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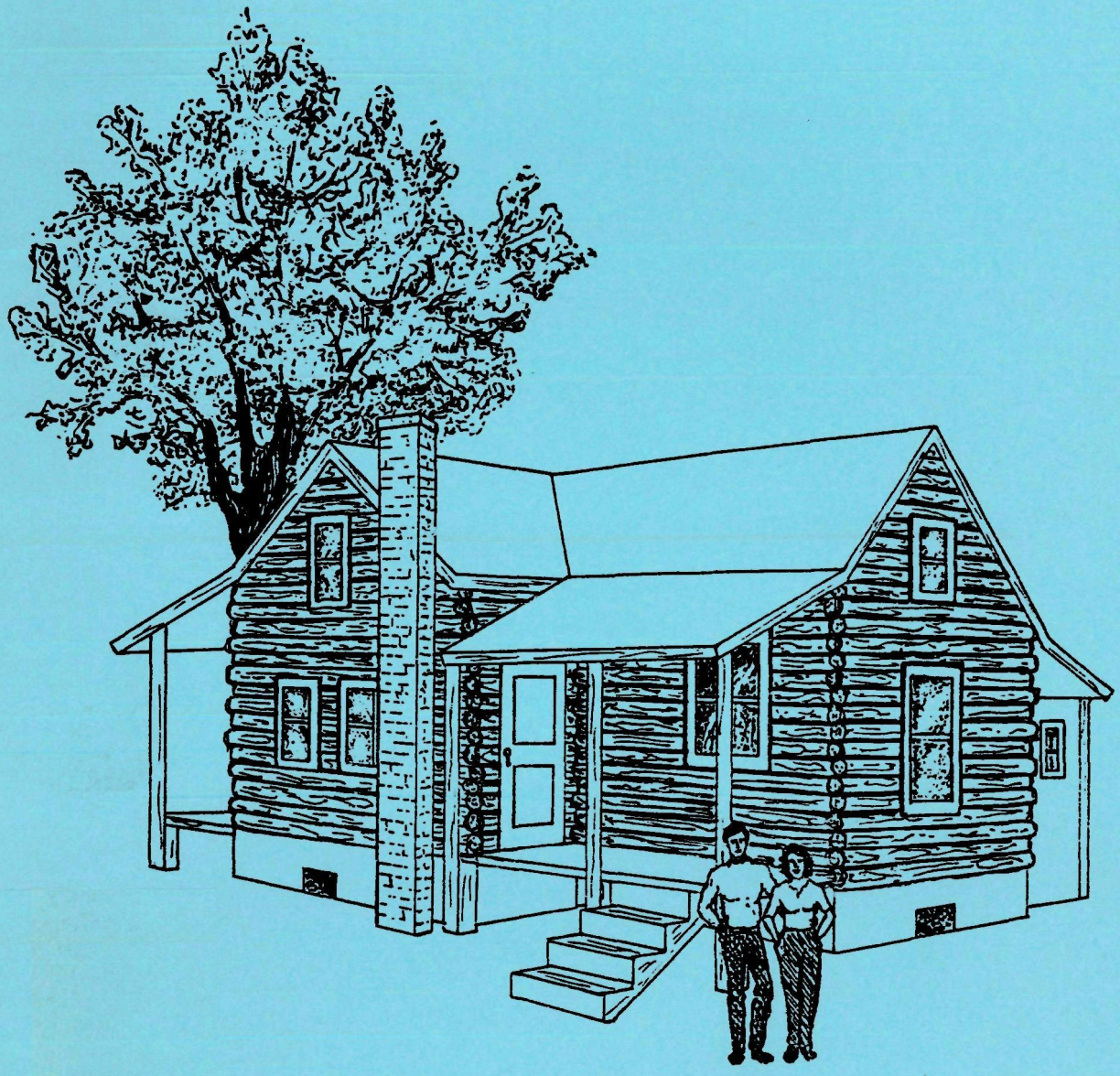
Pentachlorophenol in Log Homes: A Study of Environmental and Clinical Aspects



PENTACHLOROPHENOL IN LOG HOMES: A STUDY OF ENVIRONMENTAL AND CLINICAL ASPECTS

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PREFACE

This final report presents the results obtained on Midwest Research Institute Project No. 8201-A, Work Assignment No. 11, "Development of Field Survey and Analysis Stratagies" for the Environmental Protection Agency (EPA Prime Contract No. 68-02-3938). This work was a joint venture between MRI and the Center for Occupational and Environmental Health (COEH) of Johns Hopkins University as a subcontractor. Under the direction of Mr. John M. Hosenfeld, MRI was responsible for the overall task management, the environmental sampling (assisted by Ms. Marilyn J. Gabriel), and laboratory analyses of environmental and biological samples for pentachlorophenol (performed by Ms. Leslie Moody).

COEH, under the direction of Dr. Edward A. Emmett, was responsible for recruitment and project coordination (performed by Ms. Robin M. Friesem), assistance in environmental sampling (Dr. Peter S.J. Lees and Mr. Patrick Breysee), collection of biological samples and physical examinations (Drs. Rebecca Bascom and Diane Bennett), statistical analysis of environmental, clinical, biochemical data (Ms. Joan L. Jefferys) and data interpretation in conjunction with MRI. The clinical laboratory tests were performed by Pathologists Service Professional Associates, Atlanta, GA, and Montefiore Medical Center, Bronx, NY. This report was prepared by Mr. Hosenfeld, Ms. Friesem, Dr. Lees, Ms. Jefferys, and Dr. Emmett.

The authors also wish to thank the EPA task manager, Sandra Strassman-Sundy, for providing the appropriate guidance, background, and assistance in shepherding this project to completion.

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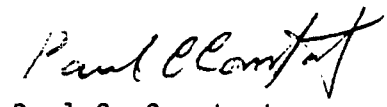

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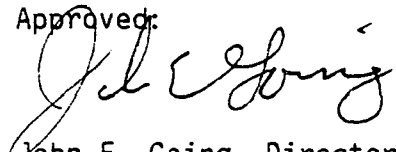

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I. SUMMARY

A. Background and Objectives

The U.S. Environmental Protection Agency's Office of Toxic Substances conducted a survey of pentachlorophenol (PCP) treated log homes and their occupants at the request of the Kentucky Department for Health Services. This study was conducted because of the possible exposure of log home residents to PCP from the treated logs. The results of this study are presented in this report.

The primary objectives of this study were (a) to determine the extent of environmental levels of PCP in log homes which had been treated with PCP; (b) to determine the extent of biological exposure in log homes treated with PCP; and (c) to examine the relationship between selected health variables and biological PCP concentrations. These health variables and biological PCP concentrations were analyzed in a search for possible effects of residues in a PCP treated log home.

B. Scope

The target population was the residents of log homes that had been treated with PCP, located in the State of Kentucky and that had been sampled in an earlier study conducted in 1980. Twelve of these previous study homes were included in the present study together with nine homes constructed from logs not treated with PCP according to the manufacturer.

C. Data Collected

Environmental and medical data were collected. An environmental evaluation of each of the 21 homes was conducted. The evaluation consisted of house treatment questionnaire administered to the head of the household, and collection of wood core, surface wipes (2), indoor air samples (3), and water samples. All samples were examined for PCP concentration.

The medical evaluation consisted of a health history questionnaire; a directed, standardized physical examination with particular attention to abnormalities of the skin and nervous system and the presence or absence of lymphoadenopathy. Sample collection from the log home residents consisted of blood drawing for serum PCP concentration, serum liver and renal function tests, and tests for blood morphology and abnormalities, and a collection of the first voided urine of the day for tests for renal and adrenal dysfunction, enzyme induction and urinary PCP--both free and conjugated. All of the biological samples were collected within 18 h of the environmental sampling in each each study participant home.

D. Major Findings

Following are the major findings of this study.

All houses examined in this study had some levels of PCP in the logs. There were actually six treatment categories in which the 21 studied log homes fell. The highest PCP levels were found in the manufacturer treated homes (4); next in the manufacturer treated homes and subsequently sealed (4); next in the manufacturer treated and subsequently sealed and neutralized (1); next in the manufacturer treated homes and subsequently neutralized (3); next exterior treatment only (4) and lowest PCP levels in never treated homes (4). The "never treated" homes had some level of PCP due to the probable spraying of the logs during storage to prevent fungal growth.

Environmental PCP contamination was detected in all the homes of the study population. Environmental PCP concentrations spanned a wide range and were up to several orders of magnitude greater in treated homes than in untreated homes. PCP was detected in 62 of 63 air samples with a limit of detection (LOD of 0.001 ng/L), in 21 of 21 composite wood core samples (LOD = 0.9 ng/g), in 21 of 21 composite wipe samples of log surfaces (LOD = 0.3 ng/100 cm^2), and in 4 of 21 water samples (LOD = 0.2 ng/L).

Significant differences ($\alpha = 0.05$) were seen among the six house treatment categories for air, wood core, and surface wipe PCP concentrations with the lowest values in the never-treated category, next lowest in the external treatment category, and highest values in the various manufacturer treated categories. PCP was found in the drinking water of four houses, all of which had been treated and all of which used a cistern as the only source of water.

Wood, air and surface-wipe concentrations of PCP were highly correlated with each other. An analysis of the relationship between air and wood core PCP concentrations in the treated and sealed and treated and neutralized categories showed significantly lower air PCP concentrations relative to wood concentrations in homes which had been treated and subsequently neutralized. However, no significant effect was seen for homes which had been treated and subsequently sealed.

Wood core PCP concentrations had a statistically significant ($\alpha = 0.05$) positive correlation with the age of the home. Among the house treatment categories the exterior treated and never-treated houses were newer houses than those in the other treated categories. It was felt that these associations reflected changes in building construction and PCP treatment practices in newer homes.

The age, sex, and time spent at home in the 48-h period before blood sampling of the participating individuals were found to be similarly distributed among the homes in the different treatment categories.

Biological PCP contamination was also detected in all samples collected from the study participants. PCP was detected in the sera (LOD = 0.25 ng/mL) and the urine (LOD = 0.08 ng/mL) of all 66 participants sampled. As was the case with measures of environmental PCP contamination, biological PCP concentrations spanned a wide range and were generally considerably higher in occupants of treated homes than in occupants of untreated homes.

The distribution of serum PCP, urinary free PCP and urinary total PCP concentrations were significantly different among the house treatment categories. Whereas the exterior treated and never-treated categories did not differ significantly from each other, concentrations in the manufacturer treated categories were mostly significantly higher. Serum PCP concentrations did not differ significantly with subject age group but both free and total urinary PCP concentrations were significantly different among the examined age groups (4 to 7, 8 to 12, and over 12 yr old) with the highest concentrations in the youngest age group and the lowest concentrations in the over 12 age group.

Mean serum, free urinary and total urinary PCP concentrations for households, adjusted for the age group distribution in the household, were highly correlated with each other. The environmental PCP concentrations (wood core, air, surface wipe) were highly correlated ($\alpha = < 0.03$)with biological PCP concentrations (serum, free urinary and total urinary) for households adjusted for the age group distribution in the household.

The age group adjusted association between estimated mean serum and total urinary PCP concentrations and certain possible health effects of PCP determined by responses to the medical questionnaire were examined. No significant ($\alpha = 0.05$) associations were seen between the PCP concentration and the reported history of eczema, acne, tumor or lump removed, rash or dermatitis in the past year, currently taking medication, fever at least once or more than once within the last 6 mo, unexplained weight loss in the last 6 mo, irritation of eyes, tearing of eyes, or swelling of eyelids since occupying the present house.

The association between mean serum PCP and total urinary PCP concentrations for households and certain biochemical variables for the household, adjusted for age group distribution in the household, were explored. No significant association was seen for liver function tests, a test of microsomal enzyme induction, and a renal function test. Statistically significant ($\alpha = 0.05$) negative associations were seen for serum total protein and serum creatinine and both biologic PCP concentrations. The reason for these negative associations was unclear; several explanations are possible and they probably do not reflect toxic effects.

The age group adjusted association between estimated mean serum and urinary total PCP concentrations and the presence or absence of lymphadenopathy or of abnormalities of skin or neurologic examination was studied. There was no significant association with lymphadenopathy or neurologic abnormalities. There was a statistically significant ($\alpha = 0.05$) positive association between the presence of skin abnormalities noted during the physical examination and PCP concentrations. It could not be determined whether this reflected more absorption of PCP through abnormal skin, effects of PCP on the skin, or some other factor.

A comparison of results from the same log home residents who participated in the 1980 and 1984 surveys was made to determine if there were differences. The concentration of PCP in serum was significantly lower in 1984 than in 1980 but the urinary levels were the same for both studies. No differences were seen for the clinical biochemistry tests performed in both studies.

E. Conclusions

Following are the major conclusions of the study.

1. PCP found in the indoor air of the log homes is a result of treatment of the logs with PCP.

2. The environmental levels of PCP in the log home are related to the type and degree of PCP treatment of the logs.

3. Cisterns in PCP treated log homes are a source of PCP to humans if the water is used for drinking purposes.

4. A source of the PCP found in the study participants was the PCP treated logs.

5. Children under age 12 living in PCP treated log homes excrete PCP at the highest rate as compared to over 12 age group.

6. The presence of skin abnormalities may be indicative of PCP exposure.

II. INTRODUCTION

Pentachlorophenol (PCP) has been used as a fungicide to treat logs used in the construction of log homes. Since people may spend an average of 10 to 20 h in their homes, the exposure to levels of PCP in treated logs may pose a risk to their health. This exposure of log home residents to PCP has become a matter of concern.

