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Ship Creek Bioassessment Investigations

C. E. Cushing
R. P. Mueller
M. T. Murphy

June 1995

Prepared for
Elmendorf Air Force Base
Anchorage, Alaska
under a Related Services Agreement
with the U.S. Department of Energy
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Pacific Northwest Laboratory
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I - Purpose of Study

Pacific Northwest Laboratory (PNL) was asked by Elmendorf Air Force Base (EAFB) personnel to conduct a series of collections of macroinvertebrates and sediments from Ship Creek to (1) establish baseline data on these populations for reference in evaluating possible impacts from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at two operable units, (2) compare current population indices with those found by previous investigations in Ship Creek, and (3) determine baseline levels of concentrations of any contaminants in the sediments associated with the macroinvertebrates.

A specific suite of indices established by the U.S. Environmental Protection Agency (EPA) was requested for the macroinvertebrate analyses; these follow the Rapid Bioassessment Protocol developed by Plafkin et al. (1989) and will be described below. Sediment sample analyses included a Microtox bioassay and chemical analysis for contaminants of concern. These analyses included, volatile organic compounds (EPA method 8010/8020), total gasoline and diesel hydrocarbons (EPA method 8015, CA modified), total organic carbon, and an inductive-coupled plasma/mass spectrometry (ICP/MS) metals scan. Appendix A reports on the sediment analyses. The Work Plan is attached as Appendix B.

II - Site Description

Ship Creek (Figure 1) enters EAFB at the boundary with Fort Richardson, flows along the southern part of EAFB, and exits near the gate in the vicinity of Salmon Run Park. Six sampling transects were selected to accomplish the objectives; they were:

Transect 1 (Tr-1): The control transect located near the footbridge below the fish hatchery west of Fort Richardson. This will separate impacts associated with either the Fort or the hatchery.

Transect 2 (Tr-2): Approximately 1200 m downstream from Transect 1 where the Walton Road crosses Ship Creek. This is located upstream from Operable Unit (OU)-1 and would serve as the control station for that OU.

S9407018.3

Figure 1. Ship Creek Showing Locations of Study Transects (Tr) and CERCLA Operable Units (OU).

Transect 3 (Tr-3): Approximately 2300 m downstream from Transect 2 near where the Davis Highway crosses Ship Creek. This is below OU-1, and comparison of data collected here with that collected at Transect 2 would provide information on possible impacts from OU-1.

Transect 4 (Tr-4): Approximately 1100 m downstream from Transect 3 just upstream from the pumping station. This will serve as the control station for OU-5 and is located upstream from that OU.

Transect 5 (Tr-5): Approximately 1800 m downstream from Transect 4 and just above the dam adjacent to the fish hatchery. This is located below OU-5 and comparison of data collected here with that collected at Transect 4 would provide information on possible impacts from OU-5.

Transect 6 (Tr-6): Approximately 2000 m downstream of Transect 5. This is below the section of OU-5 located below the fish hatchery. Data would reflect possible impacts associated with the lower section of OU-5 and from the fish hatchery.

Transects 1, 2, and 3 are located in field/pasture settings. Transect 4 is bordered by a riparian strip of vegetation which separates it from a golf course on both sides. Transects 5 and 6 are located in commercial areas; Transect 5 is bordered by a park on one side and field/pasture on the other; Transect 6 is located in the commercial area of downtown Anchorage although it is bordered on both sides by riparian vegetation. Table 1 summarizes the physical and chemical data collected at the six transects. Ship Creek averaged about 12.3 m in width, 44 cm in depth and had a flow of about 7.12 m³/s at the time of sampling. We encountered problems with our chemical measuring instruments, but it is likely that dissolved oxygen is at near saturation conditions.

Substratum was mostly cobble and gravel with some boulder size components. Little bankside erosion was noted except in the vicinity of Transects 5 and 6 where Ship Creek flows through commercial development areas.

Table 1. Chemical and Physical Measurements of Ship Creek

Transect	1	2	3	4	5	6
Width (m)	10.7	14.4	10.5	13.0	15.9	9.4
Depth (cm)	42	37	50	38	46	48
Velocity (m/s)	0.51	0.68	0.59	0.64	0.78	0.69
Temperature (°C)	9.6	9.9	8.4	8.6	11.6	11.0
TDS (mg/L)	120	120	130			

III - Methods and Materials

Physical: Stream widths were measured with a meter tape and depths along this transect were measured with a meter stick. Velocity was measured using a timed float and flow measurement calculated from these data and a correction factor for substratum size (0.8 for cobbles, 0.9 for gravel). Temperature was measured with an electronic probe.

Chemical: Total dissolved solid (TDS) was measured with an electronic probe. Problems were encountered with our dissolved oxygen (DO), pH, and, eventually, the TDS measuring instruments. Replacement parts for the DO probe were obtained, but the problems were with the instruments themselves.

Biological: Macroinvertebrate collections were made following the essentials outlined in the Rapid Bioassessment Protocol of Plafkin et al. (1989). One hundred insects were obtained at random from the riffle/run area of each transect using a kick net for calculation of the various indices and a qualitative sample of invertebrates found in coarse particulate organic matter (CPOM) was taken to provide an indication of the shredder population.

Habitat assessment was made following the protocol outlined in Plafkin et al. (1989) by scoring the following variables: bottom substrate and available cover, embeddedness, flow/velocity, channel alteration, bottom scouring and deposition, pool/riffle, run/bed ratio, bank stability, bank vegetation, and streamside cover. Each of these was scored on the ranking

system outlined in Plafkin et al. (1989) and the composite score for each test transect compared with that of the control transect by determining the percent comparability. This evaluation is designed to support the macroinvertebrate indices; thus the various habitat variables are weighted to emphasize the most biologically significant variables. A full explanation of this approach and the philosophy behind it can be found in Plafkin et al. (1989).

In the laboratory, insects were identified to genera for the Ephemeroptera, Plecoptera, and Trichoptera (EPT), and to family for other taxa. The following indices were then calculated:

- number of EPT genera
- average number of EPT/total individuals ratio
- percent dominant taxa
- family biotic index (FBI)
- preliminary Rapid Bioassessment Rating (RBA).

Sediments: Sediment samples were retrieved at each station where biota were evaluated and sampled. Samples were removed with a stainless-steel scoop and placed in appropriate sample containers. Care was taken to gently layer volatile organic compound sample composites for homogenization in the laboratory under controlled conditions.

Samples were packed in ice and maintained at approximately 4° C until received at the laboratory. Samples for chemical analysis were shipped overnight to Lockheed Analytical Laboratory (LAL) in Las Vegas, Nevada. All samples were accepted and processed within allowable holding times. Appendix A is a quality assurance report compiled by LAL and reviewed by PNL. Analytical methods used for this investigation were EPA 8010 for chlorinated solvents, EPA 8020 for volatile organic compounds (BTEX), EPA 8015M for diesel-range and gasoline-range hydrocarbons, EPA 9060 for total organic carbon and EPA 6020 for total metals (USEPA 1979). Details on the selection and appropriateness of these methods can be found in the work plan for this investigation in Appendix B.

Samples for Microtox Solid-Phase Test (SPT) analysis were treated identically to the LAL samples but were shipped to Battelle/Marine Sciences Laboratory at Sequim, Washington.

Sample preparation included homogenization of the sample with SPT dilutant to a concentration of 200,000 mg/L. Following this, the Microtox photobacterium was introduced to the solution and allowed to remain for 10 minutes. The solution was filtered and the solid fraction was placed in the light emittance counter. Results were calculated from the amount of photo activity, moisture content, and dry weight of each sample. Microtox software reduced the measured values to EC₅₀ concentrations, the effective concentration of sediment required to produce a 50% reduction in the target bacterium population.

IV - Results

Macroinvertebrates:

Number of EPT genera: The number of EPT genera, which is a measure of community health and richness (the more genera of these groups present, the better the conditions are), ranged from five at Transect 2 to nine at Transect 5 (Table 2) and showed a slight increasing trend from the Transect 1 to Transect 6.

Average number of EPT/total individuals ratio: The ratio of EPT genera/total taxa counted ranged from 0.71 at Transect 2 to 0.81 at Transect 5 (Table 2), and again increased downstream as did the number of EPT genera. Again, the higher this ratio is, the better the conditions are.

Percent dominant taxa: The results of percent dominate taxa analysis, which is a measure of community balance and evenness at the family level, indicate that *Simuliidae* and *Heptageniidae* were the dominant families in the macroinvertebrate collections and that they composed between 26% and 50% of the taxa (Table 2).

FBI: The FBI values ranged from 3.15 at Transect 1 to 4.43 at Transect 6. According to the criteria established by Hilsenhoff (1987), these indices would suggest that water quality would be considered excellent at Transects 1 and 4, very good at Transects 2, 3, and 5, and good at Transect 6. However, the range of FBIs found is quite small and would not suggest significant deterioration of the water quality in our study reach of Ship Creek.

Preliminary RBA: The percent comparability of the five test transects (Transects 2-6) in terms of habitat assessment ranged from 90% - 99% (Table 2), indicating that all test transects were essentially comparable to the reference transect, Transect 1.

Composite CPOM samples: Composite samples of CPOM were collected at each transect and the macroinvertebrates examined to determine the presence of insects belonging to the shredder functional group. We only found a single shredder organism, the caddisfly *Psychoglypha* sp., and it was found only at Transects 3 and 4. It is highly unlikely that it occurs only at these sites. The absence of a significant shredder population has been interpreted as indicating streams with poorly developed retentive structures. However, it would appear from a visual evaluation of the sites that this is not the case in Ship Creek and the absence of more shredder taxa is probably related to the time of year that our collections were made (see below). No other shredders were found in the riffle samples (Table 2).

Gabrielson and Milner (1994) reported the occurrence of two other caddisfly shredder genera in their collections in Ship Creek. These were *Onocosmoecus* sp. and *Hesperophylax* sp., two genera not collected in our samples; they also found *Psychoglypha* sp.

A list of all macroinvertebrate taxa found in this study and those of two previous studies are shown in Table 3.

Table 4 presents the overall Bioassessment Scores calculated using the protocol of Plafkin et al. (1989); these scores use the percent comparability data shown in Table 2 to arrive at an overall indication of the suitability of the various test transects (Transects 2-6) as test sites as compared to the control transect (Transect 1).

The data in Table 4 indicate that Transects 3-6 are essentially comparable to the control Transect, and that Transect 2 is moderately impaired. However, the lower ranking resulted from the absence of only a single EPT genus; thus, since it is more than likely that this genus (the 3-tailed form of *Baetis*) also occurs at Transect 2, all stations are essentially comparable in terms of the Rapid Bioassessment Protocol.

Table 2. Species List and Counts of Macroinvertebrates Collected at Ship Creek, Alaska, August 1994, and Calculated Indices

Taxa	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
EPHEMEROPTERA						
Baetidae						
Baetis (2 tail)	1	19	17	14	23	15
Baetis (3 tail)	9		8	2	13	13
Ephemerellidae						
Drunella	3	6	1	8	7	2
Heptageniidae						
Cinygmula	7	16	3	4	1	1
Epeorus	19	29	25	50	23	32
PLECOPTERA						
Chloroperlidae						
Suwallia	20	10	14	5	6	5
TRICHOPTERA						
Rhyacophilidae						
Rhyacophila			1		2	
Glossosomatidae						
Glossosoma			1			1
Limnephilidae						
Ecclisomyia				3	1	1
Bracycentridae						
Bracycentrus				8	1	
DIPTERA						
Simuliidae	38	30	28	8	23	23
Chironomidae	2	1	11	5	4	13
ANNELIDA						
Oligochaeta	1					
Total	100	111	109	107	104	106
No. EPT Genera	6	5	8	8	9	8
% Comparison ^(a)	—	83	133	133	150	133
No. EPT/Total	0.75	0.71	0.8	0.8	0.81	0.8
% Comparison ^(a)	—	95	106	106	108	106
FBI	3.15	4.12	4.23	3.65	4.03	4.43
% Comparison ^(b)	—	76	74	86	78	71
FBA	112	111	101	104	102	108
% Comparison ^(a)	—	99	90	93	91	96
Taxa Richness	9	7	10	10	11	10
% Comparison ^(a)	—	77	142	142	157	111
% Dominant Taxa	38 Simuliidae	41 Heptageniidae	26 Simuliidae Heptageniidae	50 Heptageniidae	35 Baetidae	31 Heptageniidae
(a) Ratio of study site to reference site (transect 1) x 100.						
(b) Ratio of reference site (transect 1) to study site x 100.

Table 3. EPT Macroinvertebrate Taxa of Ship Creek

	PNL ^(a)	Gabrielson and Milner ^(b)	EMO ^(c)
Ephemeroptera			
Baetidae			
Ameletus		X (few)	
Baetis (2 tail)	X	X	X
Baetis (3 tail)	X	X	X
Ephemerellidae			
Ephemerella		X	X
Drunella	X	X	X
Heptageniidae			
Cinygmula	X	X	X
Epeorus	X	X	X
Plecoptera			
Nemouridae			
Zapada		X	X
Chloroperlidae			
Alloperla		X	
Neaviperla		X	
Plumiperla		X	
Suwallia	X		X
Perlodidae			
Isoperla	X	X	X
Leuctridae			
Leutra		X	
Paraleutra		X	
Perloymia		X	
Trichoptera			
Rhyacophilidae			
Rhyacophila	X	X	X
Glossosomatidae			
Glossosoma	X	X	X
Limnephilidae			
Ecclisomyia	X	X	X
Psychoglypha	X	X	
Onocosmoecus		X	
Hesperophylax		X	
Nemotaulius			X(?)
Brachycentridae			
Brachycentrus	X	X	
Hydropsychidae			
Cheumatopsyche			X
(a) This study.			
(b) Gabrielson and Milner (1994) and Milner (personal communication: letter from Alexander Milner, April 1994, University of Alaska, Anchorage, Alaska).			
(c) EMO (1992).

Table 4. Bioassessment Scores

Transect	1	2	3	4	5	6
Family Biotic Index	6(a)	3	6	6	6	6
% Dominant Family	3	3	3	3	3	3
EPT Index	6	3	6	6	6	6
Totals	15	9	15	15	15	15
% comparability	100	60	100	100	100	100
(a) Scores for Transect 1 were assumed to be identical to a hypothetical control station.						

Sediments:

Total organic carbon values range from 0.14 to 1.26 weight percent (Table 5). Total petroleum hydrocarbons were analyzed for both gasoline- and diesel-range components (Table 5). Diesel components were not found at levels above the method detection limit of 30 mg/kg. Gasoline was detected in samples from Transect 1 (the control station) at 0.14 mg/kg and at Transect 5 (the fish hatchery) at 0.10 mg/kg.

Chlorinated solvent components were not found at levels above detection limits in all samples (Table 6). Toluene was detected in samples from Transect 1 at 1.9 mg/kg and at Transect 5 at 3.6 mg/kg (the fish hatchery). No other BTEX or non-halogenated hydrocarbon was found.

Table 5. Total Organic Carbon and Total Petroleum Hydrocarbons in Ship Creek Sediments

	T-1 6/16/94	T-2 6/16/94	T-3 6/16/94	T-4 6/16/94	T-5 6/16/94	T-6 6/16/94	Method	Detection Limit
Total Organic Carbon (wt %)	0.84	1.26	0.14	0.92	1.13	0.30	9060	0.25
TPH-Gasoline Range (mg/kg)	0.14	ND	ND	ND	0.10	ND	8015M	0.10
TPH-Diesel Range (mg/kg)	ND	ND	ND	ND	ND	ND	8015M	30
ND = not detectable.

ICP analysis for metals revealed a suite of elements consistent with the other data (Table 7). These results have been normalized (Figure 2) to EAFB background soil values (deep soil, 99% upper confidence interval) obtained in the base-wide background investigation (EMO 1992). Metals concentrations generally range from 0.5 to 1.5 times EAFB background. Sodium is somewhat enriched, up to three times background.

Results of the Microtox analysis are presented as EC₅₀ concentrations (Table 8), in effect, the concentration of suspended sediment necessary to achieve a 50% reduction in light emittance by the indicator bacteria. The actual laboratory report is attached as Appendix A. Values range between 115,934 and 15,055 mg/kg (dry weight) with the minimum value (highest toxicity) recorded at Transect 1. Sediment from Transect 3 was not capable of producing a 50% reduction in light emittance with the test protocol. Some ambiguity was noted in the test report, possibly due to the presence of organic debris and dead organisms in one of the samples. Production of ammonia or hydrogen sulfide may have interfered with the light output but does not appear to have compromised the results.

V - Discussion

Biological:

The results of the macroinvertebrate sampling of Ship Creek reveal several pertinent observations. First, in terms of its original purpose of determining the baseline populations within the stream and the suitability of the various sampling sites for use in evaluating future clean-up operations, the data reveal that there is little difference in the populations present within the stream, and that there is little or no indication of localized impacts. The Rapid Bioassessment Protocol scores (Table 4) reveal that the percent comparability of the test transects are essentially no different from that of the control site, further supporting the similarity of the sites for future comparative studies. The exception to this might be at Transect 6 which had the highest, and therefore worst, FBI water quality index rating (Table 2). This transect was located downstream of all industrialization and thus could reflect

Table 6. Chlorinated Solvent Compound Analyses of Ship Creek Sediments, µg/kg

	T-1 6/16/94	T-2 6/16/94	T-3 6/16/94	T-4 6/16/94	T-5 6/16/94	T-6 6/16/94	Method	Detection Limit
Dichlorofluoromethane	ND	ND	ND	ND	ND	ND	8010	2
Chloromethane	ND	ND	ND	ND	ND	ND	8010	2
Vinyl Chloride	ND	ND	ND	ND	ND	ND	8010	1
Bromomethane	ND	ND	ND	ND	ND	ND	8010	2
Chloroethane	ND	ND	ND	ND	ND	ND	8010	2
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	8010	2
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	8010	6
Methylene Chloride	ND	ND	ND	ND	ND	ND	8010	12
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	8010	6
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	8010	6
Chloroform	ND	ND	ND	ND	ND	ND	8010	2
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	8010	8
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	8010	1
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	8010	1
Trichloroethene (TCE)	ND	ND	ND	ND	ND	ND	8010	2
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	8010	1
Bromodichloro	ND	ND	ND	ND	ND	ND	8010	2
2-Chloroethylvinyl ether	ND	ND	ND	ND	ND	ND	8010	6
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	8010	2
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	8010	2
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	8010	2
Tetrachloroethylene	ND	ND	ND	ND	ND	ND	8010	1
Dibromochloromethane	ND	ND	ND	ND	ND	ND	8010	2
Chlorobenzene	ND	ND	ND	ND	ND	ND	8010	1
Bromoform	ND	ND	ND	ND	ND	ND	8010	2
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	8010	2
1,3-Dichloromethanebenzene	ND	ND	ND	ND	ND	ND	8010	4
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	8010	2
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	8010	2
Benzene	ND	ND	ND	ND	ND	ND	8020	1
Toluene	1.9	ND	ND	ND	3.6	ND	8020	1
Chlorobenzene	ND	ND	ND	ND	ND	ND	8020	2
Ethylbenzene	ND	ND	ND	ND	ND	ND	8020	2
m,p-Xylene	ND	ND	ND	ND	ND	ND	8020	4
o-Xylene	ND	ND	ND	ND	ND	ND	8020	2
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	8020	4
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	8020	2
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	8020	4
Acetone	ND	ND	ND	ND	ND	ND	8020	14
2-Butanone (MEK)	ND	ND	ND	ND	ND	ND	8020	6
ND = not detectable.

