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Final Report
Residential Pesticide Study

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Acknowledgements

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PREFACE

Under the Education Code, sections 17210, 17210.1, 172131, and 17213.2, school districts planning to utilize state bond funds for school property acquisition or construction are required to conduct environmental reviews for hazardous materials for kindergarten through grade 12 school facilities. Since January 2000, DTSC's role has been to provide oversight of environmental investigations at proposed new or expanding school sites to ensure protection of children, staff, community, and the environment from the potential effects of exposure to hazardous materials. In September 2004, the California Department of Toxic Substances Control (DTSC) completed a Residential Pesticide Study (Study) to evaluate the presence of chlordane and other organochlorine pesticides (OCPs) used as insecticides to control termites at three proposed school sites in California. This report was peer reviewed by the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency in March 2005.

Studies conducted between 1971 and 2004 in other regions of the United States (Massachusetts, New Jersey, Florida, Texas, Louisiana, Missouri, and Colorado) identified the persistence of chlordane in soils around houses 21 years or more after application. Chlordane and other OCPs (e.g.., heptachlor, aidrin, and dieldrin) were commonly used as pesticides on agricultural crops, lawns, and gardens, and as insecticides around structures throughout the U.S. from 1948 until 1988. The most frequently used OCP was chlordane, which was applied to over 30 million homes in the U.S., often at higher concentrations than recommended by the manufacturers. Above-ground use of chlordane was phased out between 1978 and 1983 by the United States Environmental Protection Agency (U.S. EPA), although chlordane was used as a termiticide for wooden structures until it was prohibited in 1988. Chlordane is resistant to chemical and biological degradation, adsorbs to organic matter and clay particles in soils, and slowly volatilizes to the atmosphere. Human exposure may occur through subsurface vapor intrusion into homes. Chlordane is considered to be a probable human carcinogen by U.S. EPA (U. S. EPA 1997, 2002) and is listed as a carcinogen by the State of California (OEHHA 2005). It may cause both chronic and acute health effects, and is of particular concern to children's health, impacting development of the immune; neuroendocrine, and reproductive organ systems.

For the DTSC Study in 2004, three proposed school sites, located in Los Angeles (Weemes Elementary School Expansion), San Diego (Cherokee Point Elementary School), and San Bexnardino (Jones Elementary School) were selected to evaluate the presence of OCPs at residential properties in California. The school sites were selected to study variations in location, acreage, and number of residential properties. The size of the proposed school sites ranged from 0.6 acres at Weemes to 7 acres to Cherokee and 11 acres at Jones; the number of residential properties ranged from four homes at Weemes to 38 homes at Cherokee and 51 lots with multiple unit dwellings at Jones. There was no previous agricultural, industrial, or commercial use at any of the proposed school sites.

At the three proposed school sites, DTSC staff collected a total of 176 soil samples at three depths around building perimeters. Samples were analyzed for OCPs by a California certified laboratory using U. S. EPA method 8081A. OCPs were most frequently detected in the surface soil samples (0 to 0.5 feet below ground surface); the OCPs most frequently detected were chlordane (98 percent), DDT (95 percent), DDE (91 percent), and dieldrin (71 percent) A human health screening evaluation was conducted for each property, using maximum detected concentrations to estimate potential carcinogenic risks and noncarcinogenic health hazards in conjunction with health-based toxicity criteria developed by U. S. EPA and California Office of Environmental Health Hazard Assessment (OEHHA) Risk-screening evaluation results indicated elevated risks and hazards to human health at all three sites, associated primarily with chlordane and dieldrin in surface soils. Approximately 50 percent of chlordane and dieldrin detections had an associated risk greater than 1 in a million (> 1 X 1e), and approximately 20 percent of chlordane and dieldrin detections had an associated risk greater than I in 100,000 (> I X 10^{-5}). The levels detected presented an unacceptable risk to children and adults under a residential, unrestricted land use scenario.

In addition to the three school sites included in the Study, DTSC has investigated OCPs at additional residential properties proposed for school sites in numerous California counties, including Alameda, Contra Costa, Fresno, Imperial, Los Angeles, Madera, Orange, Riverside, San Bernardino, San Diego, San Joaquin, San Mateo, Santa Cruz, Santa Barbara, Stanislaus, Tehama, Tulare, and Ventura (see attached listing). Based on results of the Study and investigation results at these additional proposed school sites, DTSC recommends sampling and analysis for OCPs be routinely conducted at proposed school sites historically used for residential properties. To facilitate the environmental review process for former residential properties, which might otherwise be expected to pose fewer environmental concerns than sites with other historic uses (e g,, agricultural, commercial or industrial), DTSC recommends that sampling for OCPs at proposed school sites be conducted in conjunction with the DTSC protocol for investigation of contamination from lead-based paint and polychlorinated biphenyls (PCBs) from transformers in Phase I Environmental Site Assessments, Preliminary Environmental Assessments, Supplemental Site Investigations, and/or Remedial Investigations.

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5/8/06
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OCP INVESTIGATIONS AT RESIDENTIAL PROPERTIES

	PROJECT NAME	CITY	COUNTY	COMMENTS
1	BURBANK E.S./HAYWARD JOINT USE PARK	Hayward	ALAMEDA	OCP's Identified
2	COMPREHENSIVE HIGH SCHOOL NO. 2	Bakersfield	KERN	OCP's Identified
4	ELEMENTARY SCHOOL SITE	Sanger	FRESNO	OCP's Identified
5	JEFFERSON ELEMENTARY SCHOOL	San Leandro	ALAMEDA	OCP's Identified
6	JOSEPH A. GREGORI HIGH SCHOOL SITE	Modesto	STANISLAUS	OCP's Identified
7	SAND CREEK ELEMENTARY SCHOOL	Brentwood	CONTRA COSTA	OCP's Identified
8	ELEMENTARY SCHOOL 2CD	Vacaville	SOLANO	OCP's Identified
9	WALNUT ELEMENTARY 2 ACRE ADDITION	Turlock	STANISLAUS	OCP's Identified
10	CHEROKEE POINT ELEMENTARY	San Diego	SAN DIEGO	OCP's Identified
11	MIDLAND ELEMENTARY SCHOOL	Poway	SAN DIEGO	OCP's Identified
12	NOBLE NEW ELEMENTARY SCHOOL NO. 1	Panorama City	LOS ANGELES	OCP's Identified
13	RICHARD PITTMAN ELEMENTARY SCHOOL	Stockton	SAN JOAQUIN	OCP's Identified
14	WEEMES ELEMENTARY SCHOOL PLAYGROUND	Los Angeles	LOS ANGELES	OCP's Identified
15	OAKDALE HIGH SCHOOL EXPANSION	Oakdale	STANISLAUS	OCP's Identified
16	SOQUEL AVENUE PROPERTY	Santa Cruz	SANTA CRUZ	OCP's Not Identified
17	STATE STREET ELEMENTARY SCHOOL	Huntington Park	LOS ANGELES	OCP's Identified
18	JOHN HAM HIGH SCHOOL	Lynwood	LOS ANGELES	OCP's Identified
19	LIVINGSTON HIGH SCHOOL EXPANSION	Livingston	MERCED	OCP's Identified
20	MADISON STREET ELEMENTARY NO. 227	Indio	RIVERSIDE	OCP's Identified
21	PATRICIA BEATTY ELEMENTARY SCHOOL	Riverside	RIVERSIDE	OCP's Identified
22	LAS JUNTAS ELEMENTARY SCHOOL	Martinez	CONTRA COSTA	OCP's Not Identified
23	JONES ELEMENTARY SCHOOL	San Bernardino	SAN BERNARDINO	OCP's Identified