In 1980, the United States Environmental Protection Agency (EPA) and the Centers for Disease Control (CDC) investigated the possible health effects of human exposure to pentachlorophenol (PCP)-treated wood used in packing crates. In that study, a family living in a commercially manufactured log home in Kentucky was found to have elevated serum and urine levels of PCP as compared to control individuals (Lakings et al. 1980). A subsequent study conducted by CDC and the Kentucky Department for Human Services included retesting some members of the index family along with 29 volunteer residents of other PCP-treated log homes, and 13 controls who did not inhabit PCP-treated log homes. Selected clinical and biochemical measurements were performed. Results demonstrated significant differences in serum and urinary PCP concentrations between residents of PCP-treated homes and controls. Inter-family differences in residents of PCP-treated homes suggested that there was a dose-response relationship between the amount of time spent in the home and serum PCP concentrations and that children experienced the highest biological PCP concentrations (CDC, 1981).

In the study reported here, an environmental and medical follow-up of those persons previously identified as inhabiting PCP-treated homes in 1980 and living in Kentucky was conducted by the Johns Hopkins University Center for Occupational and Environmental Health (COEH) and the Midwest Research

Institute (MRI) for EPA in response to a request from the Kentucky Department for Human Services. A comparison population of persons inhabiting log homes which had not been constructed of PCP-treated logs was studied concurrently. The control population was as similar as possible in demographic parameters and geographic location to the group inhabiting PCP-treated log homes.

This study was undertaken for three reasons.

1. To determine the extent of environmental levels of PCP in log homes which had been treated with PCP.

2. To determine the extent of biological exposure in log homes treated with PCP.

3. To examine the relationship between selected health variables and biological PCP concentrations.

The present study included, as far as possible, the blood sampling and analysis procedures used in the 1980 study. In addition, several components were added, particularly environmental measurements of PCP in log homes and house treatment history. Also, medical questionnaires, additional clinical biochemistries, and medical examinations were added. Efforts were made to duplicate methods of chemical analysis to ensure compatibility of results with existing data.

This report presents the conclusions of this study (Section III), and recommendations (Section IV). The methods used in the study reported here to identify, locate, and contact the study participants, the information gathering process by means of questionnaires and the sample collection methods are discussed in Section V. Sample preservation and shipment is discussed in Section VI, while Section VII describes the PCP chemical analysis methods, instrumentation, and the methods used for analysis of clinical specimens. Data analysis mehtods are presented in Section VIII for environmental and biochemical variables as well as the statistical procedures for the longitudinal study. Quality assurance and quality control matters are given in Section IX. Section X presents the results and a discussion of the findings for each of the above aspects of the study.

III. CONCLUSIONS

1. PCP in the indoor air of the log home is a result of treatment of the logs with PCP. Wood, air and surface wipe PCP concentrations within a log home were highly correlated with each other.

2. Environmental levels in log homes are related to the type and degree of PCP treatment of the logs. A number of treatment variations were identified in this study, including subsequent sealing and/or neutralization after manufacturer treatment with PCP and external treatment of the home with PCP by the home owner or builder. The treatment variations are reflected in variations in environmental PCP concentrations (wood core, indoor air, surface wipe samples) in the home and in biological PCP concentrations (serum, total urinary PCP, free urinary PCP) in inhabitants of the home.

3. Cisterns in PCP-treated log homes are a source of PCP to humans if the water is used for drinking purposes. PCP was detected in the drinking water of four homes, all of which had been treated with PCP and all of which used a cistern rather than a well or city water as the water source. The association of PCP in water and use of a cistern was statistically significant.

4. Chemical neutralization products reduce the level of PCP in the indoor air. Significantly lower air PCP concentrations relative to wood core PCP concentrations were seen in houses treated with PCP by the manufacturer which had subsequently been neutralized, but not in those which had subsequently been sealed with varnish or polyurethane.

5. A source of PCP in the study participants was the PCP-treated logs. Environmental PCP concentrations (wood core, air, surface wipe) were highly correlated with biological PCP concentrations (serum, free urinary and total urinary) for households, adjusted for age group distribution within the household.

6. Blood or urine can be monitored to determine body burdens of PCP. Mean serum, free urinary, and total urinary PCP concentrations for households, adjusted for the age group distribution in the household, were highly correlated with each other.

7. Children under age 12 living in PCP treated log homes excreted PCP at the highest rate as compared to the over 12 age group. Free and total urinary PCP concentrations were significantly different for the age groups 4 to 7, 8 to 12, and over 12 yr old when adjusted for household or for household and serum PCP concentrations. The highest urinary PCP concentrations were seen in the youngest age group and the lowest in the over 12 yr old age group. The serum PCP concentration did not differ between the age groups when adjusted for household.

8. Several biochemical tests, past illnesses or specific aspects of physical examinations cannot be used as indicators of PCP exposure in low level situations. These parameters include serum liver function tests, a test of microsomal enzyme induction (ratio of urinary 6-beta-hydroxycortisol to free cortisol), blood urea nitrogen, the incidence of past and present illnesses, and the presence of lymphadenopathy or neurologic abnormalities on physical examination.

9. The presence of skin abnormalities may be indicative of PCP exposure. There was a statistically significant positive association between the presence of skin abnormalities observed during physical examination in a household and the estimated mean serum and total urinary PCP concentrations. It was not clear whether this association might reflect increased absorption of PCP through abnormal skin, an effect of PCP on the skin, or some other factor.

IV. RECOMMENDATIONS

1. If residents of a PCP treated log home wish to reduce PCP exposure they should consider chemical neutralization on unsealed logs. However, the effectiveness of chemical neutralization on PCP levels in logs and on indoor air should be performed to confirmed by pretreatment and posttreatment studies.

2. Occupants of PCP treated log homes who obtain their water from cisterns should have the PCP water concentrations measured to ensure that no PCP is present.

3. In future studies involving household exposure to wood treatment agents, personal exposure should be carefully established by personnel monitoring, or environmental or biologic measurements. Statements by manufacturers and others about log treatment should not be relied upon to establish exposure categories.

4. Since biological PCP levels correlate with environmental levels, and since all environmental sample types correlate, future studies should focus on the easiest samples to collect and test for the extent of PCP exposure. Those samples are wood and urine.

5. The association of PCP concentration in serum and urine with serum protein and serum creatinine needs to be explored further to develop a better understanding of the meaning of this association so that the health significance, if any, might be assessed.

V. EXPERIMENTAL METHODS

The procedures are described in this section that were used to identify candidate houses, recruit the occupants, and obtain preliminary information about the history of their log home. The rationale for collecting environmental and biological samples is discussed along with the sample collection procedures themselves.

A. Study Participants

The identification of study participants is based on the identification of log homes that had been treated with PCP. Participants in the 1980 study were contacted, but additional recruitment was necessary for the unexposed, comparison households. This section describes those efforts as well as setting up the visits to the selected households.

1. Identification

There were 29 family members, representing 17 families, in the 1980 study living in PCP-treated homes in Kentucky. All were volunteers who had responded to articles in newspapers, radio, and television who contacted their State or county health departments, and were directed to CDC. EPA was provided with the names and addresses of these households by the Kentucky Department for Human Services.

In order to obtain a comparison population living in log homes not treated with PCP, contact was made with log home manufacturers and dealers. The names and addresses of 28 owners of untreated log homes who were within 100 miles of Louisville were obtained from log home builders who were listed in a guide to the industry. Five of these homes were known to have been made of logs treated with copper-8-quinolinolate and were no longer considered. The remaining 23 households were selected for further contact and recruitment.

2. Recruitment

a. Exposed Households

To obtain permission from previous participants for release of their medical records from CDC to the COEH and to identify their interest in participating in further studies, EPA sent letters to the 17 households who participated in the 1980 study, asking them to contact CDC and make their records available.

Follow-up calls were made to all respondents explaining the study plans. At the time of this follow-up telephone call, the Preliminary Contact Questionnaire (Appendix I) was administered.

b. Comparison Households

To recruit the comparison population, EPA mailed letters requesting participation to the previously identified 23 households. The letters were followed almost immediately by telephone calls. Thirteen households agreed to participate and responded to the Preliminary Contact Questionnaire. Nine of these households agreed to participate in the final study. Comparison homes were intended to be untreated with any wood preservative. In addition, age distribution similar to that of individuals in the exposed homes was sought.

3. Preliminary Contact Questionnaire

The Preliminary Contact Questionnaire was administered by telephone to a head of each household. This questionnaire established the demographics of the log home residents and the treatment status of the home as well as the name and location of the manufacturer. The results of this questionnaire were used to: (1) make the final selection of households to be included in the study, (2) devise a preliminary sampling schedule, (3) determine the number of participants, and (4) verify information gathered in subsequent questionnaires.

4. Informed Consent

Participation was voluntary. At the time of initial contact, each potential study participant was informed of the requirement to sign a consent form. At each contact, potential participants were told their participation was entirely voluntary, that they could ask questions or withdraw from the study at any time, that all information obtained was to be kept confidential and that findings would be summarized and presented in a statistical fashion so that the findings on any individual could not be identified. Any person desiring to participate was required to sign a Medical Informed Consent Form included as Appendix II. Any head of household volunteering his/her home as a site of environmental sample collection was required to sign an Environmental Sampling Consent Form, included as Appendix III.

In order to conduct the study, field personnel were arranged into separate teams with major responsibilities for the environmental sampling and the biological and medical studies, respectively.

A member of each environmental sampling team and each medical team was responsible for ensuring that the appropriate consent forms were signed before beginning work in each location. Before signing the consent form, each potential study participant was briefed on the objectives of the project, and exactly what would be required of them if they agreed to participate. A copy of the consent form(s) was provided to each study participant. Minors 12 yr old and older were asked to sign a standard consent form with a parent or guardian as co-signer. A parent or guardian was asked to sign a consent form for participating minors between 2 and 11 yr old, being certain the child understood what was about to occur. Minors less than 2 yr of age were not included in the study.

5. Household Identification and Appointment Schedule

The locations of homes to be sampled were plotted on a Kentucky state map to assist in determining the most efficient manner for the study to proceed. The homes were more or less clustered in three locations: (1) Northern Kentucky, around Florence; (2) around Danville, Kentucky, approximately 50 mi southwest of Lexington; and (3) around Louisville. Because of this relative clustering, it was decided that teams could work from the same geographic location with the environmental team setting up the sampling of a house 24 h ahead of the medical team visit. Study bases were established in the Florence, Danville and Louisville areas. This schedule determined that the environmental team would relocate to the next area about 1 day ahead of the medical teams.

The order in which areas were visited was related to location of easily accessible airports and the availability of hotel space. Blocks of days were determined for sampling each location on the basis of the number of homes to be sampled in an area and the availability of the people residing in them.

At the time of administration of the Preliminary Contact Questionnaire, each family had been asked if they would be home or out of town for the block of days when the environmental and medical teams would be closest to their homes. An inquiry was made to discover what time of the day most of the individuals in the household would be at home for the medical portion of the study. It was also important to know when an adult would be available in the morning so that a member of the environmental team could visit the home to retrieve sampling equipment previously set up for overnight sampling.

Appointments for environmental or medical team visits to each home were made 24 h to 4 days in advance and had to remain somewhat flexible because homes with children tended to set family schedules around each child's evening and weekend plans. Appointments were made by telephone and confirmed 24 h prior to the environmental team visit if made more than 2 days ahead. Directions to the house were obtained at this time.

Medical and environmental collection activities were coordinated through a sampling schedule prepared utilizing information gathered from the Preliminary Contact Questionnaires. The final scheduling was largely a field activity which provided the flexibility required to complete sampling in the allotted time.

Medical evaluations were conducted in the home by COEH staff using two medical teams, each having one physician and one trained interviewer. On the average, each team visited one home per day, typically arriving in the early evening.

6. Field Study Sequence

Most initial participant contacts occurred during the late afternoon and early evening. Generally the environmental team first visited each home in the late afternoon or early evening of the first day of sampling. At this time, the Environmental Sampling Consent Form was signed, the Environmental Questionnaire administered, air sampling apparatus set up and turned on, and wood core, surface wipe and water samples collected. Instructions and containers for urine collection were left with the residents for first morning urine collection on the following day. Early the next morning on the second day of sampling, the environmental team returned to turn off the air sampling equipment and prepare the air samples for shipment. The medical team arrived that same afternoon or early evening of the second day to complete the Medical Informed Consent Form, administer the Medical Questionnaire, draw blood and conduct the clinical examinations.

Where this sequence was not possible, the environmental team arrived in the early morning to initiate sampling. The environmental team returned to complete the sampling that same evening with the medical team; a member of either team then returned the next day to pick up the urine samples.

The medical studies, including blood drawing, were conducted within 18 h of the completion of air sampling in the home of the participants.

B. Rationale for Selection of Study Items

A critical component of the study was to select those media thought to have the potential for PCP being present as well as describing parts of the overall exposure picture. This section contains the rationale for selection of environmental and biological samples and physical examination items.

1. Environmental Measurements

a. Air PCP Concentrations

Air samples were collected in the home of every study participant to estimate the family member's PCP intake via the respiratory route. These data were collected to be correlated with the participant's PCP blood and urine data. Air sampling data were also collected to be correlated with results of wood core sampling and information gathered on the Environmental Questionnaire to determine predictors of air PCP concentrations in log homes. In addition, since worst case exposures were being sought, the study sampling was purposely targeted for the winter months when the house would be closed. It was anticipated that this would provide the highest air PCP levels and consequently the highest potential for exposure.

b. Wood PCP Concentrations

Wood core samples of logs on the interior of the home were collected in each study home to confirm statements gathered on the Environmental Questionnaire concerning the preservative treatment history of each log home included in the study. The wood core provided an indicator of the PCP contamination. The results of wood core sampling were also collected to be used as a relative measure of potential dermal PCP exposure in each log home; to be correlated with air sampling data, surface wipe sampling data, and information gathered on the Environmental Questionnaire to determine predictors of air PCP concentrations in log homes; and to be correlated with the participants' PCP residues in blood and urine.

c. Surface Wipe PCP Concentrations

Surface wipe samples were collected from interior log surfaces in every home in the study to estimate the potential for PCP dermal exposure of log home residents. Previous studies have noted that small children generally have higher biological concentrations of PCP than do adults living in the same house. The relatively greater amount of contact with building surfaces by children (e.g., from playing on the floor) has been suggested as one hypothesis for this difference. In addition, surface wipe sampling was conducted to determine the correlation with wood core sampling data and with air sampling data.

d. Drinking Water PCP Concentrations

A tap water sample was collected from each home to estimate each participant family's PCP intake via the water used for drinking, bathing,

and cooking. In the case of homes with on-site sources of water, the amount of PCP in the water would be an indicator of the PCP which had leached from the log home itself or other sources through the soil to the groundwater or otherwise contaminated the drinking water source.