Table 7. ICP Analysis of Total Metals, mg/kg

	T-1 6/16/94		T-2 6/16/94		T-3 6/16/94		T-4 6/16/94		T-5 6/16/94		T-6 6/16/94		T-1D DUPLICATE		Method	Detection Limit
Antimony	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	6020	1
Barium	56.0		70.7		64.9		70.5		61.9		64.0		53.1		"	10
Beryllium	0.40	U	0.40	U	0.39	U	0.39	U	0.40	U	0.39	U	0.40	U	"	1
Cadmium	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	"	1
Calcium	5880		7750		8000		7430		5350		10200		5502		"	100
Chromium	21.5		27.9		34.5		29.4		20.0		39.2		20.6		"	2
Cobalt	6.9	B	9.1	B	10.2		9.2	B	6.2	B	10.2		6.4		"	1
Copper	17.2		20.6		24.8		21.2		17.1		23.3		15.8		"	1
Iron	17800		24400		34100		25600		14600		29900		16772		"	10
Magnesium	5690		7530		10500		7910		4510		11300		5482		"	100
Manganese	352		438		550		530		385		628		323		"	3
Nickel	19.1	B	25.1		32.9	B	27.5	B	17.1		38.2		17.9		"	1
Potassium	936	B	1130		1120		1090		920	B	1120		869		"	100
Silver	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	"	1
Sodium	610		772		420		672		548	B	576	B	572		"	100
Tin	1.3	B	1.3	B	1.5	B	1.3		1.1	B	1.5	B	1.2	B	"	1
Vanadium	37.3		49.2		58.8		50.8		34.3		63.2		34.6		"	1
Zinc	39.1		50.4		58.9		51.1		35.1		51.9		37.6		"	4

U = below detection limits.

B = present in blank samples.

Figure 2. Metals Concentrations in Ship Creek Sediments Relative to Background

Table 8. EC₅₀ Concentrations of Microtox Analyses

Station	Location	EC ₅₀ (wet wt.)	EC ₅₀ (dry wt.)
T-1	Glenn Highway	26,312	15,055
T-2	Walton Rd.	137,608	102,106
T-3	Davis Highway	NC	NC
T-4	Pumping Station	119,340	88,524
T-5	above Hatchery	80,637	45,804
T-6	below Hatchery	166,772	115,934
NC = EC-50 could not be calculated. Luminescence could not be reduced to 50%.			

an accumulation of impacts. Thus, we can state that significant changes found in subsequent sampling of these Transects at the same time of year may be indicative of CERCLA-related clean-up activities or other perturbations.

This leads to our second major observation - the difference in the number of taxa found between our studies and those of Gabrielson and Milner (1994) and Milner^(a). They reported finding several more taxa than we found (Table 3) and this is undoubtedly related to the fact that their collections were made over several months whereas ours was restricted to a single sampling.

Table 9 presents some comparative data on the various indices discussed in this report. The higher numbers of EPT genera reported by Gabrielson and Milner (1994) and Milner^(a) probably reflect the different timing of the collections. Our data were collected in August, soon after recession of high water flows. Their data were collected in October, a time of maximum development of the insect community prior to overwintering and spring-summer emergence. Milner^(b) agrees that late fall is a much better time to collect aquatic insects in these streams than earlier when the community is still recovering from high flows and many eggs have not yet

(a) Personal communication: letter from Alexander Milner, April 1994, University of Alaska, Anchorage, Alaska.

(b) Personal communication: July 1994, Alexander Milner, University of Alaska, Anchorage, Alaska.

Table 9. Mean Indices from Various Sources of Ship Creek Data

Source	EPT genera	EPT/total	% dominant family	FBI
Gabrielson and Milner (1994)	10.7	0.2	68.3	5.1
Milner(a)	9.2	0.5	NC	NC
EMO (1992)	5.9	NC	NC	NC
This study	7.3	0.8	36.8	3.9
NC = not calculated.				

hatched. The higher percent dominant family is also reflective of a more mature community, whereas our relatively low, and often uniform, numbers indicated an immature community which has not yet established normal numerical levels.

These data were not subjected to statistical analyses because the samples were not replicated at each transect.

Sediments:

Chemical analysis of these sediments suggests no impact due to EAFB CERCLA program contaminants of concern. Chlorinated solvent components were not found above method detection limits. Diesel fuel components were also not found. The presence of gasoline components and toluene from the same samples, Transects 1 and 5, is suggestive of some contamination because of fuel; however, in all cases the values are far below applicable or relevant and appropriate regulations (ARAR) action levels (Level A, State of Alaska TPH-Gasoline = 50 mg/kg and BTEX = 10 mg/kg). The confirmation of fuel-derived hydrocarbons from both analyses in the same samples supports the validity of the data.

Microtox sediment-contact bioassay analysis is consistent with the above conclusion. The analysis directly exposes a light-emitting bacteria, *Photobacterium phosphoreum*, to a solution of sediment and distilled water and measures the light emittance as an indicator of bacterial activity. The degree of toxicity can be expressed as activity relative to some control

(a) Personal communication: letter from Alexander Milner, April 1994, University of Alaska, Anchorage, Alaska.

sample or as the effective concentration of sediment required to reduce activity to the 50% level (EC_{50}). A full discussion of the method can be found in Brouwer et al. (1990). The results of this investigation, expressed as EC_{50} values, do not suggest a pattern of contaminated sediment. The lowest EC_{50} value occurs in the sample from Transect 1. In addition, the absolute level of this value, 15,000 ppm, represents a very low toxicity compared to other investigations using the Microtox analysis (Giesy et al. 1988; Brouwer et al. 1990; Kwan and Dutka 1992; Tomulka et al. 1993). For practical usage, Tomulka et al. (1993) advise using an EC_{50} value of 100 ppm or greater as "non-toxic." Under EPA Microtox Solid-Phase protocol, an EC_{50} value of 19,000 ppm or greater is defined as "uncontaminated" (Kwan and Dutka 1992). Thus, the sediments sampled can be considered clean to slightly contaminated. The Microtox test supports the previous interpretation of the chemical analysis, that toluene is present in the sediments at the base boundary and at the fish hatchery at levels that do not pose a hazard to biotic life.

VI - Summary

The results of the macroinvertebrate analyses and calculation of an RBA indicates that there is little, if any, significant differences among the six study transects and that the data show no difference between the control station and the five test transects. Thus, use of these study sites to evaluate impacts related to CERCLA clean-up activities is justified. Macroinvertebrate taxa richness was relatively low but this is probably related to the time of sampling. Chemical analysis and Microtox bioassay of sediment indicated no important impact from EAFB sources.

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Appendix A

Report on Sediment Analyses

Pacific Northwest Division

Marine Sciences Laboratory
1529 West Sequim Bay Road
Sequim, Washington 98382-90
Telephone (206) 683-4151
Facsimile (206) 681-3699

September 7, 1994

Mark T. Murphy
Battelle, Pacific Northwest Laboratories
Geology and Geophysics
3110 Port of Benton Blvd., K6-84
Richland, WA 99352

Dear Mark:

Enclosed are the summary tables and graphs for the work performed for the Elmendorf Air Force Base Project. Included is a description of the methods and materials, a review of the results, and interpretations of the results.

Methods and Materials

Six sediment samples from Elmendorf Air Force Base were received on July 29, 1994, at the Battelle/Marine Sciences Laboratory (MSL) in Sequim, Washington. Samples were stored at approximately 4°C until needed for testing. The six sediment samples were analyzed using the *Microtox* Solid-Phase Test (SPT) procedure August 24-26, 1994.

Test Preparation

The SPT tubes were placed in a holder and incubated at 15°C. The SPT Diluent was pipetted into the appropriate SPT tubes of the dilution series.

Sediment Sample Preparation

- 1) A pipette was used to discard the overlying water from each sediment sample and then the sediment was homogenized. The following observations were noted for each of the sediment samples:
 - T-1: Fine-grained sand, flocculent suspended in overlying water; odor of rotting organisms.
 - T-2: Fine-grained sand, low water content.
 - T-3: Homogenized two field duplicates; Coarse-grained sand, low water content.
 - T-4: Silt and fine-grained sand, flocculent suspended in overlying water; very low sample volume and lots of head space.
 - T-5: Homogenized two field duplicates; Silt and fine-grained sand; Dead worms decaying on surface.
 - T-6: Homogenized two field duplicates; Silt and fine-grained sand; Dead worms decaying on surface.

Mark T. Murphy
September 7, 1994
Page 2

- 2) A 7 g sample of each wet sediment sample was weighed into an acid-cleaned 100 mL plastic beaker with 35 mL of *Microtox* diluent to produce an initial sample concentration of 200,000 mg of sediment per liter of diluent.
- 3) A teflon magnetic stirrer bar was added to the beakers and the stir rate was adjusted until the solids were well distributed in a suspension of coarse-to-very fine particles.
- 4) While the suspension was stirring, a sample was pipetted into the appropriate SPT tubes.
- 5) Eleven 1:2 serial dilutions were made by transferring suspension from one SPT tube to the adjacent SPT tube, mixing, and then transferring into the next SPT tube, mixing, etc.

Reagent Preparation

A vial of *Microtox* reagent (photobacteria) was reconstituted with *Microtox* reconstitution solution and the mixture was agitated with a pipette.

Test Procedure

- 1) A 20 μ L sample of *Microtox* reagent mixture was pipetted into each SPT tube and then each SPT tube was mixed.
- 2) After 10 min, a filter column was inserted into each SPT tube and the filter was stopped above the settled solids.
- 3) A sample of the filtrate was transferred into the corresponding cuvette in the *Microtox* 500 machine.
- 4) At the appropriate time, each cuvette was read for the light emittance and the data was entered into the computer program.

Data Analysis

The wet weight sample concentrations and the corresponding EC_{50} values were converted to dry weight by using the sample moisture content.

m = moisture fraction

$$m = \frac{\text{wet wt.} - \text{dry wt.}}{\text{wet wt.}}$$

$$\text{dry wt. } EC_{50} = \text{wet wt. } EC_{50} - ((\text{wet wt. } EC_{50})(m))$$

Mark T. Murphy
September 7, 1994
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Results

The moisture content and dry weight EC_{50} value for each sediment sample were calculated and presented in Table 1. The dry weight sample concentrations and the corresponding light emittance values for each sediment sample were plotted on a graph, as shown in Figures 1 through 6.

Conclusions

The *Microtox* Solid-Phase Test measures the influence of suspended sediment bound materials on light emittance by bacteria. This procedure allows *Microtox* photobacteria to come in direct contact with sediment bound materials in an aqueous suspension of the test sample. It therefore detects the influence of both the soluble and insoluble organic and inorganic material.

The graphs show that certain concentrations of sediment may produce an increase in light emittance from the photobacteria. This increase in light does not appear to correspond with any potential contaminants that were analyzed for this project. The EC_{50} values ranged from not calculable in sediment T-3 to 115,934 ppm dry weight in sediment T-6. There appears to be no correlation between concentrations of potential contaminants in the sediments with the EC_{50} values for each sediment. The sediment sample T-1 is the control sample and produced the lowest EC_{50} value of 15,055 ppm dry weight. Therefore, this sample required the least amount of sediment to produce a 50% reduction in photoluminescence.

The sediment from several stations was observed as having an odor and/or remains of rotting organisms. It is possible that some of these decay products (NH_4 , H_2S , etc.) may be responsible for the observed effects on light output. If further analysis using the *Microtox* test is planned, it would seem reasonable to 1) evaluate the influence of NH_3 and H_2S on light output, 2) measure NH_3 and H_2S concentrations in sediment pore water, and 3) remove organisms prior to cooling sediment samples so they won't rot.

It is recommended by Puget Sound Dredged Disposal Analysis (PSDDA) that the results of the *Microtox* test be evaluated in conjunction with other toxicity tests.

If you have any questions, please call me at (206)681-3665.

Sincerely,

Heather L. Mayhew
Scientist
Marine Ecological Processes

HLM:bh

enc

Table 1. Dry Weight Calculations for Sediment Samples, Elmendorf Air Force Base

Project Name: Elmendorf Air Force Base
 Project Number: Mark T. Murphy
 Project Manager: Date: 8-25-94
 Initials: HLM
 Page: 1 of 2

Sample ID	Weight Boat ID	Boat Wt (g)	sediment (g)	Moisture Dry Weight (wet weight)	Percent EC50	Percent EC50	EC50
T-1	1	1.3868	28.0851	16.6629	42.8%	57.2%	26.312
T-2	2	1.3810	28.2588	21.3244	25.8%	74.2%	137.608
T-3	3	1.3819	29.4447	24.1295	18.9%	81.1%	NC
T-4	4	1.3907	21.8920	16.5982	25.8%	74.2%	119,340
T-5	5	1.3908	29.6031	17.4163	43.2%	56.8%	80,637
T-6	6	1.3888	30.5974	21.6935	30.5%	69.5%	166,772
T-6 dup	7	1.3819	30.7905	22.0385	29.8%	70.2%	NA

Overlying water was drawn off each sediment sample (as much as possible) prior to Microtox solid-phase testing and dry weight determination (samples were not centrifuged). Remaining sediment was used in test.

Each sample tested by Microtox Solid-Phase Test (SPT), using large sample procedure
 Large sample procedure calls for 7g sediment in 35 mL Microtox diluent yielding initial concentration of 200,000 mg/L.
 With addition of Microtox reagent, initial concentration is diluted slightly to 197,368 mg/L. Eleven serial 2:1 dilutions of the initial concentration were tested, for a total of 12 test containers plus 3 controls (15 vials per sample).

Microtox results are shown on both wet weight and dry weight basis.

Dried 20-30 g sediment for 18 h at 100°C, cooled in desiccator before obtaining dry weights
 Very good agreement between duplicates (2.3% relative percent difference for percent moisture)

Balance Used: A & D Model ER-120A, Serial Number 3502726

NC: EC50 not calculable because luminescence was not reduced >50% relative to controls
 NA: Not analyzed

10,112.9 1.57
 907.9 48.5

Table 1. Cont'd

Project Name: Elmendorf Air Force Base Date: 8-25-94
 Project Number: Initials: HLM
 Project Manager: Mark T. Murphy Page: 2 of 2

Dry weight concentrations using percent moisture

dry wt. = wet wt. - ((wet wt.)(percent moisture))

T-3 the last 2 cuvettes got mixed so the average is 119990 mg/L

Initial wet wt. conc.	T-1	T-2	T-3	T-4	T-5	T-6
197368.41	112929	146448	119990	146404	112112	137203
98684.21	56465	73224	119990	73202	58056	68601
49342.10	28232	36612	39997	36601	28028	34301
24671.05	14116	18306	19998	18301	14014	17150
12335.53	7058	9153	9999	9150	7007	8575
6167.76	3529	4576	5000	4575	3503	4288
3083.88	1765	2288	2500	2288	1752	2144
1541.94	882	1144	1250	1144	876	1072
770.97	441	572	625	572	438	536
385.49	221	286	312	286	219	268
192.74	110	143	156	143	109	134
96.37	55	72	78	71	55	67

Same as above just sorted from low to high concentration to be pasted into deltagraph

	T-1	T-2	T-3	T-4	T-5	T-6
96.37	55	72	78	71	55	67
192.74	110	143	156	143	109	134
385.49	221	286	312	286	219	268
770.97	441	572	625	572	438	536
1541.94	882	1144	1250	1144	876	1072
3083.88	1765	2288	2500	2288	1752	2144
6167.76	3529	4576	5000	4575	3503	4288
12335.53	7058	9153	9999	9150	7007	8575
24671.05	14116	18306	19998	18301	14014	17150
49342.10	28232	36612	39997	36601	28028	34301
98684.21	56465	73224	119990	73202	58056	68601
197368.41	112929	146448	119990	146404	112112	137203

Figure 1. Sediment Sample T-1

Elmendorf Air Force Base - Solid-phase Microtox test of sample T-1
EC50 = 15,055 ppm dry weight

Figure 2. Sediment Sample T-2

Elmendorf Air Force Base - Solid-phase Microtox test of sample T-2

EC50 = 102,106 ppm dry weight

Figure 3. Sediment Sample T-3

Elmendorf Air Force Base - Solid-phase Microtox test of sample T-3
EC50 = Not calculable, luminescence was not reduced by >50%

Figure 4. Sediment Sample T-4

Elmendorf Air Force Base - Solid-phase Microtox test of sample T-4
EC50 = 88,524 ppm dry weight

Figure 5... Sediment Sample T-5

Figure 6. Sediment Sample T-6

Elmendorf Air Force Base - Solid-phase Microtox test of sample T-6

EC50 = 115,934 ppm dry weight

FIELD CHAIN-OF-CUSTODY FORM

Client Name and Address						PWO/Contract No.		Analysis Required		Laboratory Use Only	
J.B. Tomlin Battelle PNL 3110 Port of Benton Blvd. Richland, WA 99352						Sampling Site		Comments		LAL Sample ID - Aliquot No.	
						Elmendorf AFB Alaska					
Client Sample ID	Collection Date	Time	Matrix Code*	Sample Type**	Field Preserved (Y or N)	No. and Volume of Containers					
T-1	7-26-94	0930	SL	G	N	1 ~ 80ml					
T-2	7-26-94	1105	SL	G	N	1 ~ 80ml					
T-3	7-27-94	0915	SL	G	N	2 ~ 80ml					
T-4	7-27-94	1100	SL	G	N	1 ~ 80ml					
T-5	7-27-94	1600	SL	G	N	2 ~ 80ml					
T-6	7-28-94	0900	SL	G	N	2 ~ 80ml					
A											
Date Data Required:						Cooler No.	234	Received for Laboratory By: (Signature)		Date	Time (am pm)
Relinquished by: (Signature) B. Tomlin								Method of Shipment:		Airbill No.	
Received By: (Signature) Heather L. MacInnes						7-28-94 11:30pm		Cooler Survey (pass/fail) → If FAIL, do not open cooler; contact the Program Development Department and the Radiation Safety Officer IMMEDIATELY.		Date	Time (am pm)
Relinquished by: (Signature)						7-29-94 1330		Surveyed by: (Signature)		Date	Time (am pm)
Received By: (Signature)								Cooler Condition Upon Receipt at Laboratory: Seals Intact: (VN) _____ Blue Ice Adequate: (YN) _____ Blue Ice Solid: (YN) _____		Date	Time (am pm)
Relinquished by: (Signature)								Internal Cooler Temp: _____ Samples In good condition: (YN) _____ Samples surveyed (pass/fail)		Date	Time (am pm)
*Sample Matrix Codes						*Sample Type Codes					
SW - Surface Water AR - Air WW - Waste Water						G - Grab					
GW - Ground Water SL - Soil FI - Filter C - Composite						O - Other					
DW - Drinking Water SD - Sediment O - Other											

Distribution: White Copy (Original), LAL Document Control (Master File)

Yellow Copy - Client / Sample Collection Crew

Appendix B

Ship Creek Bioassessment Investigation Work Plan Elmendorf Air Force Base Anchorage, Alaska

The following appended plans and other documents are included exactly as originally submitted in conformity to the Elmendorf AFB Federal Facilities Agreement. Pagination and format have been preserved and are not consistent with the preceding text.

