C (when empty)	P	P	S	No more can be pumped	3C not empty (wrong list)
41. Finish burning all HO except the clean HO in 2C, 3C, 4C	S	S	S	All done	Keep burners going with diesel fuel

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COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION LINE	DISC LINE	SHIP LIST	TERM WHEN	REMARKS
42. Pump from 2C to 1C	S	S	S	2 m^3 transferred	Purge S suction, discharge lines
43. Incinerate from 1C	S	S	S	All done	Shut incinerator off
44. Pump from 4S to 1C	S	P	P	2 m^3 transferred	Purge lines
45. Pump from 4S to 4P	S	P	P	4S empty	4S clean
46. Pump from 6S to 4P	S	P	P	4P full	Use some of ship's diesel to top off tank 4P
Steps 47-57 and 58-62 are simultaneous					
47. Pump from 4P to 1C	P	P	S	2 m^3 transferred	Purge Port lines
48. Pump from 4P to 2P	P	P	S	2P full	
49. Pump from 4P to 3P	P	P	S	4P empty	4P clean
50. Pump from 2P to 3P	P	P	S	3P full	
51. Pump from 2P to 5P	P	P	S	2P empty	2P clean
52. Pump from 3P to 5P	P	P	S	5P full	
53. Pump from 3P to 6P	P	P	S	3P empty	3P clean
54. Pump from 5P to 6P	P	P	S	6P full	
55. Pump from 5P to 2C when empty	P	P	S	5P empty	5P clean
56. Pump from 6P to 2C when empty	P	P	S	85 m^3 in 2C	

COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION LINE	DISC LINE	SHIP LIST	TERM WHEN	REMARKS
57. Pump from 6P to 3C when empty	P	P	S	6P empty	6P clean
58. Pump from 2C to 4C	S	S	S	2C empty	2C rinsed
59. Pump from 3C to 4C	S	S	S	4C full	
60. Pump from 3C to 5C	S	S	S	3C empty	3C rinsed
61. Pump from 4C to 5C	S	S	S	5C full	
62. Pump from 4C to 1C	S	S	S	4C empty	4C rinsed
63. Pump from 2C to 1C	P	S	---	2 m^3 transferred	Purge S suction discharge lines
64. Pump from 2C to 2C, 3C, 4C	P	S	---	2 m^3 total transferred	Purge S discharge lines to tanks
65. Load 2C with fresh water	---	P	---	2C full	Water from J.I.
Steps 66 and 67 are simultaneous					
66. Incinerate 5C	S	S (to 1C)	S	5C empty	1C must be filled before 5C is empty
67. Pump from 2C to 3C	P	P	S	3C full	
Steps 68 and 69-74 are simultaneous					
68. Incinerate 1C	S	S	P	1 m left	
69. Pump from 2C to 4P	P	P	P	water only	

COMBINED CLEAN HO, DIESEL FUEL

OPERATION	SUCTION	DISC	SHIP	TERM WHEN	REMARKS
70. Pump from 2C to 4C	P	P	P	2C empty	2C clean
71. Pump from 3C to 4C	P	P	P	4C full	
72. Pump from 3C to 5C	P	P	P	3C empty	3C clean
73. Pump from 4C to 5C	P	P	P	5C full	
74. Pump from 4C to 4P	P	P	P	Water only	
75. Incinerate 1C	S	S	S	1C empty	1C rinsed All HO gone
76. Pump from 4C to 1C	S	S	S	4C empty	4C clean
77. Pump from 5C to 1C	S	S	S	Water only	
78. Pump from 4P to 1C	P	S	S	1C full	
79. Pump from 4C overboard	P	S	S	4C empty	
80. Pump from 1C overboard	S	S	S	Water only	
81. Incinerate from 5C, 1C	S	S	S	1C, 5C empty	1C, 5C clean

ATTACHMENT 2 TO APPENDIX C

CALCULATION OF RESIDUALS FROM TANK CLEANING PROCEDURE

A. Herbicide Rinse

The general formula for the TCDD residual in a tank involves a mass balance of the TCDD in the tank: "In" + "Residual" = "Out" + "New Residual". The "In" term is composed of the volume V of rinseate times the concentration C_R of the TCDD in the rinseate. The other three terms are also multiplications of volume times TCDD concentration. The assumption of complete mixing means that the TCDD concentration in the "Out" and "New Residual" terms is the same. The equation can then be solved for this concentration.

$$VC_R + v C_0 = V C_1 + v C_1 = (V + v) C_1$$

$$\text{or } C_1 = \frac{VC_R + v C_0}{V + v}$$

The residual in the tank is then $v C_1$, while in consecutive rinsing of tanks, the C_R for the next tank is also C_1. If the rinse herbicide mixes with other rinse herbicides of different concentrations, then a new bulk concentration must be calculated for this rinseate in a manner similar to the above calcuation. The calculations for the residual in each tank are presented in Table C-3 in the same sequence as in the rinse operations plan, Attachment 1 of the Appendix.

B. Diesel Fuel Rinse

The calculation of the amount of herbicide left in the tanks after a diesel fuel rinse is performed in the very same manner as before:

"In" + "Residual" = "Out" + "New Residual"

Here the initial concentration of herbicide in the residual is the same as the density, 1.275 kg/l. The calculations are presented in Table C-4 in the same order as in the tank rinsing plan. The TCDD remaining in the tank is also presented and was calculated in the same manner.