2. Clinical Studies

The following clinical laboratory tests were selected to assist in determining the health status of the individuals participating in the study. Tests were selected on the basis of clinical usefulness for the detection of potential effects of PCP as well as their use in the 1980 study by CDC.

a. Laboratory Tests on Blood and/or Serum

- Hemoglobin, hematocrit, total white blood cell count and differential count (tests for blood morphology and abnormalities).

- Serum lactic dehydrogenase, alkaline phosphatase, gamma glutamyl transpeptidase, glutamic oxaloacetic transferase, glutamic pyruvic transaminase, total bilirubin, total protein, albumin (tests for liver function), blood urea nitrogen and creatinine (tests for renal function).

- Serum PCP level.

b. Laboratory Tests on Urine

Excessive exposure to PCP might cause sub-clinical changes including microsomal enzyme induction. For this reason, a very sensitive measure of enzyme induction was selected: estimation of 6-beta-hydroxycortisol and free urinary cortisol.

- Urinalysis (tests for renal dysfunction)

- 6-Beta-hydroxycortisol and free urinary cortisol (tests for adrenal dysfunction)

- Creatinine (tests for renal dysfunction and used to normalize urinary PCP concentrations).

- Urinary PCP-free and conjugated

The selected tests are in general use except for the 6-beta-hydroxycortisol.

3. Physical Examinations

The physical evaluations consisted of standardized hepatic, neurologic, and dermatologic examinations. This type of directed physical examination was selected on the basis of reported health effects of PCP. The

Physical Examination Form is included as Appendix IV. Prior to the field work, the examination techniques of both study physicians were reviewed and standardized to ensure comparable data gathering techniques.

C. Questionnaires

In addition to the collection of physical evidence to describe the exposure to PCP, questionnaires were used to obtain information about the log home and medical aspects of its inhabitants.

1. Environmental Questionnaire

An Environmental Questionnaire was administered directly to both heads of household simultaneously by a member of each environmental sampling team. Response to this questionnaire by both adult heads of household was encouraged, as pretesting had shown that relevant items are frequently overlooked or forgotten by one person. A more complete and accurate environmental history could thus be obtained through a discussion between the heads of household. In the event of unresolvable disagreements between the respondents, the answer of the male head of household was recorded.

The Environmental Questionnaire was designed to quantify factors which were thought to possibly affect PCP concentrations in log homes or which could be used to help understand otherwise unexplained clinical findings. Questions included in the Environmental Questionnaire focused on features of the log home and occupant practices or habits which might affect environmental measurements. In addition, the floorplan of each house was sketched by the environmental team and sampling locations indicated on the questionnaire form.

The Environmental Questionnaire is included as Appendix V.

2. Medical Questionnaire

The Medical Questionnaire was administered to each participant 16 yr and older by a trained interviewer. For participants under 16 yr of age a parent or guardian completed the informed consent and responded to the questionnaire. Only certain questions, namely 1-5 and 14-30, were asked of the children. Specific questions which concerned employment and alcohol and cigarette consumption were only asked of those over 16 yr of age.

The Medical Questionnaire was administered by a trained interviewer to obtain information on:

- Possible confounding factors that might affect the results of the laboratory investigations, including smoking and alcohol habits, drug consumption, and personal history of relevant diseases;

- Other sources of exposure to PCP;

- Approximate amounts of time spent in the home for the 48 h prior to sampling;

- Selected symptoms potentially associated with exposures to PCP.

The Medical Questionnaire is included as Appendix VI.

3. Questionnaire Pretesting

The Environmental Questionnaire was pretested and revised on the basis of responses obtained from three families in the Baltimore area who reside in log homes. Pretesting was performed in the homes under circumstances similar to those anticipated in Kentucky. Some sections of the provisional questionnaire had been used previously and required little or no alteration. Other portions of the provisional questionnaire required more alteration, i.e., especially the question concerning the amount of time each individual had spent in the home during the previous 48 h.

Pretesting of the Medical Questionnaire was performed at the same time as the Environmental Questionnaire. Again, administration was done under circumstances similar to those expected in Kentucky. Similarly, appropriate revisions in the questionnaire were made.

D. Sample Collection

The presence of PCP could be determined and quantitated by the collection of environmental and biological samples as described in this section.

1. Environmental Studies

a. Air Sampling

A minimum of three air samples were collected from the home of each study participant. Samples were typically collected in the kitchen, living room, family room, and largest second floor room (usually the master bedroom). If the house was all on one level, the third air sample was collected in the room most remote from the other two samples.

The following areas were defined as rooms: kitchen, living room, family room, dining room, bedroom, den, sewing room and library. Hallways, closets, bathrooms and basements were not considered when counting rooms. Once the rooms to be sampled were identified, the indoor air sampling apparatus was placed, within practical limits, to collect a representative sample. The sample cartridge was placed at a height of 1.0 m and in the least conspicuous location possible in order to minimize disruption of normal activity. Air was collected at a height of 1.0 m as this was presumed to be an average breathing zone height of home occupants during the evening (mostly sitting) and the night (mostly reclining) when samples were collected. The sampling apparatus was not located in a high activity area (doorway) or within 5 ft of a door or a window. Attention was also given to ensure that the sampling apparatus did not create an unsafe condition (e.g., extension cord across a doorway).

The air sampling system consisted of:

- XAD-2 resin cartridge and holder;
- Critical flow orifice calibrated at 1 lpm;
- Vacuum pump with muffler;
- Elapsed time meter.

The sampling apparatus was assembled in the manner shown in Figure 1, the seals on the solid sorbent tube broken, and the pump turned on. Air was sampled in this manner for a minimum of 8 h and a maximum of 15 h. All sampling was initiated between 5 and 9 p.m. and terminated between 6 and 10 a.m. the next day. At the end of the sampling period the sorbent tube was removed and capped, the elapsed time read and recorded, and the temperature readings on the maximum and minimum thermometer recorded. The airflow rate through the system was noted and recorded at the start of and prior to the end of each sampling run; pre-calibrated rotameters were utilized for this purpose.

The location of all air sampling devices was noted in the bound field notebook and on the floor plan sketches at the end of the Environmental Questionnaire.

At a minimum, the field notebook entry for each air sample included:

- A label identical to the one attached to the solid sorbent air sampling cartridge including:
  - sample number
  - date of collection
  - time of collection
  - signature of field operator
- Brief description of home;
- Position of sampler in home;
- Pump number;
- Sample flow rate at start of sampling period;
- Start time;
- Stop time;
- Sample flow rate at end of sampling period;
- Temperature range during sampling period (from recording high-low temperature thermometer);
- Comments.

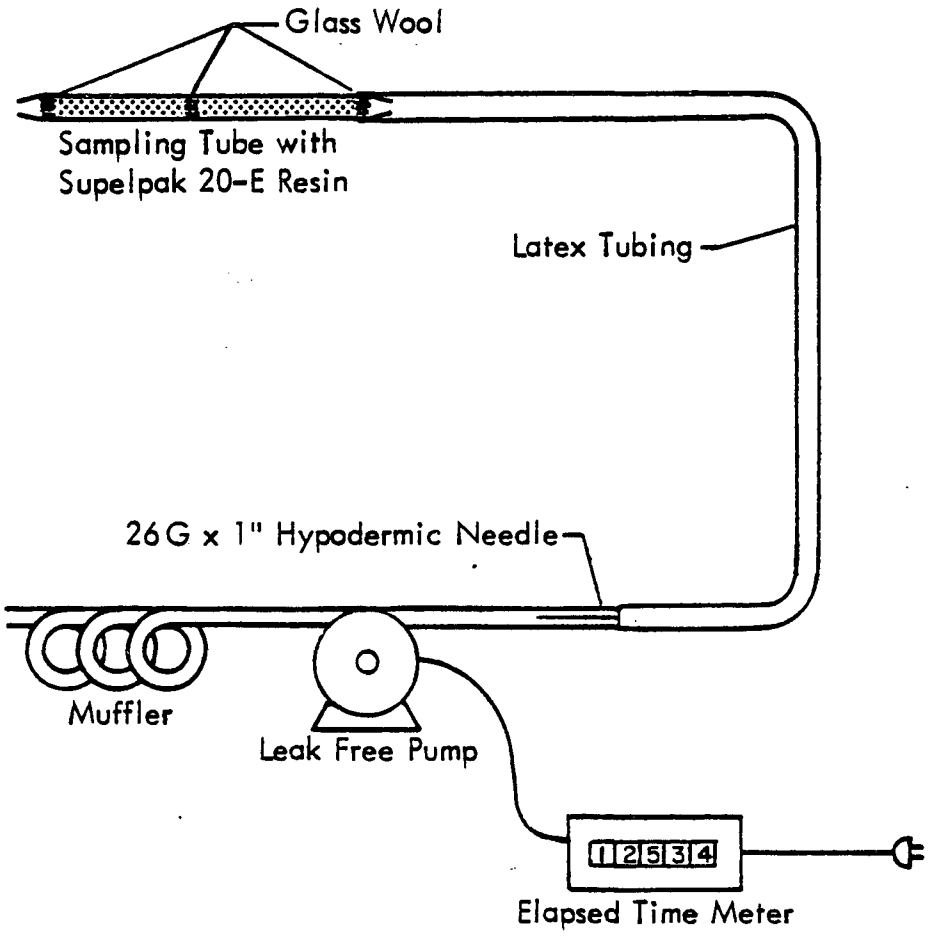


Figure 1. Air sampling apparatus.

b. Wood Core Sampling

Wood core samples were collected from logs facing the interior of each log home as glass indicators of PCP contamination. Since the sampling process often left a permanent mark on the logs sampled, sample sites were selected that were not readily visible to occupants of the house. An effort was made to have the head of the household accompany the environmental team during wood core sampling to specifically approve each sample site; few study participants expressed a desire for this precaution.

Wood core samples were taken from the interior surfaces of logs which had received a representative set of preservative treatments (if any), retreatments (if any), and sealers (if any). Typical sample locations included: inside of closets, behind kitchen cabinets, behind the refrigerator, the bottom of low overhanging logs, tops of beams near the ceiling, and the base log resting on the foundation if it was accessible from the basement.

The location of all wood core samples was noted in the bound field notebook and on the floorplan sketches at the end of the Environmental Questionnaire.

Wood core samples were usually removed from the logs using a standard 10-mm cork borer. In several of the older homes, the wood was very difficult to penetrate with a cork borer. In these cases, existing splinters were collected from the surface of the logs. A total of 12 to 21 individual cores were collected in each home and composited to form a single sample weighing approximately 1 g. The number of samples collected in each home was determined by the availability of suitable sites.

Actual sample collection required that the cork borer be firmly forced into the log using a twisting motion. Sufficient pressure was applied to force the cork borer the desired 2 mm to 3 mm into the wood. If the wood core plug remained in the cork borer when it was removed from the log, a steel rod was used to eject the sample into the sample collection bottle. If the wood core plug remained attached to the log it was easily removed by tilting the cork borer and prying the plug in the direction of the wood grain. Such wood core plugs were placed in the sample collection bottle with a pair of cleaned forceps.

Prior to the start of wood collection the cork borer and forceps were rinsed with a 1:1 solution of methanol (pesticide grade):deionized water and air dried. After a composited set of cores had been removed from a log home the cork borer was rinsed with the methanol solution and wiped dry using a clean piece of filter paper.

At a minimum the field notebook entry for each wood core sample included:

- A label identical to the one attached to the wood core sample collection bottle including:

  - sample number
  - date of collection
  - time of collection
  - signature of field operator

- Location of each individual wood core sample in home;

- Comments.

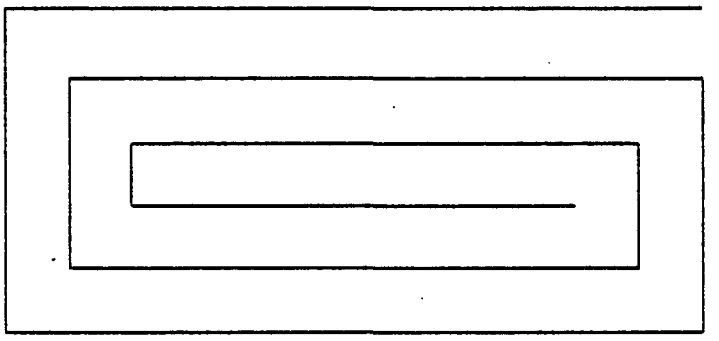
c. Surface Wipe Samples

Two separate sets of surface wipe samples were collected in every home included in this study. Each of the two sample sets was a composited sample of individual surface wipe samples. One set of wipe samples, designated "adjacent" samples, was collected in conjunction with the wood core sampling in order to evaluate the relationship between these two measures of potential PCP dermal absorption. Each individual sample in this set was collected from the log surface as close as possible to each individual wood core sample: there was, therefore, a 1:1 correspondence in the number and location of individual surface wipe samples and wood core samples.