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MEMORANDUM

TO: Stephen Di Zio, Chief
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FROM: Jim Carlisle, D.V.M., Chief
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Via: David M. Siegel, Ph.D., Chief
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DATE: March 21, 2005

SUBJECT: OEHHA COMMENTS ON THE SEPTEMBER 20, 2004 FINAL REPORT ON THE RESIDENTIAL PESTICIDE STUDY

Overall, the study appears to have been well conducted and the results reported clearly and comprehensively. I am sending separately (by electronic mail) a copy of the Final Report on the Residential Pesticide Study with a few suggested edits in "track changes" mode. None of the suggested edits are of a critical nature, but they may help the document to read better, particularly to a lay audience.

If your have any questions please contact me at (916)-323-2635 thank you.

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1. INTRODUCTION

Chlordane, an organochlorine pesticide, was used in the United States from 1948 until 1988, when it was banned by the U.S. EPA (U.S. EPA, 1990). Before 1978, chlordane was used as a pesticide on agricultural crops, lawns, and gardens and as a fumigating agent. Because of evidence of human exposure and accumulation in body fat as well as persistence in the environment and effects in wildlife, the EPA canceled the use of chlordane on food crops and phased out other above-ground uses from 1978 to 1983. From 1983 to 1988, the only approved use of chlordane was to control termites in homes, where it was poured or injected around foundations (McConnachie and Zahalsky, 1992). It was applied to over 30 million homes in the United States, and was often applied at concentrations far higher than those recommended by the manufacturer (Kilburn and Thornton, 1995).

Other organochlorine pesticides, including heptachlor and aldrin, which readily converts to dieldrin in the environment, were also commonly used as insecticides around structures (ATSDR, 2002). For this reason, while chlordane was initially the primary contaminant of concern, the full suite of organochlorine pesticides were included in chemical analysis of samples collected in this study using EPA Method 8081A.

1.1 Fate and Transport

Because of its resistance to chemical and biological degradation (WHO, 2003), chlordane is listed as one of 12 persistent organic pollutants by the EPA (Wania and Mackay, 1996; Fisher, 1999). Despite its persistence, chlordane has a low potential for groundwater contamination due to its low water solubility, but it does bind strongly to sediment particles in the water column. When applied to the soil around structures, chlordane adsorbs to organic matter and clay particles and slowly volatilizes into the atmosphere (ATSDR, 1995). The application of chlordane as a termiticide in residential areas was most prevalent in areas where termite infestations are common: from the lower New England states south and west to the lower portion of Colorado and up to Northern California (EPA, 1987).

Bennett et al. (1974) reported chlordane in the top approximately six inches of soil around foundations of two homes 21 years after it was applied as a termiticide. A sampling of soil around 30 houses in Louisiana treated with chlordane showed that chlordane levels varied from 22 to 2,540 ppm (Delaplane and La Fage, 1990). Several studies have reported chlordane concentrations in excess of 10% of the initially applied amount, 10 years or more after application (Beeman and Matsumura, 1981; Lichtenstein and Schulz, 1959; Nash and Woolson, 1967; Stewart and Chisholm, 1971; Stewart and Fox, 1971). A study in Missouri reported greater than 70% of the level of chlordane applied below ground could be accounted for seven years after application (Puri et al. 1990).

Studies have also reported concentrations of chlordane in indoor air in homes 15 years or more after treatment for termites (Livingston and Jones, 1981; Anderson and Hites, 1988). Chlordane has been detected in indoor air in New Jersey (Wright and Leidy, 1982; Fenske and Sternbach, 1987), Indiana (Anderson and Hites, 1988), Massachusetts and Florida (Lewis et al., 1994; Whitmore et al., 1994). A recent study conducted by Offenberg et al. (2004), investigated concentrations of chlordane in indoor and outdoor air in New Jersey, Texas, and California. They reported similar chlordane concentrations in Los Angeles, California and Houston, Texas, with concentrations slightly lower in Elizabeth, New Jersey.

1.2 Human Health Exposure

Because of its persistence in soils, there is potential for chlordane exposure through direct contact with soils around the foundation of homes where it was applied for termite control. In addition, exposure to chlordane via inhalation may occur through subsurface vapor intrusion to indoor air in homes treated for termites.

1.3 Human Health Effects

Acute effects of chlordane inhalation and oral exposure include gastrointestinal upset and neurological symptoms, such as tremors and convulsions. Chlordane is considered to have high acute toxicity based on short-term animal tests such as the LD_{50} test in rats. Chronic exposure of humans to chlordane by inhalation results in effects on the nervous, respiratory, and cardiovascular systems and on the liver, blood, and lung. The EPA considers chlordane to be a probable human carcinogen and has classified it as a Group B2 carcinogen (U.S. EPA, 1986). Under the 1996 proposed guidelines, it would be characterized as a likely carcinogen by all routes of exposure (ATSDR, 1994).

Further, the California Office of Environmental Health Hazard Assessment (OEHHA) identified chlordane as one of five of the first chemicals to be evaluated for the development of child-specific reference doses for non-carcinogenic effects (OEHHA, 2003). Chlordane was identified as a chemical that is commonly found at school sites and is of particular concern to children's health, exhibiting toxicity to organ systems that are developing in children, including the immune system, neuroendocrine, and female reproductive systems (OEHHA, 2003).

1.4 Background and Objective of Study

Beginning in January 2000, California legislation now requires school districts to carry out a comprehensive environmental investigation under the oversight of the California Department of Toxic Substances Control (DTSC) to ensure that new schools are built on safe properties. Due to the scarcity of available vacant property in Southern California, school districts are increasingly obligated to obtain residential properties for new schools. In comparison to industrial or commercial sites, residential properties have been expected to pose fewer environmental concerns. DTSC has not routinely evaluated residential properties for potential impacts from organochlorine pesticides. However, based on: 1) the historical widespread application of chlordane in and around homes; 2) the lack of data on pesticide residues at residential and/or commercial properties; 3) the environmental persistence of chlorinated pesticides; and 4) the potential unacceptable risks posed by residual chlordane and other pesticides in soil within residential subdivisions; DTSC now believes further investigation is warranted.

