U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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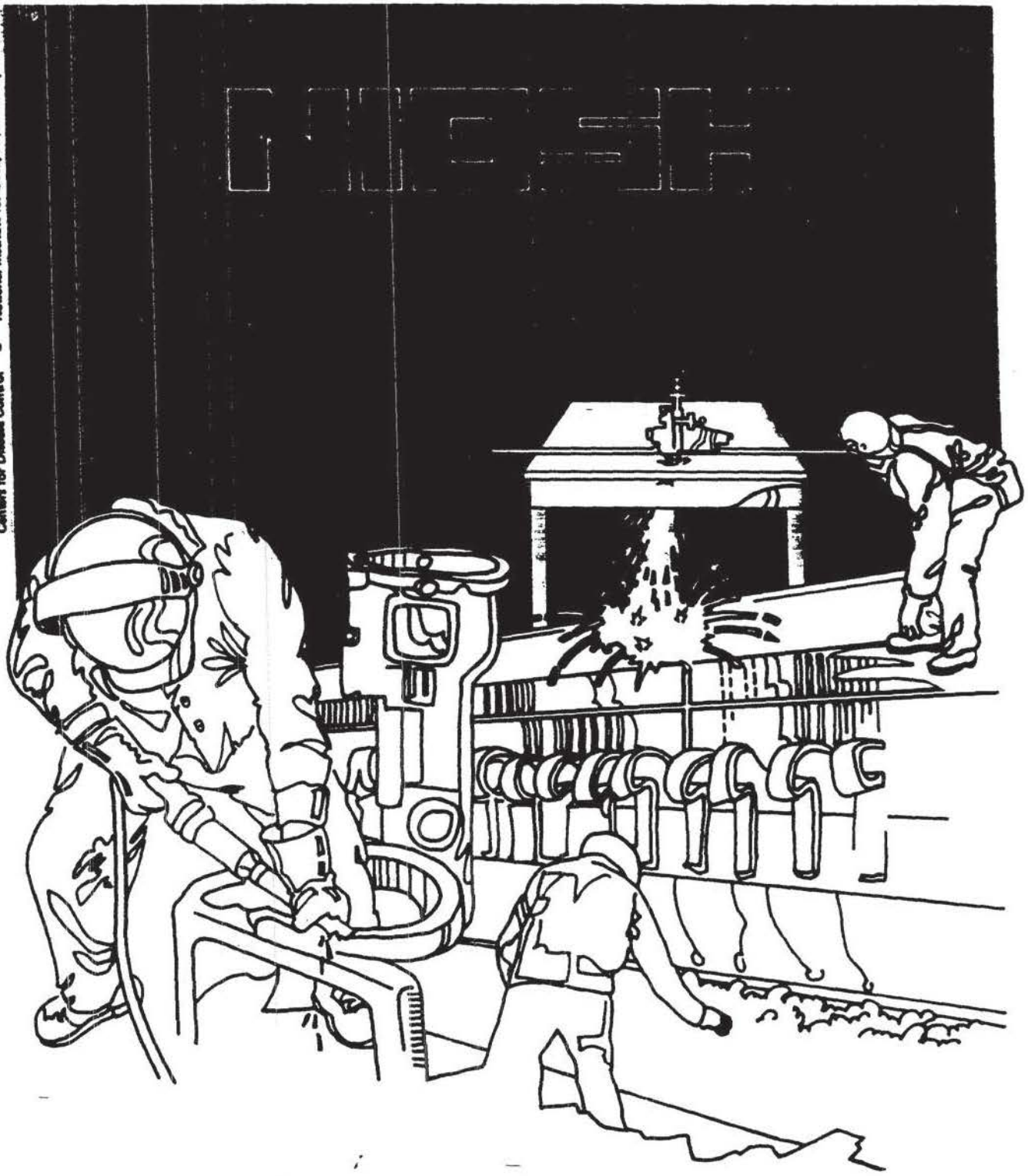

Health Hazard Evaluation Report

HETA 84-168-1823
OZARK NATIONAL SCENIC RIVERWAYS
NATIONAL PARK SERVICE
VAN BUREN, MISSOURI

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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HETA 84-168-1823
AUGUST 1987
OZARK NATIONAL SCENIC RIVERWAYS
NATIONAL PARK SERVICE
VAN BUREN, MISSOURI

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I. SUMMARY

On January 2, 1984 the National Institute for Occupational Safety and Health (NIOSH) was requested to widen the scope of an earlier investigation (HETA 83-424) evaluating employee exposure to chlordane at the Ozark National Scenic Riverways, National Park Service, U.S. Department of Interior, Van Buren, Missouri. The earlier investigation consisted of the evaluation of six buildings, four of which were employee residences owned by the National Park Service. The results of 21 area air samples taken at that time showed that chlordane concentrations ranged from 0.33 to 27.0 micrograms per cubic meter (ug/m^3) with levels in 14 of the samples exceeding the National Research Council's (NRC) criterion of 5 ug/m^3 for residences.

Based on these previous results, NIOSH collected 680 samples in 36 buildings January 1-6 and September 9, 1984. Concentrations of chlordane in these samples ranged from 0.02 ug/m^3 to 210 ug/m^3, with levels in 58 of the samples exceeding the 5 ug/m^3 NRC criterion. Of these, 36 samples exceeded the criterion in crawl spaces, 19 in the building interiors, and 3 in exterior basement entries.

A medical evaluation was also conducted; 18 Park Service employees and their family members (Group A), and ten Forest Service maintenance workers (Group B) responded to health history questionnaires and gave blood specimens for chlordane and chlordane metabolite analysis. There was no uniform pattern of symptoms or medical conditions reported by either group. Group A study participants lived in houses with air chlordane levels ranging from 0.79 ppb to 4.6 ppb. Their serum chlordane levels ranged from less than 1.0 ppb to 2.9 ppb. There were no home ambient chlordane levels measured for Group B participants. However, five of them had participated in chlordane decontamination operations of Forest Service buildings. One had a serum chlordane concentration of 24.0 ppb. He had no known history of other chlordane exposures.

No health effects attributable to chlordane were found, but based on the environmental measurements made during this investigation, individuals occupying these buildings could be exposed to potentially harmful levels of chlordane. Specific recommendations to minimize or eliminate exposures are included in Section VI in this report.

KEYWORDS: SIC 2879 (Pesticides and Agricultural Chemicals), chlordane, private residences.

II. INTRODUCTION/BACKGROUND

On August 26, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from for the Ozark National Scenic Riverways (ONSR), National Park Service, Department of the Interior, Van Buren, Missouri for technical assistance in evaluating employee exposure to chlordane.

The ONSR District office in Van Buren, Missouri is responsible for the maintenance of all Park Service buildings in the southeastern Missouri area. These include over 100 structures, including visitor centers, rental cabins, small picnic shelters, restroom facilities, and employee residences.

In October 1982, the ONSR had all of the buildings in its jurisdiction inspected and, if necessary treated for termites. Approximately 58 buildings were treated with a pesticide containing chlordane. The chlordane was usually injected into the subsurface. However, some National Park Service employees reported that chlordane was also topically applied to the interior and exterior of some of the buildings.

In February of 1983, during a renovation project, it was discovered that one of the ranger's quarters (Building #305) was still infested with termites. The contract pest control firm was called again to re-treat the building. During this second treatment, the exterior soil around the fireplace was saturated and the interior framing around the fireplace was topically misted before the wall board was replaced. The floor joists and sills along the foundation inside the building were also topically misted, and holes were made in the concrete floor slab to inject the pesticide.