SHIP CREEK BIOASSESSMENT INVESTIGATION
WORK PLAN
ELMENDORF AIR FORCE BASE
ANCHORAGE, ALASKA

DRAFT

January 1995

Prepared for
the U.S. Air Force
3rd SPTG/CEVR
9-824 L Street
Elmendorf Air Force Base, Alaska 99506
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

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1.0 Introduction

Investigative work described in this plan addresses issues and answers unresolved questions regarding a collection of potential contaminant sources at Elmendorf Air Force Base (AFB), Anchorage, Alaska (Figure 1.1), and their effect on aspects of the ecology of Ship Creek, located along the southern boundary of the base. These sites were listed in the Elmendorf AFB Federal Facilities Agreement (FFA) supporting the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup of the base. Specific objectives of the investigation are listed in Section 3.0.

S9407018.4A

Figure 1.1. Elmendorf AFB Locator Map

2.0 Background

2.1 Site Description

Elmendorf AFB is located on 13,130 acres in southcentral Alaska adjacent to the city of Anchorage (Figure 2.1). It is bordered on the north and west by Cook Inlet, on the south by urban parts of the city of Anchorage, and on the east by Fort Richardson, a U.S. Army installation. Detailed information on the base and the CERCLA action relevant to this investigation can be found in remedial investigation/feasibility study (RI/FS) reports for Operable Units (OU) 1 and 5.

2.1.1 Physiography

Elmendorf AFB lies in the Cook Inlet-Susitna lowlands, a physiographic province bordered on the west by the Alaska Range and on the east by the Chugach, Kenai, and Talkeetna Mountains. Landforms of the Cook Inlet-Susitna lowlands are primarily the result of glacial and glaciofluvial activity, modified by Holocene alluvial and colluvial action.

Bisecting the base in a northeast-southwest direction is the Elmendorf Moraine, a visually distinct terminal moraine associated with the latest stage of Naptowne glaciation, 13,690 to 11,690 years before present (Pewe and Reger 1983). Relief of the ridges and hummocks of the moraine varies between 200 and 380 feet above sea level. Ice-contact landforms are abundant in the area north of the moraine, including drumlins, eskers, kame terraces, and kettle lakes.

South of the moraine, glacial meltwater deposited coalescing fans of gravels and sands, mantled with loess. Relief is flat with elevations from 25 to 225 feet near the moraine, with incised streams of moderate gradient and high discharge.

2.1.2 Cultural Geography

The Cook Inlet-Susitna lowlands support the major population center of Alaska, comprising agricultural, industrial, and residential lands. Anchorage is the largest city in Alaska with a 1990 census population of 226,238. The population of Elmendorf AFB is 8600. The Port of Anchorage is clustered around the mouth of Ship Creek along the south and west of the base. Farther to the east, residential and industrial lands predominate.

On base, approximately 7000 acres of the 13,130 acres are undeveloped, including about 1400 acres of wetlands and surface water bodies. The 6000 acres of industrialized area support airfields, hangars, maintenance shops, office buildings, and residential space.

2.1.3 Geology

Figure 2.2 is a generalized geologic map of Elmendorf AFB. Bedrock does not crop out on the base but is exposed in the Chugach Mountains to the east. At that locality, crystalline rock is an interbedded sequence of metamorphosed sedimentary and igneous rock lumped together as the Upper Jurassic to Lower Cretaceous melange of the Chugach terrain (Beikman 1980). Overlying these units are moderately unconsolidated sedimentary rocks of the Tertiary Kenai group. These are in turn overlain by Pleistocene glacial and glaciofluvial unconsolidated sediments and Holocene alluvium. An important unit of the Pleistocene is the Bootlegger Cove clay, a low-permeability sequence that serves as a confining bed to underlying aquifers (see below). Soils of the Elmendorf AFB include coarse-grained sand and gravels, fine-grained silt and clay, and glacial till.

The region is tectonically active. A major fault, the Border Fault, fronts the Chugach Mountains to the east. Nine 8.0+ Richter magnitude earthquakes have been recorded in Anchorage over the last 85 years. The Alaska Range contains many active volcanoes, including Mount Augustine, Mount Redoubt, and Mount Spurr, which have all erupted depositing material at Elmendorf AFB within the last 10 years.

S9407018.2

Figure 2.1. Map of Elmendorf AFB Showing Relevant OU 5 and OU 1 Locations

Figure 2.2. Simplified Geologic Map of Elmendorf AFB

2.1.4 Hydrogeology

Shallow aquifer sediments within and north of Elmendorf Moraine consist of morainal (till) deposits. South of the Elmendorf Moraine, the shallow aquifer sediments are composed of alluvial fan, alluvial and outwash deposits, and tidal deposits. The most permeable and best water-producing units are present across the southern portion of the base. The least productive units are located in the northern section of the base and the bluffs overlooking Knik Arm. Due to topographic controls and sediment variation, the depth to saturation within the individual units varies from ground surface to more than 50 feet. Typical water level depths range from 5 feet near Ship Creek, to 35 feet at the closed landfill site near Building 34-018. The depth to groundwater along the heights of the Elmendorf Moraine may be approximately 50 to 60 feet below ground surface (Engineering-Science 1983a).

Shallow-aquifer groundwater flow occurs in a southerly or southwesterly direction across the southern part of Elmendorf AFB. The average hydraulic gradient within the unconfined aquifer along the southern portion of the base is 20 feet per mile (USAF 1993). Substantial amounts of stream flow within Ship Creek from its rise in the Chugach Mountain front to the Glenn Highway are lost through the alluvial fan deposits. However, the lower reach of Ship Creek, where it is entrenched in Bootlegger Cove Formation, gains groundwater flow. Thus Ship Creek is both a losing and gaining system (Weeks 1970).

Confined (artesian) hydrogeologic units include sand and gravel outwash deposits, alluvial sands, and mixed-till deposits. These units occur at moderate depths below ground surface and are typically overlain by substantial thicknesses of confining materials, such as the Bootlegger Cove formation. Outwash sands and gravels, which form the most prolific aquifer unit, occur along the southern extent of the base. This is the most dependable source of large quantities of groundwater; most municipal water system wells are completed in this unit. The least productive unit is the till, common to the installation uplands. Confined aquifer groundwater flow at Elmendorf AFB and in the Anchorage Bowl is generally in a westerly direction toward Knik Arm with a hydraulic gradient of 25 feet per mile (Engineering-Science 1983a).

Public water supplies are currently obtained from surface waters such as Eklutna Lake, the headwaters of Ship Creek, or through large-diameter, high-capacity wells completed in the confined aquifer system. Elmendorf AFB Bioenvironmental Engineering Services monitors groundwater quality of the confined aquifer on the base. The quality of water obtained from the confined system is generally good as measured by routine drinking water tests at municipal and base supply systems. These waters are generally classified as calcium and magnesium bicarbonate waters of moderate hardness.

Approximately 3 million gallons of surface water are used per day for base operations. This includes water for industrial, fire fighting, hospital, and domestic utilities use. Two surface water drainage basins occur within the Elmendorf AFB installation boundaries. North of the Elmendorf Moraine, most surface water drains into the Six Mile Creek Basin. South of the moraine, surface water generally drains south and west into Ship Creek, which is located on the southern border of the installation.

The Six Mile Creek Basin occupies a valley created by an old channel of Eagle River, approximately 10 miles north of Elmendorf AFB. The creek was once a spring-fed stream, but in 1951 it was dammed, and Lower Six Mile Lake was formed. Upper Six Mile Lake was created in the late 1950s. Lower Six Mile Lake is used as a sea- and float-plane base. Both lakes have other recreational uses, especially fishing.

Ship Creek has its headwaters in the Chugach Mountains east of Anchorage, and it discharges into Knik Arm. It is approximately 24 miles long, with a drainage basin of 117 square miles. Ship Creek flows over base property for 4.1 miles between Fort Richardson and Post Road below the base fish hatchery. The water is used at the fish hatchery and for cooling water for the power plant on base. The upper Ship Creek Basin, along the front of the Chugach Mountains, with its alluvial fan deposits,

is an important recharge area for the Anchorage confined aquifer and provides approximately one quarter of the total recharge to the system. The confined aquifer, in turn, provides drinking water for the Anchorage Bowl through large-diameter, high-capacity wells.

There are approximately seven named lakes and numerous unnamed ponds and wetland potholes. These lakes and wetland areas account for 1416 acres on the base. They range in size from about 4 to 124 acres, and maximum depths vary from 9 to 28 feet. The wetland areas are generally associated with hummocky topography and also occur within and north of the Elmendorf Moraine.

Surface water quality on the base is monitored by the Bioenvironmental Engineering Services group (Engineering-Science 1983a). They routinely monitor water at six locations and test for 20 parameters. Samples collected from Government Hill and Ship Creek generally have been uncontaminated, although elevated levels of iron concentrations have been noted.

2.1.5 Natural Resources

Metallic mineral resources are not mined on Elmendorf AFB property. Nonmetallic resources, such as sand and gravel, have been extracted for construction purposes from three pits on the base (Rothe 1983); one of these gravel pits is currently active.

Fishing for trout is permitted in Ship Creek; in the Six Mile Creek drainage; and in Hillberg, Green, Spring, Fish, Triangle, Lower Six Mile, and Upper Six Mile Lakes. These lakes do not support natural trout reproduction but are stocked annually with hatchery-reared rainbow trout. These lakes are also stocked periodically with landlocked king and silver salmon. Natural reproduction maintains large populations of rainbow trout and Dolly Varden in the Six Mile Creek drainage (Rothe 1983). The Six Mile Creek drainage has an annual return of between 2500 and 3500 salmon with all salmon species represented except steelhead. Military and civilian personnel use the Elmendorf AFB trout and Dolly Varden fishery in accordance with Alaska Department of Fish and Game (ADF&G) and military regulations.

Red, silver, king, pink, and chum salmon are found in base lakes and streams (Rothe 1983). However, only red salmon are recreationally important because fishing for the other salmonid species is restricted on Elmendorf AFB. Military regulations allow the taking of salmon from below the mouth of the Six Mile Creek in Cook Inlet waters.

Forest and woodland areas compose 78% of the cover on base. In order of abundance, paper birch, white spruce, balsam, poplar, aspen, black spruce, and alder are the dominant trees. The forest community on the base is home to over 92 species of birds at different times of the year. The most abundant are warblers, thrushes, kinglets, woodpeckers, and robins. Frequent sightings of raptors (hawks and eagles) occur on Elmendorf AFB. At least one active eagle nest is located north of Lower Six Mile Lake. Low densities of grouse and ptarmigan inhabit the forested areas. These slow-moving birds are preyed upon by owls and by coyotes and foxes, which are predominant in this habitat. Mammals found in the forest habitat on the base include moose, bear, coyote, fox, and smaller animals.

Moose are found in all areas of the base and use a variety of habitats. Summer activities center around forested and wetland areas. Winter finds them concentrating on the base lowlands where they can find willow, birch, and aspen browse habitat.

The tall shrub assemblage is dominated by alder and composes about 16% of the vegetative cover on the base. Twenty-four species of bird are found among the tall shrubs (Rothe 1983). Common snipes, flycatchers, and sparrows are common in the tall shrub plots but are rare on the forested plots.

Moose are rarely found in thick stands of alder due to the lack of browse material. This type of vegetation contains compounds that inhibit digestion (Rothe 1983). Small mammals, as seen on the

forested plots, are also found in tall shrub areas. Bears are not expected to be found in dense stands of alder because they prefer the closed, forested areas of the base.

The low shrub and sedge-grass habitats compose about 1% of the cover on the base. The types of low shrubs and grasses change with changing moisture regimes. Zones of low shrub vegetation surrounding bogs and ponds include dwarf black spruce and low scrub. Wet meadows occupy small kettles (glacial ice pit depressions) and are dominated by blue-joint grass. Slightly wetter sites support growth of sedges. Low shrub areas near wetlands are common habitat for several bird species including yellowlegs (Rothe 1983). Common snipe are abundant in the sedges and grasses of wet meadow areas.

Moose and small mammal species also use the sedge-grass assemblage. The grassy areas are heavily used by moose in spring and summer. Meadow voles prefer the moist treeless sites with dense grass cover. Geese commonly use the grassy areas and lawns of the base during spring and fall migrations.

Lake and stream habitats on the base support vegetation, fish, bird, and mammal populations. Submerged, rooted aquatic plants are found in all lakes on Elmendorf AFB. Dominant vegetation types include pond lily, water lily, pond weeds, and mare's tail. Sedges and cattails line the banks of most lakes and streams. Boggy areas support mosses, cotton grass, cranberry, rosemary, and sedges.

Upper and Lower Six Mile Lakes are productive waterfowl areas. These lakes are shallow and have sloping margins dominated by cattails and grasses. In comparison, Triangle and Fish Lakes are natural bog lakes having abrupt margins, deep water, and little cover, and are therefore less productive waterfowl habitats. Red-necked grebes are the most abundant water bird on the base. Mallard and ring-necked ducks and mew gulls are also commonly found in aquatic habitats on the base (Rothe 1983). Northern water thrushes are among the last spring birds to arrive and are common in local areas around lakes and ponds. Rusty blackbirds are abundant along Six Mile Lake. Common loons are occasionally sighted in Upper Six Mile, Lower Six Mile, Hillberg, Spring, and Green Lakes. Both common and arctic loons are annual nesters on Upper Six Mile, Lower Six Mile, and Oval Lakes.

Aquatic mammals such as beaver are common on the base. Active lodges are found on Upper and Lower Six Mile Lakes. Mink are present in Otter and Upper Six Mile Lakes. Muskrats are not abundant on the base but occasionally have been sighted.

Wetlands, lakes, streams, and moose browse areas on the base considered environmentally sensitive (USAF 1993). Wetlands support large populations of fish and birds and are particularly sensitive to pollution. In addition, closure of the fish ladder around the hatchery dam on Ship Creek by the ADF&G prevents salmon from reaching the remaining spawning beds on base.

2.1.6 Climatology/Meteorology

Elmendorf AFB is situated in a transitional climatic zone between the maritime climate effects to the south, and the interior or continental climate zone to the north (Selkregg 1972). The St. Elias and Chugach Mountains to the south act as a barrier to the maritime influences of the northern Pacific Ocean, while the Alaska Range to the north protects the area from the extreme cold air masses of the state's interior region. The proximity of the base to Cook Inlet provides additional temperate effects on the climate.

Average annual precipitation for the Elmendorf AFB area is 15.9 inches. Most of this precipitation falls from June through October. Snow with minor amounts of rain is prevalent October through April. Average snowfall during the period is 69.4 inches (5.8 inches of precipitation), which is 36% of the annual precipitation. Rainfall averages 1.49 inches during this same period. January exhibits the lowest monthly mean temperature at 12°F. The highest monthly mean temperature (58°F) is in July. Daily temperature fluctuations are generally 13°F to 14°F.

Above-surface air flow in the Elmendorf AFB area is generally toward the northeast and northwest. Surface flow, however, is more variable. During summer, surface winds blow west and northwest onto the base from Cook Inlet. In winter, these winds are more likely to blow south along Knik Arm. Surface wind velocities average 5.8 knots, although channeling of the winds near Ship Creek is common with velocities reaching 53 knots (Rothe 1983).

2.2 Project History

Detailed information on the background of this project is available in the Elmendorf AFB OU 5 RI/FS reports (USAF 1993). A summary of that discussion follows.

Elmendorf AFB (the "site") is the areal extent of the entire base and includes individual "sources" or "source areas" of contamination. The 62 source areas of suspected contamination initially identified in the Elmendorf AFB installation restoration program (IRP) ranged from large fuel spills, which require significant remedial action to address threats to public health and the environment, to small discrete hazardous waste storage areas that pose small potential risk. Of the original 62 sources, 32 source areas are regulated by the CERCLA remediation process and are listed in the FFA. Groundwater contamination, type of contaminant, source history, and potential risk were factors in placing sources under CERCLA. The 32 CERCLA sources were grouped into 7 OUs. Each OU consists of contaminant source areas with similar characteristics. The purpose for dividing the site into OUs is to make the task of overall remedial assessment more manageable. Of these areas, OU 1 and OU 5 are relevant to this investigation and will be discussed further below.

2.3 Waste Management Practices

Reviews of past waste generation and disposal practices have concluded that the sources of most hazardous waste originated in fuels management, fire training, and industrial operations. From 1945 to 1990, approximately 30,000 to 52,000 gallons per year of waste oils, fuels, solvents, and cleaners were generated at Elmendorf AFB (HLA 1988).

During the early period of base operations (1940s through early 1960s), waste chemicals, particularly solvents, were drained to the storm and sanitary sewers, floor drains, and dry wells proximal to the generating facilities. Some of the wastes were discharged to surface drainage ditches. Combustible chemicals, such as oils, fuels, and petroleum solvents, were used as fuel for fire training exercises. Some waste oils were also spread on roads for dust control (Engineering-Science 1983b). Elmendorf AFB landfills contain solid and hazardous wastes including general refuse, construction rubble, scrap metal, drums of spent chemicals, partially full cans of pesticides and paints, drums of asphalt, petroleum, oil, lubricants (POL) tank cleanout sludge, fuel filters and pads, and other small quantities of various shop wastes.