The objective of the Residential Pesticide Study (Study) was to evaluate the prevalence of chlordane and other organochlorine pesticides at levels that would pose a potential threat to human health at several proposed school sites in California. Soil samples were collected at three proposed school sites in Southern California for analysis of organochlorine pesticides. Analytical results were evaluated in a Human Health Screening Evaluation using guidelines established by the DTSC for the preparation of

Preliminary Endangerment Assessments (PEAs) (DTSC, 1999). This risk evaluation is based on the residential or unrestricted land use scenario used by DTSC to evaluate proposed school sites. This Report presents the overall findings of the Study.

2. METHODS

2.1 Study Sites

Three (3) proposed school sites undergoing environmental assessment with DTSC were selected for the Study (Figure 1). The Weemes Elementary School Expansion Site (Weemes) was located in Los Angeles, the Cherokee Point Elementary School Site (Cherokee) was located in San Diego, and the Jones Elementary School Site (Jones) was located in San Bernardino. Historical use of all three sites was residential prior to 1988; there were no historical agricultural, industrial, or commercial uses. Based on the PEA investigation previously conducted at each of the three sites, lead was present in surface soils from the use of lead-based paint.

Technical Memoranda presenting the data collection, analytical results, and recommendations for the Weemes, Cherokee, and Jones proposed school sites are located in Appendix A, B, and C, respectively.

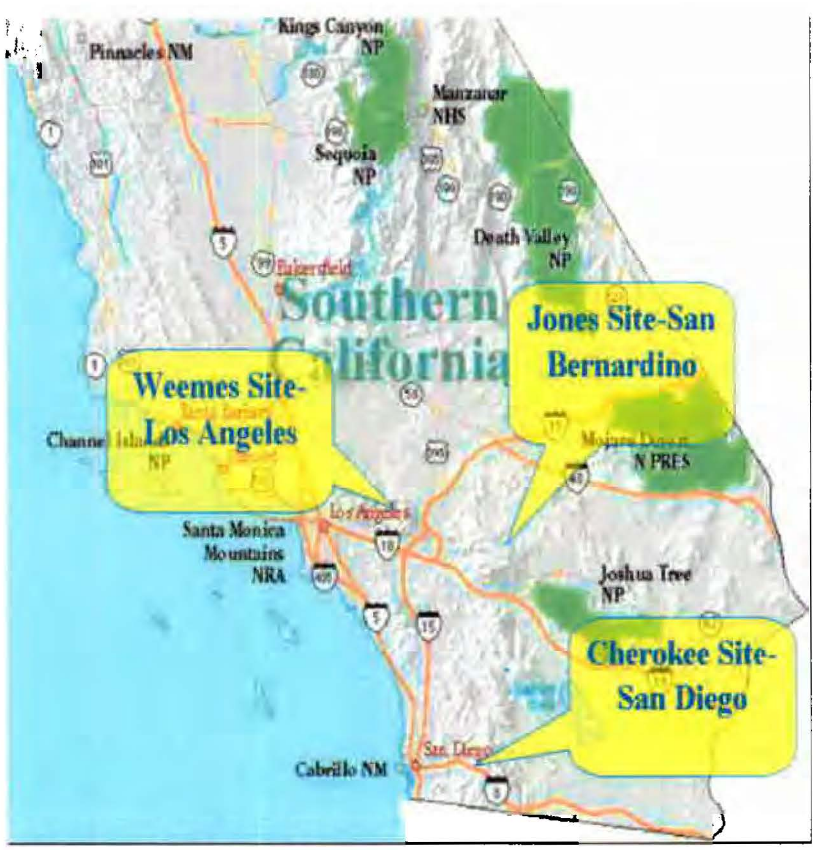

Figure 1
Study Sites

2.2 Sample Collection, Handling, and Analysis

Since organochlorine pesticides were typically applied to the footings and foundation of the homes, soil samples were collected as close as possible to the building perimeters, at or near each of the four corners. The sampling location was relocated away from the corner along the side of the building if pavement obstructed access to soil at the corner. For the surface samples, any existing vegetation on top of the soil was cleared away and the top 0.5 feet of soil was collected using disposable hand trowels. Deeper borings (two and four feet) were advanced using hand auger techniques. Once the sample depth was reached, the hand auger was removed from the boring and grab samples were collected, representing 2.0-2.5 feet below ground surface (bgs) and 4.0-4.5 feet bgs, using disposable hand trowels.

2.2.1 Sample Collection at Weemes (Los Angeles)

The Weemes Site was approximately 0.6 acres and consisted of four residential homes, which were present during sample collection. Forty-seven soil samples were collected at depths of 0-0.5 feet, 2.0-2.5 feet, and 4.0-4.5 feet. Three of the surface samples were taken from crawl-spaces underneath the homes. A total of 47 soil samples were collected at the site: 18 surface samples, 15 two-foot samples, and 14 four-foot samples.

2.2.2 Sample Collection at Cherokee (San Diego)

The Cherokee Site was approximately 7 acres. The Site consisted of 38 former residential homes, all of which had been demolished and the soil grubbed (surface vegetation removed) prior to sample collection. Locations of building footprints were determined from surveys. During the initial sampling event, 32 soil samples were collected from four randomly-selected homes at the site. Samples were collected at depths of 0-0.5 feet and 2.0-2.5 feet only, since refusal was met beyond the two foot samples. During the second sampling event, 20 soil samples were collected at an additional five randomly-selected homes. Only surface soil samples were collected during the second sampling. A total of 52 soil samples were collected at the site: 36 surface samples and 16 two-foot samples.

2.2.3 Sample Collection at Jones (San Bernardino)

The Jones Site was approximately 11 acres and consisted of residential homes, which were present during sample collection. During the initial sampling event, 46 soil samples were collected from four randomly-selected homes at the site. Samples were collected at depths of 0-0.5 feet, 2.0-2.5 feet, and 4.0-4.5 feet. One of the surface samples was collected underneath a front-porch stoop and another was collected underneath a back porch. During a second sampling event, 21 soil samples were collected from an additional five randomly-selected homes. Only surface soil samples were collected during the second sampling; one of these samples was collected underneath a stoop. A total of 67 soil samples were collected at the site: 38 surface samples, 15 two-foot samples, and 14 four-foot samples.

2.2.4. Quality Control Samples

Field duplicate soil samples and an equipment blank water sample were collected during each sampling event. A total of 10 field duplicate soil samples and five equipment blank water samples were collected. Laboratory control samples, matrix spikes, matrix spike duplicates, and method blanks were analyzed with each batch of soil samples. Analytical results and data validation are presented for the three sites in Appendices A, B, and C. All data were validated to Level IV according to the National Functional Guidelines (U.S. EPA, 1994).

3.0 ANALYTICAL RESULTS

During the Study, a total of 176 soil samples (including duplicate samples) were collected from three sites and analyzed for organochlorine pesticides by EPA Method 8081A at a State of California-certified contract laboratory. Table 1 summarizes the number of samples collected by depth at each of the three school sites. The frequency of detection of organochlorine pesticides at each site are presented separately below, followed by all sites combined.