TABLE C-3 CLEAN HERBICIDE RINSE - CALCULATIONS

Tank Numbers	Residual		Rinse Liquid		Mixture	
	ℓ	mg TCDD / ℓ	ℓ (Source Tank)	mg TCDD / ℓ	mg TCDD / ℓ	TCDD in Residual gms
4S	770	2.55	149,230(Clean)	0	1.31×10^{-2}	0.010
2C	1521	0	327,249(2C) 149,230(4S)	0 1.3×10^{-2}	4.10×10^{-3}	*
2S	760	2.55	127,240(2C)	4.10×10^{-3}	1.92×10^{-2}	0.015
3S	767	2.55	115,233(2C)	4.10×10^{-3}	2.09×10^{-2}	0.016
5S	765	2.55	116,235(2C)	4.10×10^{-3}	2.08×10^{-2}	0.016
2C	1521	4.1×10^{-3}	127,240(2S)	1.92×10^{-2}	1.63×10^{-2}	0.025
			115,233(3S)	2.09×10^{-2}		
			116,235(5S)	2.08×10^{-2}		
			113,771(2C)	4.10×10^{-3}		
4P	831	2.55	149,269(2C)	1.63×10^{-2}	3.04×10^{-2}	0.025
2P	844	2.55	127,156(2C)	1.63×10^{-2}	3.30×10^{-2}	0.028
3P	828	2.55	115,127(2C)	1.63×10^{-2}	3.44×10^{-2}	0.028
5P	826	2.55	116,174(4P)	3.04×10^{-2}	4.82×10^{-2}	0.040
6P	829	2.55	32,995(4P)	3.04×10^{-2}	5.18×10^{-2}	0.043
			78,176(3P)	3.44×10^{-2}		
3C	1478	2.55	36,996(3P)	3.44×10^{-2}	5.20×10^{-2}	0.077
			127,156(2P)	3.30×10^{-2}		
			116,174(5P)	4.82×10^{-2}		
			111,171(6P)	5.18×10^{-2}		
			5,025(2C)	1.63×10^{-2}		
4C	1490	2.55	68,857(2C)	1.63×10^{-2}	5.50×10^{-2}	0.082
			354,653(3C)	5.20×10^{-2}		
5C	1458	2.55	41,869(3C)	5.20×10^{-2}	6.35×10^{-2}	0.093
			371,673(4C)	5.50×10^{-2}		
1C	1413	2.55	51,837(4C)	5.50×10^{-2}	7.04×10^{-2}	0.100
			390,750(5C)	6.35×10^{-2}		

*Residual not calculated because tank will contain herbicide again later in the sequence of operations.

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TABLE C-4 DIESEL RINSE - CALCULATIONS

Tank Numbers	Residual			Rinse Liquid			Mixture			
	ℓ	kg Herb/ℓ	mg TCDD/ℓ	ℓ (Source Tank)	kg Herb/ℓ	mg TCDD/ℓ	kg Herb/ℓ	Herb Residual kg	mg TCDD/ℓ	TCDD Residual g
4S	770	1.275	1.31×10^{-2}	149,330(Clean)	0	0	6.5×10^{-3}	*	6.7×10^{-5}	*
2S	760	1.275	1.92×10^{-2}	127,240(4S)	6.5×10^{-3}	6.7×10^{-5}	1.40×10^{-2}	10.7	1.81×10^{-4}	0.00014
3S	767	1.275	2.09×10^{-2}	115,233(2S)	1.40×10^{-2}	1.81×10^{-4}	2.23×10^{-2}	17.1	3.18×10^{-4}	0.00024
5S	765	1.275	2.08×10^{-2}	12,007(2S)	1.40×10^{-2}	1.81×10^{-4}	2.96×10^{-2}	22.7	4.38×10^{-4}	0.00034
				104,228(3S)	2.23×10^{-2}	3.18×10^{-4}				
4S	770	6.5×10^{-3}	6.7×10^{-5}	116,235(5S)	2.96×10^{-2}	4.38×10^{-4}	2.58×10^{-2}	19.9	3.77×10^{-4}	0.00029
				11,005(3S)	2.23×10^{-2}	3.18×10^{-4}				
				19,988(4S)	6.5×10^{-3}	6.7×10^{-5}				
4P	831	1.275	3.04×10^{-2}	145,230(4S)	2.58×10^{-2}	3.77×10^{-4}	3.20×10^{-2}	26.6	5.33×10^{-4}	0.00044
				3,939(6S)	0	0				
2P	844	1.275	3.30×10^{-2}	127,156(4P)	3.20×10^{-2}	5.33×10^{-4}	4.02×10^{-2}	33.9	7.47×10^{-4}	0.00063
3P	828	1.275	3.44×10^{-2}	20,013(4P)	3.20×10^{-2}	5.33×10^{-4}	[illegible]	[illegible]	9.50×10^{-4}	0.00079
				95,159(2P)	4.02×10^{-2}	7.47×10^{-4}				
5P	826	1.275	4.82×10^{-2}	31,997(2P)	4.02×10^{-2}	7.47×10^{-4}	5.42×10^{-4}	44.8	1.23×10^{-3}	0.00101
				84,177(3P)	4.76×10^{-2}	9.50×10^{-4}				
6P	829	1.275	5.18×10^{-2}	30,995(3P)	4.76×10^{-2}	9.50×10^{-4}	6.14×10^{-2}	50.9	1.53×10^{-3}	0.00127
				80,176(5P)	5.42×10^{-2}	1.23×10^{-3}				
2C	1521	1.275	1.63×10^{-2}	51,171(6P)	6.14×10^{-2}	1.53×10^{-3}	7.99×10^{-2}	121.5	1.67×10^{-3}	0.00254
				33,998(5P)	5.42×10^{-2}	1.23×10^{-3}				
3C	1478	1.275	7.04×10^{-2}	60,000(6P)	6.14×10^{-2}	1.53×10^{-3}	9.06×10^{-2}	133.9	3.19×10^{-3}	0.00472
4C	1490	1.275	5.50×10^{-2}	85,169(2C)	7.99×10^{-2}	1.67×10^{-3}	1.00×10^{-1}	149.7	2.59×10^{-3}	0.00386
5C	1458	1.275	6.35×10^{-2}	60,000(3C)	9.06×10^{-2}	3.19×10^{-3}	1.19×10^{-1}	173.1	4.62×10^{-3}	0.00674
1C	1413	1.275	7.04×10^{-2}	85,169(4C)	1.00×10^{-1}	2.59×10^{-3}	1.19×10^{-1}	168.4	3.70×10^{-3}	0.00522

*Residual not calculated because tank will contain diesel fuel again later in the sequence of operations

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Interim Progress Report on the Determination of Soil Microorganisms in Former Herbicide Storage Areas at Gulfport, Mississippi, and Johnston Island

October 1977

by

Capt. [redacted] b6

Department of Chemistry and Biological Sciences
United States Air Force Academy, Colorado 80840

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[redacted] b6

What I have given you here is essentially Methods and Materials and tentative conclusions based on what I have done to date. The report may seem somewhat general but I am working on somewhat short notice. e.g. It would take me a good solid day of work to construct tables which would be intelligible to a "non-initiated" reader. The comparisons of the H/H, L/L, and O/O areas are what you need, though, and I can supply this data.

[redacted] b6

31 Oct 77

Introduction:

This is an interim progress report presenting data collected to date on soil microorganism levels from samples taken from two sites formerly used as storage areas for military herbicides. All work is being done in support of AFLC storage site reclamation efforts at NCBC, Gulfport, Mississippi, and Johnston Atoll, Pacific Ocean.