Since mid-1981, waste chemicals have been temporarily stored and managed at a Resource Conservation and Recovery Act (RCRA) hazardous waste storage facility on Elmendorf AFB.

2.4 Source Area Descriptions

Information on the source areas for OU 1 and OU 5 are contained in the relevant RI/FS reports on these areas. The locations of the OUs defined for Elmendorf AFB, base supply wells, and other geographic and structural landmarks are shown on Figure 2.1. Brief discussions of source areas that compose each OU are presented below.

2.4.1 Operable Unit 1

Operable Unit 1 consists of landfills LF05, LF07, LF13, LF59, and OT56 (Figure 2.1). These landfills are all close to each other, and the contaminants are similar.

Source LF05 - Sanitary Landfill: Source LF05 is on the southeastern portion of the base, west of Ammo Storage Area B, east of DRMO, and north of Ship Creek. Approximately 17 acres were used as a sanitary landfill from 1951 to 1973. Trench and fill procedures were used at the site to dispose of general refuse, scrap metal, spent chemicals, and other scrap materials. The trenches were generally excavated 14 to 16 feet below ground surface; however, one 30-foot-deep trench was excavated on the east side of the landfill. The exact locations and lateral extent of the trenches are unknown.

The landfill has been closed and is covered by brush, trees, and grasses. Scrap metal, car bodies, storage tanks, and drums are piled in the extreme northeastern portion of the source area.

Source LF07 - Sanitary Landfill: Source LF07 was a former operating solid waste landfill for Elmendorf AFB. This landfill occupies about 35 acres and has been used for disposal of base-generated refuse, scrap metal, construction rubble, drums of asphalt, and empty pesticide containers since 1985. Small amounts of shop wastes were disposed of, and an active area of this landfill received asbestos waste in the extreme southeast portion of the source area. Two gravel pits, 30 to 40 feet deep, have been operated in this source area using area fill methods. The south pit was closed in 1982 and covered with 2 to 4 feet of local soil.

Source LF13 - Disposal Site: Source LF13 is an old gravel pit that was used as a disposal site from 1967 to 1971 and is located between Source LF05 and LF07 landfills. This 2-acre source area was used to dispose of empty drums, metal piping, drums of asphalt and small quantities of quicklime. The method of operation was trench and fill of the pit. Surface drainage from this area is to Ship Creek. The source area is covered with soil and was initially covered with dense brush. Recently, the source area has been covered with second-growth trees and grass except where it has been cleared.

Source OT56 - DRMO Scrap Pile: Source OT56 is north of Source LF13, east of Source LF05, and north of Source LF07. Drums containing various types of materials are stored at this source area, and some staining of the soil has resulted.

Source LF59 - Asphalt Seep: Source LF59 is southwest of Source LF07, across the Davis Highway. This source has not been identified or addressed in any of the previous IRP investigations and reports for Elmendorf AFB.

2.4.2 Operable Unit 5

Four source areas are included in OU 5 (Figure 2.1). These source areas incorporate six original source areas at the southern perimeter of Elmendorf AFB just north of Ship Creek. These source areas were grouped together due to the potential for offsite migration of contamination, impacts on Ship Creek, and possible influence from offsite sources. Assorted POLs are the primary contaminants at the source areas in OU 5.

Source ST37 - Diesel Fuel Line Leak: Source ST37 is a diesel line fuel leak that occurred just south of the U.S. Army Corps of Engineers (COE) building during 1956 to 1958. Diesel fuel seeped out of the ground near the railroad tracks. Thousands of gallons of diesel fuel were recovered at this location during the late 1950s. An unknown amount may have remained below ground. The gravel moraine of the area is porous, and the source area is located on a south-facing bluff above the Ship Creek flood plain.

Source SD40 - Railroad Maintenance Area Oil Seepage/Source ST46 - JP-4 Fuel Line Leak: Source SD40 is near the railroad maintenance facility, approximately 600 feet north of Ship Creek, near the cooling pond on the south part of Elmendorf AFB.

Engineering-Science (1983b) documented that, during the late 1960s, quantities of brownish oil were observed seeping out of the bank near the railroad maintenance facility into the marsh area south of the facility and flowing into Ship Creek.

Source ST38 - JP-4 Fuel Line Leak/Source SS42-Diesel Fuel Spill: Source ST38 is just north of the Alaska Railroad and east of Maple Street. As a result of a fuel line leak, an unknown quantity of JP4 seeped out of the bank southeast of Building 22-010, near the drainage ditch crossing Post Road during 1964 and 1965. No fuel was recovered at this location (Engineering-Science 1983b).

Source SS42 is located at Building 22-013 (Figure 2.1). An estimated 8000-gallon, one-time spill of diesel fuel occurred on March 31, 1976. The spill occurred when the overflow valve failed during transfer of fuel from an aboveground tank to an underground tank. Most of the fuel was reportedly recovered off the frozen ground (Engineering-Science 1983b).

Source SS53 - Golf Course Seep: Source SS53 is south of Post Road, north of Ship Creek, and immediately north of the Golf Course Pro Shop. The slope where this source is located is less than 500 feet southwest of Ship Creek. In addition, Elmendorf AFB supply well BW-52 is less than 500 feet down-gradient of the source area. Petroleum hydrocarbons have been detected in base supply well BW-52.

2.5 Data Quality Analysis

Data quality objectives for this investigation were developed using U.S. Environmental Protection Agency (EPA) 1993 and discussion with remedial project managers (RPMs). The data generated by this study will support a decision on the following question:

Are the source areas of OU 1 and/or OU 5 or any other base source measurably impacting the biotic community of Ship Creek?

Resolution of this problem will result in an RPM decision on the inclusion of Ship Creek in the scope of future CERCLA work.

This decision will require conducting a cumulative assessment for the biotic impact of Elmendorf AFB source on Ship Creek populations. The results of this assessment will include various data and calculated indices that judge the ecological viability of the Ship Creek ecosystem. As such, the geographical boundaries of this investigation encompass the Ship Creek watershed where it spatially coincides with the boundary of OU 1 and OU 5. A decision rule may be posed:

If the cumulative impact from Elmendorf AFB sources to biota on Ship Creek is low to nonexistent, then the area will not be part of the scope of future CERCLA work.

The EPA protocol appropriate to this kind of ecological investigation is detailed in EPA 1993. A false positive error will result in a scope of the future Elmendorf AFB CERCLA actions that does not include cumulative ecological effects on Ship Creek, despite the contaminant impact. This error is unlikely since, if cumulative effects were important, the specific investigations would uncover impacts on biota that could not be attributed to the specific sources and further study would be required. A false negative would result in an unneeded expansion of scope to include an unimpacted site, Ship Creek.

Based on this analysis, the category of analytical data required for this study is EPA "Screening Data with Definitive Confirmation." This data category indicates that formal validation of data is required for 10%, or at least three of the samples (EPA 1993). The remainder of this document outlines the sampling plan necessary to implement the plan. Accuracy and precision criteria are discussed in Section 4.0.

3.0 Sampling and Analysis Plan

The following work is proposed to evaluate the impact of Elmendorf AFB contaminants on one aspect of the ecology of Ship Creek, the macroinvertebrates. Quality assurance (QA) concerns can be found in the QA project plan (QAPP), attached as Appendix 1.

3.1 Macroinvertebrates

The objective of this investigation is to conduct a Rapid Bioassessment Protocol II sampling at six transects on Ship Creek in the vicinity of Elmendorf AFB (Figure 3.1), calculate various biological indices, and provide a preliminary Rapid Bioassessment Rating for each transect. This protocol has been modified to preclude certain indices not appropriate to Ship Creek.

Transects will be sampled at the following locations:

- Transect 1: This will be the control transect and will be located upstream of the intersection of Ship Creek and the Glenn Highway.
- Transect 2: Approximately 1200 meters downstream from Transect 1 where the Walton Road crosses Ship Creek. This is located upstream from OU 1 and would serve as the control station for that OU.
- Transect 3: Approximately 2300 meters downstream from Transect 2 near where the Davis Highway crosses Ship Creek. This is below OU 1 and comparison of data collected here with that collected at Transect 2 would provide information on possible impacts from OU 1.
- Transect 4: Approximately 1100 meters downstream from Transect 3 just upstream from the pumping station. This will serve as the control station for OU 5 and is located upstream from that OU.
- Transect 5: Approximately 1800 meters downstream from Transect 4 and just above the dam adjacent to the fish hatchery. This is located below OU 5 and comparison of data collected here with that collected at Transect 4 would provide information on possible impacts from OU 5.
- Transect 6: Approximately 2000 meters downstream of Transect 5. This would place it below the section of OU 5 located below the fish hatchery. Data would reflect possible impacts associated with the lower section of OU 5 and from the fish hatchery.

Exact locations of transects will be determined in the field to ensure comparability. Factors used in this determination include stream discharge and depth, stream morphology, substrate texture, riparian cover, and habitat diversity.

Work will follow the basic protocol described in Plafkin et al. (1989), with the exception that only those chemical measurements shown below will be made. The protocol described in Hayslip (1993) for the Region 10 bioassessment protocol is designed more for interregional assessment of stream reaches, rather than comparing relative short distances or transects of a single stream.^(a)

A physical/chemical habitat assessment and macroinvertebrate collections will be made at each transect. All relevant data will be recorded in the field on standard forms or forms adapted for our sampling protocol. The following physical/chemical measurements to be made:

(a) Personal communication: spring of 1994, Robert W. Plotnikoff, Washington State Department of Ecology.

S9407018.3

Figure 3.1. Location of Sampling Transects for Rapid Bioassessment of Ship Creek

water temperature
dissolved oxygen concentration
conductivity
pH.

Pacific Northwest Laboratory (PNL) will measure the following habitat assessment characteristics:

predominant surrounding land use
local watershed erosion
local watershed nonpoint-source pollution
estimated stream width
estimated stream depth
high water mark
velocity/flow
dam presence
degree of channelization
canopy cover
sediment characterization (odor, oils, deposits)
bottom substratum and available cover
embeddedness
scouring
pool/riffle and run/bend ratios
bank stability
bank vegetation
streamside cover.

PNL will collect samples of macroinvertebrate biota under the following scheme.

Two 1 m² kick samples will be collected from riffle/run habitat, composited, and the indices listed below calculated. One sample will be collected from coarse particulate matter (CPOM) to qualitatively evaluate shredder abundance.

Following collection methods as described in Plafkin (1989), PNL will identify to genera all Ephemeroptera, Plecoptera, and Trichoptera, and to family for other taxa. The following indices will be calculated:

number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) genera
average number of EPT/total individuals
percent dominant taxa
family biotic index (FBI)
preliminary rapid bioassessment rating (RBA).

PNL will also provide a semi-quantitative assessment of relative densities of macroinvertebrates at the transects. These data will be obtained from the riffle/run samples. True quantitative samples are not collected in the RBA protocol.

Following the calculation of the above metrics and sediment data (see below), a full report will be written that will include sufficient text, tabular, and graphical information to permit realization of the objectives of the study. Photographs of the study sites will be included.

3.2 Sediments

In order that a well-controlled relationship is established between benthic biota and substrate, sediment samples will be collected from each of the transects. Sediments will be removed using a stainless-steel scoop or trowel from a depth of about 10 centimeters at the same sites where

macroinvertebrates are collected. Samples will be composited in the sample container without physical stirring to avoid volatile losses. Parameters analyzed are shown in Table 3.1.

Separate samples will be retrieved from each transect for bioassay. The samples will be analyzed at the Battelle/Marine Sciences Laboratory using the Microtox© Solid-Phase Test procedure. This analysis exposes a photoluminescent bacterium to a concentrated suspension of the sample. By measuring the decrease in luminescence, bacteria mortality is quantified and the results compared to the chemical analysis.

Table 3.1. Parameters and Methods for Ship Creek Investigation

Parameters	EPA Method
Volatile organic compounds/BTEX	8010/20
ICP-MS metals	6020
Mercury	7471
Total organic carbon	415
Total petroleum hydrocarbons	8015 mod.
Diesel range organics/gasoline range organics	8015 mod.

4.0 Field and Laboratory Procedures

Procedures used in this study are detailed in:

Procedures for Ground-Water Investigations (Bryce 1992)

EPA Region 10 In-Stream Biological Monitoring Handbook (Hayslip 1993).

Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish (Plafkin et al. 1989).

The specifics of these methods as they apply to this investigation follow.

Soil samples will be collected using a stainless-steel trowel as described in ASTM Standard D-4700-91, *Standard Guide for Soil Sampling from the Vadose Zone*. Samples will be sealed in pre-labeled, widemouthed glass jars and shipped in iced coolers overnight to PNL.

All sampling data will be recorded in PNL laboratory record books. Decontamination will take place prior to and between sampling. Each piece of non-disposable equipment will be scrubbed with Alconox solution, rinsed in tap water, and triple rinsed with deionized water. Decontamination water will be accumulated for Elmendorf AFB approved disposal and a rinsate blank sample will be pulled with each sample set.

4.1 Accuracy, Precision, and Completeness Objectives

All samples will be analyzed by Lockheed Analytical Laboratory (LAL), Las Vegas, Nevada, under subcontract to PNL. The data quality objectives outlined above support a Superfund data category of "screening data" (EPA 1993) with validation of at least three samples. The data will be used for screening purposes and will support an administrative decision. These data quality objectives (DQOs) suggest the analytical methods listed in Table 3.1, based upon the detection limits and the historical limits to precision and accuracy derived from LAL. These accuracy, precision, and detection limits are listed in Tables 4.1 and 4.2.

4.2 Sample Delivery, Holding, and Storage

All samples will be stored and shipped in a manner appropriate to accurately represent the site conditions and to provide the necessary level of data precision, in accord with Bryce (1992). Table 4.3 gives the preservation, storage, and holding times appropriate to each method. Any variance will be documented and chain-of-custody protocol will be in accord with LAL quality control (QC) procedures.

Samples will be sealed and labeled as described above. Insulated coolers, packing material, and commercial coolant will be used to regulate temperature until receipt by the laboratory. Samples will be shipped by overnight mail, and the laboratory will be alerted at the time of posting. QA chain-of-custody protocol will be continued upon arrival of the sample at the laboratory. Sample preservation will be maintained until extraction or analysis as appropriate. Following acceptance of the data, excess samples will be disposed of by the laboratory according to all applicable laws and regulations. Specific information on the preservation and handling procedures are contained in Table 4.2.

4.3 Sample Analysis

The chosen EPA methods appropriate to this study are listed in Table 3.1. Specific lists of analyses proposed for each source are listed above. Specific details of the methods are contained in (EPA 1979). Sample blanks will include: *trip blanks*, deionized water in 40 milliliter volatile organic

Table 4.1. Methods and Detection Limits

Metals in Soils

Constituent	Method(a)	RDL(b) (mg/kg)
Antimony	6020	40
Arsenic	6020	2.0
Barium	6020	40
Beryllium	6020	1.0
Cadmium	6020	1.0
Calcium	6020	400
Chromium	6020	2.0
Cobalt	6020	20
Copper	6010	5.0
Iron	6010	20
Lead	6020	0.60
Magnesium	6020	400
Manganese	6020	3.0
Nickel	6020	8.0
Potassium	6010	400
Silver	6020	2.0
Sodium	6020	400
Tin	6010	40
Vanadium	6020	10
Zinc	6010	4.0

Total Petroleum Hydrocarbons in Soils

Diesel range	8015-Modified	30
Gasoline range	8015-Modified	30

Volatile Organic Compounds in Soils

Benzene	8020	2
Carbon Tetrachloride	8010	0.5
Chloroform	8010	0.5
p-Dichlorobenzene	8020	2
1,1-Dichloroethane	8010	1
1,2-Dichloroethane	8010	0.5
cis-1,2-Dichloroethylene	8010	1
trans-1,2-Dichloroethylene	8010	1
Ethylbenzene	8020	2
Methylene Chloride	8010	5
Tetrachloroethylene	8010	0.5
Toluene	8020	2
1,1,1-Trichloroethane	8010	0.5
1,1,2-Trichloroethane	8010	0.2
Trichloroethylene	8010	1
Vinyl Chloride	8010	0.5
Xylene (Total)	8020	5

(a) SW-846.

(b) Contract required detection limit.

Table 4.2. Accuracy, Precision, and Completeness Criteria

Analyte	Method	Accuracy (% Recovery)	Precision (Relative % Difference)	Completeness
Metals	6010/6020	75% - 125%	±20%(a)	95%
Mercury	7471	75% - 125%	±20%	95%
Volatile organics	8010/8020	(b)	(b)	95%
Gasoline range organics	8015 mod.	75% - 125%	±20%	95%
Diesel range organics	8015 mod.	75% - 125%	±20%	95%

- (a) For analytes with concentrations greater than 10 times the detection limit of the analysis.
(b) Methods for determining accuracy and precision criteria for each analyte are described in SW-846.

Table 4.3. Sample Containers, Preservatives, and Holding Times

Constituent	Method	Container	Preservative	Holding Time
BTEX	8020	3 40-ml glass, teflon-lined septum	Cool 4°C	14 days
Volatile organics	8010	3 40-ml glass, teflon-lined septum	Cool 4°C	14 days
ICP metals	6020/6010	1-L polyethylene	Cool 4°C	6 months
Mercury	7471	1-L polyethylene	Cool 4°C	6 months
Total organic carbon	9060	1-L amber glass	Cool 4°C	28 days
Diesel range organics	8015 mod.	1-L amber glass	Cool 4°C	14 days
Gasoline range organics	8015 mod.	3 40-ml glass, teflon-lined septum	Cool 4°C	14 days

compound (VOC) vials that will be prepared by the laboratory and will accompany the sample containers, one per cooler, into the field and back to the laboratory. *Field blanks*, samples of decontamination rinse water, will be taken every 20 samples. Replicate samples will be created during sampling by splitting retrieved soil, sediment, or water onsite.

Matrix spikes will be created at the laboratory. Spike samples, replicates, and field blanks will be generated every 20 samples per medium, with a minimum of one each per sample set. Table 4.1 contains accuracy and precision performance limits of each analyte based upon EPA historical data.

4.4 Data Validation and Verification

Because the data collected by this investigation will support an administrative decision and will not be used in a risk assessment, there will be formal validation of three samples (EPA 1993). Data verification, limited to checks of accuracy, precision, representativeness, completeness, and procedural compliance of the laboratory, will be independently conducted by PNL.

4.5 Reporting Results

Data produced by LAL and included in the final report will be the following:

- analytical results
- complete chain-of-custody records
- method detection limits
- field duplicate results
- matrix spike results
- certificate of analysis
- a presentation of the accuracy and precision of the data.