Table 1
Number of OCP Samples by Depth

School Site	Number of Samples Collected 0.5-feet	Number of Samples Collected 2-feet	Number of Samples Collected 4-feet
Weemes	18	16	15
Jones	41	15	15
Cherokee	39	17	0

3.1 Weemes (Los Angeles)

Analytical results for Weemes are presented in Appendix A. Table 2 presents a summary of organochlorine pesticide detections. The highest concentration of each pesticide was detected in surface soil samples (0- to 0.5-feet bgs). In surface soil samples, chlordane and 4,4'-DDT were detected in each sample, at all four homes, including the two crawlspace samples (i.e., the detection frequency was 100%). At 2- and 4-feet bgs, only low levels of chlordane, 4,4'-DDD, 4,4'-DDE and 4,4'-DDT were detected. The OCPs detected, the reported soil concentration and the frequency of detection all substantially decrease with depth.

Table 2
Summary of OCP Detections at Weemes

OCP Detected	Maximum Concentration (mg/kg)	Detection Frequency 0.5-feet	Detection Frequency 2-feet	Detection Frequency 4-feet
Chlordane	36	18/18 (100%)	4/15 (27%)	4/14 (29%)
4,4'-DDD	1.1	15/18 (83%)	3/15 (20%)	1/14 (7%)
4,4'-DDE	1.4	16/18 (89%)	3/15 (20%)	1/14 (7%)
4,4'-DDT	16	18/18 (100%)	5/15 (33%)	2/14 (14%)
Dieldrin	2.7	12/18 (67%)	0/15 (0%)	0/14 (0%)

Endosulfan I	0.6	1/18 (6%)	0/15 (0%)	0/14 (0%)
Endrin	0.08	1/18 (6%)	0/15 (0%)	0/14 (0%)
Endrin Aldehyde	0.5	1/18 (6%)	0/15 (0%)	0/14 (0%)
Heptachlor	0.5	6/18 (33%)	0/15 (0%)	0/14 (0%)
Heptachlor Epoxide	0.1	5/18 (28%)	0/15 (0%)	0/14 (0%)
Lindane	0.1	2/18 (11%)	0/15 (0%)	0/14 (0%)

3.2 Cherokee (San Diego)

Analytical results for Cherokee are presented in Appendix B. Table 3 presents a summary of organochlorine pesticide detections. As at Weemes, the highest concentration of each pesticide was detected in surface soil samples (0- to 0.5-feet bgs). Chlordane, 4,4'-DDE, and 4,4'-DDT were detected at the greatest frequency: 95%, 95%, and 97%, respectively. At 2-feet bgs only low levels of chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT and dieldrin were detected. No samples were collected at 4-feet bgs.

Table 3
Summary of OCP Detections at Cherokee

OCP Detected	Maximum Concentration (mg/kg)	Detection Frequency 0.5-feet	Detection Frequency 2-feet
Aldrin	0.005	1/39 (3%)	0/17 (0%)
Chlordane	4.2	37/39 (95%)	8/17 (47)
4,4'-DDD	0.7	17/39 (44%)	3/17 (18%)
4,4'-DDE	2.7	37/39 (95%)	7/17 (41%)
4,4'-DDT	5.3	38/39 (97%)	7/17 (41%)
Dieldrin	0.2	27/39 (69%)	7/17 (41%)
Heptachlor	0.5	1/39 (3%)	0/17 (0%)
Heptachlor Epoxide	0.004	5/18 (28%)	0/17 (0%)
Lindane	0.01	1/39 (3%)	0/17 (0%)

3.3 Jones (San Bernardino)

Analytical results for Jones are presented in Appendix C. Table 4 presents a summary of organochlorine pesticide detections. As at both Weemes and Cherokee, the highest concentration of each pesticide detected in surface soil samples (0- to 0.5-feet bgs). Chlordane, 4,4'-DDE, and 4,4'-DDT were detected at the greatest frequency: 95%, 86%, and 88%, respectively. At 2- and 4-feet bgs, only low levels of chlordane, 4,4'-DDE, 4,4'-DDT and dieldrin were detected.

Table 4
Summary of OCP Detections at Jones

OCP Detected	Maximum Concentration (mg/kg)	Detection Frequency 0.5-feet	Detection Frequency 2-feet	Detection Frequency 4-feet
Chlordane	336	40/42 (95%)	8/15 (53%)	6/15 (40%)
4,4'-DDD	4.5	13/42 (31%)	0/15 (0%)	0/15 (0%)
4,4'-DDE	3.4	36/42 (86%)	5/15 (33%)	3/15 (20%)
4,4'-DDT	9.7	37/42 (88%)	4/15 (27%)	3/15 (20%)
Dieldrin	24	31/42 (74%)	9/15 (60%)	4/15 (27%)
Endrin	0.005	1/42 (2%)	0/15 (0%)	0/15 (0%)
Heptachlor	0.9	10/42 (24%)	0/15 (0%)	0/15 (0%)
Heptachlor Epoxide	0.8	4/42 (10%)	0/15 (0%)	0/15 (0%)
Lindane	0.04	3/42 (7%)	0/15 (0%)	0/15 (0%)

3.4 Combined Organochlorine Pesticide Dataset

Table 5 presents the frequency of detection by depth for the combined OCP dataset for all three school sites. The OCPs most frequently detected were chlordane, DDT, DDE, DDD and dieldrin.

Table 5
Summary of Detection Frequencies- All Sites Combined

OCP Detected	Detection Frequency 0.5-feet	Detection Frequency 2-feet	Detection Frequency 4-feet
Aldrin	1/98 (1%)	0/48 (0%)	0/30 (0%)
Chlordane	96/98 (98%)	20/48 (42%)	10/30 (33%)
DDD	45/98 (46%)	6/48 (13%)	1/30 (3%)
DDE	89/98 (91%)	15/48 (31%)	4/30 (13%)
DDT	93/98 (95%)	17/48 (35%)	5/30 (17%)
Dieldrin	70/98 (71%)	16/48 (33%)	4/30 (13%)
Endosulfan I	1/98 (1%)	0/48 (0%)	0/30 (0%)
Endrin	2/98 (2%)	0/48 (0%)	0/30 (0%)
Endrin Aldehyde	1/98 (1%)	0/48 (0%)	0/30 (0%)
Heptachlor	17/98 (17%)	0/48 (0%)	0/30 (0%)
Heptachlor Epoxide	9/98 (9%)	0/48 (0%)	0/30 (0%)
Lindane (γ-HCH)	6/98 (6%)	0/48 (0%)	0/30 (0%)

4.0 HUMAN HEALTH SCREENING EVALUATION

This section presents the Human Health Screening Evaluation for organochlorine pesticides detected in soil. The human health screening evaluation utilizes maximum concentrations of identified chemicals of potential concern (COPCs) to estimate contaminant intakes through the ingestion, dermal contact and inhalation routes of exposure. These estimated chemical intakes are evaluated for potential carcinogenic risks and noncarcinogenic health hazards using health-based toxicity criteria developed by the U.S. EPA and OEHHA. This human health screening evaluation is used by DTSC to evaluate proposed school sites based on a residential (unrestricted) land use scenario.