The current residents of these quarters (Building #305) became concerned because of the strong and persistent odors. They contacted the National Park Service Midwest Regional Safety Office, the Environmental Protection Agency Region VII Office, and Missouri Department of Agriculture asking for assistance.

The family living in the quarters (Building #305) included 2 adults and an infant. In July 1983 chlordane was detected in the blood of one of the adults at a value of less that 1 ng/ml. In August 1983 no chlordane was detected in the blood of the other 2 residents. In September 1983 NIOSH evaluated potential chlordane exposure in six ONSR buildings. Three of the six buildings had chlordane levels above the National Research Council's (NRC) criterion of $5ug/m^3$ for residences. The data from this study prompted ONSR to request in January 1984, a second, more

detailed study. Interim reports, dated March 9, 1984, and November 5, 1984, detailed analytical results where high levels of chlordane were found, as well as recommendations for closure of some of the buildings.

III. EVALUATION DESIGN AND METHODS

A. Environmental

The NIOSH industrial hygienist, late in January 1984, after reviewing pesticide application records and data from the previous NIOSH study, interviewing maintenance people and visiting treated buildings, chose 36 buildings (Appendix 1) as being most likely to be contaminated or cause an exposure.

Area air samples were collected in the buildings over a three day period in February 1984, and again in September 1984, at selected locations. The samples were collected using MSA Model G pumps calibrated at approximately one liter per minute. ORBO 43 (Chromesorb 102) sorbent tubes manufactured by Supelco were used as the collecting medium. NIOSH analytical method S-278 was used. The sorbent in the tubes was desorbed in toluene and analyzed on a Tracor 222 gas chromatograph equipped with an electron capture detector. The technique resulted in a limit of detection (LOD) of 0.05 ug sample.

In the previous NIOSH study chlordane sampling and analytical methods were validated. Six sets of paired samples were collected using a large (ORBO #42) and a small (ORBO #43) sorbent tube at three sampling sites. These paired and repeated samples were taken for two reasons. The first and most important reason was to make sure that any level measured was representative of the true concentration, and the second was to obtain some idea as to whether both types of sampling tubes collected similar amounts of chlordane. These results are shown in Table I. Pairs designated 1, 3, 4, and 5 show fairly consistent results. Sample #22 of Pair #2 and Sample #30 of Pair #6 appear to be outliers. (However, these outliers would not influence the data to the point that it would alter the conclusions drawn in a later section of this report.) The results shown in table I indicate that the sampling and analytical techniques used were valid.

B. Medical

Potential study participants were selected from two groups. The first group consisted of individuals living in Forest Service buildings which had been treated with chlordane in August 1982 and which had had air sampling for chlordane by the NIOSH industrial hygienist in September 1983 and 1984. All individuals known to live in such houses were asked to participate. One family in this group had lived in such a house but had moved into another house three months prior to the study. Although their current house had not been treated with chlordane, the chlordane levels were measured. The second group included individuals who lived in communities surrounding the National Park and did seasonal maintenance work on Forest Service lands. Some of these individuals were thought to have participated in chlordane decontamination of some of the Forest Service buildings beginning in May 1984. Individuals from two park maintenance areas were asked to participate as they arrived for their workshift.

During the week of September 10, 1984, the NIOSH medical officer administered questionnaires to 28 individuals. Six were resident employees, 12 were spouses or children of resident employees, and 10 were maintenance workers. The questionnaires addressed occupational exposure, places of residence, and medical history. Parents responded for minors. All participants were asked to give blood and urine specimens, except that maintenance workers were not asked to give urine specimens because their serum chlordane levels were expected to be low. Serum and urine were analyzed for chlordane, heptachlor epoxide, oxychlordane and trans-nanochlor by the gas chromatography electron capture method (1). The limit of quantitation was 1 ppb. Urine was intended to be analyzed for chlordane, oxychlordane, heptachlor epoxide and trans-nanochlor only for individuals whose serum specimen was damaged.

IV. EVALUATION CRITERIA

A. Toxicology

Chlordane is a member of a group of chemical compounds generically termed "chlorinated cyclodienes." For its use as an insecticide, and especially as a termiticide, it is available in pure and technical grades. Pure chlordane is a viscous, colorless, odorless liquid with chemical and physical properties as follows: (11)

Chemical name:	1,2,4,5,6,7,8,8-octachloro-4, 7-methano-3a, 4, 7, 7a-tetra hydroindane
Molecular weight:	410
Molecular formula:	$C_{10}H_6Cl_8$
Boiling point: (760 mm Hg)	(Decomposes); 175 C (347 F) at 2mm Hg
Physical state:	Colorless, odorless, viscous liquid
Vapor pressure:	0.00001 mm Hg (at 20°C)
Specific gravity:	1.57 - 1.67
Soluble:	In many organic solvents
Solubility in Water:	9 $ug/_L$

Reactivity:

1. Conditions contributing to instability: Temperatures above 200°C (392°F) cause decomposition with formation of chlorine and hydrogen chloride gases.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorine, phosgene, and carbon monoxide) may be released when chlordane decomposes.

4. Special precautions: Chlordane will attack some forms of plastics, rubber, and coatings.

Effects in Humans

Systemic absorption of chlordane may occur via skin absorption, inhalation or ingestion. Chlordane is metabolized to heptachlor epoxide, oxychlordane, and trans-nanochlor. Acute signs and symptoms of intoxication include: blurred vision, confusion, ataxia, delirium, cough, abdominal pain, nausea, vomiting, diarrhea, irritability, tremor, convulsions, and anuria (cessation of urine production). Chlordane is stored in adipose tissue (fat). Chlordane has produced hepatocellular carcinomas in mice in two studies. Wang and MacMahon studied death records from 1403 employees working for at least three months between 1946 and 1976 (5). There was no overall excess of deaths from cancer.

There was a statistically signficant excess of deaths from cerebrovascular disease (17 observed vs. 9.3 expected). Fishbein et al. (7) studied fifteen workers exposed to airborne chlordane at 1.2 - 1.7 ug/m^3 over periods of 1-15 years. There was no evidence of toxic effects. These epidemiological studies, however, are inconclusive in that they are too small to detect excesses in rare diseases such as liver cancer and they should not be portrayed as negative studies.

There have been two case reports of accidental chlordane ingestion involving children where serum chlordane levels were measured post ingestion. A 20-month-old boy who ingested an unknown quantity of chlordane experienced vomiting and seizures. He had a full recovery without apparent residual effects (9). His highest recorded serum level was 2.7 mg/liter (2700 ppb), recorded three and one-half hours post ingestion. Three months later the serum concentration was 17 ppb. A 4-year-old girl who ingested chlordane experienced clonic convulsions, loss of coordination, and increased excitability. She had a full recovery. The highest recorded serum chlordane level was 3400 ppb. At 130 days post-ingestion, the serum concentration was 30 ppb (10). These studies did not measure the metabolites of chlordane.