Following independent review and verification by PNL, data will be entered into spreadsheet format. Summaries of all data including undetected analytes will be contained in the final report. Laboratory reports will be included in an appendix to the report. Any material not included in the report will be archived as per PNL Records Management procedures.

5.0 Health and Safety

All work on the Ship Creek Bioassessment investigation will fully conform in spirit and letter to the base-wide Health and Safety Plan (HASP). A specific health and safety plan is attached as Appendix 2. A brief summary of salient details follows.

Sampling teams will be made up of two or more persons and will utilize 40-hour Occupational Safety and Health Administration (OSHA) certified personnel only. Site physical hazards are potentially weather stress, trips, slips and falls, animal and insect encounters, and equipment accidents. No hazardous chemicals will be introduced to the site and hazards are limited to the contaminants present. These are discussed in detail in the HASP, Appendix 2.

The chain of command including health and safety responsibilities for sampling parties is discussed in Appendix 2. Medical surveillance is assured by the use of 40-hour OSHA certified hazardous waste workers. PNL policy, as listed in the site HASP, details the response required for these employees. In addition to the general training, each team will daily review the HASP, including particular health hazards expected and tailgate safety meetings will precede daily field work.

Based upon the level of anticipated risk (Appendix 2), the level of personal protective equipment (PPE) will be Level D-Modified. This level will be maintained as long as conditions meet the requirements of the site HASP as determined by the Site Coordinator. Level D-Modified, includes:

- nitrile gloves
- steel-toe safety boots
- safety glasses
- coveralls.

Respiratory gear will not be required unless an elevation of PPE is indicated. Action levels for this are established in Appendix 2 and will be based on continuous monitoring with daily calibrated HNu and O₂/LEL meters.

Site control will be affected through the use of yellow warning tape and standard exclusion and decontamination zones, where required. Standard operating procedures relevant to these controls and emergency planning are listed in Appendix 2 and the site HASP.

6.0 Schedule

The work planned will not result in an Elmendorf AFB FFA primary document and does not appear on the CERCLA Management Plan master schedule. The schedule below has been written such that ongoing work at OU 1 can use the results with maximum efficiency.

<u>Milestone</u>	<u>Delivery Date</u>
Draft work plan complete	July 11, 1994
Agency comments received	July 21, 1994
Final work plan delivered	July 25, 1994
Field work begins	July 27, 1994
Field work ends	July 30, 1994
Analytical results back from laboratory	September 15, 1994
Draft report complete	November 1, 1994
Agency comments received	December 1, 1994
Draft final report complete	January 1, 1995

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Appendix 1-Quality Assurance Project Plan

QUALITY ASSURANCE PROJECT PLAN NO. EES-124, REVISION 0

QA PLAN FOR

**ELMENDORF AIR FORCE BASE
SHIP CREEK BIOASSESSMENT INVESTIGATION**

PREPARED BY

**PACIFIC NORTHWEST LABORATORIES
P.O. BOX 999
RICHLAND, WASHINGTON 99352**

Issue Date:

Concurrences and Approvals:

M. T. Murphy, Project Manager	Date
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P. E. Long, Technical Group Leader Geology and Geophysics	Date
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R. J. Burkey, Quality Engineer	Date
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C. D. Taylor, DOD Team Coordinator Process Quality Department	Date
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Distribution:

MT Murphy
RJ Burkey
CD Taylor
CJ Booth (PQD File Copy)
Records Management (KM Schanke)

1.0 QUALITY ASSURANCE PROGRAM

This Quality Assurance (QA) Project Plan applies to the Pacific Northwest Laboratories' (PNL's) Elmendorf Air Force Base (AFB) Ship Creek Bioassessment Investigation Project staffed by members of the Earth and Environmental Sciences Center.

The QA program described here was developed to address the U.S. Environmental Protection Agency's (EPA) QAMS-005/80, Interim Guidelines for Preparing Quality Assurance Project Plans. Procedures referenced in this QA Project Plan can be located in PNL's Quality Assurance Manual, PNL-MA-70.

PNL's current Quality Assurance program (PNL-MA-70) is based on ASME NQA-1-1989, Quality Assurance Program Requirements for Nuclear Facilities and meets the majority of the requirements of DOE 5700.6C. Further enhancements to the program with special emphasis on the use of Continuous Improvement (CI) processes are in progress.

The work conducted under this Quality Assurance Project Plan has been determined to be overall PNL Impact Level III in accordance with PAP-70-208, Impact Levels.

2.0 PROJECT DESCRIPTION

Investigative work described in this plan addresses issues and answers unresolved questions regarding a collection of potential contaminant sources at Elmendorf Air Force Base, Anchorage, Alaska, and their affects on aspects of the ecology of Ship Creek, located along the southern boundary of the base.

The project number for the Elmendorf Air Force Base Ship Creek Bioassessment Investigation is 18483.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Line authority, QA authority and support within PNL, and interfaces with Elmendorf AFB are shown in Exhibits 3.1 and 3.2. The responsibilities of key PNL personnel are summarized in Table 3.1.

Changes to organizational/interface structures shown in Exhibit 3.1 that do not reflect a change in the overall scope of the activities or a change of requirements will not require a QA Project Plan revision but will be documented in writing in the project files.

The Work Breakdown Structure (WBS) for the Elmendorf AFB Project is shown in Exhibit 3.3.

TABLE 3.1. Responsibilities of Key Personnel

<u>Personnel</u>	<u>Responsibilities</u>
Earth and Environmental Sciences Center Management	Provides Management review of the project. Assures appropriate and qualified staff are available.
Project Manager (MT Murphy)	Interfaces with Elmendorf project personnel and provides reports of activities. Provides overall PNL direction of the project. Ensures that the QA project plan is prepared and implemented and that data, QA information, and reports are produce in a timely manner. Has direct contact with the PNL Quality Engineer.
Field Sampling Staff	Perform sampling and testing activities in accordance with methods in Field Sampling Plan.
Quality Engineer (RJ Burkey)	Provides the Project Manager with QA requirements interpretation and implementation assistance. Provides for Quality Assurance training as necessary. Provides for independent quality assurance assessments. Is responsible for reviewing QA project plans.
Process Quality Department DOD Team Coordinator	Provides QA support (e.g., QA requirement interpretation, external audit preparation, QA project plan development or revision, document review and interfacing with client QA personnel). Provides oversight to verify project activities are performed consistent with applicable requirements identified in this QA Project Plan.

**PROJECT ORGANIZATION
ELMENDORF AFB**

4.0 DATA QUALITY OBJECTIVES

The data collected for the Elmendorf AFB Project are used to identify and quantify contaminant problems and to assess contaminant migration. These assessments are intended to meet the needs of the Air Force Base, the U.S. Environmental Protection Agency, the Alaska Department of Environmental Conservation, and the general public. The Elmendorf AFB Project has considered these needs in establishing the Data Quality Objectives (DQOs) to be applied to data collection for the Project.

The intent of the DQOs established for chemical constituents is to quantify these constituents below concentrations that are of concern to public health and safety (e.g., the USEPA Drinking Water Standard). Table 4.1 contains the applicable Quality Control measurements and the minimum frequency they need to be performed during sampling and analysis.

The characteristics used to define data quality are precision, accuracy, completeness, representativeness, comparability. For this project only precision, accuracy, completeness and comparability will be used to assess data quality. The definitions used for these terms are as follows:

4.1 Definitions

Precision - a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions.

For this project, measures of analytical precision will be determined by the analysis of laboratory replicates. Laboratory replicates will be prepared by homogenizing and splitting a sample in the laboratory, and carrying the subsamples through the entire analytical process.

Precision can be expressed in terms of the relative percent difference (RPD).

$$RPD = \frac{C_1 - C_2}{C_{av}} \times 100$$

RPD=Relative percent difference

C₁=Measured concentration from sample

C₂=Measured concentration from the sample duplicate

C_{av}=Average value of the two measured concentrations

Accuracy - a measure of the bias of a system or measurement. It is the closeness of agreement between an observed value and an accepted value.

For this project, accuracy of chemical analyses will be determined through the analysis of matrix spikes, method blanks, equipment blanks, and, when available, standard reference material (SRM). SRMs are materials that have been certified by a recognized authority (e.g., National Institute of Standards and Technology) and which are treated and analyzed as an actual

Table 4.1 Frequency of Collection of Quality Control Samples

Type of Sample	Frequency of Collection
Field Duplicate	1 per 10 samples (10%)
Equipment Blank	1 per 20 samples (5%)
Transfer Blank	1 per 10 samples (10%)
Laboratory Duplicate	1 per 20 samples (5%)
Matrix Spike	1 per 20 samples (5%)
Method Blank	1 per 20 samples (5%)
Standard Reference Material	1 per 20 samples (5%)

sample. Matrix spikes will be performed by adding a known quantity of target analytes into a sample and preparing and analyzing the sample the same as a regular sample. Method blanks will be used to measure contamination associated with laboratory processing and analyses. Equipment blanks will be used to measure contamination associated with sampling procedures.

For measurements where matrix spikes are used, percent recovery will be calculated as follows:

$$\%R = 100 \times \frac{S-U}{C_{sa}}$$

%R=Percent recovery
S=Measured concentration in spiked aliquot
U=Measured concentration in unspiked aliquot
C_{sa}=Actual concentration of spike added

For situations where a SRM is used, relative percent difference will be calculated as follows:

$$RPD = \frac{C_1 - C_2}{C_2} \times 100$$

RPD=Relative percent difference
C₁=Measured value
C₂=Certified value

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

Target completeness values are 75% for sample collection, and 95% for sample analysis.

$$\%C = 100 \times \frac{V}{n}$$

%C=Percent Completeness
V=Number of Valid Data Points Acquired
n=Total Number of Data Points

Comparability - expresses the confidence with which one data set can be compared to another.

Comparability for this project will not be quantified, but will be addressed through the use of consistent field procedures and EPA laboratory procedures. Comparability of other data will be discussed, when appropriate, in the final report.

Representativeness - expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Representativeness will be addressed primarily in the sample design, through the selection of sampling sites and procedures. Representativeness also will be ensured by the proper handling and storage of samples and container, preservative, and analysis within the specified holding times so that the material analyzed reflects the material collected as accurately as possible. These requirements are presented in Table 3.1 of this Work Plan.

4.2 Corrective Action for Results Outside Established DQOs

Results outside the established criteria in Table 5.7 of this Work Plan shall be brought to the attention of the Project Manager who shall determine the document the appropriate corrective action on a Request For Data Review Form (Exhibit 4.1). These actions may include, but are not limited to, review of data and calculations, flagging of suspect data or re-analyses of individual or entire batches of samples.

5.0 SAMPLING PROCEDURES

All samples shall be collected in accordance with approved procedures. Some of the procedures are adapted from applicable portions of PNL-MA-567, Procedures For Ground Water Investigations. Table 5.6 of this Work Plan specifies sample containers, holding times, and preservatives for each constituent group.

6.0 SAMPLE CUSTODY AND FIELD DOCUMENTATION

The chain-of-custody of samples from the field to the analytical laboratory shall be controlled in accordance with NHFP-AD-4, Sediment Sample Chain-of-Custody Procedure, the chain-of-custody forms used in this procedure are from Lockheed Analytical Services, Las Vegas, Nevada (Exhibit 6.1).

A Field Record Form shall be completed for each sample site sampled during each sampling event. The form to be used is shown in Figure 4 of NHFP-AD-4, Sediment Sample Chain-of-Custody Procedure.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

All measurement and test equipment (M&TE), for which PNL is responsible, must be controlled in accordance with PAP-70-1201, Calibration Control System.

- Category 1 M&TE is calibrated by an approved metrology organization. All organizations providing Category 1 calibration services must be evaluated by the PNL Process Quality Department in accordance with PNL-MA-70, QAP-70-701, Preaward Evaluations/Surveys, before being utilized.
- Category 2 M&TE is calibrated by the user. Requirements for documenting user calibration of Category 2 M&TE are included in PNL-MA-70, PAP-70-1201, Calibration Control System.
- Category 3 M&TE is not calibrated and is for indication only.

All M&TE to be used for this sampling activity is either Category 2 or Category 3 M&TE.

7.1 pH Meter Calibration

The pH meters used by PNL field personnel must be calibrated daily before use in accordance with NHFP-FA-3, Calibration of pH Meter and Measurement of Field pH. The calibration must be documented on the pH Meter Calibration Record form. A calibration check must be performed before taking pH measurements at each sampling site. If it is found during the check that the criteria specified in NHFP-FA-3, Calibration of pH Meter and Measurement of Field pH are not met, the pH meter shall be recalibrated before use.

7.2 Conductivity Meter Calibration

Conductivity meters used by PNL field personnel must be calibrated daily before use in accordance with NHFP-FA-2, Calibration of Conductivity Meter and Measurement of Field Conductivity. The calibration must be documented in the Conductivity Meter Calibration Record.

7.3 Digital Thermometer Calibration Check

A digital thermometer calibration check must be performed daily before using the thermometer by comparison to a Category 1 calibrated mercury thermometer as specified in NHFP-FA-1, Temperature Measurement Procedure. This calibration check must be documented in the Digital Thermometer Calibration Log.

7.4 Analytical Chemistry Calibration

Calibration methods for all chemical analytical processes shall be addressed in each specific procedure. As a minimum, calibrations shall include the following:

- standards that are traceable to nationally recognized standard organizations
- standards that are within their expiration date
- using standard concentrations that bracket the expected concentration of the samples.

8.0 ANALYTICAL PROCEDURES

Analytical procedures are specified in Table 3.1 of this Work Plan. These procedures are standard recognized EPA procedures. Table 4.3 of this Work Plan specifies sample containers, holding times, and preservatives for each constituent group.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

The report from the analytical laboratory shall include the following information:

- Results of sample analyses reported in mg/kg for soil samples, ppb for ground-water, and ppb for all blanks.
- Results of procedural blank analyses.
- Amounts expected and recovered, and percent recoveries, for matrix spike samples.
- Results of replicate analyses reported as RPD.
- Results of the analyses of SRMs, certified values, and the PD between the results and the certified values.

Any qualified data shall be readily identified. Data packages shall be of CLP quality to enable complete data validation. These data shall be reviewed by PNL to determine reasonableness with previously collected data and the QC data. Selected data is validated in accordance with the following methodology:

- U.S. Environmental Protection Agency Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, 1988
- U.S. Environmental Protection Agency Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses, 1988.

A minimum of 5% of the data is selected for validation at random and additional key data samples are also chosen for validation.

The data shall be reported to the client via a PNL technical report.

10.0 PERFORMANCE AND SYSTEM ASSESSMENTS/APPRAISALS

Due to the nature and complexity of this project, no performance nor system assessments/appraisals in the field will be performed.

11.0 PREVENTIVE MAINTENANCE

Routine equipment and facility maintenance and instrument services ensure the timely and effective completion of a sampling effort. Field equipment maintenance (limited primarily to calibration and calibration check activities) is the responsibility of the field sampling staff as well as the Project Manager.

12.0 PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Because of the nature of environmental measurements, it is frequently difficult or impossible to know the "true" value of the measured parameter. The accuracy of the measured value must instead be inferred through the use of QC samples of known composition. This project uses this method to verify that the data quality objectives (DQOs) established in Section 4 of this QA Plan and Table 3.1 of this Work Plan have been met. Precision, accuracy, comparability and completeness will be calculated following equations presented in Section 4. The results will be reported in data tables in the final technical memoranda. These results will be compared against the DQOs established in this QA Plan and this Work Plan comparison will also be reported in the final technical memoranda.

13.0 CORRECTIVE ACTION

Corrective action shall be initiated by the Project Manager when deviations from procedural requirements occur.

Unplanned deviations from procedural requirements must be documented by completing a Deficiency Report (DR) in accordance with PAP-70-1502, Deficiency Reports. Any staff member may initiate a DR. The DR must identify the requirement deviated from, the cause of the deviation, whether any results were impacted, and any corrective action necessary to remedy the immediate problem and prevent recurrence.

Planned deviations must be documented in advance and include justification. All planned deviations shall be approved by the Task Leader and shall be documented by a letter to the file or a notation in a field note book.

When significant conditions adverse to quality are identified, the cause of the conditions and corrective action taken to preclude repetition will be documented and reported to immediate management for review and assessment by a Corrective action Request in accordance with PAP-70-1602, Corrective Action.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Deviations from this QA project plan, as well as the results of surveillances and audits, must be documented, described and reported to the Project Manager as discussed in Section 13.0, Corrective Action, of this plan. Line management shall be included on the distribution of all audit reports. Quality Assurance related information must be reviewed by the cognizant PNL Quality Engineer.

Significant problems encountered in day-to-day operations must be reported to line management immediately by the Project Manager.

Problems identified by project personnel must be reported to the project manager immediately for resolution. Problems involving data quality must be thoroughly documented.

15.0 RECORDS

Project records shall be indexed and maintained in accordance with PAP-70-1701, Records System. A Records Inventory and Disposition Schedule (RIDS) shall be prepared and submitted for review and approval by the Records Specialist and Quality Engineer. Records retention schedules shall be based on DOE Order 1324.2A, Records Disposition, and applicable regulatory requirements.

The Project Manager shall assure that documents are reviewed for technical adequacy, accuracy, and completeness to verify that the documents support fitness for operation and conformance to specifications and procedures. If an error is made on any documentation, an individual may correct the error by drawing a line through the error and entering the correct information. The error shall not be obliterated. All non-editorial corrections shall be initialed and dated.

Any problems or deficiencies noted in the records must be properly resolved and documented in accordance with PNL's deficiency system (see Section 13).

16.0 PROCUREMENT CONTROL

Procurement of items and subcontracted services are governed by PAP-70-401, Preparation, Review, and Approval of Purchase Requisitions. A preaward survey was performed on the analytical services contractor, Lockheed Analytical Services of Las Vegas, Nevada, in September 1993, in accordance with QAP-70-701, Preaward Evaluations/Surveys.

17.0 STAFF TRAINING

Staff performing activities affecting quality shall be issued training assignments which include the administrative and technical procedures listed within this QA project plan, according to PAP-70-201, Indoctrination and Training. Documentation of these training assignments shall be maintained by PNL Laboratory Training.

18.0 DOCUMENT CONTROL AND DOCUMENT REVIEWS

Distribution and control of this Work Plan shall be performed in accordance with PAP-70-601, Document Control.

Modifications to this QA project plan shall be made in accordance with PAP-70-205, Quality Assurance Plans, i.e., either by total revision or by issuance of an Interim Change Notice (ICN). Any PNL staff member may request an interim change to this QA project plan at any time by submitting a Document Change Request (DCR) to the Project Manager or Quality Engineer.