4.1 Exposure Pathways and Media of Concern

Using DTSC Guidance for performing human health evaluations as part of a PEA (DTSC, 1999), it was assumed that each site was completely uncovered and soils were available for direct contact. Three pathways of exposure were considered: ingestion of soil, dermal contact with soil, and inhalation of suspended soil particulates. Consistent with PEA Guidance, health effects were conservatively evaluated for a residential receptor. Estimated carcinogenic risks were evaluated for a combined child and adult over an assumed 30-year exposure period. Noncarcinogenic health effects were evaluated for a child, with maximum potential exposures.

4.1.1 Soil Exposure Pathways

COPCs in soil include organochlorine pesticides. Potential residential exposure to organochlorine pesticides was evaluated through incidental ingestion and dermal contact. Exposures by these two routes were estimated according to the equations shown in Appendix D.

4.1.2 Water Exposure Pathways

Groundwater impacts at the three proposed school sites were considered extremely unlikely and the groundwater pathway was not evaluated further in this human health screening assessment.

4.1.3 Air Exposure Pathways

Potential residential exposure to organochlorine pesticides detected in soil was evaluated for inhalation of suspended soil particulates. Exposure through the inhalation route was estimated according to the equation shown in Appendix D.

4.2 Exposure Concentrations and Chemicals

For the purposes of this human health screening evaluation, potential carcinogenic risks and noncarcinogenic health hazards were estimated 1) for surface soils using the maximum reported soil concentrations detected on-site; and 2) for subsurface soils at 2-feet and 4-feet bgs, in order to assist decision-makers regarding the depth of future soil removal.

4.3 Toxicity Values

Toxicity values are used to characterize the relationship between the exposure to an agent and the incidence of adverse health effects in exposed populations. In a quantitative carcinogenic risk assessment, the dose-response relationship of a carcinogen is expressed in terms of a slope factor (oral) or unit risk (inhalation), which are used to estimate the probability of risk of cancer associated with a given exposure pathway. Cancer slope factors and unit risk factors as published by Cal-EPA (01/2003) and EPA (Integrated Risk Information System (IRIS)) were used in this human health risk assessment.

For noncarcinogenic effects, toxicity data developed from animal or human studies are typically used to develop noncancer acceptable levels, or reference doses (RfDs). A chronic reference dose is defined as an estimate of a daily exposure for the human population, including sensitive subpopulations, that is likely to be without appreciable risk of deleterious effects during a lifetime. The oral chronic reference doses, as published in IRIS or EPA's Health Effects Assessment Summary Tables (HEAST), were used in this evaluation. Inhalation reference doses were calculated from the Cal/EPA Reference Exposure Levels (RELs), as published by the Office of Environmental Health Hazard Assessment (OEHHA, 2001). If an REL was unavailable for a particular chemical, the inhalation reference dose from IRIS or HEAST was used.

4.4 Risk Characterization Summary

Risk characterization is the process used to assess the potential carcinogenic risk and noncarcinogenic health hazards for the populations of concern represented by the chemical contaminants in soil at the site. Potential carcinogenic effects were estimated from the predicted intakes and chemical-specific dose-response information. Potential noncarcinogenic effects were estimated by comparing the predicted intakes of COPCs to their respective toxicity criteria (i.e., inhalation reference doses (RfD_i)).

4.4.1 Noncarcinogenic Health Effects for Soil Contaminants

In order to estimate the potential effects from exposure to multiple COPCs, the hazard index (HI) approach was used. The HI is defined as the summation of the hazard quotients for each COPC, for each route of exposure, and is represented by the following equation:

$$HI = \frac{\text{Predicted Dose}_a}{RfD_a} + \frac{\text{Predicted Dose}_b}{RfD_b} + \ldots + \frac{\text{Predicted Dose}_i}{RfD_i}$$

A total HI less than or equal to unity is indicative of acceptable levels of exposure for chemicals assumed to exhibit additive health effects. To be truly additive in effect, chemicals must affect the same target organ system or result in the same critical toxic endpoint. A HI less than or equal to 1.0 suggests that adverse health effects would not be expected following a lifetime of exposure, even in sensitive members of the population.

4.4.2 Carcinogenic Health Effects for Soil Contaminants

Quantitative estimates of upper-bound incremental cancer risk due to site-related contamination were evaluated for each COPC according to the following equation:

$$R_i = \text{Intake}_i \times SF_i$$

Where,

R_i = Estimated incremental risk of cancer associated with the ith chemical

$Intake_i$ = Intake or lifetime average daily dose for the ith chemical, mg/kg-day

SF_i = Cancer slope factor for the ith chemical, $(mg/kg\text{-}day)^{-1}$

Carcinogenic risk was assumed to be additive and was estimated by summing the upper-limit incremental cancer risk for all carcinogenic COPCs.

4.5 Site Specific Risks and Hazards

4.5.1 Weemes (Los Angeles)

The residential hazard index for exposure to maximum reported concentrations of pesticides in surface soil at Weemes was 2.6, which is above the DTSC level of concern (HI = 1) and indicative of potential adverse health effects from exposure to site soils. This estimated hazard was primarily attributable to chlordane (approximately 41% of the total hazard), dieldrin (approximately 31% of the total hazard), 4,4'-DDT (approximately 18% of the total hazard) and heptachlor/heptachlor epoxide (approximately 5% of the total hazard).

The total excess carcinogenic risk from ingestion of surface soil, dermal contact with surface soil, and inhalation of suspended surface soil particulates was 1.7×10^{-4}. This risk is above the DTSC point of departure (i.e., a risk of one-in-one-million or 1×10^{-6}), and is outside of the risk management range defined by regulatory agencies (1×10^{-6} to 1×10^{-4}). Consequently, the total site risk would be considered unacceptable under an unrestricted, residential land use scenario. This estimated risk was primarily attributable to chlordane (approximately 47% of the total risk) and dieldrin (approximately 44% of the total risk).

The residential hazard index associated with exposure to subsurface soils was 0.03, which is well below the DTSC level of concern. The total excess cancer risk associated with exposure to subsurface soils was 7.7×10^{-7}, which is below the DTSC point of departure and below the lower end of the risk management range. Based on the above results, unacceptable carcinogenic risk and noncarcinogenic health hazards would only be associated with site soils between 0- and 2-feet bgs. No adverse health effects would be expected from unlimited exposure to subsurface soils (2- to 4-feet bgs).