The second set of surface wipe samples, designated "exposure" samples, was collected from surfaces which family members were most likely to contact in order to evaluate dermal exposure to PCP. Both log and non-log surfaces were sampled. Approximately one-third of the individual samples in this composited set were collected from floor and stair surfaces which may be touched by children. The total number of wipes collected (12 to 21/sample) reflects the field sampler's judgement on the number of surfaces that may be potentially touched.

The location of all surface wipe samples was noted in the bound field notebook and on the floor plan sketches at the end of the Environmental Questionnaire.

Individual surface wipe samples were collected in a manner designed to eliminate cross-contamination of sample sets. The member of the environmental sampling team collecting the wipe samples was required to wear disposable latex gloves to prevent contamination during wipe sample collection. After selecting a sample location, a cardboard template was placed on the surface to be sampled and an area 10 cm x 10 cm lightly outlined on the surface with a soft pencil. A Whatman Smear Tab was then saturated with a 1:1 solution of pesticide grade methanol and deionized water from a Teflon squeeze bottle and the entire 100 cm^2 area wiped once, using one face of the Smear Tab. The methanol:water solution had previously been analyzed before sample collection to ensure that it was PCP-free. To ensure that each section of the sampling area was wiped only once, the surface was wiped in a standard pattern of progressively decreasing concentric squares until the entire sampling area had been wiped.



If the Smear Tab dried before the entire sampling area had been wiped, it was resaturated with the methanol and water solution and the wipe continued. Care was taken not to use a new Smear Tab and not to rewipe any sections of the sampling area which had been previously wiped.

When an entire set of surface wipe samples from the home had been collected, the gloves and template were disposed of. To avoid cross-contamination, new gloves and a template were used for each sample collection between homes.

At a minimum, the field notebook entry for each surface wipe sample included:

- A label identical to the one attached to the surface wipe sample collection bottle including:
  - sample number
  - date of collection
  - time of collection
  - signature of field operator
- Location of each individual surface wipe sample (adjacent and exposure) in home;
- Comments

d. Drinking Water Samples

A drinking water sample was collected from the kitchen cold water tap. Filters or traps used to clean the water, if present on the tap, were not disturbed since the purpose of sample collection was to estimate the PCP content of the water as consumed. Presence of filters or traps was noted on the Environmental Questionnaire.

The kitchen cold water tap was turned to the full open position. After the water has been allowed to run for 1 min, the sample was collected in a chemically clean 1-L glass bottle. A unique coded identifying label was then attached and the bottle placed in the cooler and protected from direct light.

In houses where there were filters or traps on some (but not all) of the water taps, a sample was collected from both types of tap.

At a minimum the field notebook entry for each water sample included:

- A label identical to the one attached to the water sample collection bottle including:
  - sample number
  - date of collection
  - time of collection
  - signature of field operator
- Brief description of home;
- Comments

2. Biological Studies

a. Blood Samples

Blood drawing was performed by a physician. Approximately 10 mL of blood were collected in a red top Vacutainer tube for PCP analysis, 10 mL in a silicon separator tube (SST) for biochemistry tests, and 5 mL in a single lavender top evacuated tube (with EDTA preservative) for hematologic tests. Most children had their blood drawn using a small bore needle on a butterfly holder and a 30-cc syringe before being transferred to Vacutainer tubes.

After drawing the blood specimen, a sample label bearing the participant's identification number was affixed to the field notebook in the same area as the entry for the specimen. Labels with the same numbers were attached to each Vacutainer tube. A fifth label was affixed to the Medical Questionnaire and a sixth to the Medical Informed Consent Form.

Blood collected in the red top Vacutainer tube was allowed to clot and then spun to separate the serum. Serum was transferred with prewashed Pasteur pipettes to 15-mL prewashed vials and sealed with Teflon-lined caps. The vial had a preprinted label attached containing the same sample identification number and all other pertinent information as on the Vacutainer . These specimens were frozen on dry ice and sent to MRI for PCP analysis.

Blood in the SST was allowed to clot and was then spun to separate the serum which was poured into transport vials supplied by the testing laboratory, Pathlogists Service Professional Associates, Inc. (PSPA). A preprinted sample label bearing the same number as the SST was attached to the transfer vial before the transfer was performed. Vials of serum were kept cold on wet ice until courier pick-up.

The EDTA-containing evacuated tube was gently inverted several times immediately after collection to allow the anti-coagulant mixing. Gentle agitation was continued for several minutes. This tube was stored intact on wet ice until courier pick-up. Two blood smears for differential counts were made immediately following completion of blood drawing. Slides were labeled with the participant's name and study number to be sent to PSPA. Specimens were to be retrieved by the courier within 24 to 48 h following collection. The courier transported the specimens in containers with cool packs (4°C). The specimens were then shipped by air, the same day picked up, to the laboratory for analysis.

b. Urine Samples

Urine collection kits and written and verbal instructions were delivered by the environmental sampling team for the urine specimen to be collected on the following day. The environmental team also retrieved the urine specimen jars when they returned to the home to pick up sampling equipment. Participants were instructed to collect the first voided urine of the day into prelabeled, chemically clean 250-mL clear, wide mouthed, glass bottles with Teflon-lined tops. Urine was transferred, using an individual chemically clean Pasteur pipette for each specimen, from the bottle to vials for storage and shipment to the appropriate laboratory. Two 20-mL aliquots of urine were transferred to chemically clean 30-mL vials with Teflon liners. These samples were frozen on dry ice and returned to the environmental team for shipment to MRI for PCP analysis. A third 20 mL of urine for urinalysis was transferred to a screw-cap bottle. This bottle was stored on wet ice and retrieved by the courier service with the blood specimens for PSPA. A fourth aliquot of 15 mL of urine was transferred to a polyethylene vial, which was immediately frozen on dry ice and kept frozen for shipment to Montefiore Medical Center following completion of field sampling. The aliquot was analyzed for 6-β-hydroxycortisol, free cortisol, and creatinine.

3. Medical Examination

A medical evaluation was performed on all study participants by one of two trained occupational medicine physicians. Before the study the physicians were trained to perform the planned physical evaluations in a standard manner. The medical evaluation consisted of a brief medical history, general physical examination, standardized neurologic, dermatologic examinations and measurement of liver size at the midclavicular at quiet respiration. Special attention was paid to the presence of chloracne, conjunctivitis, skin or subcutaneous infections, and dermatitis.

VI. SAMPLE PRESERVATION AND SHIPMENT

Sample preservation was a requirement to ensure sample integrity from the collection point, during shipment and up to analysis. This section describes the procedures employed for the environmental and biological samples.

A. Environmental

1. Air Samples

Immediately after the collection of each air sample, the solid sorbent tube was removed from the collection system, sealed with Teflon tape, capped, labeled, and placed in a 16 mm x 125 mm clear glass culture tube with a Teflon-lined screw cap. The culture tube and sorbent tube were immediately placed in a cooler containing dry ice and protected from direct light.

The samples were maintained at dry ice temperatures (-78°C) at all times after collection until immediately prior to analysis. Air sample sorbent tubes were air freighted to the MRI laboratories at the end of the field work.

2. Wood Core Samples

As each individual wood core plug was removed from a log it was immediately placed in its respective chemically clean sample collection bottle, i.e., labeled adjacent or exposure, using the method previously described. All individual cores for each type of samples from a log home were composited into respective single labeled 1-oz wide-mouth glass bottle with a Teflon®-lined screw top. After a complete set of cores was collected the top was sealed, a label tightly affixed, and then the sample bottle placed in a cooler containing dry ice.

The sample remained chilled to dry ice temperatures at all times after collection until immediately prior to analysis. Wood core samples were held in this manner and air freighted to the MRI laboratories at the end of the field sampling period.

3. Surface Wipe Samples

As each individual surface wipe sample was completed, it was immediately placed in a sample collection bottle. Each set of wipe samples was composited in a single chemically clean labeled 1-oz wide-mouth glass bottle with a Teflon®-lined screw top. After a complete set of wipe samples were collected, the top was tightly closed, a label affixed, and the sample bottle placed in a cooler containing dry ice.

The sample remained chilled to dry ice temperatures at all times after collection until immediately prior to analysis. Surface wipe samples held in this manner were air freighted to the MRI laboratories at the end of the field sampling period.

4. Water Samples

Immediately after collection of the water sample was complete, it was capped with a Teflon®-lined screw cap, labeled, and placed in a cooler containing wet ice.

The sample remained chilled to wet ice temperatures at all times after collection until immediately prior to analysis. Water samples were held in this manner and air freighted to the MRI laboratories at the end of the field sampling period.

B. Biological

1. Blood

Red top Vacutainer and silicon separator tubes (SST's) were spun and transferred to transport glass vials within 2 h. Lavender Vacutainer tubes were mixed thoroughly (not centrifuged). Blood specimens collected in a home were transported on ice to the study team work base. Blood specimens to be sent for PCP analysis were frozen on dry ice after transfer from red top Vacutainer tubes until given to MRI personnel.

Serum separated into the PSPA-provided transport vials from the SST was preserved on ice until pick-up by courier from PSPA within 24 to 48 h of collection. All specimens on a single individual to be sent to PSPA were packaged in a sealed plastic bag with the appropriate sample analysis requisition and kept on wet ice until transfer to the courier. Slides were carried in a slide envelope also inside the individual participant's specimen bag. The courier followed PSPA's standard transport procedure in shipping all specimens to the laboratory in Atlanta, Georgia.

2. Urine

Urine specimen jars were transported by the environmental team from the home to the work base over wet ice. At the work base, specimens were transferred by the medical team into containers for analysis. In all cases, this transfer was performed within 36 h of sample collection. Custody of the two urine samples to be used for PCP determination was then transferred to the environmental monitoring team from MRI. Specimens were kept on wet ice prior to processing and then dry ice after an aliquot was prepared.

Each urine specimen to be sent to PSPA for urinalysis was stored in the appropriate individual's specimen bag with the sample analysis requisition and blood specimens. This bag was kept in a cooler on ice until transferred to the PSPA courier. The courier followed PSPA's standard procedures for handling and shipment of specimens.

The fourth aliquot of urine was transferred to a polyethylene vial and was immediately frozen on dry ice and kept frozen for shipment to Montefiore Medical Center following completion of field sampling. These specimens were shipped by a rapid carrier (Federal Express Company) still frozen on dry ice. Montefiore Medical Center was telephoned when the specimens were shipped to alert the receiving area to expect the frozen specimens and to notify his laboratory when they arrived.

If any urine remained in the sample collection container after the aliquots were taken, it was frozen in that container and shipped to MRI for archiving.

VII. ANALYTICAL METHODS

The methods used to determine the presence of PCP in the samples are described in this section. The procedure used for determining PCP in urine and blood was adapted for use with air, water, wood, and wipe samples. The clinical analysis tests are also described.

A. Environmental Sample Analysis for PCP

The analysis procedures used in the present study were designed to duplicate the methods previously used by the Centers for Disease Control (CDC) in a study of the same exposed log home residents. The analysis procedure for PCP was an adaptation of the method by Needham et al. (1981).

1. Air

a. Score the XAD tube between the front and back and break.

b. Add the internal standard and reverse extract PCP from the front half by attaching the tube to a champaigne column with a piece of Teflon tubing and running 10 mL of methylene chloride through the tube.

c. Evaporate the methylene chloride and redissolve residue in 5 mL of hexane.

d. To the hexane add 100 µL of acetylating reagent (2 mL acetic anhydride and 5 mL pyridine).

e. Incubate at 45°C for 15 min, then cool.

f. Wash 2 times (6 mL/2 mL) with pH 9.2 buffer (1.24 g boric acid, 53.4 mL 0.2 M NaOH to 200 mL deionized H_2O).

g. Take hexane to dryness with N_2.

h. Redissolve residue in 5 mL hexane.

i. Transfer to autosampler vials for analysis.

j. Inject 5 µL and compare to standard solution of PCP acetate (Chau 1974).

2. Water

a. Transfer 100-mL sample of water to a separatory funnel and adjust to pH 2 with conc. H_2SO_4.

b. Add 5 g NaCl and 18.6 ng on internal standard.

c. Extract 2 times with 2 mL of methylene chloride.

d. Drain the methylene chloride through a disposable pipet filled with Na_2SO_4.

e. Take the extract to dryness with a stream of N_2.

f. Dissolve the residue in 5 mL of hexane.

g. Proceed as in step d in the air method.

3. Wood Core

a. Transfer 0.5 g of the wood core sample to a 20-mL culture tube.

b. Add the 37.2 ng of the internal standard, and 10 mL of hexane and rotate for 1 h.

c. Decant 5 mL of the hexane to another 10-mL culture tube.

d. Proceed as in step d in the air method.

4. Wipe Samples

a. Transfer the entire sample to a 20-mL culture tube and add 37.2 ng of the internal standard.

b. Extract wipe samples with 10 mL of hexane for 1 h.

c. Decant extract to a 20-mL culture tube.

d. Add another 10 mL of hexane and extract for another hour.

e. Combine extracts and concentrate to about 5 mL.

f. Proceed as in step d in the air method.

B. Biological Specimen Analysis for PCP

1. Urine

a. Unhydrolyzed

(1) Quantitatively pipette 2 mL of urine into a 10-mL culture tube with Teflon-lined screw cap.

(2) Spike with 37.2 ng of internal standard (2,4,6-tribromophenol) and rotate for 15 min.

(3) Add 150 µL of conc. H_2SO_4 and 6 mL of hexane and rotate for 1 h.

(4) Centrifuge the sample to 2,000 rpm for 10 min to break emulsion.

(5) Remove aqueous layer.

(6) Proceed as in step d in the air method.

b. Hydrolyzed

(1) Quantitatively pipette 2 mL of urine into a 10-mL culture tube with a Teflon-lined screw cap.

(2) Spike with 37.2 ng of internal standard and rotate for 15 min.

(3) Add 150 µL of conc. H_2SO_4 and incubate at 100°C for 1 h.