APPLICABLE ADMINISTRATIVE PROCEDURES

PAP-70-201	Indoctrination and Training
PAP-70-205	Quality Assurance Plans
PAP-70-208	Impact Levels
PAP-70-401	Preparation, Review, and Approval of Purchase Requisitions
PAP-70-601	Document Control
PAP-70-1201	Calibration Control System
PAP-70-1502	Deficiency Reports
PAP-70-1602	Corrective Action
PAP-70-1701	Records System
QAP-70-701	Preaward Evaluations/Surveys

APPLICABLE TECHNICAL PROCEDURES

NHFP-AD-4	Sediment Sample Chain-of-Custody
NHFP-FA-1	Temperature Measurement Procedure
NHFP-FA-2	Calibration of Conductivity Meter and Measurement of Field Conductivity
NHFP-FA-3	Calibration of pH Meter and Measurement of Field pH

Appendix 2-Health and Safety Plan

Appendix 2
HEALTH AND SAFETY PLAN (HASP)
Elmendorf AFB CERCLA Project
Ship Creek Bioassessment Work Plan (July 1994)

PLAN PREPARED BY: Mark Murphy

Date: _____

PLAN APPROVED BY: Mark Murphy

Date: _____

CONCURRED BY: Michael Fullmer, PNL Health & Safety

Date: _____

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1.0 Introduction

The health and safety program for Pacific Northwest Laboratory (PNL) personnel working at Elmendorf Air Force Base (AFB) consists of a base health and safety plan (HASP) and task specific addendums. The HASP contains general information which applies to all or most areas of the site. The HASP also contains the project description, personnel responsibilities, site hazards, personal protective equipment (PPE), air monitoring guidelines, site control, decontamination procedures, and an emergency response plan. The task specific HASPs are written to add additional information regarding the specific source areas and field activities. The addendums not only define the specific field activities and team members, but they contain changes or clarifications of: the potential hazards, air monitoring requirements, PPE, decontamination procedures, and emergency contacts. The addendums can be more or less restrictive than the base HASP, depending on the type of field activities being conducted. This document is a task specific HASP addendum that is appended to the Elmendorf AFB Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Project Ship Creek Bioassessment Work Plan.

This task specific HASP will be kept onsite during field activities and will be reviewed and updated as necessary. This plan adopts, by reference, the standards of practice (SOPs) contained in the Elmendorf AFB Operable Unit (OU) 5 remedial investigation/feasibility study (RI/FS) Work Plans (USAF 1993) written by PNL.

This health and safety program is intended to comply with federal and state hazardous waste regulations, standards, and Elmendorf AFB safety requirements. If there are inconsistencies between the regulations and Elmendorf AFB procedures, the most restrictive requirements will be followed. If inconsistencies exist between the HASP and the addendums, the addendum has precedence over the base plan.

2.0 Project Description

The work being conducted at Elmendorf AFB that is covered under this document is the Elmendorf AFB CERCLA Project Ship Creek Bioassessment activity associated with the Elmendorf AFB OU 5 RI/FS.

3.0 General Information

CLIENT: U.S. Air Force, Alaska Air Command

PROJECT MANAGER: Mark Murphy/PNL

TASK MANGER: Bert Cushing/PNL

SITE NAME: Elmendorf AFB

SITE LOCATION: Anchorage, Alaska

PURPOSE OF FIELD VISIT: To sample and investigate biota and sediments located along Ship Creek.

DATE HEALTH AND SAFETY PLAN PREPARED: June 1994

DATE OF FIELD WORK: July 1994

BACKGROUND INFORMATION: This is a field investigation to establish ambient concentrations of natural and anthropogenic chemical species in biota and sediments along Ship Creek.

4.0 Site Description and Characteristics

4.1 Site Description

Elmendorf AFB is located (Figure 4.1) on 13,130 acres in south central Alaska adjacent to the city of Anchorage. It is bordered on the north and west by Cook Inlet, on the south by urban parts of the city of Anchorage, and on the east by Fort Richardson, a U.S. Army installation.

Specific information regarding each source area is included in the sampling and analysis plan (SAP).

4.2 Site History

Specific information on the locations of the OUs defined for Elmendorf AFB, base supply wells, and other geographic and structural landmarks are in the SAP. Brief discussions of source areas relevant to this investigation are given below.

Operable Unit 1 consists of landfills LF05, LF07, LF13, LF59, and OT56 (Figure 4.2). These landfills are all close to each other, and the contaminants are similar. These sources include:

- Source LF05 - Sanitary Landfill
- Source LF07 - Sanitary Landfill
- Source LF13 - Disposal Site
- Source OT56 - DRMO Scrap Pile
- Source LF59 - Asphalt Seep.

Four source areas are included in OU 5. These source areas incorporate six original source areas at the southern perimeter of Elmendorf AFB just north of Ship Creek. These source areas were grouped together due to the potential for offsite migration of contamination, impacts on Ship Creek, and possible influence from offsite sources. Assorted petroleum, oils, and lubricants (POLs) are the primary contaminants at the source areas in OU 5. These sources include:

- Source ST37 - Diesel Fuel Line Leak
- Source SD40 - Railroad Maintenance Area Oil Seepage
- Source ST46 - JP-4 Fuel Line Leak
- Source ST38 - JP-4 Fuel Line Leak/Source SS42-Diesel Fuel Spill
- Source SS53 - Golf Course Seep.

S9407018.4A

Figure 4.1. Elmendorf AFB Locator Map

S9407018.2

Figure 4.2. Map of Portions of OU 5 and OU 1 Relevant to this Plan

5.0 Overview of Planned Activities

The CERCLA investigations underway at Elmendorf AFB will encompass a variety of field activities including: installation of groundwater monitoring wells; soil borings; and soil and groundwater sampling. The specific field activities covered by this HASP are identified in the Ship Creek Bioassessment Project SAP include ecological assessments and sediment sampling.

6.0 Project Organization and Tasks to be Performed Under This Plan

6.1 Project Organization

PNL is working under contract to the U.S. Department of Energy (DOE) who is completing this work under a related services agreement with the U.S. Air Force.

6.2 Description of Subcontractors

The subcontractors working on this task are Lockheed Analytical Laboratory, Las Vegas, Nevada.

Lockheed will be responsible for all analytical chemistry.

6.3 Recordkeeping

A copy of the records required by 29 CFR 1910 will be maintained by the lead site safety coordinator (SSC) for all personnel, including subcontractor personnel, involved in the field investigation activities identified in the task-specific addendums.

Record keeping activities include:

- 3-day, Elmendorf AFB-specific, on-the-job training (OJT)
- medical surveillance records
- cardiopulmonary resuscitation (CPR) and first aid training certificates
- site health and safety briefing records
- accident reporting forms
- 40-hour training and current 8-hour annual refresher training certificates
- 8-hour supervisory training certificates for supervisory personnel.

Additional records of field activities will be kept in individual logbooks maintained by sampling team personnel. These logbooks are used to record site conditions, the results of monitoring and sampling, the time spent onsite by individuals, and the events that occurred during field activities.

7.0 Waste Characteristics

7.1 Waste Types

Liquid X Solid X Sludge X Vapor X

All waste types may not be present at each source area.

7.2 Characteristics

Corrosive X Ignitable X Radioactive X Carcinogenic X
Volatile X Toxic X Reactive X Unknown X

All waste characteristics may not be present at each source area.

8.0 Hazard Evaluation and Control

8.1 Physical Hazards

Some physical hazards are common to many of the field activities. These hazards and control measures are summarized below.

8.1.1 Heat Stress

The potential for heat stress is not high at Elmendorf AFB. The highest potential is during the summer months. Extreme cold for a short period of time can cause severe injury to the surface of the body (frostbite) or result in profound generalized cooling of the body core (hypothermia) which can result in death.

Areas such as fingers, toes, and ears have a high surface area to volume ratio and are therefore more susceptible to the effects of cold. The two factors that influence the development of a cold injury are: ambient air temperature and wind velocity. Windchill is used to describe the chilling effect of moving air in combination with low temperature, and as a general rule the greatest incremental increase in chill occurs when a 5 mph wind increases to 10 mph.

8.1.1.1 Frostbite

Local injury due to cold is known as frostbite. The onset of frostbite is painless and gradual, and the injury can occur before the victim is aware that it has occurred. There are several degrees of frostbite.

- Frost nip or incipient frostbite: Characterized by sudden blanching or whitening of the skin.
- Superficial frostbite: The skin has a waxy or white appearance and is firm to the touch, but the tissue beneath is resilient.
- Deep frostbite: Tissues are cold, pale, and solid. This is a serious injury which requires first aid.

To help prevent frostbite from occurring personnel will: keep extremities warm, wear warm clothing, take rest breaks in a warm area, reduce wind by construction of a wind shield; and check for symptoms. If frostbite occurs, the victim should be moved to a warm area if moving the victim will not cause serious harm. The affected areas should be warmed with water (102°F - 105°F) or the areas covered with warm cloths for 30 minutes, and the victim should drink a warm liquid (not coffee, tea, or alcohol). If possible, elevate the injury. Extreme care should be taken to avoid breaking the blisters, and injured areas should be covered with sterile, soft, dry material. Keep the victim warm and seek medical attention immediately. Further injury can be caused if the affected area is rubbed, if anything cold is placed on the frostbitten area, if the victim is placed near a hot stove, or if the victim is moved after the affected area has thawed.

8.1.1.2 Hypothermia

Systemic hypothermia can be caused by exposure to freezing or rapidly dropping temperatures. Its symptoms are exhibited in five stages.

- Shivering
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F

- Unconsciousness, glassy stare, slow pulse, and slow respiration
- Freezing of the extremities (frostbite)
- Death

To treat hypothermia, remove the victim from the cold and get them into a warm area. Remove wet clothing and cover the victim with dry clothing or blankets. The body should be warmed up slowly.

8.1.2 Cold Stress

Cold stress is not anticipated to be a significant problem. However, depending on the necessary PPE and the weather, cold stress could present a problem.

8.1.3 Slipping or Falling

Especially during inclement weather, there will be a potential of personnel slipping and/or falling. To help prevent this from occurring, personnel will use extreme caution around frozen or wet areas and will wear boots that have good traction. In areas of extreme mud, wood pallets, or similar devices will be used.

8.1.4 Back Injury

Lifting or pulling heavy objects can cause back injury if not done properly. The use of proper lifting techniques will be used to prevent such injuries. If necessary, mechanical lifting aids will be made available.

8.1.5 Falling or Flying Objects

Falling or flying objects can occur when working underneath something or around heavy equipment. Hard hats and safety glasses will be worn to help prevent injuries from falling or flying objects from occurring.

8.1.6 Noise

Because the field activities are being conducted on an Air Force Base, there will be noise from aircraft taking off and landing. The use of heavy equipment and other vehicular traffic will add additional noise. Personnel will wear hearing protection, if necessary, and monitor for noise to help prevent injuries from occurring.

8.1.7 Moving Vehicles

Because the field work is being conducted on an active Air Force Base, there will be vehicular traffic. Personnel who work near areas with heavy vehicular traffic will wear safety vests to increase their visibility to passing drivers, if necessary.

8.2 Chemical Hazards

Based on the current information of the past and present waste disposal practices, five contaminant sources have been identified. They are: spills and releases, land disposal operations, road oiling, pest control, and general ongoing site activities. Specific information on these chemicals can be found in Attachment 3.

8.2.1 Spills and Releases

The most common source of chemical contamination is from leaks in tanks and piping or from

incidental release and spills of POL. Many contaminated areas involve POL contamination, primarily in the form of diesel, motor gasoline, or JP-4. Incidental low volume spills and releases of solvents have also occurred. In the past, trichloroethene (TCE) was used at the site, and it and its degradation product, 1,2-dichloroethene (1,2-DCE), have been detected in the groundwater at several locations. Currently, 1,1,1-trichloroethane (1,1,1-TCA), methyl ethyl ketone (MEK), methylisobutyl ketone (MIBK), acetone, and PD-680 Stoddard solvent are being used. When solvents are used for cleaning metal, heavy metals are often associated with the spent solvent.

8.2.2 Land Disposal Operations

There are several landfill areas on the base that receive or have received a wide variety of materials. Primarily, they received general base refuse, but disposal of paints, thinners, and solvents has also been reported. Some disposal areas have received sludge which contains lead from tank cleaning operations and waste grit which contains lead, cadmium, and chromium. Sandblasting wastes may have been disposed of in other areas of the site as well. There are other areas which contained buried or partially buried drums of unknown contents. Munitions and cartridge disposal present a potential explosion hazard, as well as a heavy metals contamination.

8.2.3 Road Oiling

Waste oil, contaminated fuels, and spent solvents were previously used to oil the roads on the base. It is possible that PCB contaminated oils were also used for this purpose. As mentioned previously, heavy metals are frequently associated with spent solvents.

8.2.4 Pest Control

DDT was used extensively until 1966. DDT application at the base included aerial spraying. As mentioned above, pesticides which are currently in use are: Baygon, D-Tox-4E, Diazinon, Dursban, Malathion, Pyrethrins, and Resmethrin.

8.2.5 General Site Activities

Due to normal base activities there will be exhaust particles from vehicle and aircraft traffic. These particulates may contain polyaromatic hydrocarbons (PAHs) such as benzene, toluene, xylenes, and ethylbenzene (BTEX). In the past, ethylene glycol was used to deice the planes, and currently, isopropyl alcohol and methanol are used. Sandblasting operations which are currently conducted at the base produce waste which contains high concentrations of lead, cadmium, and chromium. In addition to the waste materials, hazardous substances such as fuel, solvents, and cleaners are also stored in various areas of the site.

8.2.6 Potential Chemical Hazards

Attachment 3 shows the base-wide potential chemicals hazards, the exposure limits, and the symptoms of overexposure. In some areas of the base some of the listed chemical hazards may not be present.

8.2.7 Potential Routes of Exposure

8.2.7.1 Dermal

If contamination is encountered, dermal contact with contaminated media is possible. Protective clothing will help eliminate this route of exposure.

8.2.7.2 Inhalation

Inhalation is a potential route of exposure if contamination is present. Air monitoring will help

identify when contamination is present and will be used as a basis for implementing engineering and work practice controls and for upgrading protective equipment.

8.2.7.3 Other

If contamination is encountered, incidental ingestion is a potential route which will be controlled with the use of good work practices and protective equipment.

8.3 Radiologic Hazards

No Radiologic Hazards are likely because of the lack of any known source for radioactive waste at OU 5.

8.4 Natural Hazards

8.4.1 Moose and Bear

Moose and bear are present on Elmendorf AFB and should not be approached. Before entering a work area, personnel should observe the surroundings for moose and bear. If moose or bear are present, do not enter the work location, and observe wildlife from a safe distance (>200 feet) until the animal(s) leaves. If the work area requires traversing thick brush, workers should observe the area first, and proceed with caution, making noise, such as talking, whistling, or singing, to make their presence known to animals that may be in the area.

8.4.2 Mosquitos

Mosquitos may pose a hazard. Corrective actions include wearing full-length clothing to minimize exposed flesh, using headnets, and using mosquito repellent.

8.5 Hazards Posed by Chemical Substances Provided by PNL

In accordance with state and federal regulations, Material Safety Data Sheets (MSDSs) are provided for the following chemicals: trisodium phosphate (TSP), Liqui-nox, methanol, nitric acid, hydrochloric acid, Mine Safety Association (MSA) respirator sanitizer, hydrogen, methane, and isobutylene. Depending on the required monitoring equipment, all of these chemicals may or may not be present for a particular task.

8.6 Procedures to Locate Buried Utilities

No drilling or excavating is planned.

9.0 Personnel

9.1 PNL Site Personnel

The team members will be:

Bert Cushing, Task Leader
Jennifer Topping, Site Worker

9.1.1 General Site Workers

In contaminated areas (i.e., exclusion zones), the decontamination areas (i.e., contamination reduction zone), and areas where there is a possibility for exposure, all personnel must be under a medical surveillance program and be trained in accordance with 29 CFR 1910. In addition, at least one personnel in each source area must be currently certified in first aid and CPR.

Personnel who are not trained in hazardous waste work as required by the federal and state standards will not be allowed in the exclusion zones or the contamination reduction zones.

The responsibilities of all employees include the following.

- Each employee working in areas of the site where there is a potential for exposure is responsible for verifying that their medical status and training are current prior to working in those areas.
- All personnel who work on the site must sign in at the site (see Attachment 1) indicating the date and time of visit and project number.
- All employees will agree to follow the Elmendorf AFB's safety program prior to working on the site.
- All employees will read and agree to follow the PNL HASP and the addendums.
- All employees will conduct their work in a safe manner.
- Employees are responsible for correcting an unsafe work condition. If they are unable to correct the unsafe condition and feel that the condition could cause serious harm, they may halt the work. If work is halted the employee must contact the SSC or the project manager.
- Employees are responsible for reporting faulty equipment to the SSC or the project manager and for shutting down the field work until the equipment is operational and reliable.

9.1.2 Site Safety Coordinator

In addition to the responsibilities listed in Section 9.1.1, the SSC is responsible for:

- documenting that all personnel entering areas where there is a potential for exposure meet federal and state hazardous waste regulations (see Attachment 2)
- holding a pre-entry safety meeting on the source area's specific hazards
- completing site entry procedures
- conducting (or assigning a qualified person to conduct) the air monitoring in their area as

outlined in the HASP and the addendums

- emergency planning
- taking the lead in all emergency situations in their source area until a professional emergency response team arrives
- establishing the work zones for their source area
- setting up and maintaining an effective decontamination process for their source area
- documenting that all personnel and equipment leaving the contaminated areas have been effectively decontaminated.

9.1.3 Project Manager

The project manager is responsible for:

- ensuring that the project is being conducted in a safe manner
- informing all personnel of the safety precautions required at the site
- controlling the movement of all onsite personnel (i.e., keeping untrained personnel in areas where no exposure potential is present).

9.2 Subcontractor Personnel

Lockheed will not be involved in site work.

9.3 Health and Safety Field and Team Chain of Command and Procedures

9.3.1 Client

U.S. Air Force, 3 SPTG/CEVR, Elmendorf AFB
Project Manager: Sharon Stone

9.3.2 PNL

PNL Project Manager: Mark Murphy
PNL Health and Safety Manager: Michael W. Fullmer
PNL Task Manager: Bert Cushing

10.0 General Training

The general training requirements are discussed in Section 9.1.1. In addition to these requirements, personnel working on the site must complete a pre-entry briefing which contains site-specific information. The lead SSC will conduct a pre-entry safety meeting for all new employees on the site and periodically thereafter. At a minimum, the training must cover the information listed below. The SSC will keep records of training in the logbook or field notebook.