B. Occupational Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The OSHA standard and the American Conference of Governmental Industrial Hygiensts (ACGIH) recommend a theshold limit value (TLV) of 500 ug/m^3 chlordane in the occupational setting based on an eight to 10 hour workday. The source of criteria used to assess air concentrations of chlordane (5ug/m^3) was developed by the National Research Council's Committee on Toxicology in 1979 in responding to the Department of Defense's request for a military housing guideline. This exposure limit is based on the following facts: (1) exposure duration in the buildings evaluated at ORNL was 24 hours, 7 day/week, (2) women and children were exposed and (3) the cyclodienes, of which chlordane is one, are deposited in body fat, with a biological retention half-life on the order of days to several weeks. Because these compounds are all persistent in the environment, they can be effective as termiticides for up to 20 years after application (4,6). The National Academy of Science Committee on Toxicology report to the Air Force (2) stated "The Committee on Toxicology could not determine a level of exposure to chlordane below which there would be no biological effect of prolonged exposure to families in military housing." At that time it suggested an interim airborne concentration standard of 5 ug/m^3 be implemented, based upon "known concentrations of chlordane in military housing, a review of reported health complaints of

residents of contaminated housing, and a comparison with the acceptable daily intake derived from long-term animal feeding studies".

V. RESULTS AND DISCUSSION

A. Environmental

During the course of this investigation, NIOSH collected 680 samples in 36 buildings January 1-6 and September 9, 1984. Concentrations of chlordane in these samples ranged from 0.02 ug/m^3 to 210 ug/m^3, with levels in 58 of these samples exceeding the 5 ug/m^3 National Research Council's evaluation criterion for residences (Table II). Of these, 36 samples exceeded the criterion in crawl spaces, 19 in the building interiors and 3 in exterior basement entries. Appendix III contains a detailed description of the environmental sampling results for each building.

B. Medical

Twenty-four serum and 16 urine specimens were collected from the 28 study participants. All 16 Park employees, 5 spouses, and 2 children gave serum samples. The parents of the remaining five children preferred that their children give urine specimens only. (One child was unable to produce a urine sample).

Analysis of symptoms and medical conditions reported on the questionnaire by the 18 Group A study participants revealed no consistent pattern. Twenty-eight percent (5 of 18) participants complained of nose or sinus irritation, and these individuals were distributed in four of six households. The airborne chlordane concentration in the 2 homes having persons without such symptoms ranged from 1.0 to 1.3 ug/m. Homes with symptomatic persons had levels ranging between 0.79 and 4.6. Only one individual stated that symptoms of nose or sinus irritation began at the same time or after the chlordane treatment to the house. Seventeen percent (3 of 18) of the participants complained of headache in the month preceeding the survey.

Only one of 9 serum samples from Group A had detectable chlordane, 2.9 ppb (Table IV). None of the urine specimens had detectable chlordane. Two Group A families had previously lived in Forest Service housing which had also been treated with chlordane and for which we have air level measurements. Ambient chlordane exposure in these houses at the time of this study ranged from 1.5 - 8.2 ppb. None of the 3 serum samples from this group had detectable chlordane or trans-nonachlor. The combined heptachlor epoxide and oxychlordane combined concentrations ranged up to 1.4 ppb.

None of the seven urine samples, four from children and three from Group A adults whose serum samples were damaged, contained detectable chlordane metabolites. Ambient chlordane exposure in these individual's homes ranged from 0.79-4.6 ppb.

Five of the ten serum samples from maintenance workers (Group B) were damaged in shipping. One of the 2 persons who participated in a chlordane decontamination operation had a serum chlordane concentration of 24 ppb and <1 ppb of heptachlor epoxide/oxychlordane. The other 4 had no detectable chlordane. One person who did not participate in the decontamination had a trace amount of heptachlor epoxide/oxychlordane. Group A participants did not complain of any symptoms or conditions that could be related epidemiologically to chlordane exposures in their households. The four individuals exposed to 4.6 ug/m^3 in air did not appear to complain of a disproportionate number of symptoms. Because of the small number of study participants, however,there was little chance of finding statistically significant relationships, dose-response trends, or uncommon effects. In addition, the duration of participant chlordane exposure may have been insufficient to elicit adverse outcomes. It is also possible that Forest Service employees are healthier and/or less prone to voice medical complaints. The younger children in the study did not answer the questionnaire themselves. Therefore, any existing health problems would have to be more manifest to be observed and reported by the parent.

Based upon the information gathered during this investigation, individuals currently residing in houses with ambient chlordane levels between 0.79 and 4.6 ug/m^3 did not appear to experience any overt chlordane-related adverse health effects at the time of this study. One individual who had partipated in a decontamination operation had a chlordane level somewhat above that of other study participants (24.0 ppb), but well below the level found in cases of acute toxicity. Participation in the chlordane decontamination operation in May 1983 for 8 hours is the only chlordane exposure recalled by this individual. Exposure at that time was most likely via inhalation and skin.

VI. RECOMMENDATIONS

1. Buildings 248A & B, 436, 444, 504, 523A & B should be secured and not used because of the presence of high chlordane levels. These buildings should be resampled yearly and can be reopened when chlordane levels fall below the 5/ug/m^3 evaluation criterion. Windows and doors should be left partially open to provide natural ventilation.

Chlordane sampling should be done during the warmer summer months. An examination of the data shows that of 49 samples taken in September 1984 (temperature 80° F to 90° F) (Appendix IV) 40 were higher (many significantly) than those collected in the same areas in February 1984 (temperature 10° F to 60° F). It would not be unreasonable to assume that temperature plays a significant role in the vaporization rate of chlordane.

The installation of a vapor barrier (see Appendix II) and positive ventilation in the crawl spaces would also facilitate the removal of chlordane from these buildings.

2. Buildings 222, 305, 445, 446, 473A & B showed high levels of chlordane in the crawl spaces. We recommend that a vapor barrier of Saranex or Capran-C plastics (Appendix II) be installed to prevent vaporization of chlordane into the living space. Positive ventilation of the crawl space would prevent chlordane build-up and facilitate the removal of the contaminant from the space.

3. The airborne levels in house crawl spaces were higher than living space levels. Barriers to prevent intry of children should be installed if individuals working in crawl spaces become ill; chlordane poisoning should be considered. The serum chlordane concentration would be useful information if symptoms suggest acute chlordane indications. Environmental results and recommendation for each building appear in Appendix III.

4. Individuals participating in chlordane decontamination operations should be provided with protective garments and equipment to prevent oral, dermal and inhalation exposures.

VII. REFERENCES

1. Manual of Methods for the Analysis of Pesticides, Residues in Human and in Environmental Samples. U.S. EPA, Environmental Toxicology Division, Research Triangle Park. Sec. 5a., December 1974.

2. Chlordane in Air Force Family Housing: A Study of Slab-on-Grade Houses. USAF Occupational and Environmental Health Laboratory Report: 83-129EH111DPB, Brooks Air Force Bases, Texas, April 1983.

3. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment for 1982, ACGIH, Cincinnati OH, 1982.

4. IARC Monographs on Evaluation of the Carcinogenic Risk of Chemicals to Humans 20: 45-65, 1979.

5. Wang HH and MacMahon B, "Mortality of Workers Employed in the Manufacture of Chlordane and Heptachlor", JOM 21: 745-748, 1979.

6. An Assessment of the Health Risks of Seven Pesticides Used for Termite Control. Committee on Toxicology, Board on Toxicology and Environmental Health Hazards, Commission on Life Sciences, National Academy Press, Washington, D.C., August, 1982.

7. Fishbein, W.J., White, J.V., and Isaacs, H.J. 1964 Survey of Workers Exposed to Chlordane. Ind. Med. Surg 33: 726-727, 1964.