Materials and Methods:

In July 1977, the Gulfport site was surveyed for areas of herbicide spillage, character and composition of soils, and other factors necessary to make a recommendation for a procedure for returning the site to a usable condition. In order to conduct a meaningful monitoring program on-site, 12 soil samples were taken from carefully selected locations. These soil samples were placed in glass collection jars for chemical analysis (by the USDA Environmental Monitoring Laboratory at Gulfport) and microbial analysis (by the Dept of Chemistry and Biological Sciences, United States Air Force Academy). Samples were chosen from three characteristic locations: areas with no visually detectable spillage and no herbicide odor (designated O/O), areas of light spillage and light herbicide odor (designated L/L), and areas of heavy spillage and pronounced herbicide odor (designated H/H). In addition, notes were made on ground characteristics associated with each sample (e.g. presence of asphalt, sand, vegetation, shell, hardpan or gravel, whether collected from ditchbank or ditchbottom). In order to facilitate immediate relocation without driving stakes, sampling sites were marked using a technique combining compass heading and distance from a fixed point in the approximate center of the area. All samples were taken from the top three inches only as previous work has shown that only trace concentrations of herbicide exist below that level. Controls were taken from an area close to the storage site where no herbicide had been spilled.

¶ In addition to the Gulfport samples, 16 coral samples were collected on 26 Aug 79 by Major [redacted] Consultant Environmentalist, from the former herbicide storage site on Johnston Atoll. These were received by the Dept. of Chemistry and Biological Sciences during the first week in September. Table 1 shows ~~Gulf~~ ~~applicable~~ collection data for Gulfport samples. Table 2 shows ~~applicable~~ collection data for Johnston Island Samples.

Following collection of the Johnston Island samples, it was felt that certain sites in the storage area should be studied even more thoroughly. Consequently, a third group of 12 samples were collected and sent to the Air Force Academy for analysis.

Soil and coral samples are being analyzed for soil microorganisms using procedures described by Young (3) and Cairney (2)

Results:

All Gulfport samples and the initial 15 samples from Johnston Island have been analyzed for populations of bacteria, fungi, and Actinomycetes. ~~The following~~ Chart 3 shows bacterial and fungal counts for the samples. Although Actinomycetes were detected, bacterial and fungal growth on Actinomycete isolation plates precluded accurate counts.

Based on data analyzed to date, the following statements can be made:

(next p.)

1. There is no significant differences in bacterial population levels between control samples and samples designated O/O, L/L, or H/H at Gulfport or J. Is. Samples designated O/O at Gulfport had a slightly lower bacterial count than other Gulfport samples. The control sample at Gulfport, however, (a O/O sample) had a bacterial count in the range of the L/L, H/H samples collected. This increase could possibly be due to the comparatively heavy vegetation at the control site.

2. Levels of fungi in Gulfport soils were ~~was~~ essentially constant from sample to sample regardless of O/O, L/L, or H/H designation.

3. Levels of fungi from Johnston Island have been difficult to determine using currently used techniques. The Johnston Island coral may be naturally low in fungi. Further experimentation will be necessary to determine why fungi do not grow at all or do not grow in a repeatable fashion from Johnston Island soils. Various media at various pH levels will be used for this purpose.

4. It is too early to tell whether any shift has occurred in fungal or bacterial species from O/O to H/H samples. Identification work is in progress to determine predominant genera and species from sample to sample.

5. The presence of large quantities of herbicides has not sterilized the soil at either the Gulfport or Johnston Island storage areas. Even areas saturated with herbicide exhibit an abundant microflora.

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Further note:

It must be stressed that this is an interim progress report. Much work needs to be accomplished on identification of organisms in samples already taken. In addition, at least two more sample sets will need to be analyzed before definite trends in microfloral populations can be stated with any certainty.

TABLE I. Samples Collected from Herbicide Orange Storage Site, 28 July 1977.

Sample Number	Description*	Depth of Sample (Inches)
1	1, 010, H/H, C, 160	0-3
2	2, 042, 0/0, S, B, 117	0-3
3	3, 074, L/L, S, H, 160	0-1
4	4, 135, 0/0, C, 117	0-3
5	5, 158, H/H, S, H, 216	0-3
6	6, 164, 0/0, S, H, 180	0-3
7	7, 180, L/L, C, 255	0-3
8	8, 194, L/L, S, G, 294	0-1
9	9, 240, L/L, S, B, 435	0-3
10	10, 340, H/H, S, G, 210	0-3
11	11, 033, H/H, S, H, 168	0-1
12	12, 050, 0/0, S, V, 750	0-3

*Code is as follows:

First Number Set: (1 - 12) Sample number

Second Number Set: (000-360) Compass heading, degrees, taken at storage site center point.

First Letter Set: (0/0, L/L, H/H) Refers to a subjective evaluation of the stain and herbicide odor present at the site where each sample was collected (0/0 = no stain and no odor; L/L = light stain and slight odor; H/H = dark stain and heavy odor).

Following Letter Set(s): (Site Description) Sample site characteristics

A = Asphalt
B = Ditch Bottom
C = Oyster Shells
D = Ditch bank
H = Hardpan
G = Gravelly
S = Sandy
V = Vegetation

Third Number Set: (117-750) Number of feet in the specified direction to the area where the sample was collected.

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Chart 3

Bacterial and Fungal Levels in Gulfport and Johnston Island Soil/Coral Samples

3a. (Gulfport Samples)

Sample # ~~(Gulfport)~~	* Bacteria	* Fungi
Control (#12)	2.7×10^8	4.5×10^6
1	1.5×10^8	5.0×10^6
2	9.2×10^7	2.0×10^6
3	9.5×10^7	5.1×10^6
4	9.5×10^7	3.0×10^6
5	1.1×10^8	2.9×10^6
6	9.8×10^7	** NG
7	2.0×10^8	4.9×10^6
8	2.5×10^8	2.0×10^5
9	2.0×10^8	4.0×10^5
10	2.5×10^8	** ND
11	6.8×10^7	6.1×10^5

* All numbers represent number of colony producing units per gram of sample

** NG = no growth after 7 days

ND = not determined (due to presence of swarming bacterium on all dilution plates)

RANDOM =

Table 2.