- Emergency procedures for personnel injury, suspected overexposures, fires, explosions, chemical, and vapor releases.
- Location of onsite emergency equipment and supplies of clean water.
- Local emergency contacts, hospital routes, evacuation routes, and assembly points.
- Site communication including the location of the nearest phone to each source area and location of the mobile phone.
- The purpose of the two-way radios and what channel to use in the event of an emergency.
- Names of personnel trained in first aid and CPR in each source area.
- Work zones as they have been established.
- Decontamination procedures.
- Notification procedures for contacting PNL's medical consultant and the injured team member's occupational physician.
- Identify emergency evacuation routes and onsite assembly points.
- New workers on the site will be briefed on the emergency response plan before entering the exclusion zone.
- The "buddy system" will be enforced for field activities involving potential exposure to hazardous materials and during any work within the exclusion zone. Each person will observe his/her partner for symptoms of chemical overexposure, cold stress, and provide emergency assistance when warranted. Personnel working in the exclusion zone will maintain line of sight contact or maintain communications (i.e., two-way radios) with the site support facilities.

Emergency Signals: The following emergency signals shall be used:

Grasping throat with hand	— Emergency—help me
Thumbs up	— OK—understood
Grasping buddy's wrist	— Leave site now
2 short blasts or sounds, repeated	— All clear
Continual sounding of horn	— Emergency—leave site

10.1 Additional Training

Some tasks and/or equipment may require specific training. If such conditions arise, training will be conducted by a knowledgeable person, who is approved by PNL, prior to conducting such work.

11.0 Personal Protective Equipment Specification

Most of the work conducted in this investigation will be at uncontaminated locations. The level of PPE will be Level D. Level D includes:

coveralls
hard hat, where required
steel-toe safety boots
safety glasses.

On-base, the level of PPE will elevate to D-Modified (Level D plus, gloves). Capacity for elevating the level of PPE above this will be maintained at the site. PPE details are contained in Table 11.1. Action levels that will drive PPE changes are given in Table 11.2.

Table 11.1. Personal Protection Equipment

Required Equipment	Level of Protection^(a)
Rubber steel toed/shank boots Leather steel toed/shank boots Outer and inner gloves. Safety glasses. Safety goggles are required when a splash potential is present. Cotton or tyvek coveralls Polycoated tyvek are required when a splash potential is present. Hard hats when overhead hazards are present.	Level D (modified)
The equipment required in Level D as well as a full face respirator Polycoated tyvek taped to boots and gloves.	Level C

(a) Levels D modified and C are the only levels of protection expected at the site. If higher levels of protection are deemed necessary, non-emergency work will cease and job will be re-planned.

Table 11.2. Required Monitoring Equipment and Action Levels of Upgrading Personnel Protective Equipment

Equipment Reading^(a)	Action
Explosimeter:	
< 10% LEL ^(b)	Continue with caution
10-20% LEL	Continue with caution while implementing control measures such as mechanical ventilation
> 20% LEL	Halt operations and evacuate the area until the readings are below 10% LEL
O₂:	
19.5-21% O ₂	Continue operations in Level D PPE
Needle deflects upward and then drops to zero	Halt operations and evacuate the area until the readings are approximately 20% O ₂
< 15% O ₂	Halt operations and evacuate the area until readings are approximately 20% O ₂
< 19.5% O ₂	Halt operations and evacuate the area until readings are approximately 20% O ₂
HNu:	
< 5 ppm	Continue operations in Level D PPE
5 - 10 ppm	Continue operations in Level C PPE
> 10 ppm	Halt work

(a) Readings are above background.

(b) Lower explosive limit.

12.0 Air Monitoring Program

Periodic monitoring of the site is required to determine the effectiveness of engineering and work practice controls, to re-evaluate levels of protection, and to determine if site conditions have changed. All instruments will be calibrated in a clean environment per the manufacturer's instructions at the beginning of each day. At the end of each day, all of the instruments will be checked against the calibration gas and then will be charged so they are ready for use when necessary. The instruments will be visually inspected on a routine basis (at least weekly) to help verify that the equipment is operating correctly.

Calibration and monitoring results will be recorded in a logbook as results are obtained. Any information such as monitoring and sample results that could provide exposure information will be communicated to the subcontractors as it is obtained.

Since the monitoring equipment is the basis for the levels of protection, it is very important that the equipment be working properly. Each piece of monitoring equipment will be inspected to determine if it is working correctly. If the equipment is not working or is not calibrated correctly, the work must be halted until the equipment is operational and reliable. The lead SSC will be contacted whenever equipment is nonoperational.

Because the equipment does not function in low temperatures, to the extent possible the monitoring equipment must be kept in a warm, dry environment between tests. All monitoring equipment must be kept in a heated work area and must be sealed in a zip-lock bag or "baggie" except when in use. These procedures will prolong the effectiveness and prevent damage by condensation. The HNu is nonfunctional in atmospheres of 95% or greater humidity, and therefore should not be used in such conditions. If such conditions exist, an organic vapor analyzer (OVA) will be used or work will be halted until the humidity is less than 95%.

Some field activities will require all of the equipment mentioned, while other activities may require only some of the equipment listed.

At a minimum, monitoring will be conducted at the beginning of each shift and on a routine basis (e.g., every 30 minutes) throughout the field activities, whenever work begins at a new area onsite, when different contaminants are encountered, or when a different work activity begins. After acquiring the approval of the lead SSC, the source area SSC can reduce the frequency of monitoring for a specific activity at a given location if the readings are continually low. Any changes in air monitoring requirements will be documented in the SSC logbook.

13.0 Site Procedures and Work Limitations

13.1 Site Entry Procedures

- Attend safety briefing before starting field activities.
- Read and agree to follow the base's safety program and the PNL HASP and addendums.
- Locate the telephone which is closest to the field activities to be used in the event of an emergency.
- Confirm and post the emergency telephone numbers at each source area.
- Determine wind direction, install wind flags, and establish work zones at each source area.
- Set up decontamination facilities at each source area.
- Conduct site entry monitoring at each source area.

13.2 Decontamination Procedures

The decontamination stations will be established on the upwind edge of the exclusion zone to help prevent contaminated materials from being transported to the "clean" areas of the site and samples from being cross contaminated.

13.2.1 Personnel

If disposable boot covers are worn, wash with TSP (or Liqui-nox) and water, rinse with water, and remove. Wash and rinse outer gloves and boots as described above, and remove outer gloves. If tyvek are worn, remove. If a respirator is worn, remove and decontaminate as required by the manufacturer. Remove inner gloves. Employees will wash their hands and face with soap and water. Showers will be taken as soon as possible.

13.2.2 Monitoring Equipment

Monitoring equipment will be wiped with methanol and then with water. If it is anticipated that the equipment will become contaminated, it will be wrapped in plastic to help prevent the instruments from becoming contaminated. If plastic is used to protect the equipment, it will be discarded prior to the equipment leaving the contamination reduction zone.

13.2.3 Sampling Equipment

Sampling equipment will be washed with TSP (or Liqui-nox) and rinsed with water, distilled water, and methanol. The equipment will be allowed to air dry and then it will be rinsed again with distilled water.

13.2.4 Samples

Contaminated sample containers will be wiped with a towel and distilled water.

13.2.5 Cars and Heavy Equipment

All vehicles taken into the contaminated areas of the site must be steam cleaned prior to leaving the site. To reduce contamination inside of vehicles, plastic sheeting will be used to cover the floor, seats, and any other areas which may come into contact with contaminated materials.

13.3 Disposal Procedures of Materials Generated by PNL

- No waste cuttings or fluids will be generated by this work.
- Laboratory samples will be returned to the site, client, site owner, or responsible party for disposal following analysis unless otherwise specified.

13.4 Spill Containment Procedures

Large-scale spill containment procedures are not necessary because PNL will not be handling large amounts of liquid materials. However, to contain spills during decontamination, activities will take place over plastic sheet or plastic buckets.

In the event that oil or hydraulic fluids spills or leaks from the heavy equipment, the affected soil will be excavated until visually stained material is removed. This material would be placed in drums and disposed of in accordance with applicable regulations.

13.5 Confined Space Entry Procedures

No confined space entry will occur as part of this work.

13.6 Work Procedures and Limitations

- Avoid visibly contaminated areas.
- No eating, drinking, chewing tobacco or gum, or smoking in the source area. Personnel will wash their hands and face prior to eating, drinking, or smoking.
- No contact lenses.
- When respirators are required, personnel can have no facial hair that would interfere with respirator fit. Personnel working in Level D can have facial hair if they are prepared to shave or leave work area if respiratory upgrade is required.
- Buddy system is effect at all times in exclusion zone.
- Site work will be performed during daylight hours whenever possible. Any work conducted during hours of darkness will require an addendum which specifies the lighting requirements.
- Fuel supplies will be properly stored and grounded.

14.0 Emergency Response Plan

14.1 Pre-Emergency Planning

The SSC is to perform the following pre-emergency planning tasks before starting field activities and will coordinate emergency response with the operating facility when appropriate.

- Confirm that each field team is in contact with the lead SSC or another field team.
- Review emergency procedures for personnel injury, exposures, fires, explosions, and chemical vapor releases.
- Confirm that a mobile phone or two-way radios are available for emergency calls.
- Confirm and post emergency telephone numbers (Form 311) and route to hospital in the field trailer. At each source area, the emergency telephone numbers and hospital maps will be easily accessible to all employees.
- Review names of personnel trained in first aid and CPR who are in each sampling area.
- Review notification procedures for contacting PNL's medical consultant and team member's occupational physician.
- Post site map marked with locations of emergency equipment and supplies at the field trailer.
- Locate emergency supplies and clean water at source area.
- Review contingency plan for applicability to any changed site conditions, alterations in onsite operations, or personnel availability.
- Designate one vehicle as the emergency vehicle at each source area; place hospital directions and map inside; keep keys in ignition during field activities.
- Drive route to hospital.
- Inventory and check-out site emergency equipment and supplies in each source area.
- Setup personnel decontamination stations at each source area.
- Brief new workers of emergency response plan.

The SSC is to verify that all source areas have completed the pre-emergency planning.

14.2 Emergency Recognition and Prevention

Prevention of emergencies will be aided by the effective implementation of the health and safety procedures specified in this HASP. The initial site safety briefing will emphasize recognition of the types of emergencies anticipated onsite. Periodic safety briefings will be conducted by the SSC as field activities proceed. Hazards that warrant specific emergency recognition and prevention techniques will be discussed.

14.3 Emergency Equipment

The following emergency equipment and supplies will be available and the locations known to all

personnel.

- ABC fire extinguishers (10#)
- Industrial first-aid kits (for each field team)
- Stretcher or blanket (at field trailer)
- Supplies of potable water (for each field team)
- Facility emergency equipment

14.4 Contingency Plan

The SSC will assume charge in the event of an emergency in their source area and the lead SSC will assume overall responsibility.

14.4.1 Emergency Medical Treatment

The SSC will assume charge during a medical emergency until the ambulance arrives, or until the injured person is admitted to the emergency room. The SSC will also perform the following duties.

- Prevent further injury.
- Initiate first aid and/or CPR.
- Verify that the ambulance and/or hospital has been called.
- Determine if decontamination will make the injury worse. If it will, seek medical treatment immediately.
- Make certain that the injured person is accompanied to the emergency room.
- Notify the PNL project manager of the injury.
- Notify the U.S. Air Force or subcontractor's project manager if their employee has been injured.
- Notify the injured person's human resources department.
- Prepare an incident report.

14.4.2 Evacuation

- Evacuation routes will be designated by the SSC in each sampling location before work begins.
- Assembly points at each sampling area and away from it will be designated before work begins.
- Personnel will exit the exclusion zone and assemble at the assembly point at the sampling area upon hearing the emergency signal for evacuation of the exclusion zone.
- Personnel will assemble at the assembly point away from the sampling area upon hearing the emergency signal for a sampling area evacuation.
- The SSC and a buddy will remain at the sampling area after the area has been evacuated to assist (if possible) local responders and advise them of the nature and location of the incident.

- The SSC accounts for all personnel in the assembly zone at the sampling area.
- A person designated by the SSC (before work begins) will account for personnel at the assembly area away from the sampling area.
- The SSC writes up the incident as soon as possible after it occurs.

14.4.2.1 Evacuation Routes

Evacuation routes will be designated by the SSC in each sampling location before work begins.

14.4.2.2 Evacuation Signals

- Grasping throat with hand—EMERGENCY—HELP ME
- Grasping buddy's wrist—LEAVE AREA NOW
- Thumbs up—OK, UNDERSTOOD
- Continuous air horn—EMERGENCY—EVACUATE
- Two short blasts on air horn—ALL CLEAR

14.5 Onsite Local Emergency Response Numbers

The local emergency response numbers list below must be posted onsite. Table 14.1 is a summary of the emergency telephone numbers which must be posted onsite.

- Ambulance: Elmendorf AFB Medical Center 911 or 552-5556
- Base Clinic: Elmendorf AFB Medical Center 911 or 552-5556
- Poison Control Center: Elmendorf AFB Medical Center 911 or 552-5556
- Base Security: 911
- Fire: 911
- Explosive Unit: 911

14.6 Offsite Local Emergency Response Numbers

- Hospital: Humana Hospital
2801 DeBarr Road
264-1222

Table 14.1. Emergency Phone Numbers

Department	Phone
Base Security	911 or 377-5130
Fire	911 or 377-4266
Explosives Unit	911 or 377-1654
Ambulance	911 or 377-2296
Elmendorf AFB Medical Center	911 or 552-5556
Humana Hospital	264-1222
Elmendorf Utilities	552-3727

14.7 Emergency Route to Hospital

Figure 14.1, which shows the route to the hospital is attached to this plan and will also be in all emergency vehicles identified during the pre-entry safety briefing.

14.8 Hospitals

- Elmendorf AFB Medical Center
552-5556
- Humana Hospital
2801 DeBarr Road
264-1222

14.9 PNL and Client Emergency Contacts

- **PNL Medical Consultant**
Hanford Environmental Health Foundation
- **PNL Health and Safety Manager**
Michael W. Fullmer
(509) 376-8358
- **PNL Project Manager**
Mark Murphy
(509) 376-8337
- **Air Force**
Sharon Stone
(907) 552-7111

14.10 Local Utilities

- Elmendorf Civil Engineering
(907) 552-3727

S9407018.1

Figure 14.1. Route to Hospital for Elmendorf AFB Site Work

15.0 Plan Approval

This site safety plan has been written for the use of PNL's employees and subcontractors. PNL claims no responsibility for its use by others. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

16.0 References

29 CFR 1910, U.S. Department of Labor, "Occupational Safety and Health Administration." Code of Federal Regulations.

U.S. Air Force (USAF). 1993. *Operable Unit 5 Remedial Investigation Report*. Pacific Northwest Laboratory Contractor Report.

ATTACHMENT 1

EMPLOYEE SIGNOFF

The employees listed below have been provided a copy of this health and safety plan, have read and understood it, and agree to abide by its provisions.

[illegible]

ATTACHMENT 2

RECORD OF HAZARDOUS WASTE FIELD ACTIVITY

SITE NAME:
SITE SAFETY COORDINATOR:
PROJECT NUMBER:
RECORD OF ACTIVITIES FOR (DATES):

[illegible]

Attachment 3
Potential Chemical Contaminants at Elmendorf Air Force Base (EAFB)^a

Compound	PEL ^b (ppm)	TLV ^c (ppm)	Symptoms of Overexposure
Acenaphthene	NL ^d	NL	This compound can cause eye and skin irritation.
Acetone	750	750	Acetone is moderately toxic by various routes and is a skin and eye irritant.
Acetophenane	NL	NL	This compound is moderately toxic by ingestion.
Aluminum	15 mg/m ^{3e}	10 mg/m ^{3f}	Inhalation of fine aluminum powder has reportedly caused pulmonary fibrosis. Dust of the metal is moderately flammable and explosive.
Ammonia	359	25	Eyes, nose, and throat irritation, dyspnea, chest pain
Anthracene	0.2 mg/m ^{3h}	0.2 mg/m ^{3h}	Anthracene may be irritating on skin contact.
Antimony	0.5 mg/m ³ⁱ	0.5 mg/m ³ⁱ	Antimony can cause irritation to the nose, throat, mouth and skin. It can also cause coughing, dizziness, headaches, nausea, vomiting, diarrhea and stomach cramps. Furthermore, it can affect the sense of smell.
Arsenic	0.01 mg/m ³	0.2 mg/m ³	This compound can cause systemic, skin, and gastrointestinal (GI) effects. It is a human carcinogen and an experimental teratogen, and there is mutagenic data.
Asphalt	NL	5 ^j	Asphalt is a moderate irritant which may contain some carcinogenic compounds.
Barium	0.5 mg/m ^{3k}	0.5 mg/m ^{3k}	Exposure to barium can cause upper respiratory tract, eye and skin irritation. It can also cause muscle spasms and a slow pulse.
Benzene	1	10 ^l	Benzene is moderately toxic by inhalation, ingestion, and subcutaneous routes. It is a strong eye and mild skin irritant. When inhaled affects the CNS (narcotic effects) and blood system (leukemia). It is a human carcinogen and an experimental teratogen and tumorigen. There is also mutagenic data on this compound.
Benzene Hexachloride (Beta-BHC, Lindane)	NL	NL	This compound is a central nervous system depressant. Symptoms of exposure include: excitation, hyperirritability, and loss of equilibrium.
Benzo(a)anthracene	NL	NL	This compound is an experimental carcinogen. It is found in oils, waxes, smoke, food and drugs.
Benzo(b)fluoranthene	NL	NL	—
Benzo(k)fluoranthene	NL	NL	—
Benzo(g,h,i)perylene	NL	NL	—
Benzo(a)pyrene	0.2 mg/m ³	0.2 mg/m ^{3h,m}	Prolonged exposure to benzo(a)pyrene can produce chronic dermatitis and reproductive changes. Benzo(a)pyrene is considered a known carcinogen. Prolonged skin exposure has been linked to an increase in skin cancer among workers. This compound is considered the most potent of the carcinogenic polyaromatic hydrocarbons (PAHs).
Beryllium	0.002 mg /m ³ⁿ	0.002 mg/m ^{3- n}	Beryllium can cause pulmonary damage and is an experimental and suspected human carcinogen.
Bis(2-ethyl-hexyl)phthalate	5 mg/m ³	5 mg/m ³	This compound effects the human gastrointestinal tract and is a mild skin and eye irritant. It is also a suspected human carcinogen.
Butylbenzylphthalate	NL	NL	This compound is moderately toxic by inhalation.
2-Butanone (Methyl-ethyl Ketone, MEK)	200	200	MEK is moderately toxic by ingestion and dermal contact. This compound affects the peripheral nervous system (PNS) and the central nervous system (CNS). It is a strong skin and eye irritant and is an experimental teratogen.
Di-n-Butylphthalate	5 mg/m ³	5 mg/m ³	Di-n-Butylphthalate can cause upper respiratory and stomach irritation.
Cadmium	0. 2 mg/m ³	0. 05 mg/m ^{3m,o}	Cadmium is poisonous to humans by inhalation and other routes. The effects are dependent on the cadmium compound. Cadmium dust is carcinogenic.
Carbon Disulfide	4P	10P	This compound can cause dizziness, headaches, poor sleep, fatigue, nervousness, eye and skin burns, and dermatitis.
Chlorobenzene	75	10	This compound is moderately toxic by ingestion. It has strong narcotic effects with slight irritant qualities. It can also cause liver and kidney damage.
Chloroethane (Ethyl chloride)	1,000	1,000	Chloroethane can cause incoordination, inebriate, abdominal cramps, cardiac arrest and liver and kidney damage.
Chloromethane (Methyl Chloride)	50	50P	Chloromethane can cause dizziness, nausea, vomiting, visual disturbances, staggering, slurred speech and convulsions. It also can cause liver and kidney damage and is considered carcinogenic.
2-Chlorophenol	NL	NL	2-Chlorophenol is moderately toxic by ingestion and is poisonous by subcutaneous exposure.