8. Infante PF, Epstein SS and Newton WA, "Blood Dyscrasias and Childhood Tumors and Exposure to Chlordane and Heptachlor", Scand. J. Work Environ and Health 4: 137-150, 1978.

9. Curley A and Garrettson L, "Acute Chlordane Poisening: Clinical and Chemical Studies", Arch Environ Health 18: 211-215, 1969.

10. Aldrich FD and Holmes JH. "Acute Chlordane Intoxication in a Child: Case Report with Toxicological Data," Arch Environ Health 19: 129-132, 1969.

11. NIOSH/OSHA, "Occupational Health Guidelines for chemical Hazards," NIOSH pub #81 - 123, January 1981

12. Carson, GA. HETA 83-424-1403 "Ozark National Scenic Riverways Van Buren, Missouri - 1984.

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IX. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. The Superintendent, Ozark National Scenic Riverways
2. Midwest Regional Safety Officer, National Park Service
3. Missouri Department of Agriculture
4. Public Health Service Officer, National Park Service
5. NIOSH Denver Region
6. OSHA Region VII

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

PAIRED AND REPEAT SAMPLE RESULTS

Chlordane Air Concentrations
Ozark National Scenic Riverways
Van Buren, Missouri
HETA 84-168

Building Location	Pair #	Date	Sample #	Tube Type	Concentration
	1	9-27-83	5	43	5.1
305 Fireplace		9-27-83	4	42	6.0
Mantle	2	9-28-83	23	43	7.4
		9-28-83	22	42	14.0
	3	9-27-83	6	43	25.0
305 Crawl		9-27-83	3	42	27.0
Space	4	9-28-83	25	43	19.0
		9-28-83	24	42	21.0
	5	9-27-83	10	43	14.0
436 Kitchen		9-27-83	9	42	12.0
	6	9-28-83	30	43	1.0
		9-28-83	29	42	15.0

TABLE II

Chlordane Air Concentrations
Ozark National Scentic Riverways
Van Buren, Missouri
HETA 84-168

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
219 Welch Lodge					
Dining Hall	1	2/1/84	23	0.4	
	2	2/2/84	127	0.43	
	3	2/3/84	228	0.37	0.40
Sleeping Room #4	1	2/1/84	24	0.4	
	2	2/2/84	126	0.52	
	3	2/3/84	229	0.53	0.48
Sleep Room #18	1	2/1/84	25	0.3	
222 Carr's Store Round Spring					
Crawl Space	1	2/2/84	125	3.1	
	2	2/3/84	225	4.1	3.6
	3	9/11/84	607	33.0	
Bedroom	1	2/2/84	123	0.36	
	2	2/3/84	226	0.33	0.35
Front Counter	1	2/2/84	124	0.32	
	2	2/3/84	222	0.37	0.35

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
248A Duplex Quarters - Round Springs					
Crawl Space	1	2/1/84	20	40.0	
	2	2/2/84	120	34.0	
	3	2/3/84	224	26.0	33.0
	4	9/11/84	606	75.0	
Bedroom	1	2/1/84	22	3.3	
	2	2/2/84	122	2.5	
	3	2/3/84	223	5.2	3.7
	4	9/11/84	605	4.2	
Living Room	1	2/1/84	21	2.2	
	2	2/2/84	121	3.0	
	3	2/3/84	222	4.8	3.3
	4	9/11/84	604	4.6	
248B Duplex Quarters - Round Springs					
Crawl Space	1	2/1/84	17	7.6	
	2	2/2/84	117	8.4	
	3	2/3/84	221	11.0	9.0
	4	9/11/84	603	52.0	
Bedroom	1	2/1/84	18	0.52	
	2	2/2/84	118	1.1	
	3	2/3/84	219	0.55	0.72
	4	9/11/84	602	6.3	
Living Space	1	2/1/84	19	0.64	
	2	2/2/84	119	1.5	
	3	2/3/84	220	0.66	0.93
	4	9/11/84	601	8.2	
305 Private Residence - Powder Mill					
Crawl Space	1	2/4/84	300	2.3	
	2	2/5/84	401	0.97	
	3	2/6/84	500	0.85	1.4
	4	9/11/84	648	30.0	

TABLE IT
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
305 Private Residence (continued)					
Basement Area	1	2/4/84	301	1.7	
	2	2/5/84	400	1.1	
	3	2/6/84	504	1.1.	1.3
	4	9/11/84	647	8.8	
Study	1	2/4/84	302	1.1	
	2	2/5/84	403	1.0	
	3	2/6/84	502	1.0	1.0
	4	9/11/84	646	3.0	
Living Room	1	2/4/84	303	1.4	
	2	2/5/84	404	1.2	
	3	2/6/84	501	0.92	1.2
	4	9/11/84	645	4.0	
Inside Exterior Wall	1	2/4/84	304	4.0	
Crawl Space, Sill Plate	1	2/5/84	402	3.2	
	2	2/6/84	503	1.6	2.4
306 Seasonal Quarters-Two Rivers					
Crawl Space	1	2/4/84	308	0.28	
	2	2/5/84	408	0.02	
	3	2/6/84	508	0.05	0.12
Kitchen	1	2/4/84	309	0.28	
	2	2/6/84	509	0.05	0.20
Living Area	1	2/5/84	409	0.02	0.02

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
310 Seasonal Quarters-Powder Mill					
Living Room	1	2/4/84	305	0.30	
	2	2/5/84	406	0.04	
	3	2/6/84	506	0.21	0.18
Crawl Space	1	2/4/84	306	0.30	
	2	2/5/84	405	0.60	
	3	2/6/84	505	0.50	0.47
401 Cabin					
	1	2/1/84	72	n.d.	
	2	2/2/84	168	0.14	
	3	2/3/84	269	0.05	0.06
402 Cabin					
Center Area	1	2/4/84	350	n.d.	
	2	2/5/84	450	n.d.	
	3	2/6/84	559	n.d.	n.d.
403 Cabin					
Center Area	1	2/4/84	353	n.d.	
	2	2/5/84	451	n.d.	
	3	2.6.84	563	n.d.	n.d.
404 Cabin					
Center Area	1	2/4/84	354	0.44	
	2	2/5/84	454	0.24	
	3	2.6.84	552	0.30	0.33
Crawl Space	1	2/4/84	355	2.2	
	2	2/5/84	455	1.5	
	3	2/6/84	551	1.2	1.6

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
405 Cabin					
Crawl Space	1	2/4/84	357	5.5	
	2	2/5/84	457	1.4	
	3	2/6/84	557	1.9	2.9
Center Area	1	2/4/84	358	1.7	
	2	2/5/84	456	0.55	
	3	2/6/84	553	0.38	0.88
406 Cabin					
Crawl Space	1	2/4/84	366	1.0	
	2	2/5/84	459	0.28	
	3	2/6/84	564	0.30	0.53
Center Area	1	2/4/84	368	0.35	
	2	2/5/84	458	0.21	
	3	2/6/84	565	0.19	0.25
407 Cabin					
Center Area	1	2/4/84	367	0.75	
	2	2/5/84	460	0.30	
	3	2/6/84	569	0.30	0.45
Craw Space	1	2/4/84	369	2.5	
	2	2/5/84	460	0.98	1.2
408 Cabin					
Crawl Space	1	2/4/84	372	1.0	
	2	2/5/84	465	0.48	
	3	2/6/84	554	0.32	0.6
Center Area	1	2/4/84	373	0.18	
	2	2/5/84	464	0.10	
	3	2/6/94	555	0.14	0.14
	4	9/11/84	643	1.3	