(4) Allow to cool, add 6 mL of hexane and proceed as in step d in the air method.

2. Serum

a. Quantitatively transfer 1 mL of serum into a 10-mL culture tube with Teflon®-lined screw cap.

b. Add 37.2 ng of internal standard and rotate for 15 min.

c. Add 1 mL of 2 M H_2SO_4 and 6 mL of hexane and rotate for 1 h.

d. Centrifuge specimen to break emulsions.

e. Transfer the hexane layer to a clean 10-mL culture tube and proceed as in the unhydrolyzed urine method [step d in the air method].

C. Instrumental Analysis

The level of PCP in the various extracts obtained above were determined by packed column gas chromatography with electron capture detection (GC/ECD). A selected set of extracts with a positive ECD response for PCP were submitted for gas chromatographic/mass spectrometric (GC/MS) confirmation.

1. Gas Chromatography/Electron Capture Detection (GC/ECD)

Instrument: Varian 3700
Column: 3% OV-101 on 20 M Ultrabond® packed in a 6 ft glass column, 2 mm ID
Injector Temperature: 200°C
Column Temperature: 170°C
Detector Temperature: 300°C

Carrier Gas: Nitrogen
Flow Rate: 30 mL/min
Detector: Electron capture ^{63}Ni
Injector: 5 µL with Varian autosampler

2. Gas Chromatography/Mass Spectrometry (GC/MS)

Instrument: Finnigan MAT CH-4 magnetic sector mass spectrometer with Varian 3700 gas chromatograph
Column: 3% OV-101 on 20 M Ultrabond® packed in a 6 ft glass column
Injector Temperature: 200°C
Column Temperature: 170°C
Carrier Gas: Helium
Flow Rate: 30 mL/min
Transfer Line and Jet Separator Temperature: 250°C
Ionization Voltage: 70 ev
Ions Monitored:

PCP Acetate	TBP Acetate
263.8467	329.7773
265.8467	331.7693

Injection Volume: 5 µL

D. Clinical Specimen Analysis

1. Hematology and Biochemistry

Using standard Sequential Multiple Analyzer Computer (SMAC) procedures, PSPA performed the following tests on serum collected in silicon separator tubes:

- lactic dehydrogenase
- alkaline phosphatase
- gamma glutamyl transpeptidase
- glutamic oxalacetic transaminase
- glutamic pyruvic transaminase
- total bilirubin
- total protein
- albumin
- blood urea nitrogen
- creatinine

The following tests were performed by PSPA on each specimen from blood tubes containing EDTA, using a Coulter S Plus III counter and standard procedures for this instrument: hemoglobin, hematocrit, total white blood cell count, and automated differential blood cell count.

2. Urinalysis

Standard urinalysis was performed on urine samples by PSPA for specific gravity, color/appearance, pH, protein, glucose, ketones, bilirubin, blood, nitrite and urobilin, as well as microscopic analysis for white blood cells, cells, bacteria and casts.

3. Urine Chemistry

Urine specimens were sent to Montefiore Medical Center for the following tests: 6-β-hydroxycortisol, urinary free cortisol, and creatinine.

6-β-Hydroxycortisol was measured by direct radioimmunoassay in 0.01 mL without extraction (Voccia et al. 1979; Sanger 1983). Three internal standards and a "pool" sample were used in each assay. Intra- and inter-assay variations were checked using a constant urine pool. Any assay showing more than ± 20% deviation from the pool mean was rejected and then reanalyzed.

Urinary free cortisol was measured by competitive protein binding assay requiring about 1 mL of urine (Kream et al. 1978). Urine aliquots (routinely 0.1 and 0.2 mL) were applied directly to Whatman 3 mm filter paper strips in 10-mL disposable glass tubes. Free cortisol was extracted from the strips with dichloromethane at room temperature. Extracts were decanted, the solvent evaporated and the residue directly assayed for free cortisol utilizing diluted pooled human plasma as the source of cortisol binding globulin. Free cortisol was measured using 1,2-^{3}H cortisol as tracer ligand. 64,000 counts per unit of ^{3}H cortisol (specific activity 50.7 curies/mmol) were added to each 1 mL of assay incubation fluid. Recoveries of radioactive cortisol added to urine averaged 94.5 ± 1.2 (SD)%.

A blank of normal saline was carried through the assay as a quality control check. Inter- and intra-assay variations were checked by a urinary pool containing 3.8 ± 0.7 µg/100 mL. Two point determination (assayed were duplicate pairs of 0.1 mL and 0.2 mL urine) was carried out. Differences of more than 20% resulted in rejection. Ratios of the standard over blank were done on all assays of urinary free cortisol. Reproducibility was constantly in excess of 95%.

Urinary creatinine was measured by the alkaline picric method (Beckman 1982) and performed on a Beckman ASTRA-8 automated instrument.

VIII. DATA ANALYSIS METHODS

The objectives of the study were to:

1. Determine the extent of environmental levels of PCP in log homes which had been treated with PCP.

2. Determine the extent of biological exposure in log homes treated with PCP.

3. Examine the relationship between selected health variables and biological PCP concentrations.

Objectives 1 and 2 were stated in advance and the sample collections were so directed. The statistical analysis on objective 1 focused on those multivariate analysis of variance and covariance to test for differences by type of house treatment. The statistical analysis of objective 2

focused on the null hypothesis that there is not a difference between biological exposure and PCP log treatment with special analysis refinements by age of occupant.

The health effects issue of objective 3 meant that a wide range of health variables were examined to determine if any associations occur. Since these possible interrelationships were not known prior to data analysis, the scope of the analysis was exploratory in nature. Any effects/associations found must be viewed with caution because of the multiplicity of comparisons done. Any effects hypothesized must be submitted for futher verification.

The data analysis methods are divided into two sections. The first explores the environmental and biochemical variables while the second section focuses on the comparison of the present study results to those obtained in the 1980 study.

A. Statistical Analysis of Environmental and Biochemical Variables

The PCP data may be divided into two types of variables: those measured on the house, such as environmental PCP concentrations, and those measured on the individual, such as serum or urine PCP concentrations. Measurements on individuals in the same household will tend to be more similar than measurements on individuals from different households. For this reason, the household to which an individual belonged was taken into account. If it was desirable to adjust for environmental PCP concentration (one aspect of household), then the class variable household was included in the underlying linear model. If adjusting for environmental exposure would have removed the association by over-adjusting, then mean household values were used in the underlying model and each observation was weighted by the number of people in the household (N = 21). For example, in examining the association between serum PCP concentrations and a serum biochemical level, adjustment for house would remove the effect of environmental exposure to PCP. Yet environmental PCP is a major determinant of serum PCP (both are measures of exposure) and removal of the effect of environmental exposure would remove almost all the variability in serum PCP, potentially leading to a spuriously low correlation. This weighting variable must be included since the error variances of the household means are not all equal but are inversely proportional to the number of people in the household. Use of a weighting variable affects least squares means variance estimates, partial correlation coefficients and tests of significance; means and total degrees of freedom remain unchanged.

The Statistical Analysis System (SAS) computer package was used for all analyses. The UNIVARIATE procedure was used to produce summary statistics for continuous variables. The statistics generated include mean, standard deviation, standard error, skewness, median, minimum, maximum, box plots and normal probability plots. The procedure also included a test for normality; for sample sizes of 50 or less the Shapiro-Wilk W statistic (Shapiro and Wilk 1965) was calculated, but for sample sizes greater than 50 the more common Kolomogorov D statistic was used.

House demographic variables and environmental PCP concentration data (average of three air samples, wood core, "adjacent" surface wipe and

"exposure" surface wipe) were analyzed for all houses and by the following seven house treatment categories: treated; treated and sealed; treated and neutralized; treated and sealed and neutralized; external treatment only; never treated; and treatment unknown. Discrete demographic variables were cross-tabulated by house treatment category. Univariate statistics were produced for the continuous house demographic variables and the environmental PCP concentrations for all houses. Univariate statistics were also generated for the natural logarithm of the PCP concentrations. From the skewness, the box plots, the normal plots, and the normality test statistics, the distributions of the transformed concentrations seemed to be better approximated by a normal distribution than those of the untransformed data. The natural log transformed data were used for all further analyses involving environmental PCP concentrations.

Univariate statistics on continuous house demographic variables and the transformed environmental PCP concentrations were also generated for each house treatment category. For each variable, the General Linear Model (GLM) procedure was used to perform a one-way analysis of variance (ANOVA) by the first six treatment categories followed by Duncan's Multiple Range Test for differences among the categories (Duncan 1955). The house with unknown treatment was not included in tests of significance because of difficulty in interpreting results.

The association between house demographic variables and wood core PCP concentration (as a measure of environmental PCP) was examined for all houses and for only those houses treated in the same manner (i.e., not including untreated or unknown treatment), to identify potentially confounding house demographic variables. For discrete variables, mean wood core PCP concentrations for levels of the discrete variable were compared using a t-test (T TEST procedure) or ANOVA (GLM procedure). For continuous variables, scatterplots (PLOT procedure) were generated (Appendix VII). The CORR procedure was used to calculate Pearson correlation coefficients and the associated p-values were calculated to determine the presence of an association. Spearman coefficients and p-values, which do not require the assumption of normality, were calculated to confirm the conclusions.

Pairwise associations among the four environmental PCP concentrations were also addressed with scatterplots (Appendix VIII) and Pearson/ Spearman correlation coefficients and p-values.

Demographic variables on study individuals as well as biologic PCP concentrations (hydrolyzed and unhydrolyzed urine concentrations per gram of urine creatinine and serum concentrations) were analyzed for all individuals and by house treatment category. Discrete demographic variables were cross-tabulated. Univariate statistics were calculated for continuous demographic variables, biologic PCP concentrations and the natural logarithm of the PCP concentrations. Once again the distribution of the transformed concentrations was better approximated by a normal distribution. All further analyses involving biologic PCP concentrations used the transformed data. For each continuous variable, univariate statistics were generated for each house treatment category and differences among the six categories with known treatment were tested for statistical significance using one-way ANOVA of the household means weighted by the number of people in the household.

The association between demographic variables on study individuals and wood core PCP concentration was examined using the mean household values weighted by the number of people in the household to identify potentially confounding person demographic variables. For discrete variables, the GLM procedure was used with dummy variables expressing the proportion of household members in each category to perform t-tests. Mean wood core PCP concentrations for each category were estimated using the ESTIMATE feature of the GLM procedure. For continuous variables, weighted Pearson correlation coefficients were calculated using the CORR procedure.

Knowledge of human behavior and biology suggested that biologic PCP concentrations might be different in the age groups 4-7, 8-12, and greater than 12 yr for individuals exposed to the same environmental concentration of PCP. The GLM procedure was used to generate and compare the least square means for biologic PCP concentrations in these age groups adjusted for household (and consequently, environmental PCP exposure). Least square means for urine PCP concentrations in these age groups adjusted for serum PCP concentrations were also generated using GLM. Differences in least square means among the three age groups suggested that age groups should not be combined. These three age groups were used in all further analyses involving an age adjustment.

The association between the biologic PCP concentrations and the various environmental PCP concentrations was explored using scatterplots, Pearson/Spearman correlations and general linear models adjusting for age. Plots of the residuals of the regression of biologic PCP concentrations on air, wood core and "exposure" wipe PCP concentrations and age group by house number suggest that the residuals do not represent random error; i.e., biologic PCP concentrations are not all independent but tend to cluster within household. The analyses performed did not take this clustering into account due to constraints of time and available software.

The MANOVA feature of the GLM procedure was used with dummy variables expressing the proportion of household members in each of the three age groups to calculate partial correlation coefficients and associated significance levels among mean serum, free urinary PCP, and total urinary PCP concentrations for household (weighted by the number of people in the household) adjusted for age group distribution in the household. Partial correlation coefficients between mean biologic PCP concentrations for household and environmental PCP concentrations were calculated in the same manner.

The GLM procedure and the age group dummy variables were used again to perform an analysis of variance of mean biologic PCP concentration for household (weighted by the number of people in the household) by the six known house treatment categories adjusted for age group distribution in household. An F-test for differences among the six treatment categories that was significant at the 0.05 level was followed by pairwise t-tests at the 0.05 level. This method is analogous to an analysis of covariance in the case of a continuous age variable.

Univariate statistics were calculated for each biochemical or hematological variable and for the natural logarithm of each variable. The transformed variable was used in all further analyses if normality was improved. Partial correlation coefficients between mean biochemical or hematological variables for household and mean biologic PCP concentrations for household were calculated in the same manner as partial correlation coefficients among the mean biologic PCP concentrations for household. Correlations involving serum or urine creatinine were adjusted for both the age group distribution and the sex distribution in household.

All physical examination and health variables were expressed as binary variables. The associations between these variables and biologic PCP concentrations were examined using the same method used to explore the association between discrete demographic variables and wood core PCP concentration with the age group dummy variables included in the model to adjust for age group distribution in household. Mean biologic PCP concentrations were estimated for each category of the physical exam or health variable using the ESTIMATE feature of the GLM procedure and the age distribution of all study individuals.

B. Statistical Procedures for the Longitudinal Study

A number of log homes residents had been previously evaluated by the Center for Disease Control in 1980. Accordingly, a comparative analysis was made of PCP and serum biochemical values obtained in 1980 and 1984 on these individuals. The 1980 and 1984 biologic data from the PCP study could be described as coming from a two factor experiment (family and year) with repeated measures on one factor (year). The actual observations within a family can be represented as follows:

		Year	
Family	Subject	b_1	b_2
	1	x_{i11}	x_{i12}
	:	:	:
	.	.	.
ai	k	x_{ik1}	x_{ik2}
	:	:	:
	.	.	.
	n	x_{in1}	x_{in2}

where the symbol x_{ikj} denotes a measurement on subject k in family i in year j.

