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Assessment of Surface Soil Contamination at Soil and Crop, Inc. Othello, Washington

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ABSTRACT

Soil, water, and sediment samples were collected March 23-24, 1988, from Soil and Crop, Inc., Othello, Washington, and analyzed for a range of nutrients, metals, volatile organics, pesticides, and herbicides to determine contamination levels resulting from spills and/or rinsate disposal at the facility. Results of these analyses indicated that contamination of surface soils with nitrates, ammonia, several metals, pesticides, and herbicides is widespread throughout the site. A wet well located in the main mixing building has also been heavily contaminated with a similar variety of constituents, in addition to, several volatile organic compounds. All on-site liquid storage and mixing tanks were empty at the time of this investigation.

INTRODUCTION

Soil and Crop, Inc., located in Othello, Washington, which occupies an area of approximately four acres, has operated as a combination production and mixing facility for suspension fertilizers between 1963 and 1986. A variety of pesticides and herbicides have also been handled at the site. As a result of these activities, contamination of ground water and soils has occurred (TVA, 1985; Hart Crowser, 1986; Ecology, 1986). Recent information obtained through oral examination of the owner identified several additional areas of potential contamination that were not included in these previous investigations. The Toxics Investigations and Ground Water Monitoring Section (TIGWMS) was therefore requested by Ecology's Eastern Regional Office (ERO) to conduct surface soil sampling to determine the levels of contamination present in areas identified during the deposition where spills or rinsate disposal may have occurred. A second objective of this investigation was to determine the contents of several on-site liquid storage tanks.

METHODS

Sampling

Soil, sediment, and water sampling was conducted March 23-24, 1988, by Denis Erickson and Dale Norton from TIGWMS, in conjunction with Sherman Spencer and Flora Goldstein of the ERO. Sampling locations are shown in Figure 1.

Soils

To characterize each sampling location, three to five soil borings were dug with a pick and shovel to a depth of one foot. Based on visual observations, soils at the site consisted of approximately 2.5-3.5 inches of gravel fill overlying brown sandy silt. Sample collection involved scraping the sides of each boring with a stainless steel spoon to expose a new surface and then compositing soil from the top of the