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
409 Cabin					
Center Area	1	2/4/84	370	0.66	
	2	2/5/84	462	0.23	
	3	2/6/94	561	0.24	0.38
Crawl Space	1	2/4/84	371	3.0	
	2	2/5/84	463	0.65	
	3	2/6/94	562	1.9	1.9
410 Cabin					
Center Area	1	2/4/84	356	0.32	
	2	2/4/84	466	0.06	
	3	2/6/84	550	0.22	0.44
Crawl Space	1	2/4/84	359	0.73	
	2	2/5/84	467	0.29	
	3	2/6/84	558	0.30	0.44
411 Cabin					
Center Area	1	2/4/84	351	0.26	
	2	2/5/84	452	0.08	
	3	2/6/84	560	0.60	0.17
Crawl Space	1	2/4/84	352	2.1	
	2	2/5/84	453	0.38	
	3	2/6/84	556	1.1	1.2
412 Cabin					
Center Area	1	2/1/84	71	1.0	
	2	2/2/84	167	1.4	
	3	2/3/84	271	1.7	1.4

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
Center Area	1	2/1/84	73	0.63	
	2	2/2/84	166	0.89	
	3	2/3/84	270	0.81	0.78
	4	9/11/84	642	0.89	
413 Cabin					
Center Area	1	2/1/84	74	--	
	2	2/2/84	158	0.14	
	3	2/3/84	261	--	0.14
414 Cabin					
Center Area	1	2/1/84	70	0.23	
	2	2/2/84	159	0.20	
	3	2/3/94	262	0.28	0.24
Other	1	2/1/84	75	--	
	2	2/2/84	160	0.15	
	3	2/3/84	263	0.14	0.10
415 Private Residence (Concessionairs Big Springs)					
Living Area	1	2/1/84	67	0.13	0.13
	2	9/11/84	637	0.17	
Bedroom	1	2/1/84	68	n.d.	
	2	2/2/84	170	0.22	
	3	2/3/84	273	0.19	0.21
	4	9/11/84	638	0.26	
Basement	1	2/1/84	69	0.34	
	2	2/2/84	171	0.78	
	3	2/3/84	274	1.0	0.71
	4	9/11/84	636	6.9	
Kitchen	1	2/2/84	169	0.22	
	2	2/3/84	272	0.19	0.21

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
422 Dining Lodge Big Spring					
Dining Room	1	2/1/84	62	n.d.	
	2	2/2/84	161	0.14	
	3	2/3/84	264	0.08	0.11
	4	9/11/84	641	0.39	
Kitchen	1	2/1/84	63	0.12	
	2	2/2/84	162	0.19	
	3	2/3/84	265	0.27	0.19
	4	9/11/84	639	0.35	
Basement, Near Stairs	1	2/1/84	64	0.18	
	2	2/2/84	163	0.28	
	3	2/3/84	266	0.30	0.25
	4	9/11/84	640	2.8	
Back Basement	1	2/1/84	65	0.21	
	2	2/2/84	164	0.36	
	3	2/3/84	267	0.43	0.33
Living Quarters	1	2/1/84	66	n.d.	
	2	2/2/84	165	0.17	
	3	2/3/84	268	0.14	0.16
436 Private Residence-Mill Creek					
Crawl Space	1	2/4/84	312	12.0	
	2	2/6/84	511	6.1	9.1
	3	9/11/84	671	120.0	
Kitchen	1	2/4/84	310	4.8	
	2	2/6/84	512	1.9	3.4
	3	9/11/84	672	15.0	
Bedroom	1	2/4/84	311	2.5	
	2	2/6/84	510	1.5	2.0
	3	9/11/84	673	10.0	

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
444 Private Residence Highway Z					
Crawl Space	1	2/1/84	52	15.0	
	2	2/2/84	150	19.0	
	3	2/3/84	251	20.0	18.0
	4	9/11/84	660	210.0	
Living Room	1	2/1/84	50	3.5	
	2	2/2/84	151	3.6	
	3	2/3/84	252	4.3	3.8
	4	9/11/84	661	7.0	
Bedroom	1	2/1/84	51	3.4	
	2	2/2/84	152	4.0	
	3	2/3/84	250	4.1	3.8
	4	9/11/84	662	5.1	
445 Private Residence					
Crawl Space	1	2/1/84	61	19.0	
	2	2/2/84	157	16.0	
	3	2/3/84	260	30.0	21.7
	4	9/11/84	667	120.0	
Living Area West	1	2/1/84	57	1.1	
	2	2/2/84	172	1.5	0.87
	3	9/11/84	664	3.2	
Upstairs, West	1	2/1/84	58	0.47	
	2	2/2/84	174	0.54	
	3	2/3/84	257	0.65	0.55
	4	9/11/84	663	2.2	
Living Area, East	1	2/1/84	59	0.38	
	2	2/2/84	173	1.0	
	3	2/3/84	258	1.8	1.1
	4	9/11/84	666	4.5	

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
445 Private Residence (continued)					
Upstairs, East	1	2/1/84	60	0.65	
	2	2/2/84	175	0.75	
	3	2/3/84	259	1.2	0.87
	4	9/11/84	665	2.9	
446 Private Residence-Big Springs					
Basement	1	2/1/84	53	1.3	
	2	2/2/84	153	1.6	
	3	2/3/84	253	2.2	1.7
	4	9/11/84	668	17.0	
Bedroom, First Floor	1	2/1/84	55	0.9	
	2	2/2/84	155	0.9	
	3	2/3/84	255	1.0	0.93
Second Floor	1	2/1/84	56	0.9	
	2	2/2/84	156	1.2	
	3	2/3/84	256	1.4	1.2
	4	9/11/84	669	4.1	
Kitchen	1	2/1/84	54	0.9	
	2	2/2/84	154	1.0	
	3	2/3/84	254	0.97	0.99
	4	9/11/84	670	2.9	
473A Duplex-Big Springs					
Crawl Space	1	2/4/84	362	14.0	
	2	2/5/84	471	12.0	
	3	2/6/84	575	8.9	11.6
	4	9/11/84	632	16.0	

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
Bedroom	1	2/4/84	361	2.7	
	2	2/5/84	472	2.1	
	3	2/6/84	568	1.9	2.2
	4	9/11/84	631	1.9	
Living Area	1	2/4/84	360	2.7	
	2	2/5/84	473	2.5	
	3	2/6/84	567	2.1	2.4
	4	9/11/84	630	1.6	
473B Duplex-Big Springs					
Crawl Space	1	2/4/84	365	10.0	
	2	2/5/84	470	10.0	
	3	2/6/84	570	6.9	9.0
	4	9/11/84	635	19.0	
Bedroom	1	2/4/84	364	0.35	
	2	2/5/84	468	0.48	
	3	2/6/84	573	0.44	0.42
	4	9/11/84	634	1.3	
Living Area	1	2/4/84	363	0.63	
	2	2/5/84	469	0.69	
	3	2/6/84	574	1.5	0.94
	4	9/11/84	633	1.2	
504 Private Residence-Alley Springs					
Living Areas	1	2/1/84	13	0.57	
	2	2/1/84	14	0.43	
	3	2/2/84	110	0.65	
	4	2/3/84	208	1.0	0.66
	5	9/11/84	614	1.6	
Basement Center	1	2/1/84	15	1.6	
	2	2/2/84	109	2.6	
	3	2/3/84	209	3.8	2.7
	4	9/11/84	617	20.0	