Chromium	0.5 mg/m ³	0.05 mg/m ³ _{r,s}	Chromium metal and insoluble salts are toxic by inhalation and chromium (VI) is carcinogenic. The trivalent form is less toxic than the hexavalent.
Chrysene	0.2 mg/m ³	0.2 mg/m ³ _{h,m}	Chrysene has been shown to accumulate in adipose and in mammary tissue. Long term exposure in laboratory animals and epidemiologic studies have indicated that this compound is carcinogenic.
Chloroform	2	10 _i	Chloroform can cause dizziness, mental dullness, nausea, disorientation, headache, fatigue and eye and skin irritation. Chloroform is considered carcinogenic.
Cobalt	0.05 ^{3t}	0.05 mg/m ³ ^{3t}	Exposure to cobalt can cause coughing, dyspnea, decreased pulmonary function, dermatitis, and respiratory hypersensitivity.
Copper	1 mg/m ³ _u	1 mg/m ³ _u	Copper, as metals and dust, can cause nasal mucous membrane, pharynx, and eye irritation. Dermatitis, nasal perforation, and a metallic taste are other symptoms of exposure to this compound.
2,4-D	10 mg/m ³	10 mg/m ³	2,4-D is poisonous by ingestion and subcutaneous exposures. It is moderately toxic by skin contact. It affects the CNS (depression of CNS) and GI systems (liver and kidney injury). 2,4-D is an experimental carcinogen and teratogen. There is also mutagenic data for this compound.
D-Tox-4E	NL	NL	-
DDE	NL	NL	See DDT.
DDT	1 mg/m ³ _p	1 mg/m ³	DDT is poisonous by ingestion, skin contact, and subcutaneous exposures. It affects the CNS and is an experimental carcinogen, teratogen, and mutagen. DDT is stored in the fat of animals and bioaccumulates.
Diazinon	0.1 mg/m ³ _p	0.1 mg/m ³ _p	This compound is poisonous by ingestion, skin contact, subcutaneous, and possibly by other routes. It effects the CNS and can cause skin and eye irritation. There is mutagenic data for this compound.
Dibenzo(a,h)anthracene	NL	NL	This compound can be absorbed orally and is slowly absorbed after dermal contact.
Dibenzofurans	NL	NL	-
1,4-Dichlorobenzene	75	75 _v	This compound can cause headaches, eye irritation, nausea and vomiting. It is also carcinogenic.
Dichlorodifluoromethane	1,000	1,000	Dizziness, tremors, unconsciousness, cardiac arrhythmia, cardiac arrest. Effects on the central venous system and peripheral nervous system.
1,1-Dichloroethane (Ethylidene dichloride)	100	200	This compound is moderately toxic by ingestion. In animals it has caused liver damage. 1,1-DCA is an experimental teratogen and tumorigen.
1,2-Dichloroethane (1,2-DCA)	1	10	Exposure to 1,2-DCA can cause irritation of the respiratory tract and conjunctiva, corneal clouding, equilibrium disturbances, narcosis, and abdominal cramps. The EPA lists this compound as a carcinogen.
trans-1,2-Dichloroethane (t-1,2-DCA)	1	10	1,2-DCA is a poison by inhalation and ingestion and is moderately toxic by skin contact. Inhalation of vapors can cause irritation of respiratory tract, conjunctiva, corneal clouding, equilibrium disturbances, narcosis, and abdominal cramps. This substance is considered a human carcinogen.
1,1-Dichloroethylene (1,1-DCE)	1	5	1,1-DCE can cause nose and skin irritation, injury to liver and kidneys.
cis-1,2-Dichloroethene (c-1,2 DCE)	NL	NL	-
2,4-Dichlorophenol	NL	NL	This compound is an experimental carcinogen and is moderately toxic by ingestion and subcutaneous routes. It is combustible when exposed to heat or flame.
cis-1,3-Dichloropropane	1 _p	1 _p	This compound is an experimental neoplastigen and has mutagenic data.
Dieldrin	0.025 mg/m ³ _p	0.025 mg/m ³ _p	Headaches, dizziness, nausea, vomiting, and sweating. Carcinogenic.
Diesel Fuel	i		There is mutagenic data for diesel particles and they are a suspected carcinogen.
Diethyl Ether	400	400	Dizziness; drowsiness; headache; excitedness; nausea; vomiting; eye, upper respiratory system, and skin irritation.
Diethylphthalate	NL	NL	This compound is an eye irritant and a systemic irritant by inhalation.
2,4-Dinitrophenol	NL	NL	This compound can cause skin irritation, and there is mutagenic data on this compound.
2,4-Dinitrotoluene	1.5 mg/m ³ _p	1.5 mg/m ³ _p	This compound can cause anoxia, cyanosis, anemia and jaundice. It is also considered carcinogenic.
n-Dioctylphthalate	NL	NL	This compound is a skin and severe eye irritant.

Dursban	NL	NL	--
Endosulfan A	0. 1 mg/m ^{3p}	0.1 mg/m ^{3p}	--
Ethyl Benzene	100	100	This compound is moderately toxic by irritation to skin, eyes, and mucous membranes and by ingestion and inhalation. On eye contact it may cause irritation at first, then dizziness, irritation of nose and throat, and a sense of constriction in the chest. It is an experimental teratogen.
Ethylene glycol	50 ^w	50 ^w	Ethylene glycol is moderately irritating by the eyes, skin, mucous membranes, and by ingestion. If ingested it can cause initial CNS stimulation followed by depression. Later it can cause kidney damage, which can be fatal. It is very toxic in particulate form upon inhalation.
Fluoranthene	NL	NL	Fluoranthene is moderately toxic by ingestion and skin contact.
Fluorene	NL	NL	Fluorene may be toxic through inhalation, ingestion or dermal contact, and absorption.
Gasoline	NL	300	Gasoline can cause eye and skin irritation. Some components of gasoline are toxic (see benzene, fluorene, ethyl benzene, and xylenes).
Heptachlor epoxide	0.5 mg/m ^{3p}	0.5 mg/m ^{3p,x}	This compound is poisonous by ingestion and is an experimental carcinogen.
Indeno(1,2,3)pyrene	NL	NL	--
Iron	NL	NL	Oral exposure to iron can result in severe toxicity specially in children ingesting medicine. Toxic effects include vomiting; bloody, black stools; shock; metabolic acidosis; and liver damage.
Isopropyl alcohol	500	400	This compound is moderately toxic by ingestion. It has a low toxicity by the dermal route, but it is an eye irritant and can cause corneal burns. Isopropyl alcohol acts as a local irritant and in high concentrations as a narcotic. This compound has good warning properties because it causes eye, nose, and throat irritation at relatively low concentrations. There is some evidence that people can develop a slight tolerance to this compound.
Jet Fuel	y	NL	--
Lead	0.05 mg/m ^{3q}	0.15 mg/m ³	Lead is a poison by ingestion and can effect the CNS. Inhalation of lead dust can lead to carcinogenic effects in the lungs and kidneys. It is an experimental teratogen.
Magnesium	NL	5 mg/m ³	Industrial exposures to this compound have resulted in conjunctivitis, nasal inflammation, coughing with sputum, and increased serum calcium. Magnesium particulates can become imbedded in the skin and produce lesions that do heal.
Malathion	10 mg/m ³ P	10 mg/m ^{3p}	Poisonous to humans by ingestion. It affects the CNS by inhibiting an organic phosphate cholinesterase and cause an allergic sensitization of the skin. Malathion is an experimental carcinogen.
Manganese	5 mg/m ^{3w}	5 mg/m ^{3z}	Exposure to this compound can cause mental confusion, a dry throat, coughing, a flu-like fever, lower back pain, vomiting and fatigue.
Mercury	NL	0.1 mg/m ^{3aa}	Exposure to mercury can cause gastrointestinal tract and central nervous system effects.
Methanol	200 ^P	200 ^P	Methanol is a poison by ingestion and skin contact and it is moderately toxic by inhalation and other routes. It is an eye and skin irritant and is a systemic irritant by inhalation. Its main effects are on the nervous system, particularly the optical nerves and possibly the retinae, and can progress into permanent blindness.
2-Methyl-4,6-di-nitrophenol	0.2 mg/m ^{3p}	0.2 mg/m ^{3p}	This compound can cause a sense of well being, headache, fever, lassitude, sweating, excess thirst, coughing, and shortness of breath.
Methylene Chloride (Methane Dichloride)	500	50 ^m	This compound is poisonous by ingestion and moderately toxic by inhalation. Inhalation of methylene chloride can cause blood and CNS effects. It is also a severe skin and moderate eye irritant. There is mutagenic data for this compound.
Methylisobutyl Ketone (MIBK)	50	50	This compound is moderately toxic by ingestion and inhalation. It is also moderately irritating via skin and eye exposure.
2-Methylnaphthalene	NL	NL	This compound is similar in structure to naphthalene and may therefore have similar toxicity.
4-Methyl-2-Pentanone	NL	NL	This compound is a strong irritant.
2-Methylphenol (2-cresol)	5 mg/m ³	5 mg/m ³	2-methylphenol can effect the central nervous system and can cause confusion, irregular respiration, respiratory failure, weak pulse, and lung, liver and kidney damage. In addition, this compound can burn the skin and eyes.
4-Methylphenol (creosote)	NL	NL	Creosote is a complex chemical mixture of varying composition depending on the source and method of production. Dermal exposure can cause mild to severe skin irritation to photo-toxicity that can progress to severe skin lesions.

Naphthalene	10	10	Inhalation of naphthalene may cause eye irritation, headache, and confusion. Ingestion may cause abdominal pain, nausea, and vomiting. Systemic effects such as bladder irritation, kidney effects, and blood effects have been noted after skin and eye contact. Occurrence of cataracts upon chronic exposure of naphthalene vapors and dust has been observed in humans. Skin irritation has been observed after chronic exposures.
Nickel	0.1 mg/m ^{3bb}	0.1 mg/m ^{3bb,cc} Nic 0.05,41	Symptoms of over exposure to nickel include: headache, vertigo, nausea, and vomiting. It is considered a carcinogenic compound.
Nitrates	NL	NL	Inorganic nitrates can cause serious harm or be fatal if ingested in large doses. There is some evidence of increased cancer due to exposure to this compound. Inorganic nitrates may explode when shocked, exposed to heat or flame, or by spontaneous chemical reaction. Furthermore, inorganic nitrates are oxygen carriers and under proper conditions can give their oxygen to other chemicals, which may in turn detonate.
4-Nitrophenol	NL	NL	4-Nitrophenol is poisonous to experimental animals by ingestion, subcutaneous and other routes.
N-nitrosodiphenylamine	NL	NL	N-nitrosodiphenylamine is an eye irritant and is toxic by the ingestion route. It is also an experimental carcinogen.
Paint	NL	NL	–
Paint Thinners	NL	NL	–
PD-680	NL	NL	–
Pentachlorophenol (PCP)	0.5 mg/m ^{3p}	0.5 mg/m ^{3p}	PCP can cause irritation to the eyes, nose and throat. It can also cause sneezing, coughing, weakness, headaches, dizziness, nausea, vomiting, dyspnea, chest pain, fever and dermatitis.
Petroleum hydrocarbons	400y	NL	Petroleum is an experimental neoplastigen and carcinogen.
Phenanthrene	0.2 mg/m ^{3h}	0.2 mg/m ^{3h}	This compound is an irritant through inhalation and ingestion exposure. Phenanthrene may also be dermally absorbed.
Phenol	5p	5p	Phenol is a poison by ingestion and is moderately toxic by skin contact. It is a severe eye and skin irritant. Absorption through the skin can occur rapidly causing damage to the kidneys, liver, spleen, and edema to the lungs. Dermatitis is commonly associated with exposure to this compound. There is mutagenic data for phenol and it is an experimental carcinogen, neoplastigen, and tumorigen.
Phosphates	NL	NL	The toxicity of phosphates is dependant on the specific compound.
Polychlorinated biphenyls (PCB)	42% chlorine: 1 mg/m ^{3p} 54% chlorine: 0.5 mg/m ^{13p}	42% chlorine: 1 mg/m ^{3p} 54% chlorine: 0.5 mg/m ^{3p}	PCBs are poisonous by inhalation, ingestion, and skin contact. This compound can affect the skin or the liver. It is an experimental teratogen and a suspected human carcinogen.
Pyrene	0.2 mg/m ^{3h}	0.2 mg/m ^{3h}	Pyrene is an experimental carcinogen and is a skin irritant.
Pyrethrins	NL	5 mg/m ³	Pyrethrin I or II is poisonous by ingestion and is an allergen. It is rapidly detoxified in the GI tract, but it can cause GI, respiratory, and CNS effects. Chronic exposures can lead to liver damage.
Resmethrin	NL	NL	Resmethrin is an artificial pyrethrin. This compound is poisonous by ingestion and is an allergen. It can cause GI, respiratory, and CNS effects.
Selenium	0.2 mg/m ^{3dd}	0.2 mg/m ^{3dd}	This compound cause eye, nose, and throat irritation, visual disturbance, headaches, chills, fever, bronchitis, metallic taste, garlic breath, gastrointestinal disturbance, and dermatitis.
Stoddard Solvent	100	100	Stoddard solvent is slightly toxic by inhalation. In humans it causes eye irritation.
Styrene	50	50p	This compound is poisonous by ingestion and moderately toxic by inhalation. It is also a skin and eye irritant, causing severe eye itching in humans. It is a systemic irritant and causes CNS effects. There is mutagenic data for this compound.
Sulfates	NL	NL	The toxicity of sulfates is dependent on the specific compound.
2,4,5-T	10 mg/m ³	10 mg/m ³	–

Tetrachloroethene (PCE) 1P	50		PCE can cause eye, nose and throat irritation, nausea, flushed face and neck, vertigo, dizziness, headache. This compound is also considered carcinogenic.
2,3,4,6-Tetrachlorophenol	NL	NL	This compound is poisonous by ingestion, skin contact and subcutaneously. It is also an experimental carcinogen.
Titanium	NL	NL	—
Toluene	100	100 ^{ee}	This compound is moderately toxic by inhalation. Inhalation of this compound can cause an impairment of coordination and reaction time, headache, nausea, eye irritation, and loss of appetite. There is mutagenic data for this compound.
1,1,1-Trichloroethane (1,1,1-TCA)	350	350	1,1,1-TCA is moderately toxic by ingestion. In humans it can cause psychotropic, GI, and CNS effects. It is also a moderate skin and eye irritant.
Trichloroethene (TCE)	50	50	TCE is toxic by inhalation and ingestion. Inhalation of this compound can cause headache and drowsiness. It is also a strong skin and eye irritant. There is mutagenic data and it is an experimental teratogen, carcinogen, and tumorigen.
Trichlorofluoromethane	1,000 ^m	1,000 ^m	In humans this compound can affect the eye (systemic) and the PNS. It is an experimental carcinogen.
2,4,5-Trichlorophenol	NL	NL	This compound is moderately toxic by ingestion and subcutaneous routes and is an experimental carcinogen.
2,4,6-Trichlorophenol	NL	NL	This compound is a skin and eye irritant. See 2,4,5-Trichlorophenol.
Vandium	NL	NL	The toxicity of vandium depends on the compound but they primarily cause conjunctivae and respiratory tract irritation. Vandium is an experimental carcinogen.
Vinyl chloride	1P	5P	Vinyl chloride is a known human carcinogen. Inhalation of this compound causes irritation to the skin, eyes, and mucous membranes.
Waste Oil	d	NL	The toxicity of waste oils is very variable depending on how the oil was used. Frequently, waste oils contain heavy metals.
Xylenes (total)	100	100	It is moderately toxic by inhalation and ingestion, causing systemic irritant effects. This compound causes severe eye irritation with some temporary conjunctival irritation possible, and is a moderate skin irritant.
Zinc	NL	NL	Zinc can cause skin and pulmonary system irritation. Oxides of zinc are more toxic than the pure compound and toxicity varies with the various oxides.

^aTable compiled August 1991, updated April 1992.

^bOSHA 8-hour permissible exposure limit.

^cACGIH 8-hour threshold limit value.

^dNo level in literature.

^eTotal metal dust.

^fMetal dust.

^gShort-term exposure limit; 15-minute time weighted average.

^hCoal tar pitch volatiles.

ⁱAs Sb.

^jNIOSH considers this compound carcinogenic (with no further categorization).

^kSoluble compounds.

^lIntended to change to 10 ppm.

^mSuspected carcinogen.

ⁿAs Sb.

^oIntended to change to 0.01 mg/m³.

^pDanger of cutaneous absorption.

^qAs chromium (III).

^rAs water insoluble chromium (VI).

^sKnown carcinogen.

^tDust and fumes, as Co.

^uDust and fumes, as Cu.

^vIntended to change to 10 ppm and be listed as carcinogenic.

^wConcentration shall not be exceeded during any part of working exposure.

^xIntended to change to 0.05 mg/m³ and be listed as carcinogenic.

^yPetroleum distillates.

^zDust and compounds, as Mn.

^{aa}Inorganic compounds, as Hg.

^{bb}Soluble compounds, as Ni.

^{cc}Intended to change to 0.05 mg/m³ and be listed as carcinogenic.

^{dd}As Se.

^{ee}Intended to change to 50 ppm.

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