[redacted] 15 coral samples from the storage site and [redacted] at J.I., marked as follows:

Sample	#1	- Control Sample	-	0"-6"	Coral Sample	0/0*
"	#2	- Site Sample	-	0"-6"	Coral Sample	0/0
"	#3	- " "	-	0"-6"	" "	0/0
"	#4	- " "	-	0"-6"	" "	0/0
"	#5	- " "	-	0"-6"	" "	L/L**
"	#6	- " "	-	0"-6"	" "	L/L
"	#7	- " "	-	0"-6"	" "	L/L
"	#8	- " "	-	0"-6"	" "	L/L
"	#9	- " "	-	0"-6"	" "	H/H***
"	#9A	- " "	-	6"-12"	" "	H/H
"	#9B	- " "	-	12"-24"	" "	H/H
"	#9C	- " "	-	18"-24"	" "	H/H
"	#9D	- " "	-	0"-6"	" "	H/H
"	#10	- " "	-	0"-6"	" "	H/H
"	#11	- " "	-	0"-6"	" "	H/H
"	#12	- " "	-	0"-6"	" "	H/H

* - From site with no visable signs of spill and no H.O. odor

** From site with some light H.O., stain and slight odor of H.O.

*** - From site with heavy H.O., stain and strong odor of H.O.

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Chart 3b.
(Johnston Island Samples)

Sample # (~~Johnston Isl~~and)	*Bacteria	*Fungi
1 (CONTROL)	3.2×10^8	**RANDOM
2	INCONCLUSIVE/ERRATIC	**NG
3	5.1×10^8	NG
4	INCONCLUSIVE/ERRATIC	RANDOM
5	INCONCLUSIVE/ERRATIC	RANDOM
6	2.7×10^8	NG
7	OG	NG
8	2.2×10^8	RANDOM
Ø		
9A	2.1×10^8	NG
9B	OG	NG
9C	1.1×10^8	RANDOM
9D	2.8×10^8	RANDOM
10	1.7×10^8	NG
11	4.9×10^8	NG
12	1.5×10^8	NG

From: Mr. [redacted] b6
NCBC, Gulfport, MS
September 8, 1982

HERBICIDE DRUMS SHIPPED
via SHIP BOTTOM from
CBC GULFPORT to VIETNAM

1969		1970	
July	2,839	January	6,212
August	6,461	February	6,933
September	3,488	March	6,828
October	5,468	April	1,279
November	3,669	May	-0-
December	1,891	June	-0-
	23,816		21,252

Total: 45,067

Blue, White, Herbicide Orange & Orange II

MISSISSIPPI STATE PORT AUTHORITY AT GULFPORT
POST OFFICE BOX 40
GULFPORT, MISSISSIPPI 39501

6/11/77 INCINERATOR SHIP VULCANUS 860,000 GAL OF ORANGE BAND HERBICIDE

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(1) VESSELS LIFTING MILITARY CARGO 1967 – 1969
PORT OF GULFPORT

1-5-67	SS. KYSKA	MILITARY CARGO
1-9-67	SS ALLEGHANY VICTORY	MIL CARGO
1-13-67	SS [illegible] MORRIS	MIL CARGO
2-14-67	SS DOCTOR LYKES	MIL CARGO
2-18-67	SS JAMES LYKES	" "
2-25-67	SS LAKEWOOD VICTORY	" "
2-26-67	SS LIPSCOMB LYKES	" "
3-11-67	SS CAPE SAN MARTIN	" "
4-6-67	SS MARGARET LYKES	" "
4-11-67	SS TYSON LYKES	" "
4-15-67	SS HATTIESBURG VICTORY	" "
5-15-67	SS LAWRENCE VICTORY	" "
5-16-67	SS WINGLESS VICTORY	" "
5-21-67	SS TOPA TOPA	" "
5-24-67	SS SANTA INES	" "
5-25-67	SS DOLLY THURMAN	" "
6-2-67	SS HIGH POINT VICTORY	" "
6-4-67	SS ADA BELLE LYKES	" "
6-7-67	SS CHRISTOPHER LYKES	" "
6-14-67	SS CITADEL VICTORY	" "
6-22-67	SS PENN VICTORY	" "
6-29-67	SS DOUGLAS VICTORY	" "
7-1-67	SS ZOELLA LYKES	" "
7-7-67	SS ALOHA STATE	" "
7-9-67	SS GREEN MT STATE	" "
7-19-67	SS TILLIE LYKES	" "
7-28-67	SS GARDEN CITY	" "

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②

8-2-67	SS ASHLEY LYKES	LIFT MILITARY CARGO
8-10-67	SS RUTH LYKES	" " "
8-18-67	SS GREEN COVE	" " "
8-23-67	SS CITY OF ALMA	" " "
9-17-67	SS HOOSIER STATE	" " "
9-21-67	SS WOLVERINE STATE	" " "
9-25-67	SS ROSWELL VICTORY	" " "
10-8-67	SS GREEN BAY	" " "
10-30-67	SS OVERSEAS ROSE	" " "
12-10-67	SS GARDEN CITY	" " "
12-12-67	SS SAGAMORE HILL	" " "
12-21-67	SS BRIGHAM VICTORY	" " "
1-6-68	SS MARGARET LYKES	" " "
2-1-68	SS LETITIA LYKES	" " "
2-6-68	SS COTTON STATE	" " "
2-15-68	SS DEL ALBA	" " "
2-21-68	SS HARRY CULBRETH	" " "
2-25-68	SS WINGLESS VICTORY	" " "
3-2-68	SS SEATRAIN FLORIDA	" " "
3-5-68	MS INDIAN SECURITY	" " "
3-7-68	SS VANDERBILT VICTORY	" " "
3-8-68	SS ALLISON LYKES	" " "
3-13-68	SS DEL SOL	" " "
3-26-68	MS OLD DOMINION STATE	(POLES)
4-14-68	SS GARDEN CITY	" " "
4-21-68	SS BEREA VICTORY	" " "
4-29-68	SS CHRISTOPHER VICTORY	" " "

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(3)

5-9-68	SS AMERICAN PRIDE	LIFT MIL. CARGO
5-11-68	SS U.S. DEFENDER	" " "
5-13-68	SS NANCY LYKES	" " "
6-2-68	SS ROBIN MOWBRAY	" " "
6-5-68	SS FREDERICK LYKES	" " "
6-8-68	SS U.S. VICTORY	" " "
6-10-68	SS DEL RIO	" " "
6-21-68	SS WESLEYAN VICTORY	" " "
6-22-68	SS DEL SOL	" " "
7-6-68	SS JAMES	" " "
7-7-68	SS COLOMBIA TIGER	" " "
7-12-68	SS BEREA VICTORY	" " "
8-7-68	SS HOWELL LYKES	" " "
8-15-68	SS AIMEE LYKES	" " "
8-28-68	SS ALLISON LYKES	" " "
9-5-68	SS PENN VICTORY	" " "
9-9-68	SS OVERSEAS HORACE	" " "
9-12-68	SS STEEL ADVOCATE	" " "
9-28-68	SS DEL SOL	" " "
0-5-68	SS TRANSPACIFIC	" " "
-9-68	SS PRESIDENT ARTHUR	" " "
-14-68	SS AMERICAN CHARGER	" " "
0-29-68	SS ALCOA MARKETER	" " "
-31-68	SS GREEN PORT	" " "
-14-68	SS CHARLOTTE LYKES	" " "
-14-68	SS LAFAYETTE VICTORY	" " "
-20-68	SS MANDERSON VICTORY	

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(4).