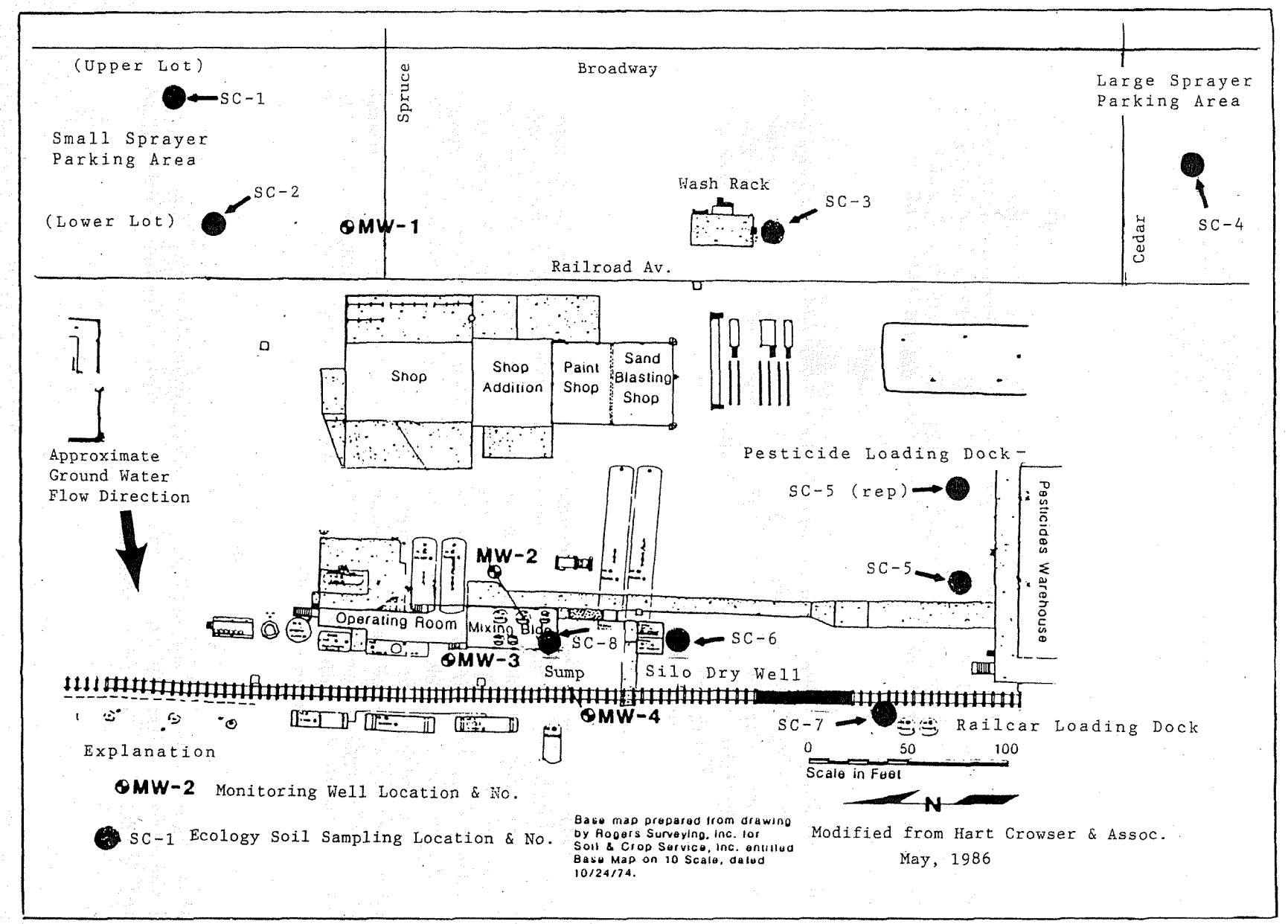

Figure 1. Site map and sampling stations; Soil and Crop, Othello, WA.

sandy silt layer to the bottom of the hole, into a stainless steel beaker. The sample was then homogenized. Aliquots for VOA analysis were scraped directly from the sides of each boring. All samples were placed in priority pollutant-cleaned glass jars with teflon-lined lids supplied by I-Chem Hayward, California, wrapped in plastic bags and stored on ice for transport to the Ecology/EPA Environmental Laboratory at Manchester, Washington.

Sediment

Surface sediment from the sump in the mixing building was collected using a 0.02m2 Petite Ponar grab sampler. To obtain sufficient sample volume the top 2cm from each of three separate grabs was removed with a stainless steel spoon, composited into a stainless steel beaker, and homogenized by stirring. Containers and handling procedures employed were similar to those described above for soils.

Water

Prior to obtaining sump sediments, water samples were collected as surface grabs by directly filling sample containers. All equipment used in sampling (i.e., spoons, beakers, and Ponar) was precleaned with sequential washes of hot tap water/liquinox detergent, 10 percent nitric acid, distilled/deionized water, pesticide-grade methylene chloride, and pesticide-grade acetone, then air-dried and wrapped in aluminum until being used in the field.

Analysis

The chemical analyses, methods, and laboratories used in the investigation are listed in Table 1. Quality of the data set was evaluated through the use of blanks, spiked samples, and duplicate analyses. In general, no major analytical problems were encountered in the analysis of these samples, and consequently the data set is considered acceptable with the following caveats. Methylene chloride and acetone were detected at low levels in method blanks, and as a result all detected values for these two compounds have been flagged. Laboratory precision calculated from duplicate analysis was excellent for all parameters (+/- 10 percent for conventionals, metals, volatile organics, organochlorine and organophosphorus pesticides and +/- 15 percent for herbicides) with the exception of aldrin and dieldrin which were +/- 50 percent and +/- 86 percent, respectively.

RESULTS

The results of analyses of soil, sediment, and water samples from Soil and Crop, Inc. are summarized in Table 2. A complete list of all organic compounds analyzed and associated detection limits are in Appendix A.

Table 1. Analytical methods used for Soil and Crop Investigation, March 23-24, 1988.