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
504 Private Residence (continued)					
Exterior Basement Stairwell	1	2/1/84	16	13.0	
	2	2/2/84	108	11.0	
	3	2/3/84	210	22.0	15.3
	4	9/11/84	616	27.0	
505 Seassonal Cabin-Alley Spring					
Craw Space	1	2/1/84	9	2.4	
	2	2/2/84	111	4.9	
	3	2/3/84	213	4.8	4.0
Living Space	1	2/1/84	10	0.47	
	2	2/2/84	112	0.56	
	3	2/3/84	214	0.63	0.55
	4	9/11/84	618	0.40	
506 seasonal Cabin-Alley Springs					
Living Space	1	2/1/84	11	0.17	
	2	2/2/84	114	0.5	
	3	2/3/84	216	0.43	0.37
	4	9/11/84	619	1.0	
Crawl Space	1	2/1/84	12	1.6	
	2	2/2/84	113	2.6	
	3	2/3/84	215	1.8	2.0
508 Private Residence-Alley Springs					
Bedroom	1	2/1/84	7	0.1	
	2	2/2/84	107	0.16	
	3	2/3/84	206	0.15	0.14
Living Room	1	2/1/84	8	0.1	
	2	2/2/84	106	0.16	
	3	2/3/84	207	0.10	0.12

TABLE II
(Continued)

Building Location	Repeat #	Date	Sample #	Conc ug/m^3	Average
521 Alley Center-Alley Springs					
Classroom	1	2/2/84	115	0.47	
	2	2/3/84	218	0.49	0.32
Kitchen	1	2/2/84	116	0.42	
	2	2/3/84	217	0.39	0.27
523A Duplex Quarters-Alley Springs					
Crawl Space	1	2/1/84	4	11.0	
	2	2/2/84	103	30.0	
	3	2/3/84	205	40.0	27.0
	4	9/11/84	613	45.0	
Bedroom	1	2/1/84	5	7.6	
	2	2/2/84	105	8.7	
	3	2/3/84	204	18.0	11.4
	4	9/11/84	612	6.4	
Living Area	1	2/1/84	6	8.5	
	1	2/2/84	104	10.0	
	2	2/3/84	203	18.0	12.2
	3	9/11/84	611	6.6	
523B Duplex Quarters-Alley Springs					
Crawl Space	1	2/1/84	1	14.0	
	2	2/2/84	100	11.0	
	3	2/3/84	200	16.0	13.7
	4	9/11/84	609	33.0	
Bedroom	1	2/1/84	2	2.6	
	2	2/2/84	101	3.1	
	3	2/3/84	201	4.0	3.2
	4	9/11/84	608	1.2	
Living Room	1	2/1/84	3	3.3	
	2	2/2/84	102	3.1	
	3	2/3/84	202	5.1	3.8
	4	9/11/84	610	0.84	

TABLE III

Composition of Study Groups

Group A (Residents of Forest Service Buildings)		
Forest Service Employees (5 male and 1 female)		
	Park Ranger or Technician	3
	Waste Treatment Specialist	2
	Naturalist	1
Others		
	Spouses of Forest Service Employees (5 females)	5
	Children of Forest Service Employees (3 male and 4 female)	7
	Total**	18
Group B (Residents of Surrounding Communities)		
Forest Service Maintenance Workers		
	(All Male)	10
	Total	28

**Five of 23 Group A members declined participation.

Table IV

Chlordane Exposure Data for Group A Participants
Who Lived in Six Chlordane Contaminated Residences

Number of persons	chlordane level in air (ppb) (range & mean)	average hours/day spent in house	number of days spent in house over last one month	months spent in house (total)	range of serum chlordane (ppb) #	Results	range of the sum of serum heptachlor epoxide and oxychordane (ppb)	range of serum trans-nonchlor (ppb)
7	0.79-1.2 (0.95)	8-20	25-26	3-13	4	all <1	<1-1.4	all <1
7	1.2-1.9 (1.5)	12-20	26-30	1	3	all <1	<1	all <1
4	4.2-4.6 (4.4)	14	26	23	2	<1, 2.9	<1, trace	all <1

APPENDIX I

Description of Building Evaluated

A. Building 219 - Welch Lodge

This is a large, frame, single story building on a concrete slab, there is no crawl space or basement. The building houses a kitchen, dining hall and a large dormitory area equipped with bunk beds. Chlordane was applied in September of 1982 as a surface spray at the external soil line of the foundation.

B. Building 222 - Carrs Store - Round Springs

This is a two-level building of frame construction with a concrete foundation. It has a crawl space under the street level entrance. Chlordane was applied September 1982 on the internal foundation and wooden sills as a surface spray.

C. Building 248A - Duplex Quarters - Round Springs

This section of the duplex was built in 1978 and is a single story ranch type home with three bedrooms, of frame construction with a concrete foundation. There is a crawl space under the bedrooms and living space. Chlordane was applied in September 1982 as a surface spray on the internal foundation and wooden sills and the external soil line of the foundation.

C1. Building 248B - Duplex Quarters - Round Springs

This section of the duplex was built in 1978 and is a single story ranch type home, with three bedrooms, of frame construction with a concrete foundation. There is a crawl space under the bedrooms and living space. Chlordane was applied in September 1982 as a surface spray on the internal foundation on the wooden sills and at the external soil line of the foundation.

D. Building 305 - Private Residences - Powder Mill

This is a government-owned building used as a private residence. It is a single story structure of frame construction with a full basement and a crawl space. Chlordane was applied in October 1982 using a subsurface technique, and again applied in February 1983. During this application, the chlordane mixture was misted inside the basement, on the floor joists and sills, as well as being poured into holes drilled in the basement slab and on top of the ground on the exterior of the building.

E. Building 306 - Seasonal Quarters - Two Rivers

This is a log cabin with a concrete foundation. Chlordane was applied in September 1983 as a surface spray around the internal foundation, wooden sills and the soil around the external foundation.

F. Building 310 - Cabin - Seasonal Quarters - Powder Mill

This is a cabin of frame construction with a concrete foundation and a crawl space. Chlordane was sprayed in September 1982 along the exterior soil line of the foundation and along the interior foundation and on the wooden sills.

G. Building 401 - Rental Cabin - Big Springs

This is a single story structure on a concrete slab with rock and wood walls, there is no crawl space. Chlordane was applied in August 1982 as a surface spray along the exterior soil line of the foundation.

H. Building 402 - Rental Cabin - Big Springs

This is a single story structure on a concrete slab with rock and wood walls, there is no crawl space. Chlordane was applied in August 1982 as a surface spray along the exterior soil line of the foundation.

I. Building 403 - Rental Cabin - Big Springs

This is a single story structure on a concrete slab with rock and wood walls, there is no crawl space. Chlordane was applied in August 1982 as a surface spray along the exterior soil line of the foundation.

J. Building 404 - Rental Cabin - Big Springs

This building is of frame construction with a concrete foundation and a crawl space. Chlordane was applied in in August 1982 as the internal foundation on wooden sills and also along the soil line of the foundation.

K. Building 405-409-410-411-412 - Rental Cabins - Big Springs

These buildings are all of frame construction with a concrete foundation and all have a crawl space. Chlordane was applied in September 1982 at the internal foundation on wooden sills as well as at the soil line of the exterior foundation.