12-6-68	SS PRESIDENT BUCHANAN	WET MIL CARGO
12-19-68	SS OVERSEAS JASON	" " "
12-27-68	SS OVERSEAS EVELYN	" " "
1-12-69	SS BRINTON LYKES	" " "
1-19-69	SS GREEN BAY	" " "
1-23-69	SS CHARLOTTE LYKES	" " "
1-25-69	SS US TOURIST	" " "
1-27-69	SS ROBIN HOOD	" " "
2-4-69	SS SAN MATEO VICTORY	" " "
2-8-69	SS JESSE LYKES	" " "
2-9-69	SS LOUISE LYKES	" " "
2-23-69	SS STELLA LYKES	" " "
2-24-69	SS DEL SOL	" " "
2-24-69	SS SHIRLEY LYKES	" " "
2-27-69	SS U.S. MATE	" " "
3-5-69	SS GREEN SPRINGS	" " "
3-7-69	SS SOLON TURMAN	" " "
3-9-69	SS GENEVIEVE LYKES	" " "
3-9-69	SS JOSEPH LYKES	" " "
3-19-69	SS VELMA LYKES	" " "
3-23-69	SS GREEN LAKE	" " "
3-26-69	SS GREEN FOREST	" " "
3-29-69	SS SUE LYKES	" " "
4-8-69	SS FREDRICK LYKES	" " "
4-10-69	SS WILLIAM LYKES	" " "
4-11-69	SS NANCY LYKES	" " "
4-16-69	SS OVERSEAS DAPHNE	" " "
4-18-69	SS ROBIN GOODFELLOW	" " "

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(5)

4-20-69	SS RUTGERS VICTORY	LIFT	MIL.	CARGO
4-20-69	SS THUNDERBIRD	"	"	"
4-26-69	SS MERIDIAN VICTORY	"	"	"
4-26-69	SS U.S. PILOT	"	"	"
4-28-69	SS GREEN BAY	"	"	"
5-1-69	SS ALAMO VICTORY	"	"	"
5-11-69	SS TULANE VICTORY	"	"	"
5-14-69	SS AMERICAN CHALLENGER	"	"	"
5-23-69	SS BRITIAN VICTORY	"	"	"
5-24-69	SS GREEN PORT	"	"	"
5-25-69	SS ZOELLA LYKES	"	"	"
6-14-69	SS BURBANK VICTORY	"	"	"
6-15-69	SS ROBIN TRENT	"	"	"
6-23-69	SS MORMACSCAN	"	"	"
6-24-69	SS MORMACGLEN	"	"	"
6-30-69	SS SHELDON LYKES	"	"	"
7-3-69	SS ELIZABETH LYKES	"	"	"
7-6-69	SS MALLORY LYKES	"	"	"
7-18-69	SS CHARLOTTE LYKES	"	"	"
7-20-69	SS ROBIN GOODFELLOW	"	"	"
7-25-69	SS U.S. BUILDER	"	"	"
7-29-69	SS AMERICAN RACER	"	"	"
8-1-69	SS ALAMO VICTORY	"	"	"
8-9-69	SS MASON LYKES	"	"	"
8-11-69	SS ALBANY	"	"	"
9-5-69	SS AMERICAN FALCON	"	"	"
9-11-69	SS AMERICAN CHAMPION	"	"	"
9-24-69	SS AMERICAN CHARGER	"	"	"

JULY (7-3-69 to 7-29-69)

AUG (8-1-69 to 8-11-69)

SEPT (9-5-69 to 9-24-69)

2487

⑥

10-12-69	SS RUTH LYKES	OCT	LIFT MIL. CARGO
10-14-69	SS ASHLEY LYKES		" "
10-27-69	SS JAMAS		" " "
11-17-69	SS ROBIN MOWBRAY	NOV	" "
11-25-69	SS WILD RANGER.		" " "
12-6-69	SS MALLORY LYKES	DEC	" " "
12-22-69	SS GREEN LAKE		" " "
12-28-69	SS GREEN SPRINGS		" "
12-28-69	SS RUTH LYKES		" " " + DIXON.
12-29-69	SS AIMEE LYKES		" " "
JAN-1970	0		
17-FEB 1970	SS ASHLEY LYKES		MIL. CARGO
11 MAR 1970	SS. ALMA VICTORY		" "
25 MAR 1970	SS RUTH LYKES		" "
8 APR 1970	SS FREDERICK LYKES		" "

2488

15% Shortage

100,000 acres under chemical management in the northwest

1. Use

Forests - 300/509 million acres unproductive due to brush

Rangelands - 320 million acres dominated by brush

Dr. Newton's Plot Work in Western Oregon
2-4 lbs ai/A
Excellent Control

Signifance of EPA Ruling
Hearings 5 April - ?
"Rule of Reason"

2. Eglin Ecological Studies

3. Soil Biodegradation
Chemistry * HAP
Dugway

Cometabolism

(Brief (Handout))
- Chemistry
- Meterological
- Microbiological Studies
- Ecological Survey

Potential Sites

4. Tony's Data

2489

Cost of Soil Biodegradation ②

2.3 million gallons
× 8.6 pounds/gal

19.8 million pounds

at 1000 pounds/acre
requires 19800 acres

BARRELL 3-4 MONTHS

Width of swath = 15.33 ft.
1 acre = 45360 ft²

15 WEEKS

Linear distance to equal 1 acre
= $\frac{43560}{13.33}$ = 3270 ft.

Total linear distance of injection
= $\frac{3270 \times 19800}{5280}$ = 12300 stat. miles

40 | 615, 40, 215

Total time of injection at 5 mph 4 CATS
= $\frac{12300}{5}$ /8/ 2460 hours.] 615 hrs

Allowance for end-turns, rest periods, lunch break, start ups & shut down, minor repairs etc. 20%

Total time to pay for D-8 CAT & operator
= 2460 × 1.20 = 2960 hours.