4.5.2 Cherokee (San Diego)

The residential hazard index for exposure to maximum reported concentrations of pesticides in surface soil at Cherokee was 0.4, which is below the DTSC level of concern (HI = 1), and indicative of no potential adverse health effects from exposure to site soils. This estimated hazard was primarily attributable to chlordane (approximately 41% of the total hazard), dieldrin (approximately 15% of the total hazard), and 4,4'-DDT (approximately 35% of the total hazard).
The total excess carcinogenic risk from ingestion of surface soil, dermal contact with surface soil, and inhalation of suspended surface soil particulates at Cherokee was 2.2 x

10^{-5}. This risk is above the DTSC point of departure (i.e., a risk of one-in-one-million or 1×10^{-6}), but within the risk management range defined by regulatory agencies (1×10^{-6} to 1×10^{-4}). Consequently, the total site risk is considered unacceptable under an unrestricted, residential land use scenario. This estimated risk was primarily attributable to chlordane (approximately 45% of the total risk), dieldrin (approximately 30% of the total risk), 4,4'-DDT (approximately 15% of the total risk) and 4,4'-DDE (approximately 8% of the total risk.

The residential hazard index associated with exposure to subsurface soils at Cherokee was 0.09, which is well below the DTSC level of concern. The total excess cancer risk associated with exposure to subsurface soils was 6×10^{-6}, which is above the DTSC point of departure but well within the risk management range. Based on the above results, unacceptable carcinogenic risk is only associated with site surface soils between 0- and 0.5-feet bgs.

4.5.3 Jones (San Bernardino)

The residential hazard index for exposure to maximum reported concentrations of pesticides in surface soil at Jones was 18.4, which is well above the DTSC level of concern (HI = 1), and indicative of potential adverse health effects from exposure to site soils. This estimated hazard was primarily attributable to chlordane (approximately 54% of the total hazard) and dieldrin (approximately 38% of the total hazard).

The total excess carcinogenic risk from ingestion of surface soil, dermal contact with surface soil, and inhalation of suspended surface soil particulates at Jones was 1.5×10^{-3}. This risk is well above the upper end of the risk management range defined by regulatory agencies (1×10^{-6} to 1×10^{-4}). Consequently, the total site risk is considered unacceptable under an unrestricted, residential land use scenario. This estimated risk was primarily attributable to chlordane (approximately 52% of the total risk) and dieldrin (approximately 46% of the total risk).

The residential hazard index associated with exposure to soils at 2-feet bgs was 0.07, which is well below the DTSC level of concern. The total excess cancer risk associated with exposure to subsurface soils was 6×10^{-6}, which is slightly above the DTSC point of departure but well within the risk management range.

The residential hazard index associated with exposure to soils at 4-feet bgs was 0.02, which is well below the DTSC level of concern. The total excess cancer risk associated with exposure to subsurface soils was 2×10^{-6}, which is slightly above the DTSC point of departure but well within the risk management range.

4.6 Discussion of Risk Assessment Results

From the site-specific risk summaries presented in Sections 4.5.1 through 4.5.3, site risks were primarily driven by two OCPs at each of the three sites, namely chlordane and dieldrin. The most frequently detected OCPs appear to be lognormally distributed. To graphically present the data, the individual and combined data sets were lognormally transformed and the data were plotted as probability distributions, also known as normality plots.

Figure 2 presents the normality plot of the chlordane data for the combined data set of 176 samples from all three proposed school sites. In order to visualize the risk for each sample point, the risk management range for chlordane was overlaid on the normality plot. The chlordane data were presented as combined surface and subsurface data (LOGCHLORALL), surface data (LOGCHLORSURF), chlordane data at 2-feet bgs (LOGCHLOR2) and chlordane data at 4-feet bgs. (LOGCHLOR4).

Risks attributed to chlordane were primarily associated with surface soils (0- to 0.5-feet bgs). Approximately 50% of the chlordane detection at 0.5-feet bgs were above a 1 x 10^{-6} risk. Approximately 19% of the chlordane detections at 0.5-feet bgs were above a 1 x 10^{-5} risk. Only 4% of the chlordane detections at 2-feet or below were above a 1 x 10^{-6} risk.

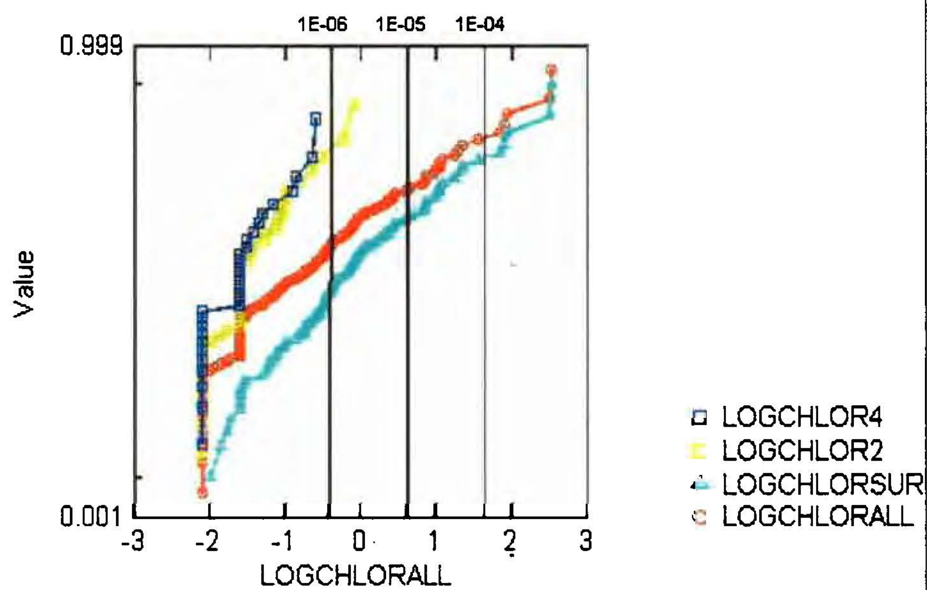

Figure 2
Normality Plot of Chlordane Data, Combined Data Set

Figure 3 presents the normality plot of chlordane detected in surface soil for each of the three proposed school sites. The slope of the chlordane data from the Cherokee Site differs substantially from the other two school sites in that risks based on chlordane concentrations at Cherokee are notably lower than the risks based on concentrations detected at Jones and Weemes.

Both the Weemes and Jones sites were sampled prior to building demolition, while the Cherokee site was sampled after the buildings were demolished and the soil graded. Consequently, the chlordane concentrations in soil at Cherokee were likely diluted by mixing and re-distribution. Even so, 36% of the surface soil chlordane risks at the Cherokee site were above 1×10^{-6}. These results may indicate sampling for organochlorine pesticides can be conducted either pre- or post-demolition, since concentrations which posed unacceptable risks will be detected by either sampling scheme. More research is needed to support this assumption.