L. Building 406-407-408 - Rental Cabins - Big Springs

These buildings are all of frame construction with rock foundations and all have crawl spaces with exterior vents. Chlordane was applied in September 1982 as a surface spray along the external foundation.

M. Building 413 - Rental Cabin - Big Springs

This is a single story frame building on a concrete slab with no crawl space. Chlordane was applied in September 1982 as a surface spray along the external soil line of the foundation.

N. Building 414 - Rental Cabin - Big Springs

This building is constructed of cut rock on a rock foundation. It has wooden window frames and a basement. Chlordane was applied September 1982 as a surface spray along the external soil line of the foundation.

O. Building 415 - Cabin-Concessionairs Quarter - Big Springs

This is a single story, two bedrooms, full basement residence, of concrete construction. Chlordane was applied as a surface spray along the internal foundation, and wooden sills as well as along the external foundation during September 1982.

P. Building 422 - Dining Lodge - Big Springs

This is a single story building with a concrete basement with rock and wood walls. It houses a gift shop, dining room and a kitchen, as well as two single room quarters at the rear. Chlordane was applied in September 1982 as a surface spray along the external soil line of the foundation.

Q. Building 436 - Private Residence - Mill Creek

This is a government owned private residence. It is a single story frame building with no basement. Chlordane was applied in September 1982 as a surface spray along the soil line of the foundation.

R. Building 444 - Private Residence - Highway 7

This is a private two bedroom residence currently used as a biology laboratory. It is of frame construction with a concrete foundation. There is a crawl space. Chlordane was applied in September 1982 as a surface spray on the interior foundation, on the wooden sills as well as along the exterior soil line of the foundation.

S. Building 445 - Private Residence - Big Springs

This is a two story frame house with a concrete foundation, and no basement, but a crawl space. Chlordane was applied in September 1982 as a surface spray along the internal foundation and wooden sills as well as along the soil line of the external foundation.

T. Building 446 - Private Residence - Big Spring

This is a four bedroom two story frame house with a concrete foundation. Chlordane was applied in September 1982 as a surface spray along the interior foundation and wooden sills as well on the soil line of the external foundation.

U. Buildings 473-A & B - Duplex - Big Springs

These are residences of frame construction with concrete foundations. Both have crawl spaces with access through the floor in the closet. Chlordane was applied September 1982 as a surface spray along the internal foundation, on the wooden sills as well as along the soil line of the external foundation.

V. Building 504 - Private Residence - Alley Springs

This is a single story frame residence with a full basement and rock walls and foundation. Chlordane was applied September 1983 as a surface spray along the internal foundation and wooden sills as well as along the soil line of the external foundation.

W. Buildings 505-506 - Cabins - Alley Springs

These building are of frame construction with a rock foundation and they both have crawl spaces. They are used as quarters. Chlordane was applied in September 1983 as a surface spray along the internal foundation on the wooden sills as well as along the soil lines of the exterior foundation.

X. Building 508 - Private Residence - Alley Springs

This residence is of frame construction with a block foundation. Chlordane was applied in September 1983 as a surface spray along the soil line of the exterior foundation.

Y. Building 521 - Alley Center - Alley Springs

This is a large frame structure built on a slab. There is a large open room used as a class room and some kitchen space. Chlordane was applied in September 1983 as a surface spray along the soil line of the exterior foundation.

Z. Buildings 523A & B -Duplex - Alley Springs

These residences are duplexes of frame construction with a concrete foundation. Both have crawl spaces. Chlordane was applied in September 1983 as a surface spray along the interior foundation, on the wooden sills as well as along the soil line of the exterior foundation.

Appendix II

REPORT ON USE OF PLASTIC BARRIERS IN PLENUM STRUCTURES
from
Council on Protection of Buildings from Wood Destroying Organisms

This is a report of the meeting of the Advisory Committee on Air Quality Improvement in Residential Construction on 16 December 1983.

"Tests on the permeability of three plastic films to the termiticides chlordane and chlorpyrifos (Dursban) were conducted at the University of Florida. Polyethylene, polyvinylidene chloride (Saranex), and polyamide (Capran-C) were tested in a dessicator. 1 mil and 6 mil Polyvinyl was penetrated in less than six days when in contact with the termiticides, and between 48 and 85 days when not in contact with the termiticides. It was concluded that polyethylene was not a satisfactory barrier to penetration by either chlordane or chlorpyrifos. One mil capran C and saraneh, in direct contact with chlordane and chlorpyrifos continued to prevent penetration up to 181 days (time of report). Both films appear to be effective barriers and are commercially feasible for use in residential construction.

Appendix III

Chlordane Concentrations by Building

During this study some 680 samples were collected by the NIOSH investigator in 36 buildings. The concentration ranges and recommendations based on that data are listed below, by building.

A. Building 219, Welch Lodge

Seven air samples were taken over three consecutive days (Table II) covering the dining hall, sleeping room #4 and sleeping room #18. Chlordane levels ranged from .3 to 53 ug/m^3. These levels were well below the 5 ug/m^3. The NIOSH investigators saw no reason to restrict access to this facility.

B. Building 222, Carrs Grocery Store

Six air samples were taken on two consecutive days (Table II) in February 1984 and one sample in September 1984. Sampling sites located were in the crawl space, bedroom and at the front counter. (Table II) Chlordane levels in February ranged from 4.1 (crawl space) to 0.32 ug/m^3. The September sample (crawl space) showed a concentration of 33 ug/m^3. We recommended that a vapor barrier of either Saranex or Capran-C plastics be installed in the crawl space preferably with positive ventilation of the crawl space until chlordane levels are reduced below the 5 ug/m^3 level, so as to preclude vaporization into the living space.

C. Building 248A - Duplex Quarters

Nine air samples were taken on three consecutive days (Table II) in February 1984. Sampling sites were located in the crawl space, bedroom and living room. One sample in each of these areas was taken in September of 1984. The February samples showed high levels of chlordane (26-40 ug/m^3) in the crawl space. Levels in the bedroom ranged from 2.5 to 5.2 ug/m^3 and in the living room from 2.2 to 4.8 ug/m^3. The September samples showed the level of chlordane to be 75 ug/m^3 in the crawl space, 4.2 ug/m^3 in the bedroom and 4.6 ug/m^3 in the living room. We recommended that a vapor barrier of either Saranex or Capran-C plastics be installed in the crawl space preferably with positive ventilation of the crawl space until chlordane levels are reduced below the 5 ug/m^3 level. Because chlordane levels were near or above the evaluation criteria for this building as well as in the second half of the duplex (Building 248-B below) we recommended that these buildings not be occupied until samples indicate that all levels in the living spaces were below the 5 ug/m^3 evaluation criteria.

C1. Building 248B Duplex Quarters

Nine air samples were taken on three consecutive days (Table II) in February 1984. Sampling sites were located in the crawl space, bedroom and living space. One sample was taken at each of these areas in September of 1984. The February samples showed chlordane concentrations ranged from 7.6 to 11 ug/m^3 in the crawl space, 0.52 to 1.1 ug/m^3 in the bedroom and 0.64 to 1.5 ug/m^3 in the living space. September samples showed 52 ug/m^3 in the crawl space, 6.3 ug/m^3 in the bedroom and 8.2 ug/m^3 in the living space. Recommendations were the same as for the first section of the duplex (Building 248A, above)

D. Building 305-Private Residence

Fifteen samples were take over three consecutive days (Table II) in February 1984, covering the crawl space, basement area, study, living room, inside the exterior wall, and the crawl space sill plate. Chlordane levels ranged from 0.85 to 4.0 ug/m^3. Four samples were taken in September 1984, in the crawl space, basement, study and living room. Chlordane concentrations in the crawl space (30 ug/m^3) and basement (8.8 ug/m^3) were in excess of the evaluation criteria. We recommended that a vapor barrier of Saranex or Capran-C plastics be installed in the areas preferably in combination with positive ventilation.