Cost of D-8 CAT & operator
at \$30/hr. = 2960 × 30 = \$89000.
more realistic at \$50/hr = 2960 × 50 = \$148000

Number of 40 hour weeks reqd.
= $\frac{2960}{40}$ = 74 weeks or 1 year 5 months

2490

~~Cost of Soil Biodegradation~~ ②

Total number of drums ≅ 42000
Pounds / drum = 473 pounds
Drums emptied/hr (at max. rate)
$= \frac{42000}{24 \cdot 60} \cong 17/\text{hr.}$

approx. 1 every 3 minutes

Will probably need 2 x emptying equipment listed + fork lift truck, heavier crushing equipment, three instead of two reservoir units. 2 tractor to pull reservoir units and soil compactor. Additions to equipment:

Emptying eq.	$5000
Fork truck	5000
Incr. crushing eq.	5000
Add. reservoir unit	3500
Two small tractors	10000
	$28500
Original estimate	31000
new estimate	$59500
	or ~ 60000

Believe need to add another 2-man emptying crew to keep up with 17 drums/hr. Could double on mixing & crushing if emptying gets ahead.

New estimate of total manpower requirements
= 11 men for 18 months
= 16.5 man years at $15000 (avg.)
= $248 K.

plus living expense at $300 / man-month
= 11 x 18 x 300 = $59.3 K
≅ $60 K.

plus fringe benefits (unemployment ins., accident ins., medical examinations, vacation etc.), about 10% on salary = ~$25K

Total labor cost = 248 + 60 + 25
New estimate = $333

Cost of 92000 gal mine fluid at 25¢/gal = $23K
Fuel for tractors and lift truck $ 7K
Total expendibles $30K

Summary!

	thousand $
D-8 CAT plus operator	148
Equipment	60
Expendibles	30
Labor	333
Total cost of operation at site.	$571

Effect of reduced quantity:

assume base cost of equipment
$\cong$ \$30 K (for minimal quantity)

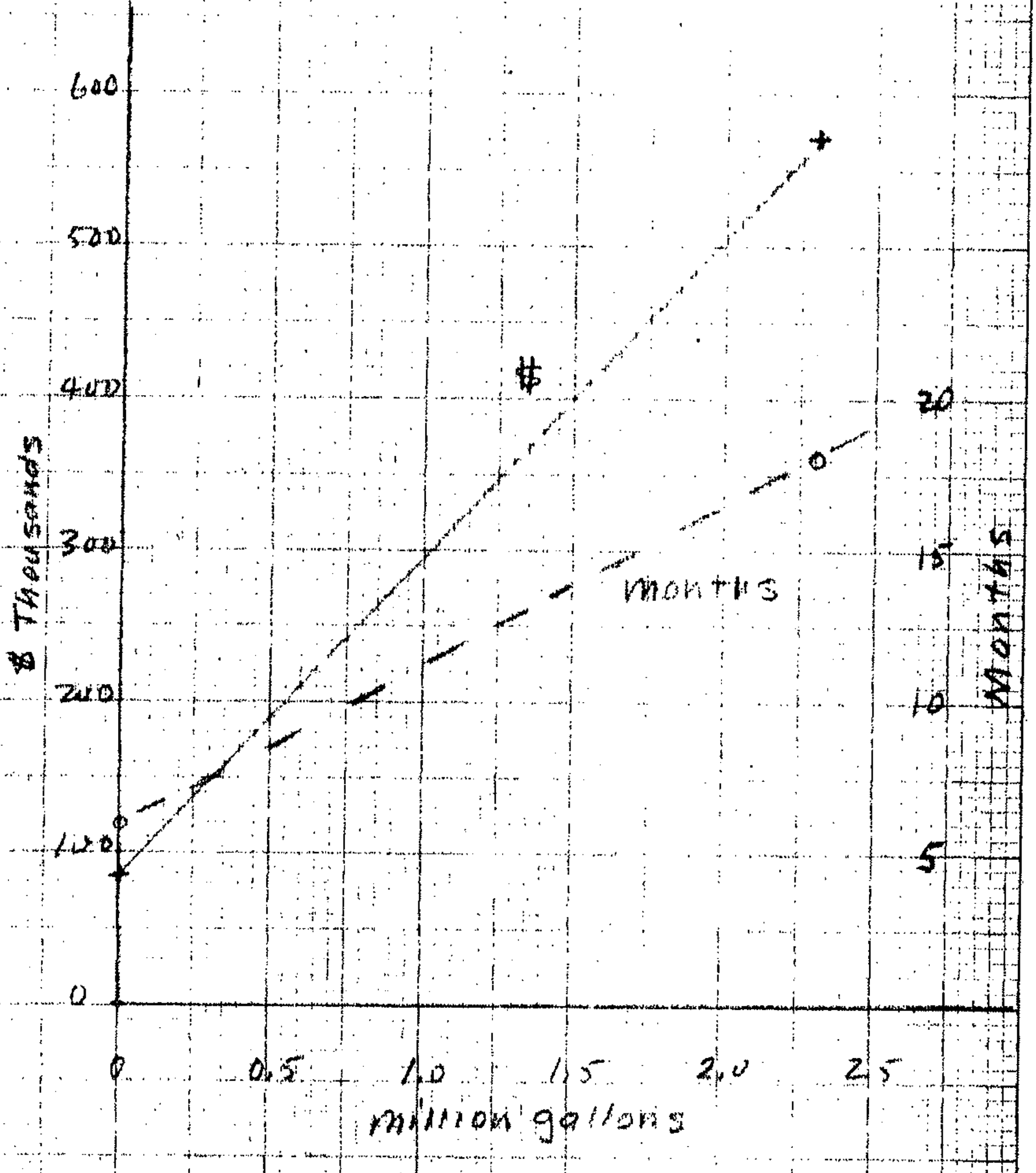
assume minimum crew
= 6 men

assume minimum time 6 months

Base labor cost = 3 × 15 × 1.10 + 3 × .300 × 6
= 50 + 5 = 55 K.

Other items scale with quantity.

Time to dispose of smaller quantity scales linearly from 18 months for 2.3 mil. gals. to 6 months for very small quantity.