Analysis	Method	Reference	Laboratory
Soil/Sediment			
Total Solids	No. 209F	APHA, 1985	Laucks, Inc., Seattle, WA
Total Organic Carbon	No. 9060	EPA, 1984(b)	" " "
Nitrate	No. 353.2	EPA, 1979	Wash. State University
Ammonia	No. 350.1	" "	" " "
As, Bo, Cd, Cr, Cu, Pb Mn, Zn	ICP Atomic Emission No. 6010	EPA, 1984(b)	Ecology/EPA Laboratory Manchester, WA
Hg, K	Atomic Absorption Spectroscopy*	EPA, 1985	" "
Volatile Organics	Purge and Trap GC/MS No. 625	EPA, 1984(a)	Analytical Resources, Inc. Seattle, WA
Organochlorine Pest/PCB	Gas Chromatography/ Electron Capture No. 8080	EPA, 1984(b)	" " "
Organophosphorus Pesticides	Gas Chromatography Mass Spectroscopy No. 8140	EPA, 1984(b)	" " "
Organochlorine Herbicides	Gas Chromatography Mass Spectroscopy No. 8150	EPA, 1984(b)	" " "
Water			
pH	Beckman pH meter	-	Field
Total Solids	No. 209A	APHA, 1985	Ecology/EPA Laboratory Manchester, Wa.
Total Non-Volatile Solids	Constant weight @ 550 C	" "	" "
Total Suspended Solids	No. 209C	" "	" "
Total Non-Volatile Susp. Solids	Constant weight @ 550 C	" "	" "
Total Hardness	No. 314B	" "	" "
Chloride, Sulfate	Ion Chromatography No. 429	" "	" "
Nitrate+Nitrite	No. 353.2	" "	" "
Total Phosphorus	No. 365.1	" "	" "
As, Bo, Cd, Cr, Cu, Hg K, Mn, Pb, Zn	Atomic Absorption Spectroscopy*	EPA, 1979	" "

*=Digestion-Total metals soil: HNO_3/H_2O_2, except Hg which uses cold vapor procedure

Total recoverable metals water: HNO_3, except Hg which uses cold vapor procedure

Table 2: Summary of analyses of soil/sediment/water samples collected by Ecology March 23-24, 1988 from Soil and Crop, Othello, WA (see below for units).

Location	Small Sprayer Parking		Wash	Large Sprayer	Pesticide Loading Dock		Silo Dry	Railcar Loading	Mixing Building Wet Well	
	Upper Lot	Lower Lot	Rack	Parking			Well	Dock		
Station	SC-1	SC-2	SC-3	SC-4	SC-5	Replicate	SC-6	SC-7	SC-8	SC-8
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Water	Sediment
Sample Depth (ft)	0.3-0.8	0.3-1.0	0.2-0.8	0.3-0.8	0.3-0.9	0.3-1.0	0.3-1.0	0.2-0.8	-	0-0.07
Sample No. 13-	8245	8252	8246	8247	8248	8249	8250	8251	8232	8233
Conventionals										
pH (s.u.)	-	-	-	-	-				5.8	-
Total Solids (%)	88.3	87.6	87.4	89.9	86.6	89.9	87.4	89.2	0.08	33.6
TNVS	-	-	-	-	-	-	-	-	530	-
TSS	-	-	-	-	-	-	-	-	34	-
TNVSS	-	-	-	-	-	-	-	-	24	-
Total Hardness	-	-	-	-	-	-	-	-	30J	-
TOC (%)	0.4	0.7	0.5	0.5	0.4	0.4	0.4	0.7	-	1.5
Chloride	-	-	-	-	-	-	-	-	58	-
Sulfate	-	-	-	-	-	-	-	-	220	-
NO3	11	21	120	230	85	65	740	190	-	1.3
NO2+NO3	-	-	-	-	-	-	-	-	5.8	-
NH3	2.1	7.9	700J	600J	690J	260J	3900J	120	43	110J
T.PO4	-	-	-	-	-	-	-	-	9.2	-
Metals										
Arsenic	5U	15	7.6	12	6.1	15	14	12	22	5U
Boron	10	13	43	10	13	16	11	15	2900	110
Cadmium	0.5U	0.5U	3.2	0.5U	0.5U	0.5U	1.0	6.8	5.5	10
Chromium	7.6	6.5	21	6.6	6.8	17	29	15	13	140
Copper	18	16	80	13	16	39	16	24	200	1500
Lead	5.0	5.0	58	52	5.0U	26	5.0U	8.5	9	64
Manganese	380	350	730	340	360	450	290	400	13000	17000
Mercury	0.009	0.006U	0.036	0.011	0.012	0.023	0.011	0.018	0.05U	0.15
Potassium	1500	1600	4800	2400	1800	1400	2000	1800	11000	350
Zinc	42	56	880	42	62	1500	76	370	2300	3000
Volatiles										
Methylene Chloride	**10B**	**10B**	**6.5B**	**11B**	**14B**	**12B**	**18B**	**15B**	-	**47B**
Acetone	7.2U	6.7U	7.6U	**6.0JB**	**4.9JB**	7.0U	**6.5JB**	6.6U	-	40U
Carbon Disulfide	1.3U	1.2U	1.3U	1.2U	1.3U	1.2U	1.3U	1.2U	-	**40**
Benzene	1.1U	1.0U	1.1U	1.0U	1.1U	1.0U	1.1U	1.0U	-	**2.9J**
Toluene	0.8U	0.8U	1.3	0.8U	0.9U	0.8U	0.9U	0.8U	-	4.6U
Chlorobenzene	0.9U	0.9U	1.0U	0.9U	1.0U	0.9U	1.0U	0.9U	-	**550**
Ethylbenzene	0.8U	0.8U	0.3J	0.8U	0.9U	0.8U	0.9U	0.8U	-	**230**
Total Xylenes	1.9U	1.8U	3.2	1.7U	2.0U	1.8U	2.0U	1.7U	-	**1300**
Pesticides/PCB										
Aldrin	**24**	3U	30U	**64C**	**117J**	**2400**	**3**	60U	-	20U
Dieldrin	**40**	**20**	**380**	**57**	**650J**	**390**	**82**	**2000**	-	**44**
4,4' DDE	6U	6U	**240**	6U	6U	300U	6U	120U	-	40U
4,4' DDT	6U	**16**	60U	6U	6U	300U	**26**	**2200**	-	40U
Endrin	**64**	6U	60U	**710**	**16**	**5000**	**9**	**170**	-	**20J**
Methoxychlor	6U	6U	**190**	6U	6U	300U	6U	120U	-	40U
Endrin Ketone	**20**	**5**	60U	**97**	**68J**	**1200**	**3J**	**100**	-	40U
Metribuzin	10U	**31**	**630**	**140**	**740**	**23**	10U	10U	-	1000U
Hexazinone	**110**	**74**	**450**	**230**	**33**	**24**	20U	20U	-	2000U
Disulfoton	20U	20U	**7800**	20U	30U	20U	20U	20U	-	**79000**
Tetrachlorvinphos	30U	30U	**5400**	30U	**820**	**32**	**21J**	**19J**	-	3000U
Alachlor	40U	40U	**980**	**4900**	60U	40U	40U	40U	-	4000U
Dinoseb	5U	5U	**55**	5U	**9**	5U	5U	**8**	-	50U
Dicamba	5U	5U	**10**	**35**	5U	5U	**25**	5U	-	50U
2,4-D	20U	20U	**30**	20U	20U	20U	20U	20U	-	**20J**