The change in a biologic variable from year b_1 to year b_2 may be tested using a repeated measures analysis. The linear model upon which the analysis is based may be written as:

$$X_{ikj} = \mu + \alpha_i + \pi_{k(i)} + \beta_j + \alpha\beta_{ij} + \beta\pi_{jk(i)} + \varepsilon_{ikj}$$

The symbol $\pi_{k(i)}$ indicates that the effect of subject k is nested within family i. If the family and subject effects are random and the year effect is fixed, then for the case of p families each with n subjects, the analysis of variance table is given by:

Source of variation	Degrees of freedom	Expected mean square
Between subjects	np - 1	
Family	p - 1	$\sigma^2_\varepsilon + q\sigma^2_\pi + nq\sigma^2_\alpha$
Subjects within family	p(n - 1)	$\sigma^2_\varepsilon + q\sigma^2_\pi$
Within subjects	np	
Year	1	$\sigma^2_\varepsilon + \sigma^2_{\beta\pi} + n\sigma^2_{\alpha\beta} + np\sigma^2_\beta$
Family x year	p - 1	$\sigma^2_\varepsilon + \sigma^2_{\beta\pi} + n\sigma^2_{\alpha\beta}$
Subjects within family x year	p(n - 1)	$\sigma^2_\varepsilon + \sigma^2_{\beta\pi}$

To test the hypothesis that year has no effect ($\sigma^2_\beta = 0$) the appropriate F ratio is given by:

$$F = \frac{\text{Mean Square}_{\text{Year}}}{\text{Mean Square}_{\text{Family x Year}}}$$

The repeated measures analysis was limited to subjects over 12 yr of age in 1980 because of the small number of observations available on children and the effects of age on biologic variables in this age group. Variables which were tranformed using the natural logarithm transformation for the analyses presented in the original PCP report were also transformed for this analysis. The Statistical Analysis System (SAS) procedure for general linear models (GLM) was used to obtain the repated measures analysis of variance table for each of the 11 biologic variables measured in 1980 and in 1984. The appropriate F ratios were calculated from the mean squares for year and family x year.

IX. QUALITY ASSURANCE AND QUALITY CONTROL

The quality assurance and quality control consisted of multiple activities designed to assure the quality of the study. Protocols for both field and laboratory work were developed. Quality control samples were prepared in the field and laboratory. Method optimization experiments and method validations were done. Confirmatory analysis was performed with gas chromatography/mass spectrometry (GC/MS). Details of each of these QA/QC activities are described below in greater detail.

A. Protocols

1. Environmental

A manual was prepared for the sampling of PCP in the home environment. The manual served as a guide for the field sampling activities previously mentioned. It covered administration of questionnaires, scheduling of visits to each home, all aspects of air, wood, wipe and water sampling, processing of blood and urine samples, and the sample numbering system. The manual was followed by each environmental team who together sampled the first house. This common sampling of the first house was to ensure a standardized and common approach by each of the two teams when they split up the sampling assignments.

2. Medical

The administration of the Medical Questionnaire was included in the environmental manual. The collection of blood samples and the standardized physical examination procedures were performed by study physicians.

3. PCP Analysis

A Quality Assurance Program Plan was submitted to the EPA Work Assignment Manager in accordance with the provisions of the contract with EPA. The 11-point document concerned with the determination of PCP covered the project description and organization, facilities and equipment, data generation and processing and assessment, corrective action, and documentation and reporting. This document was submitted to the EPA prior to the start of PCP analysis.

4. Clinical Laboratory

a. PSPA

Hematology, blood biochemistries and urinalyses were performed by PSPA. This laboratory was accredited by the College of American Pathologists (Registry No. 10-1047), National Centers for Disease Control (Registry No. 10-1016), Medicare (No. 11-8022) and Georgia Department of Public Health (044-022). PSPA participates in two regional quality assurance programs, the Quality Assurance survey and the Georgia State Proficiency Evaluation, and two national programs, the College of American Pathologist Interlaboratory comparison program and the CDC Proficiency Testing Program.

b. Montefiore Hospital Laboratory

Montefiore performed analysis in urine specimens for 6-beta-hydroxycortisol, free cortisol and creatinine. Inventory was checked prior to shipment and an inventory list included. Specimens were transported on dry ice from the field to Baltimore as air freight. Duplicates were sent for 12 percent of the specimens. All specimens were shipped from COEH on dry ice via Federal Express.

B. QA/QC for Environmental Sampling and Analysis

1. Environmental Field Samples

a. Air Samples

A blind field blank sorbent tube was prepared at the beginning and end of sampling in each of the three sampling areas (i.e., a total of six field blanks). The blanks were randomly numbered to preclude analytical bias.

A duplicate sample or field spike sample was collected from approximately every fourth house sampled. The environmental sampling team randomly selected whether a duplicate or field spike sample was to be collected at a given house. Duplicate samples were collected in an identical manner to the primary samples and were located as closely as possible to one of the three primary samples. Which primary sample was duplicated was randomly selected. The field spikes were prepared by a member of the MRI field crew using a known concentration of PCP (11.8 ng/μL) which was added to the specified sample to obtain a range from 350 to 600 μg/sample.

b. Wood Core Samples

Since the main purpose of these samples was to grossly verify the presence of PCP in the log home and since it was nearly impossible to get a sufficiently large sample for analytical purposes, a minimal number (one) of field quality control checks were collected on wood core samples.

c. Surface Wipe Samples

A blind field blank composite surface wipe sample was prepared and analyzed from every third house sampled. The blanks were randomly numbered to preclude analytical bias. The blanks were prepared by wetting the smear tab filter paper with the methanol:water solution and placing it in the composite sample until 15 tabs had been prepared.

A duplicate sample or field spike sample was collected and analyzed from every third house sampled. Each environmental sampling team randomly selected whether a duplicate or field spike sample would be collected at a given house. Duplicate samples were collected in an identical manner to the resident exposure set of samples (as opposed to the wood core set of wipe samples) and were located as closely as possible to the primary samples. The field spikes were prepared by a member of the MRI field crew using a known concentration of PCP (11.8 ng/μL) which was added to the specified sample to obtain a range from 700 to 900 μg/sample.

d. Drinking Water Sample

A blind field blank water sample utilizing distilled water was prepared for every third house sampled. The blanks were randomly numbered to preclude analytical bias.

A duplicate sample or field spike sample was collected and analyzed from every third house sampled. Each environmental sampling team randomly selected whether a duplicate or field spike sample would be collected at a given house. Duplicate samples were collected in a manner identical to the primary samples. The field spikes were prepared by a member of the MRI field crew using a known concentration of PCP (11.8 ng/μL) which was added to the specified sample to obtain a range from 550 to 600 μg/sample.

2. Chemical Analysis

Since the method of Needham had not been used previously in the MRI laboratory, a brief method evaluation study was conducted.

a. Method Variables Experiment

The purpose of this experiment was to determine the effect of each step in the Needham method. A partial factorial design experiment, as described by Stowe and Mayer (1966), was used to determine the effect of each variable. This approach is well-suited to efficiently screen for the important variables or steps in a method. The experimental design for the urine method is shown in Table 1. Nine different variables were designated for testing along with two dummy variables. The dummy variable results are included as a measure of the precision plus any error in measuring the responses. A urine sample from one of the study participants was used for the experiment. The sample was spiked with a surrogate standard, 2,4,6-tribromophenol (TBP), at 93 ppb. No PCP was added since the sample should have endogenous PCP.

b. Quality Control Samples

Each sample analyzed had a surrogate standard added. This surrogate, 2,4,6-tribromophenol, was used to monitor the extraction efficiency and provide an estimate of analyte recovery.

During sample analysis, the samples were placed into batches of 10-15 samples based on the sample matrix. With each batch analyzed, a minimum of one laboratory duplicate sample and one blank were run.

C. QA/QC for Data Analysis

Data processing encompasses all manipulations of information collected to change its form of expression, its location, its quantity or its dimensionality. This includes coding, data entry, validation, storage, transfer, alteration and analysis. The goal of quality assurance in data processing is to prevent errors and loss of data. Quality control assures that the information contained in the original data source is faithfully reproduced.

The COEH project Quality Assurance Officer supervised the following aspects of data processing and maintained a log of all changes to the data base and the associated quality assurance procedures performed to certify accuracy and completeness. Each data processing or quality assurance procedure

Table 1. Method Variables Determination - PCP in Urine

	Method variable	Levels		Run no./random order											
		Low (-)	High (+)	1	2	3	4	5	6	7	8	9	10	11	12
A	Amount of urine	2 mL	4 mL	+	+	-	+	+	+	-	-	-	+	-	-
B	Dummy	-	-	+	-	+	+	+	-	-	-	+	-	+	-
C	Mixing of sample plus surrogates	15 min	60 min	-	+	+	+	-	-	-	+	-	+	+	-
D	Acidification with H_2SO_4 (conc.)	120 µL	500 µL	+	+	+	-	-	-	+	-	+	+	-	-
E	Hexane extraction	4 mL	10 mL	+	+	-	-	-	+	-	+	+	-	+	-
F	Extraction	1 h	2 h	+	-	-	-	+	-	+	+	-	+	+	-
G	Dummy	-	-	-	-	-	+	-	+	+	-	+	+	+	-
H	Acetylating reagent	100 µL	500 µL	-	-	+	-	+	+	-	+	+	+	-	-
I	Reaction temperature	45°C	60°C	-	+	-	+	+	-	+	+	+	-	-	-
J	Reaction time	5 min	15 min	+	-	+	+	-	+	+	+	-	-	-	-
K	Buffer washes	6 mL/2 mL	10 mL/5 mL	-	+	+	-	+	+	+	-	-	-	+	-

was fully documented with step-by-step instructions and description of results. The audit trail created makes it possible to recreate the working data files from the raw data at any time during data processing.

1. Coding and Data Entry

Coding was done using the project coding manual, according to the rules specified. If a decision was required on the part of the coder, the decision was documented in the manual so that all coding was consistent. The data were entered at a terminal and written onto disk storage space. All data entry were visually verified against the code sheets after entry.

2. Validation

After entry all data were validated. The contents of each data field were checked against the valid codes or by reviewing the mean, standard deviation, and range for that field. In addition, frequency tables were generated for each field so that outlying values might be validated against the original data source. The contents of related fields were checked for consistency. Errors discovered during the validation process were corrected and the changes fully documented.

3. Storage

Data were computer stored so that the integrity and security of the data base were maintained yet each data point might be uniquely identified and retrieved. Each data file created was documented with a record layout, variable labels and codes. The current working data file was stored on disk. Every 2 wk during data processing, working files on disk were copied onto magnetic tape as a backup. In addition, the raw data file was archived on magnetic tape after validation. All data files, whether on disk or magnetic tape were accessed by project personnel only.

4. Transfer

Data transfer among media was kept to a minimum to prevent errors. Examples of transfer include moving information from paper forms to code sheets, code sheets to disk, disk to magnetic tape and magnetic tape to disk. After each data transfer, a card or record count was used to ascertain completeness of the transfer. Quality assurance procedures to ascertain accuracy depended upon the nature of the transfer: transfers from paper forms to code sheets were checked by the coder; transfers from code sheets to disk were visually verified by the data clerk; disk to tape or tape to disk were not verified for accuracy since the transfer was done by computer and the overall error rate should therefore be negligible.

5. Alteration

Alteration refers to any procedure that changes the values for data items, the number of data items (dimensionality) or the size of the data set (number of records). In the case of data reduction, the resulting data set

had fewer values, items or records. This resulted in a loss of information and the original data can not be recovered from the new data set. After any alteration, the Quality Assurance Officer checked the internal correctness of the process as well as the appropriateness as reflected by the end uses of the altered data.

6. Analysis

Data analyses involved comparison of a conceptual model with the suitably altered database. It frequently included a computation of summary statistics, standard errors, confidence intervals, tests of hypotheses and model validation (goodness of fit tests). Documentation included the particular software package and procedure used and the method for handling missing values. The Quality Assurance Officer ensured that analyses were performed using a standard package program and that the statistical procedures were robust to violations of the assumptions of the underlying model.

The SAS standard package of statistical programs that was used in these computations is under continual review by the manufacturer for reliability.

X. RESULTS AND DISCUSSION

The culmination of the sampling and analysis effort is presented in this general section and the results described in greater detail in the following subsections. The study population is described in terms of recruitment, characteristics of the study homes, and the participants themselves. The PCP levels, statistical results and correlations are described for the concentrations found in the homes as a result of sampling the air, the logs themselves, log surfaces, and drinking water. The biological PCP levels and correlations are described for the concentrations in serum and urine and the effect of participant's age. Relationships were investigated between selected PCP measurements such as environmental samples, log treatment history, serum and urinary concentrations, and environmental and biological concentrations. The relationship between biological PCP levels and clinical findings are explored against questionnaire responses, clinical laboratory results, and physical examination findings. The present study results were compared against like sampling and analysis conducted in the 1980 study. Finally, the results of the quality assurance activities are discussed.

A. Study Population

1. Result of Recruitment Effort

Letters were sent to the heads of the 17 households who participated in the 1980 CDC study. Of these households, 15 indicated a willingness to participate in the current study. At this point, two households were lost to further study. One household no longer occupied a log home and declined to participate; and the other did not respond to the invitational letter and was not listed in the current phone directory so that telephone contact could

not be made. Of the 15 households which responded, two houses were outside the geographical area to be studied and one family no longer occupied their log home. The remaining 12 households were selected for study.

Each of these 12 houses underwent environmental sampling. However, because the occupants of one home were absent during the period of sampling, only 11 households were available for both the medical and environmental studies.

The names and addresses of 23 owners of houses which had been constructed of logs which allegedly had not been treated with PCP or with copper-8-quinolinolate were obtained from log home manufacturers and dealers. Thirteen households responded to invitational letters and/or telephone calls and agreed to participate. Only nine of these households were able to participate at the time of the final study. Of the four households which dropped out at this point, one occupied the log home only on weekends. The other three stated that they were too busy working on the house or accomplishing other tasks to participate.