COST OF SOIL BIODEGRADATION

2494

Council on Environmental Quality

Dr. [redacted] b6
Staff Assistant

Environmental Protection Agency

Mr. [redacted] b6
Director
Office of Federal Activities

Colonel [redacted] b6
DOD Coordinator
Office of Federal Activities

Mr. [redacted]
General Counsel b6

Mr. [redacted] b6
Hazardous Materials Control

Mr. [redacted] b6
Hazardous Materials Control

Mr. [redacted] b6
Office of Solid Waste

Department of Transportation

Mr. [redacted] b6
Office of Environmental Affairs

Commander [redacted] b6
U. S. Coast Guard

Mr. [redacted] b6
Office of Hazardous Waste

Mr. [redacted] b6
Office of Hazardous Waste

Department of Agriculture

Dr. [redacted] b6
Pesticide Degradation Lab

Department of Health, Education and Welfare

Mr. [redacted] b6
Special Asst to the Asst Secretary for Health

Department of Interior

Mr. [redacted] b6
Review Officer
Office of Environmental Project Review

Mr. [redacted] b6
Chief Toxicologist
Bureau of Sport Fishes and Wildlife

Department of Commerce

Mr. [redacted] b6
Asst Director for Environmental Impact Statements

National Oceanic and Atmospheric Administration

Dr. [redacted] b6
Dep Director of Ecology and Environmental Conservation

Department of Defense

Mr. [redacted] b6
Act Director for Environmental Quality, ASD (H&E)

Camp Carroll Site Questions

캠프 캐롤 기지에 대한 질문

23 May 2011 (v1)

Mr. [redacted]e will be referred to as [redacted]rm this point forward)

1. When did you arrive at Camp Carroll, when did you leave?
언제 캠프 캐롤에 도착(근무시작)하였으며, 언제 떠났습니까?
Mr. [redacted]orked in Camp Carroll for 35 years. 1950-1995

2. What was your command and your work position?
귀하의 부대 이름은 무었이였으며, 귀하의 업무상 위치는요?
He worked in S&T, MSC-K as a forklift operator.

3. Do you remember your chain of command? (Supervisor, branch chief, director, commander?)
혹시 귀 부대의 지휘관들을 기억하십니까? (직속상관, 사무실 책임자, 혹은 지휘관?)
He remembers his supervisors' name—[redacted]who worked in S&T, MSC-K.

4. Please describe what was disposed of at Camp Carroll? And when?
캠프 캐롤에 처리된 것이 무었이였는지 설명을 부탁합니다. 그리고 언제인지요?
He was told to go over to helipad area which is near Landfarm. When he got there, a trench was already dug. Someone delivered five-gallon drums to that area to be buried. He worked with other KNs to bury ~100 drums of five-gallon drums.

5. Please describe what it looked like, where it was located, what the area looked like.
처리된 것이 어떻게 생겼으며, 어디에 있었으며, 그 지역은 어떻게 생겼는지요?
It's near Landfarm area. (When he was shown the map of Camp Carroll, he pointed to the area near fence line.) See Map #1.

6. Can you point out where it was disposed? Did it have a special name? Are you aware of the reason why it was disposed?
정확히 어디에 처리가 되었는지 지적할 수 있습니까? 특별한 이름이 있었습니까? 혹시 왜 그것이 처리되어야 했는지 이유를 아십니까?
See Map #1. No special name was given to him at that time other than a "helipad." He was told that these drums were being buried temporarily; they were planning to excavate them in the future to be sent to the States.

7. How long did the transportation and disposal take?
그것을 이동하는것과 처리하는데 시간이 얼마나 걸렸습니까?
Mr. [redacted]oes not know about the duration of transportation, but he stated that it took them all day to bury them.

8. How much was disposed? In the same location or other locations too?
얼마나 많은 양이 처리되었습니까? 똑 같은 장소입니까 아니면 다른 곳도 있습니까?
About 100 five-gallon-drums in the same location.

9. Where did the containers originally come from?
용기는 원래 어디서 온 것입니까?

He does not know where they came from.

10. Where were they stored prior to disposal? Did it have a special name? Any other locations where they were stored?
처리하기 전에 그것들은 어디에 저장되어 있었습니까? 그것들에 특별한 이름이 있습디까?
그것들이 저장된 또 다른 장소가 있습디까?
He does not know.

11. What was the condition in storage?
저장소의 상태는 어떠했습니까?
They looked sturdy and reinforced.

12. How were they moved?
어떻게 그들이 이동되었졌습니까?
They were moved by a truck. He does not remember drivers nor trucks.

13. Who was involved with the transportation and disposal?
이동과 처리 과정에 누가 관여되었습니까?
He does not remember.

14. Describe the containers (all the same, any markings)?
용기 모양을 묘사해 주십시요 (모두가 똑 같았습니까, 어떤 표식이라도?) **They were 5 gallon drums. The color was Green and there were no markings.**

a. What were they made of?
무엇으로 구성되어 있었습니까? **They looked like extra-reinforced drums that have been made for storage or transportation.**

b. If leaking, what did the substance(s) look/smell like? **Nothing was leaking. No odors whatsoever.**
혹시 물질이 새고 있었다면, 그 내용물은 어떤 형태였습니까/ 냄새가 납니까?

c. If leaking, what percentage of the containers do you think were leaking? Where was it leaking? How much was leaking from the containers? **N/A**
혹시 물질이 새고 있었다면, 용기들 중 몇 퍼센트 정도가 새고 있었다고 생각합니까? 이디서 새고 있었디까? 용기들 중에서 얼마만큼 새고 있었디까?

d. If leaking, what did you do with the material that leaked both during transportation and disposal? **N/A**
혹시 물질이 새고 있었다면, 이동이나 처리 과정중 새어나온 물질을 어떻게 하였습니까?

15. Describe how you disposed of the containers?
그 용기들을 어떻게 처리되어졌는지 설명해 주십시요?

a. Length of trench, width, and depth of burial.
매장을 위한 구덩이의 길이, 넓이 및 깊이는?
The size of that trench was about two drums wide, and 6 feet deep.

b. Were they still leaking?
여전히 그들이 새고 있었습니까?
They were not leaking.

c. how where the containers arranged in the trench?
구덩이속에서 그 용기들은 어떻게 정리되어 있었습니까?

They were arranged neatly two by twos. There were spacers in between drums to make sure there were no movements of drums during burial. Also, when they delivered the drums, they were put in bigger drums. And each drum was doubled bagged with an "oil paper" and then with vinyl warps.

d. What type of soil was excavated? What did you do with the excavated soil?
어떻 종류의 흙이 발굴되었습니까? 발굴된 흙은 어떻게 하였습니까?

He does not know the type of soil. They used the soil to rebury the trench.

e. How did you cover?
어떻게 덮었습니까?