Units = Conventionals - soil/sediment, ppm, dry weight; water ,ppm unless otherwise indicated
Metals - soil, ppm, dry weight; water, ppb; Organics - ppb, dry weight

- = Not analyzed
B = Analyte detected in blank
U = Not detected at detection limit shown
J = Estimated concentration
C = Tentative hit unconfirmed due to interference on confirmation column

Soils

Soils at the site can be characterized as having an organic carbon content typical of inorganic soils. Nitrate and ammonia concentrations ranged between 11-740 ppm and 2.1-3900 ppm respectively, with the highest values for both constituents occurring at the Silo Dry Well (station SC-6). No consistent patterns of contamination were evident in metals concentrations throughout the site with the exception of the Wash Rack (station SC-3) area which had the highest soil concentrations of boron, copper, lead, manganese, mercury, and potassium. Cadmium, lead, and zinc were the most variable metals covering a concentration range of one to three orders of magnitude across the site. All other metals ranged between factors of two to six.

Low levels of two volatile organic compounds (toluene - 1.3 ppb, and xylene - 3.2 ppb) were detected in surface soil from the Wash Rack area. No volatiles were detected in the remaining soil samples.

Contamination of surface soils with a variety of organochlorine and organophosphorus pesticides and herbicides appeared to be widespread throughout the site. In fact, all soil samples collected during this investigation contained measurable concentrations of at least five of the 15 different pesticides/herbicides or breakdown products detected. Again, no consistent pattern was seen in contamination levels with the exception of the Wash Rack area which had the highest concentrations of DDE, methoxychlor, hexazinone, disulfoton, tetrachlorovinphos, dinoseb, and 2,4-D. Concentrations of individual compounds exceeded 1 ppm at the following locations: Wash Rack, disulfoton-7.8 ppm and tetrachlorovinphos-5.4 ppm; Large Sprayer Parking, alachlor-4.9 ppm; Pesticide Loading Dock, aldrin-2.4 ppm, endrin-5 ppm, and endrin ketone-1.2 ppm; and Railcar Loading Dock, dieldrin-2 ppm and DDT-2.2 ppm. The results of analysis of replicate (two independent samples collected at a single station) soil samples from the Pesticide Loading Dock indicate that pesticide/herbicide concentrations are quite variable at this location.