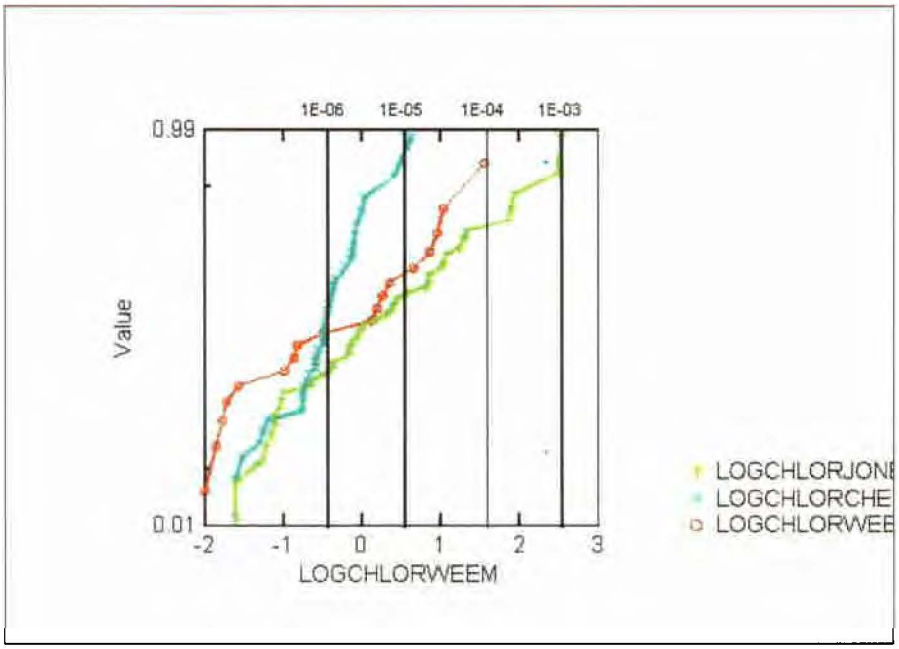

Figure 3
Chlordane in Surface Soil by School Site

Figure 4 presents the normality plot of the dieldrin data for the combined data set of 176 samples from all three proposed school sites overlaid by the risk management range for dieldrin. The dieldrin data were presented as combined surface and subsurface data (LOGDIELDALL), surface data (LOGDIELDSURF), dieldrin data at 2-feet bgs (LOGDIELD2) and dieldrin data at 4-feet bgs. (LOGDIELD4).

The dieldrin dataset is very similar to the chlordane dataset, with risks from dieldrin primarily associated with surface soils (0- to 0.5-feet bgs). Approximately 47% of the dieldrin detections at 0.5-feet bgs were above a 1 x 10^{-6} risk. Approximately 18% of the dieldrin detections at 0.5-feet bgs were above a risk of 1 x 10^{-5}. Only 8% of the chlordane detections at 2-feet or below had a risk above 1 x 10^{-6}.

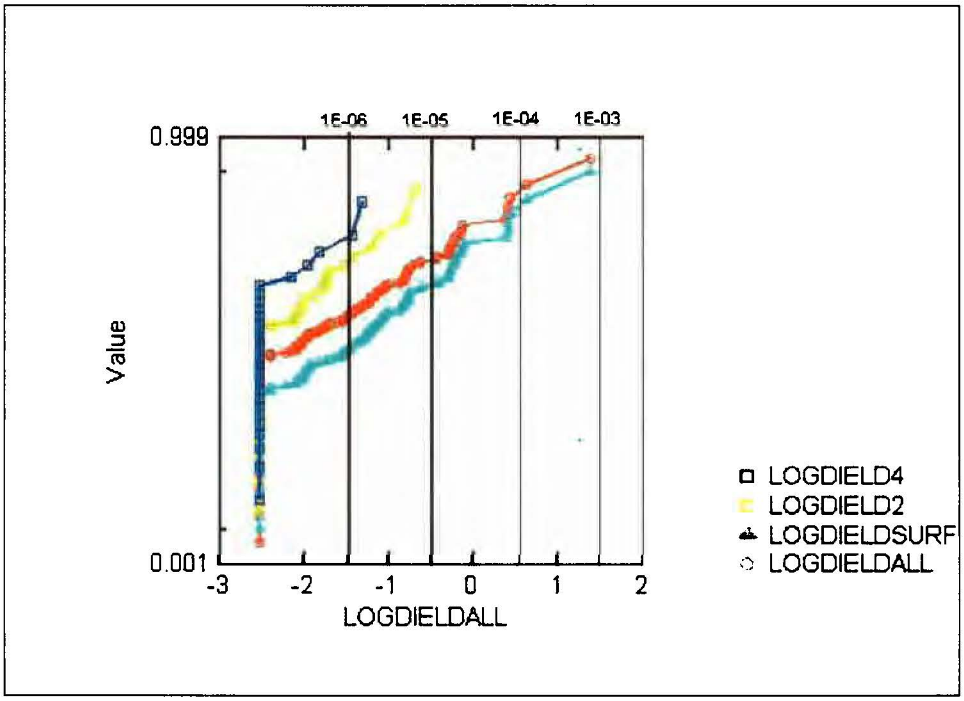

Figure 4
Normality Plot of Dieldrin Data, Combined Data Set

Figure 5 presents the normality plot of dieldrin detected in surface soil for each of the three proposed school sites. Again, the same pattern was observed as for chlordane.

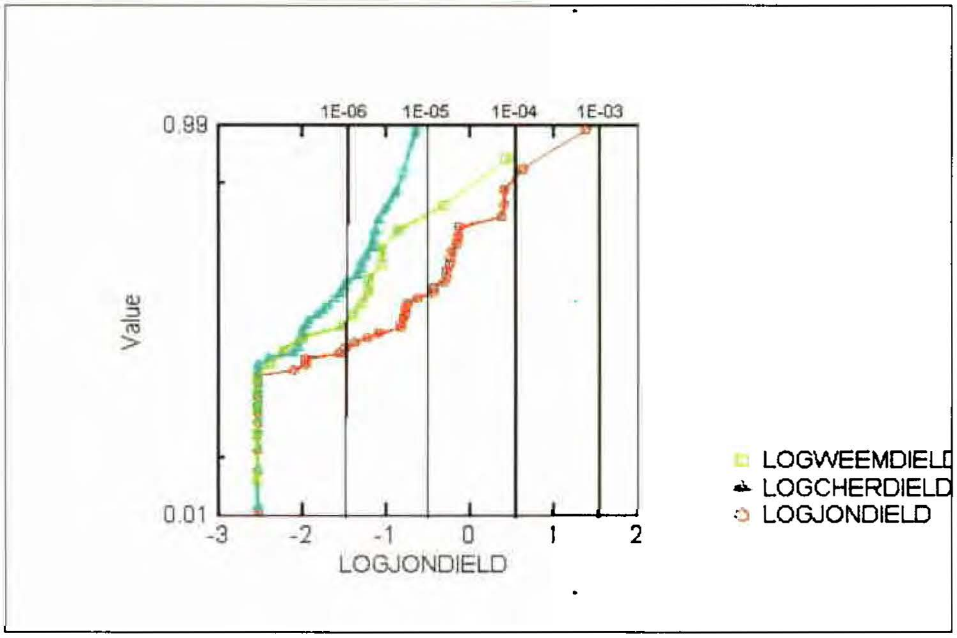

Figure 5
Dieldrin in Surface Soil by School Site

The next two highest contributors to site risks from OCPs were DDT and DDE. Figures 6 and 7 present the normality plots of the combined data sets for DDT and DDE, respectively. The "x" in the figures represents the log concentration resulting in a risk of 1 x 10^{-5}. Approximately 6% of the DDT detections and 2% of the DDE detections at 0.5-feet bgs were above a risk of 1 x 10^{-5}. Only one DDT detection at 0.5-feet exceeded a risk of 1 x 10^{-5}. No DDT or DDE detections at 2-feet exceeded a 1 x 10^{-6} risk.