E. Buildings 306, 310, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, and 427.

The samples taken in these buildings all showed chlordane concentrations well below the 5 ug/m^3 evaluation criteria and there are no reason to restrict their use. (Table II)

F. Building 436-Private Residence

Six air samples were taken over two consecutive days in February (Table II) covering the crawl space, kitchen and bedroom. One additional sample was taken during September 1984. The February results showed a chlordane concentrations in the crawl space of 12 and 6.1 ug/m^3; in the kitchen 4.8 and 1.9 ug/m^3 and in the the bedroom 2.5 and 1.5 ug/m^3. The samples taken in September showed chlordane levels to be 120/ug/m^3 in the crawl space, 15 ug/m^3 in the kitchen and 10.0 ug/m^3 in the bedroom. Because of the high levels of chlordane found in the September samples NIOSH recommended that this building not be occupied until the levels are below the evaluation criteria of 5 ug/m^3. We also recommended that a vapor

barriers of Saranex or Capran-C plastics be installed in the crawl space along with positive ventilation to minimize the transfer of chlordane into the living space.

G. Building 444-Private Residence

Nine samples were taken on three consecutive days (Table II) in February 1984, covering the crawl space, living room and bedroom. Chlordane concentrations in the crawl space were 15.0 19.0 and 20.0 ug/m^3, in the living room 3.5, 3.6 and 4.3 ug/m^3 and 4.0, 4.1 and 3.4 ug/m^3 in the bedroom. Single samples in each of these areas taken in September of 1984, showed a concentration of 210. ug/m^3 in the crawl space, 7.0 ug/m^3 in the living room and 5.1 ug/m^3 in the bedroom. Because of the high levels of Chlordane found in the September samples NIOSH recommended that this building not be occupied until the levels are below the 5 ug/m^3 evaluation criteria. The NIOSH, investigator also recommended that a vapor barrier of Saranex or Capran-C plastics be installed in the crawl space along with the use of positive ventilation to minimize migration of Chlordane into the living spaces.

H. Building 445-Private Residence

Fourteen samples were taken on three consecutive days in February 1984, (Table II) covering the crawl space; living area, west; upstairs, west; living area, east; and upstairs, east. With the exception of the crawl space all samples showed chlordane concentrations well below the 5 ug/m^3 evaluation criteria. Crawl space concentrations were 19.0, 16.0 and 30.0 ug/m^3. One sample in each area was taken in September 1984 and again all chlordane concentrations, except in the crawl space were well below the evaluation criteria of $5/ug/m^3$. The crawl space concentration was $120.0/ug/m^3$. The NIOSH investigator recommended the installation of a vapor barrier in the crawl space of either Saranex or Capran-C plastic along with posetive ventilation to minimize migration of chlordane into the living area. We see no reason to restrict use in this building.

I. Building 446-Private Residence

Twelve samples on three consecutive days in February (Table II) were taken covering the basement, first floor bedroom, second floor and kitchen. All Chlordane concentrations were well below the $5/ug/m^3$ evaluation criteria. One sample at each of these locations was taken in September 1984. All chlordane concentrations, except the basement ($17/ug/m^3$) were well below the $5/ug/m^3$ evaluation criteria. NIOSH recommends that a vapor barrier of Saranex or Capran-C plastics be installed along with positive ventilation, to minimize migration of chlordane into the living space. The NIOSH investigator saw no reason to restrict the use of this building.

J. Building 473 A&B - Duplex

Nine samples on three consecutive days (Table II) were taken in February covering the crawl space, bedroom and living area in both sections of the building. With the exception of the crawl spaces, all Chlordane concentrations were well within the 5/ug/m^3 evaluation criteria. The crawl space in 473A showed chlordane concentrations ranging from 8.9 to 14./ug/m^3 and the crawl space in 473B showed concentrations ranging from 6.9 to 10.0/ug/m^3. One sample in each section of the duplex in September of 1984 again showed that with the exception of the crawl spaces, all chlordane levels were well below the evaluation criteria of 5/ug/m^3. The crawl spaces showed a concentration of 16.0 and 19.0/ug/m^3 respectively. The NIOSH investigator recommended that a vapor barrier of Saranex on Capran-C plastics along with positive ventilation be installed to minimize migration of chlordane into the livding areas. He saw no need to restrict the usage of this building.

K. Building 504-Private Residence

Ten samples on three consecutive days (Table II) were taken in February 1984. The samples covered the living areas, basement center and the exterior basement stairwell. The chlordane concentrations in the living areas ranged from 0.43 to 1.0/ug/m^3. A single sample take in September 1984 showed a chlordane concentration of 1.6/ug/m^3. The basement center samples showed concentrations of 1.6, 2.6 and 3.8/ug/m^3 in February and 20.0/ug/m^3 in September. The exterior basement stairwell showed chlordane concentrations of 13.0, 11.0 and 22.0/ug/m^3 in February and 27.0/ug/m^3 in September. The previous NIOSH study (HETA 83-424) showed chlordane levels of 22.0 and 25.0/ug/m^3 respectively. Because of the continuing high levels of chlordane in the basement and basement stairwell and because we are not aware of any technique to effectively decontaminate building structure or soil we recommended that this building he sealed and resampled at some time in the future. When levels fall below 5/ug/m^3 it can be re-occupied.

L. Building 505 and 506 Cabins, 508 and 521-alley center Private Residences

Six samples from each building were taken (Table II) during February 1984. All samples were well below the evaluation criteria of 5/ug/m^3 and we saw no reason to restrict occupancy of this building.

M. Building 523A & B

Nine Samples on three consecutive days (Table II) were taken in section A of the duplex in January 1984. Results showed that chlordane concentrations in the crawl space were 11.0, 30.0 and 40.0/ug/m^3; in the bedroom 7.6, 8.7 and 18.0/ug/m^3; in the living area 8.5, 10.0 and 18.0/ug/m^3. Single samples collected in September of 1984 showed concentrations of 45.0, 6.4 and 6.6./ug/m^3 respectively. Nine samples were also collected on three consecutive days in February section B of the duplex. Chlordane concentrations were 14.0, 11.0 and 16.0/ug/m^3 in the bedroom; and 3.3, 3.1 and 5.1/ug/m^3 in the living room are sample taken in each area in September of 1984, showed concentrations of 33.0, 1.2 and .84/ug/m^3 respectively. Because of the high concentrations of chlordane found in this duplex the building should be secured. Sampling at sometime in the future could be conducted and when chlordane levels full below 5/ug/m^3 could be re-occupied.

Appendix IV

Ambient temperatures During Sample Collection
The outdoor temperatures at which air samples were collected were:

2/1/84	50° - 60° F
2/2/84	50° - 60° F
2/3/84	40° F
2/4/84	26° - 40° F
2/5/84	26° F
2/6/84	10° - 30° F.
9/11/84	80° F
9/12/84	85° - 90° F
9/13/84	80° - 85° F