Mixing Building Sump

Analysis of water and sediment from the mixing building sump indicated this area has been heavily affected by past activities at the facility. Water from the sump was characterized by having a high solids and ammonia content. In addition, elevated concentrations of arsenic, boron, copper, manganese, potassium, and zinc were found. Sump sediments contained the highest concentrations of boron (110 ppm), cadmium (10 ppm), chromium (140 ppm), copper (1500 ppm), lead (64 ppm), manganese (17000 ppm), mercury (0.15 ppm), and zinc (3000 ppm) measured during the present investigation.

Volatile organic compounds detected in sump sediments were as follows; carbon disulfide (40 ppb), benzene (2.9J ppb), chlorobenzene (550 ppb), ethylbenzene (230 ppb), and xylene (1300 ppb). Dieldrin, endrin, and 2,4-D were all present at <50 ppb. Disulfoton, a relatively toxic and mobile insecticide, was measured at 79 ppm.

Tanks

Previous investigations at Soil and Crop by the Tennessee Valley Authority in 1985 detailed the contents of many of the on-site storage tanks, primarily various types of liquid fertilizer suspensions. At the time of Ecology's site investigation on March 23-24, 1988, all liquid storage and mixing tanks on-site were reported to have been pumped dry. Visual inspection of the tanks confirmed they were empty.

DISCUSSION

Table 3 compares metals and pesticides/herbicides data on soils collected at approximately the same locations by Hart Crowser in 1986 and Ecology during the present investigation. These data indicate that metals levels are quite similar between the two studies; however, pesticide/herbicide concentrations measured by Ecology in 1988 are much lower then those seen in 1986. It is unclear whether the observed differences are the result of environmental variability, degradation of the compounds, or sampling and analytical differences between the two studies. The most likely explanation is that all three factors are involved to some degree.

To place metals results from the present study into perspective, Table 4 summarizes concentrations of metals reported in surface soils from the United States. Based on mean concentrations, it appears that arsenic and cadmium are slightly elevated in surface soils at the site, while potassium and zinc are substantially higher than values reported for other areas of Washington and the U.S.

Listed in Table 5 are toxicity, solubility, and persistence information for pesticides/herbicides detected at Soil and Crop, Inc. Limited information is available on typical pesticide residuals in soils. Monitoring data on aldrin, dieldrin, DDT, and endrin levels in soils from five fields near Quincy and Moses Lake, Washington, are shown in Table 6. These data indicate that aldrin, dieldrin, and endrin concentrations at Soil and Crop are much higher than in areas where these pesticides were applied for agricultural purposes. However, as noted earlier, taking the analytical precision estimates for aldrin (+/- 50 percent) and dieldrin (+/- 86 percent) into account could alter the observed concentrations substantially.

SUMMARY

Contamination of surface soils with nitrates, ammonia, several metals, pesticides, and herbicides appears to be widespread throughout the Soil and Crop facility. In addition, a sump (wet well) located in the bottom of the mixing building has been heavily contaminated with a similar variety of compounds. This sump also provides a direct pathway for contaminant migration to ground water. At the time of Ecology's site investigation in March 1988, all liquid fertilizer storage and mixing tanks at the facility were empty.

Table 3. Comparison of metals and pesticide analysis of selected surface soil samples collected by Hart Crowser and Ecology from Soil and Crop, Inc., Othello, WA (mg/kg, dry weight).

Location	Wash Rack		Pesticide Loading Dock		
Station No.	SS-1	SC-3	SS-4	SC-5	SC-5 rep.
Date Sampled	4/86*	3/88	4/86*	3/88	3/88
Sample No.	-	138246	-	138248	138249
Metals					
Boron	21	43	12	13	16
Copper	65	80	26	16	39
Manganese	910	730	460	360	450
Potassium	2600	4800	1200	1800	1400
Zinc	1100	880	200	62	1500
Pesticides					
Dieldrin	1U	0.38	1U	0.65J	0.39
DDT	1U	0.06U	1U	0.006U	0.3U
Fonofos	15	-	1U	-	-
Metribuzin	1U	0.63	6.4	0.74	0.023
Hexazinone	1U	0.45	1U	0.033	0.024
Tetrachlorovinphos	-	5.4	-	0.82	0.04U
Disulfoton	190	7.8	1U	0.03U	0.02U
EPTC	3.2	0.4U	1U	0.06U	0.04U
Alachlor	25	0.98	1U	0.06U	0.04U

- = Not analyzed
U = Not detected at detection limit shown
J = Estimated concentration
* = Hart Crowser, 1986.