The trench was lined with a vehicle tarp before drums were buried. After all the drums were lined up, the ends of the tarp was used to cover over the drums. And then another tarp was used to put on top of drums. It was almost water-proof. Mr. [redacted] and other KNs used shovels to bury them. Even though it was really hot, they were wearing poncho; they tightened the hood of ponchos pretty tightly and around their waist.

f. Were you there long enough to notice if any vegetation grew back?
이후 어떤 식물이 자라날때 까지 충분한 기간동안 근무하였습니까

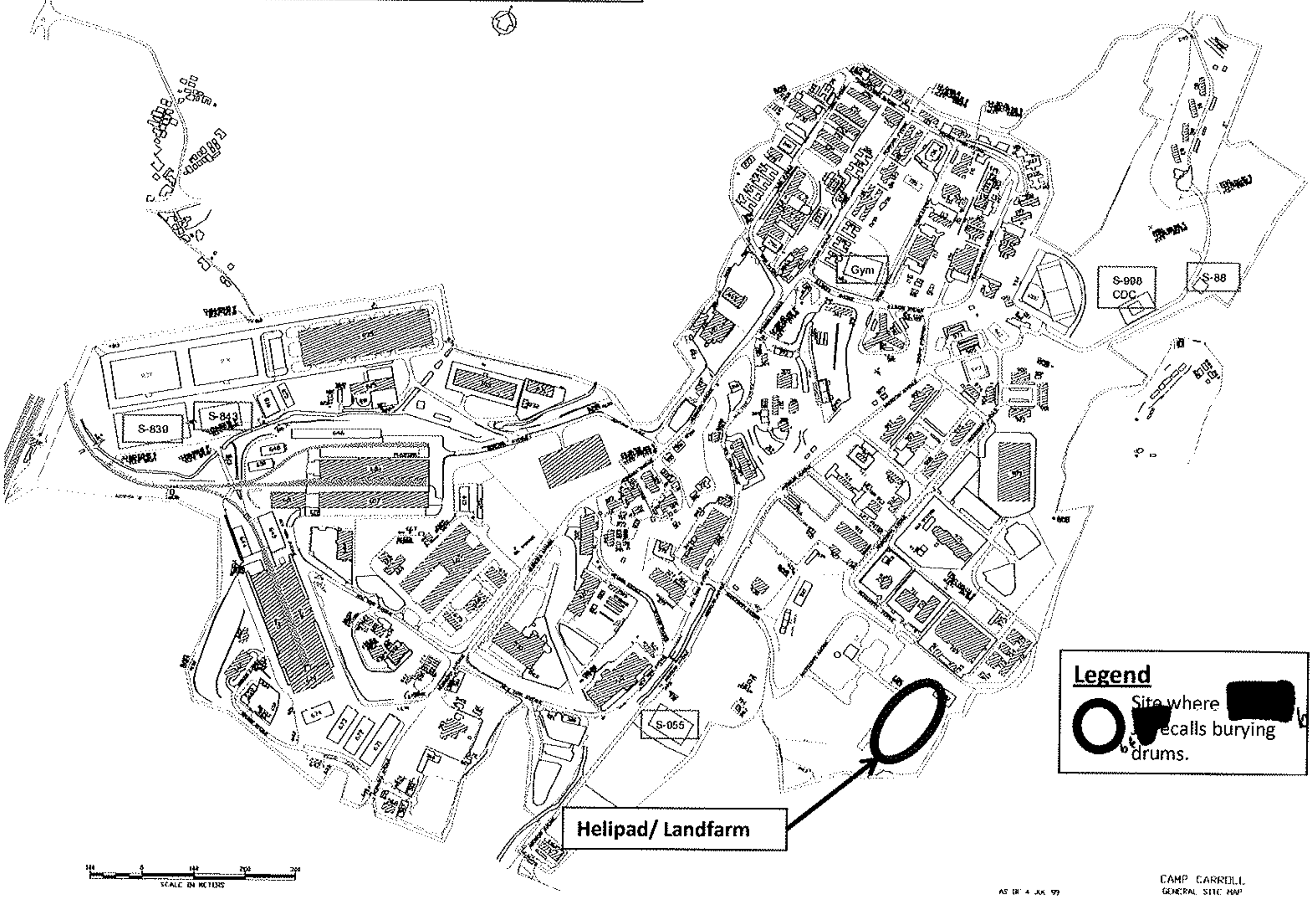
He does not remember.

16. Are you aware if the containers were removed after they were buried?
그들이 매장된 이후 그 용기들이 혹시 이동되어졌는지 알고 계십니까?

He is not aware of any removal.

2498

Mr. [redacted] Interview
Friday, 21 June 2011



2499

Camp Carroll Site Questions—
캠프 캐롤 기지에 대한 질문
Mr. [redacted](He will be referred to as [redacted]om this point forward)

18 June 2011

1. When did you arrive at Camp Carroll, when did you leave?
언제 캠프 캐롤에 도착(근무시작)하였으며, 언제 떠났습니까?

Mr. [redacted]as worked in Camp Carroll for 37 years. 1965-SEP,2002.

2. What was your command and your work position?
귀하의 부대 이름은 무었이였으며, 귀하의 업무상 위치는요?

He worked in various different positions to include a contractor in Heating branch, Power Crane Operator and Mechanic etc...

3. Do you remember your chain of command? (Supervisor, branch chief, director, commander?)
혹시 귀 부대의 지휘관들을 기억하십니까? (직속상관, 사무실 책임자, 혹은 지휘관?)

He does not remember any specific US names. He does remember other Korean workers who were with him at that time. They were Mr. [redacted]and Mr. [redacted] (They subsequently joined into the interview and confirmed what Mr. [redacted]s saying.)

4. Please describe what was disposed of at Camp Carroll? And when?
캠프 캐롤에 처리된 것이 무었이였는지 설명은 부탁합니다. 그리고 언제인지요?

Mr. [redacted]as never seen drums of Agent Orange being buried in Camp Carroll. There are various different places that are contaminated with POL products.

First, there was BOQ hill where 5-10 drums of diesel was buried. See Map 1.

Second, the hill behind the MSC-K where an underground fuel tank was located. The fuel tank was leaking and contaminating the ground. (This was removed and the soil was removed.)

Third, he discovered a fuel leakage in the yard right in front of the BLDG 607. Mr. [redacted]dug up all the contaminated soil from that location for few days, and the US Soldiers (whose names he can't remember) dumped the soil to <u>Location A (Map 1)</u>. At that time, he knew it was Marathion because someone from the warehouse said that it smelled like Marathion.

Fourth, near helipad right behind the fence line and Landfarm, 44th Engineers told him to dig a trench and put expired C-rations and food items and trash (chairs) to include drums. He emphasized that there was no Agent Orange; it was mostly trash and food items.

5. Please describe what it looked like, where it was located, what the area looked like.
처리된 것이 이떻게 생겼으며, 이디에 있었으며, 그 지역은 어떻게 생겼는지요?

He does not remember exactly what types of drums were.

6. Can you point out where it was disposed? Did it have a special name? Are you aware of the reason why it was disposed?
정확히 어디에 처리가 되었는지 지적할 수 있습니까? 특별한 이름이 있었습니까? 혹시 왜 그것이 처리되어야 했는시 이유를 아십니까?

See #4.