Based on occupant responses to the Preliminary Contact Questionnaire, it was anticipated that 12 of the homes in the final study population had been treated with PCP and that 9 homes had not been treated with PCP.

The houses were grouped for study logistical purposes into three geographic regions (see Figure 2) in northern and central Kentucky: the Florence area (1 treated and 5 untreated homes), the Danville area (1 treated and 3 untreated homes), and the Louisville area (10 treated and 1 untreated homes).

Field studies were conducted in the 21 recruited homes during the 11 day period from February 15 to 25, 1984.

2. House Characteristics

It was originally anticipated that the houses would fall into two groups according to PCP treatment: a group of 12 houses from the 1980 CDC study which had been treated with PCP, and the 9 other houses, identified by manufacturers and dealers and the Preliminary Contact Questionnaire as not having been treated with PCP. In fact, analysis of the responses from the environmental questionnaire and a review of the results of PCP concentrations from the wood core samples revealed that all but four of the supposedly untreated homes had been treated with PCP in some manner. This necessitated a change in the original study design.

Resident responses to the Environmental Questionnaire, however, indicated that the houses could be classified into six treatment categories with regard to PCP, including: those houses constructed of logs immersed in PCP; those houses which had initially been treated by immersion in PCP but had been subsequently treated with a sealant or a chemical neutralizer or both with a view to reduce PCP exposure; those houses sprayed externally with PCP after construction; and those houses which had never been treated. In one house the occupant did not know the PCP treatment history.

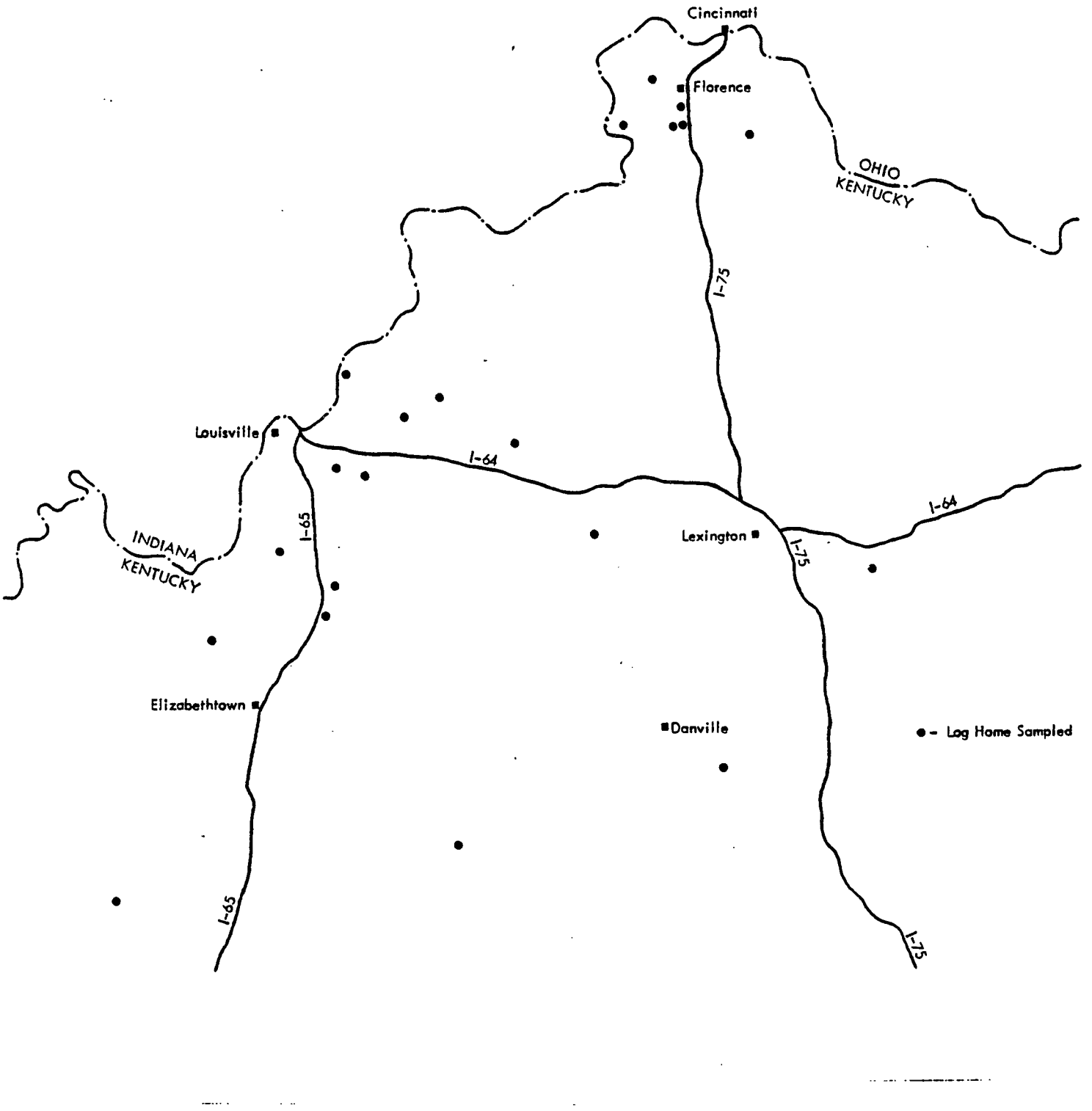


Figure 2. Location of study log homes sampled in Kentucky.

As a result, the following house treatment categories were developed. As will be seen later, the wood core PCP concentration data indicated that this was a useful categorization.

Treated: Included all log homes which were reported to have been treated by the manufacturer with a PCP-containing wood preservative in a manner which immersed the entire log (either by dipping or pressure treating) and had not subsequently been sealed or chemically neutralized. This process resulted in both the interior and exterior surfaces of the house being PCP-treated. There were four houses so treated in the study population.

Treated and Sealed: Included all log homes which were reported to have been treated with a PCP-containing wood preservative in the manner described in the "Treated" category (above) and in which the interior surfaces of the house had been subsequently treated with some type of sealant. The four houses included in this category had the majority of the interior log surfaces treated with polyurethane (two houses) or varnish (two houses).

Treated and Neutralized: Included all log homes which were reported to have been treated with a PCP-containing wood preservative in the manner described in the "Treated" category (above) and in which the interior surfaces of the house had been treated with a chemical agent designed to react with, and thereby neutralize, PCP in the wood. The three houses included in this category had the majority of the interior log surfaces treated with Permatox-Pentite®, manufactured and distributed by Chapman Chemical Corporation (Memphis, Tennessee) for this express purpose. Although the specifics of the chemical reaction are proprietary, the mode of action is described as chemical neutralization.

Treated and Sealed and Neutralized: Included all log homes which were reported to have been treated with a PCP-containing wood preservative in the manner described in the "Treated" category (above) and treated with a sealant in the manner described in the "Treated and Sealed" category (above) and treated with a neutralizer in the manner described in the "Treated and Neutralized" category (above). One house received both treatments. Although the order of treatment was not stated by the homeowner, it is presumed that the logs were neutralized and then sealed.

Exterior Treatment: Included all log homes which were reported to have been treated with a PCP-containing wood preservative by spray-application of the preservative to the exterior surfaces of the house at the time of construction. Interior surfaces of homes included in this category were reported not to have been treated with a PCP-containing wood preservative. There were four houses so treated in the study population.

Never Treated: Included all log homes which had been reported to have never been treated on any surface with a PCP-containing wood preservative. There were four such houses in the study population.

Treatment Unknown: For one house the treatment history was unknown by the original owner-occupant-builder. Analysis of the wood core samples

collected from the house confirmed that the house had been treated with a PCP-containing wood preservative, but the method of application was unknown and it was not known whether it had been subsequently sealed and/or neutralized. Environmental and questionnaire data from this house are included in descriptive tables; however, this house is excluded from comparative analysis by house treatment category.

Responses to the Environmental Questionnaire indicated that five houses had been retreated in some manner since construction. All such houses fell into the Treated, Treated and Sealed, or Treated and Neutralized categories. In every case, only very small areas in the house interior (usually ends of beams or new cuts) had been treated. None of the exteriors of the study homes had been retreated. For the purpose of this study, this retreatment was not considered significant and, therefore, did not affect the categorization of houses.

The number of houses in each PCP treatment category is given in Table 2. Table 3 indicates the PCP treatment by house category. As noted above, a number of houses had been retreated with a PCP-containing preservative, but in all cases there was no more than one retreatment.

Tables 4, 5, 6 and 7 show the age of houses, length of occupant residence, number of rooms in houses and floor area of houses by house treatment category. Note that several members of the study population were not the original occupants of their homes.

Table 8 shows the heating sources of the houses by house treatment category. Fourteen houses had central heating units, all of which used a forced hot air distribution system. Eighteen houses used heating stoves. Kerosene space heaters were used in four homes and electric space heaters in nine homes. Coal or oil space heaters were not used in any home.

Table 9 shows other selected house characteristics by treatment category. It is seen that all but one house had double glazed or storm windows and used electric cooking. In most houses, non-PCP containing pesticides had been used at least once to control insects. Most houses had ceiling fans. Cathedral ceilings were found in eight houses. Only one house, which was in the Treated and Neutralized group, had urea-formaldehyde foam insulation. In one house a gas stove was used.

Table 10 shows the drinking water sources by house treatment category.

3. Personal Characteristics of Study Participants

A total of 72 individuals took part in the study, although there were 80 inhabitants above the age of 4 that resided in the study houses. One participant did not complete the study questionnaire but did provide some samples so that most data is reported for only 71 participants. The ages of participants ranged from 4 to 66, with a mean age of 26.1 and a median age of 30. Demographic characteristics of the 71 participants are displayed in Table 11. There was an even distribution of male and female participants. There were 50 participants aged greater than 12, 11 aged from 8-12, and 10 aged from 4-7. All participants were white.

Table 2. Number of Houses in Each PCP Treatment Category

Treatment category[a]	Identifying symbol	Number of houses
Treated only	T	4
Treated & sealed	TS	4
Treated & neutralized	TN	3
Treated & sealed & neutralized	TSN	1
Exterior treatment only	XT	4
Never treated	NT	4
Treatment unknown	TU	1
Total		21

[a]Treatment category based on history of log treatment according to homeowner.

Table 3. PCP Treatment by House Treatment Category from Occupant Responses to Environmental Questionnaire

Treatment history	House treatment category					
	T (N=4)	TS (N=4)	TN (N=3)	TSN (N=1)	XT (N=4)	NT (N=4)
Treated by manufacturer	4	4	3	1	0	0
Treated at construction	1	0	1	1	3	0
Retreated after construction	2	1	0	0	1	0
Interior sealed after construction	0	4	0	1	0	1
Chemically neutralized after construction	0	0	3	1	0	0

Table 4. Age of Home[a] in Years by House Treatment Category

Treatment category	N	Mean	Standard deviation	Range
T	4	6.25	0.96	5 - 7
TS	4	6.00	2.94	3 - 10
TN	3	7.00	1.00	6 - 8
TSN	1	9.00	-	9 - 9
XT	4	2.25	1.89	1 - 5
NT	4	2.00	2.00	1 - 5
TU	1	2.00	-	2 - 2
ALL	21	4.67	2.87	1 - 10

[a]The age of the home was calculated from the questionnaire which asked only for the year in which the house was constructed.

Table 5. Length[a] (in Years) of Occupant Residence by House Treatment Category

Treatment category	N	Mean	Standard deviation	Range
T	4	5.75	1.26	4 - 7
TS	4	4.25	0.96	3 - 5
TN	3	6.33	1.15	5 - 7
TSN	1	8.00	-	8 - 8
XT	4	2.00	1.41	1 - 4
NT	4	1.75	1.50	1 - 4
TU	1	2.00	-	2 - 2
ALL	21	4.00	2.32	1 - 8

[a]All study participants had lived in their home at least 1 yr, as rounded to the nearest year.

Table 6. Number of Rooms[a] in House by House Treatment Category

Treatment category	N	Mean	Standard deviation	Range
T	4	6.75	1.26	5 - 8
TS	4	6.25	0.96	5 - 7
TN	3	7.00	1.00	6 - 8
TSN	1	6.00	-	6 - 6
XT	4	7.50	1.29	6 - 9
NT	4	7.50	1.73	6 - 9
TU	1	9.0	-	9 - 9
ALL	21	6.95	1.20	5 - 9

[a]Hallways, bathrooms, basements and closets were not considered rooms. Basements were usually uninhabited spaces and were remote from treated logs.

Table 7. Floor Area[a] of House (in Square Feet) by House Treatment Category

Treatment category	N	Mean	Standard deviation	Range
T	4	1,860	244	1,590 - 2,160
TS	4	1,770	403	1,200 - 2,140
TN	3	1,890	441	1,600 - 2,400
TSN	1	1,540	-	1,540 - 1,540
XT	4	1,730	325	1,460 - 2,170
NT	4	1,770	490	1,380 - 2,480
TU	1	1,740	-	1,740 - 1,740
ALL	21	1,780	333	1,200 - 2,480

[a]Includes all living spaces except basement.