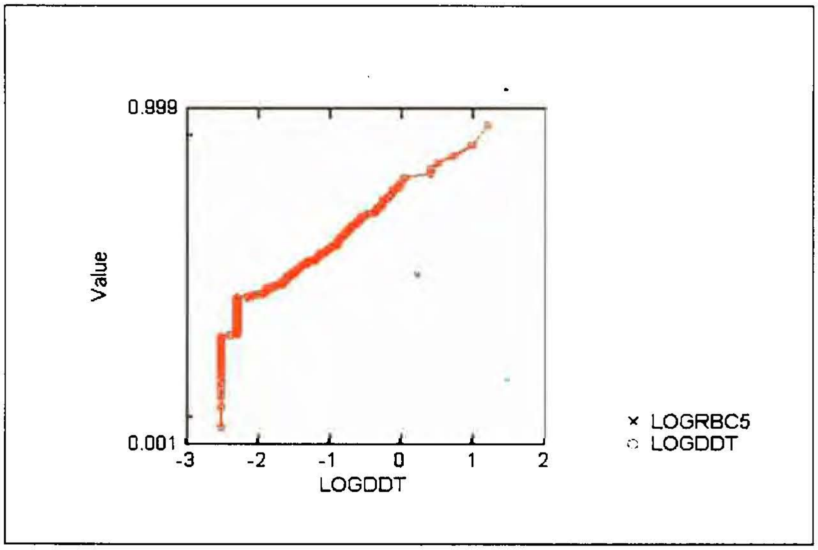

Figure 6
Normailty Plot of DDT Data, Combined Data Set

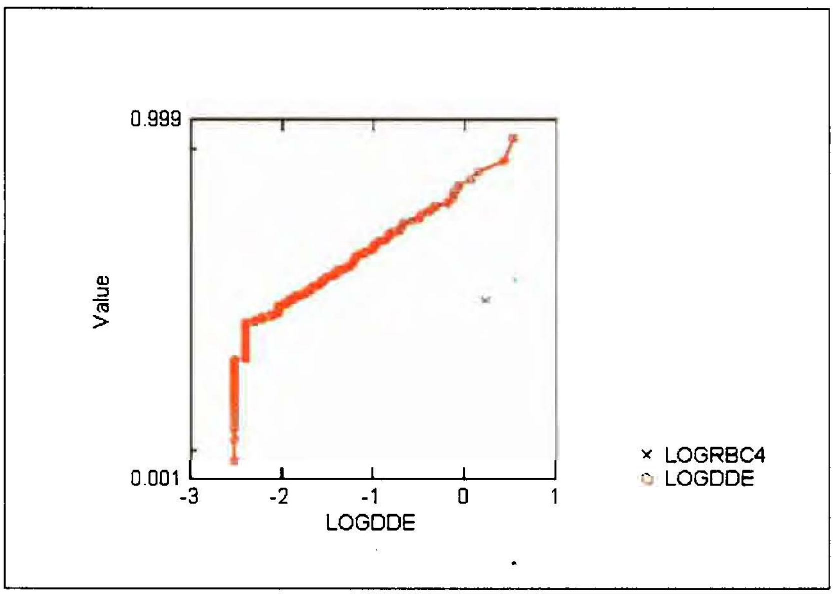

Figure 7
Normailty Plot of DDE Data, Combined Data Set

5.0 SUMMARY AND CONCLUSIONS

Soil samples were collected from three proposed school sites in Southern California. All three sites were historically used for residential properties. A total of 176 soil samples were collected at three depths around the perimeter of the residential structures at two sites; samples were collected at two depths around the footprint of residential structures that had been demolished at one site. Samples were analyzed for organochlorine pesticides by EPA Method 8081A.

Organochlorine pesticides were most frequently detected in surface soils (0-0.5 feet bgs). The following organochlorine pesticides were detected at the greatest frequency in surface samples: chlordane (98%), DDT (95%), DDE (91%), and dieldrin (71%).

Based on a Human Health Screening Evaluation, carcinogenic risk and non-carcinogenic hazard was calculated for each detected organochlorine pesticide. Results indicate elevated site risks and hazards were primarily associated with chlordane and dieldrin in surface soils. Approximately 50% of chlordane and dieldrin detections had an associated risk above 1×10^{-6}, and approximately 20% of chlordane and dieldrin detections had an associated risk above 1×10^{-5}.

These findings indicate a high frequency of organochlorine pesticide (OCP) detections in surface soils around residential structures in three locations in Southern California. Further, the levels of OCPs detected present a potential unacceptable risk to children and adults under a residential, unrestricted land use scenario.

6.0 RECOMMENDATIONS

Results of this Study indicate there is potential for organochlorine pesticides to be present in soil at residential properties at levels that would pose a risk to students and adults under an unrestricted land use scenario. Based on these results, DTSC recommends sampling and analysis for organochlorine pesticides be routinely performed at proposed school sites historically used for residential properties.

Sampling may be conducted in conjunction with the current protocol for investigation of lead in soil from lead based paint (DTSC, 2001). As with sampling for lead, initial sampling for OCPs can be limited to collection of four (4) surface soils around the perimeter of the structures. Analysis for OCPs can be performed on splits of soil samples already being collected for lead analysis. Based on results of the Human Health Screening Evaluation, further investigation, including additional sampling at lateral and vertical intervals from the original samples, may be required.

As with the current regulations that allow the inclusion of results of testing for lead and polychlorinated biphenyls in Phase I Environmental Site Assessments for proposed school sites, organochlorine pesticide investigation results may be presented in a Phase I Addendum for the site. This will require the development of risk-based screening concentrations for OCPs by the DTSC Human and Ecological Risk Division, modification of existing DTSC guidance on sampling for lead-based paint (DTSC, 2001), as well as changes in the existing regulations on content of a Phase I or Phase I Addendum prepared for a proposed school site.

7.0 LIMITATIONS

This study is limited in its focused approach. While only residential structures were sampled, organochlorine pesticides were likely also applied to commercial structures of similar age. Future studies should include sampling of commercial structures. Additional investigation should also include sites in Nothern California to allow for potential differences in application and persistence of pesticides based on differences in insect populations, type of building materials, soil types, and climate.

Based on results at the Cherokee Site, where structures had been demolished and the Site graded prior to sampling, unacceptable risks were detected even though soil was disturbed and organochlorine pesticides likely diluted. This suggests sampling can be conducted either pre- or post-demolition, although more research is needed to substantiate this assumption.

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