Table 4. Comparison of metals concentrations reported in surface soils from the United States with values from Soil and Crop, Inc. (mg/kg dry weight basis)

Source	Area	Metals (mg/kg) As	Bo	Cd	Cr	Cu
Soil and Crop, Inc. mean (range)	WA	11(5u-15)	16(10-43)	1.5(0.5u-6.8)	14(6.5-29)	28(13-80)
Holmgren, et al., 1987 mean (range)	U.S.	-	-	0.27(0.01u-2.3)	-	30(0.3u-735)
Holmgren, et al., 1987 mean (standard Dev.)		-	-	0.19(0.07)	-	27(8.9)
Ebens and Shacklette, 1982 grand mean (range of means)	U.S.+	5.9(3.3-9.3)	34(11-74)	-	42(13-63)	18(6.3-36)
range all observations		(0.1u-76)	(2.2u-120)	-	(5.5-350)	(1.6-120)

Source	Area	Metals (mg/kg) Pb	Mn	Hg	K	Zn
Soil and Crop, Inc. mean (range)	WA	20(5u-58)	410(340-730)	0.02(0.006u-0.036)	2200(1400-4800)	900(42-1500)
Holmgren, et al., 1987 mean (range)	U.S.	18(0.2u-4100)	-	-	-	57(1.5u-400)
Holmgren, et al., 1987 mean (standard Dev.)		9(4)	-	-	-	67(15)
Ebens and Shacklette, 1982 grand mean (range of means)	U.S.+	14(7.1-26)	320(180-720)	0.024(0.021-0.041)	1.8(1.5-2.3)	57(26-83)
range all observations		(1.2u-100)	(30-3800)	(0.01u-0.23)	(0.56-3.2)	(12-170)

u = Not detected at detection limit shown
* = Inorganic agricultural soils (n = 116)
+ = Western United States
- = No data

Table 5. Characteristics of pesticides detected in soil samples from Soil and Crop, Inc., Othello, WA

Pesticide	Toxicity* (mg/kg)	Solubility (ppm) @ 25 in H_2O	Persistence in Soil+ (weeks)
Aldrin	38-67	0.01-0.2	>52**
Dieldrin	37-87	0.1-0.25	>78**
DDE	880	-	-
DDT	113	0.001	>78**
Endrin	7-15	0.23	-
Methoxychlor	6000	0.1-0.25	8**
Metribuzin	1100-2300	1200	6-36
Hexazinone	1690	32000	4-48
Disulfoton	2-12	25	1-42
Tetrachlorvinphos	4000-5000	-	-
Alachlor	1800-9300	240	1-10
Dinoseb	40-60	52	2-52
Dicamba	1040-2900	4500	1
2,4-D	375	900	1-4

* = Acute rat oral LD-50
\+ = Resultant average persistence, expressed as half-life in agricultural soil unless otherwise noted
** = Approximate minimum time for 90% disappearence from soil

Table 6. Comparison of pesticide levels in soils from five fields near Quincey and Moses Lake, WA with those measured at Soil and Crop, Inc., Othello, WA (ug/kg, dry weight)

Location	Quincy and Moses Lake*	Soil and Crop, Inc.
Sample Date	1965-67	1988
Pesticide	mean(range)No. samples	mean(range)No. samples
Aldrin	70(4-140)3	330(3u-2400)8
Dieldrin	120(10-210)17	450(20-2000)8
DDT	830(20-2800)19	300(6u-2200)8
Endrin	-(10)1	750(6u-5000)8

u = Not detected at detection limit shown
* = Stevens, et al.,(1970)

RECOMMENDATIONS

Based on the findings of this investigation, the following recommendations are made:

- The highest priority area at Soil and Crop, Inc. for cleanup activities should be the sump (wet well) located in the basement of the mixing building for the following reasons; variety of compounds detected, the high concentration levels (especially for disulfoton, 79 ppm) and the sump itself provides a direct pathway for contaminant migration to ground water.

- Second priority cleanup areas should include the Wash Rack and Pesticide Loading Dock.

- The site should be secured from public access, especially to the Mixing Building, Wash Rack, and Pesticide Loading Dock areas, until an assessment of potential health risks associated with the observed contamination can be completed.

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APPENDIX