Table 8. Heating Sources of Houses by House Treatment Category

House heating method	House treatment category							
	T (N=4)	TS (N=4)	TN (N=3)	TSN (N=1)	XT (N=4)	NT (N=4)	TU (N=1)	TOTAL (N=21)
Central heating unit								
Natural gas	0	1	0	0	0	0	0	1
LPG	1	0	0	0	0	0	0	1
Electric	1	2	1	1	3	4	0	12
Wood	0	0	0	0	0	0	1	1
No central unit other than solar	2	1	2	0	1	0	0	6
Forced hot air heat	2	3	1	1	3	4	1	15
Heating stove used	4	3	2	1	4	4	0	18
Fireplace(s) in house	3	3	2	1	3	2	1	15
Kerosene space heater used	1	1	1	0	0	1	1	5
Electric space heaters used	3	1	2	1	1	1	1	10

Table 9. Selected House Characteristics by House Treatment Category

House characteristic	House treatment category							
	T (N=4)	TS (N=4)	TN (N=4)	TSN (N=4)	XT (N=4)	NT (N=4)	TU (N=1)	TOTAL (N=21)
Used wood preservative other than PCP	3	0	1	0	1	2	0	7
Urea formaldehyde foam insulation	0	0	1	0	0	0	0	1
Double glazed storm windows	4	3	3	1	4	4	1	20
Ceiling fan used	3	3	1	1	4	2	1	15
Cathedral ceiling in home	1	1	1	1	3	1	1	9
Interior use of pesticides	4	3	2	0	3	1	1	14
Exterior use of pesticides	4	3	3	1	2	2	1	16
Cooking fuel								
Electric	3	4	3	1	4	4	1	20
Gas	1	0	0	0	0	0	0	1
At least one current smoker	4	4	1	0	2	1	0	12

Table 10. Drinking Water Source by House Treatment Category

Water source	House treatment category							
	T (N=4)	TS (N=4)	TN (N=3)	TSN (N=1)	XT (N=4)	NT (N=4)	TU (N=1)	TOTAL (N=21)
City	0	2	1	1	2	2	0	8
Own well	4	1	0	0	0	0	0	5
Cistern	0	1	2	0	2	2	1	8

Table 11. Demographic Characteristics of the Study Participants

Characteristic	Number of persons (N=71)	Percentage of participants
Sex		
Male	35	49
Females	36	51
Age distribution		
4-7 yr	10	14
8-12 yr	11	16
Greater than 12 yr	50	70
Marital status		
Married	37	52
Widowed	1	2
Never married	33	46
Level of education		
No formal education	6	9
1st through 6th grade	15	21
7th grade through high school	25	35
At least 1 yr college without graduating	13	18
College graduate	5	7
Additional education	7	10

The employment status and habits of participants greater than 16 yr of age are indicated in Table 12. Only individuals over 16 yr of age were asked questions pertaining to cigarette smoking, alcohol consumption, and occupation. Ever smoked was defined to mean having smoked more than 20 packs of cigarettes or 12 oz of tobacco in a lifetime. A current smoker was defined as a regular smoker for up to 1 mo prior to questionnaire administration. A current drinker was defined as someone who drank one glass of beer or wine or 1 oz of liquor or more in the last month.

The response to questions concerning past medical history for selected diseases and for the occurrence of fever in the previous 6 mo among all participants is indicated in Table 13. The frequency of complaints of eye irritation, tearing, eyelid swelling and acne over the time the subject had occupied the current house is indicated in Table 14.

The distribution of study participants in three age groups (4-7, 8-12, and older than 12) by house treatment category is given in Table 15. There were no remarkable differences among the age distributions for the different house treatment categories. Between 60 and 80 percent of the individuals in each house treatment group were older than 12. Table 16 displays the sex of study participants by house treatment category. The distributions are quite similar; no remarkable differences are seen in any group.

Table 17 shows the range, median, and standard error for the number of hours in the 48-h period prior to blood sampling which study participants had spent in the house, arranged by house treatment category. The mean number of hours was quite high for each group, ranging between 28 and 37 h. Table 18 shows the results of ANOVA for the time spent in the house as described in Table 17. No significant differences were seen among the categories.

Table 19 presents the range, median, mean and standard error for the number of school years completed by the participants by house treatment group. Table 20 shows the results of ANOVA of the mean household years of schooling completed, by house PCP treatment category. No differences were seen among the treatment categories. Although this analysis may seem superfluous, as a quality control check of data, it proves that no extraneous or artificially introduced interrelationships exist in the data.

Table 21 shows the distribution of selected characteristics of study participant by house treatment category.

B. PCP Concentrations in Homes

1. Air Sampling Results

Three air samples were collected in every home in the study population, together with appropriate quality control samples (i.e., blank, duplicate or spike) in selected homes, according to the protocol previously described. The results of analysis of these samples is presented in Table 22.

Table 12. Employment and Habits of Adult Participants

Characteristic	Number of respondents (N=44)	Number of positive responses	Percentage of positive responses
Cigarette smoking			
Ever smoked	44	20	45
Current smoker	44	14	32
Alcohol consumption			
Currently drink	36	29	80
Average ≦ 6 oz/wk	29	26	90
Average 7-40 oz/wk	29	2	7
Average > 40 oz/wk	29	1	3
Employment			
Employment outside home currently	44	35	80
Ever employed working with wood preservatives	44	6	14
Currently employed working with wood preservatives	44	4	9
Ever employed working with pesticides	44	3	7
Currently employed working with pesticides	44	3	7

Table 13. Past Medical History of Selected Illness Among Study Participants Determined from Medical Questionnaire Responses

Disease	Number of positive responses (N=71)	Percentage of positive responses
Ever had:		
Hepatitis	0	0
Cirrhosis	0	0
Jaundice	2	3
Cancer	2	3
Eczema	3	4
Acne	11	15
Psoriasis	2	3
Tumor or lump removed	9	13
Rash or dermatitis within the last year	28	39
Fewer within previous 6 mo	29	41

Table 14. Prevalence of Selected Complaints Among Study Participants Since Resident in Current Home

Complaint	Number of positive responses (N=71)	Percentage of positive responses
Eye irritation	18	25
Tearing	10	14
Swelling of eyelids	8	11
Acne	10	14

Table 15. Distribution of Study Participants in Three Age Groups by House Treatment Category

Age range	House treatment category							
	T (N=15)	TS (N=12)	TN (N=12)	TSN (N=5)	XT (N=12)	NT (N=10)	TU (N=5)	TOTAL (N=71)
4-7	4	0	3	1	2	0	0	10
8-12	1	3	1	1	2	2	1	11
Older than 12	10	9	8	3	8	8	4	50
Mean age	27.1	26.1	24.4	19.6	30.3	26.2	24.4	26.1
Range of ages	5-61	9-53	5-47	6-58	4-66	8-42	10-43	4-66

Table 16. Sex of Study Participants by House Treatment Category

Sex	House treatment category							
	T (N=15)	TS (N=12)	TN (N=12)	TSN (N=5)	ST (N=12)	NT (N=10)	TU (N=5)	TOTAL (N=71)
Male	8	5	6	2	7	5	2	35
Female	7	7	6	3	5	5	3	36

Table 17. Number of Hours Spent in Log Home by Participants During the 48-h Period Prior to Blood Sampling by House Treatment Category

Treatment category	N	Range	Mean	Standard error	Median
T	15	22.0 - 48.0	35.6	2.05	39
TS	12	23.5 - 33.0	27.7	0.82	27
TN	12	4.0 - 48.0	31.2	3.27	29
TSN	5	26.0 - 48.0	36.9	4.63	32
XT	12	3.5 - 44.0	30.3	2.97	30
NT	9	29.5 - 40.0	33.4	1.22	32
TU	5	26.0 - 33.5	28.9	1.47	30
ALL	70	3.5 - 48.0	31.9	0.99	31

Table 18. Results of ANOVA of Mean Household Hours Spent in the Log Home[a] During the 48-h Period Prior[b] to Blood Sampling[a] by House Treatment Category[b]

Treatment category	Number of houses (N=18)	Least squares mean	Standard error	Overall P-value
T	4	35.6	1.98	0.440
TS	3	27.7	2.21	
TN	3	31.2	2.21	
TSN	1	36.9	3.42	
XT	4	30.3	2.21	
NT	3	33.4	2.55	

[a]Least squares mean weighted by number of people in household.
[b]The house of unknown treatment category is excluded.

Table 19. Number of Years of School Completed by Study Participants by House Treatment Group

Treatment category	N	Range	Mean	Standard error	Median
T	15	0 - 16.0	8.7	1.45	12.0
TS	12	0 - 15.0	10.0	1.31	12.0
TN	12	0 - 18.0	9.9	2.00	12.5
TSN	5	0 - 17.0	7.8	3.14	8.8
XT	12	0 - 17.0	10.7	1.60	12.5
NT	10	2.0 - 18.0	11.9	1.68	13.0
TU	5	5.0 - 12.0	9.4	1.33	8.5
ALL	71	0 - 18.0	9.9	0.65	12.0

Table 20. Results of ANOVA of Mean Household Years of School Completed[a] by House Treatment Category[b]

Treatment category	Number of houses	Least squares mean	Standard error	Overall P-value
T	4	8.7	1.24	0.581
TS	3	10.0	1.38	
TN	3	9.9	1.38	
TSN	1	7.8	2.14	
XT	4	10.7	1.38	
NT	3	11.9	1.51	

[a]Least squares means weighted by number of people in household.
[b]The house of unknown treatment category is excluded.

Table 21. Selected Characteristics of Study Participants by House Treatment Category

Variable	House treatment category						
	T (N=15)	TS (N=12)	TN (N=12)	TSN (N=5)	XT (N=12)	NT (N=10)	TU (N=5)
Marital status							
Married	8/15	6/12	6/12	2/5	7/12	6/10	2/5
Widowed	-	-	-	-	-	1/10	-
Never married	7/15	6/12	6/12	3/5	5/12	3/10	3/5
Cigarette smoking[a]							
Ever smoked	7/9	3/9	3/7	1/2	3/8	3/7	0/2
Currently smoke	6/7	3/3	1/3	0/1	2/3	1/3	-
Alcohol consumption[a]							
Ever drink	8/9	9/9	5/7	1/2	6/8	6/7	1/2
Currently drink	6/8	9/9	4/5	0/1	5/6	5/6	0/1
Employment[a]							
Outside home	6/9	9/9	5/7	1/2	5/8	7/7	2/3
Ever with wood preservatives	1/9	1/9	1/7	0/2	1/8	2/7	0/2
Ever with pesticides	1/9	0/9	0/7	0/2	0/8	1/7	1/2
Hobby exposure to wood preservatives or pesticides	5/15	2/12	7/12	1/5	7/12	3/10	1/5
Pesticide use in home	2/15	0/12	1/12	0/5	4/12	0/10	0/5
Garden	9/15	5/12	7/12	0/5	3/12	4/10	5/5
Pesticide use in 1983	8/9	5/5	6/7	-	2/3	b	5/5
Pesticide use in 1982	7/9	5/5	6/7	-	0/5	4/4	5/5

[a]Question only applicable to 44 participants greater than 16 yr of age.
[b]4/4 Don't know.
Note: One of the 72 participants did not complete the study questionnaire.

Table 22. Individual and Mean PCP Air Concentrations (ng/L) Measured in 21 Log Homes Arranged by House Treatment Category

House	Air PCP concentration (ng/L) Sample 1	Sample 2	Sample 3	Mean
Treated				
T-1	0.311 (0.383)[a]	0.150	0.181	0.214
T-2	0.138	0.074	0.058	0.090
T-3	0.743 (0.729)	0.904	0.782	0.810
T-4	0.887	0.358	0.637	0.594
Treated & sealed				
TS-1	0.663	0.565	0.629	0.619
TS-2	0.098	0.283	0.175	0.185
TS-3	0.216	0.199	0.324	0.246
TS-4	0.904	0.716	0.655	0.758
Treated & neutralized				
TN-1	0.062	0.067	0.121	0.083
TN-2	0.085	0.053	0.066	0.068
TN-3	0.048	0.114	0.025	0.062
Treated & sealed & neutralized				
TSN-1	0.137	0.153 (0.255)	0.339	0.210
External treatment				
XT-1	0.127 (0.076)	0.083	0.014	0.075
XT-2	0.038 (0.038)	0.021	0.026	0.028
XT-3	0.110	0.052	0.043	0.068
XT-4	0.169	0.075	0.094	0.113
Never treated				
NT-1	0.008 (0.002)	0.001	ND[b]	0.003
NT-2	0.012 (0.008)	0.021	0.019	0.017
NT-3	0.016	0.029	0.011	0.019
NT-4	0.006	0.001	0.001	0.003
Treatment unknown				
TU-1	0.017	0.018	0.012	0.016

[a]Duplicate side-by-side sample collection shown in parenthesis but not included in mean.
[b]ND - Not detected at limit of detection for sample volume (0.001 ng/L).

PCP was detected in 62 of the 63 samples collected. Detected concentrations ranged from 0.001 ng/L to 0.904 ng/L but were fairly consistent within any given house, usually varying by no more than a factor of two. The mean of the three air samples displayed in Table 22 was used in all subsequent statistical analyses which included air concentrations of PCP.

The PCP residues in air are summarized by house treatment category in Table 23. The concentrations were found to have a log-normal distribution; medians and geometric means are, therefore, presented together with the 95% confidence interval about the geometric means. This information was used to construct Table 24 which shows the results of ANOVA. Since the ANOVA showed that there were significant differences among treatment groups, Duncan's Multiple Range Test was used to determine which groups differed at the 0.05 level. Duncan's Multiple Range Test tables order the treatment categories by the magnitude of their geometric means being tested. As seen on the table, air concentrations of PCP for Never Treated houses are significantly lower than those for all treated houses. Among treated houses, the air concentrations for Treated and Sealed houses are significantly higher than those for houses that were Treated and Neutralized or had External Treatment. Therefore, it is concluded that there are real and significant differences in the air concentrations of PCP among several of the treatment categories.

2. Wood Core Sample Results

From 12 to 21 individual wood core samples were collected from the interior surfaces of logs in every home and subsequently composited to a single sample for each home according to the protocol previously described. As previously mentioned, some samples consisted of wood cores and others of wood splinters. However, it was not possible to determine the comparability of core and splinter samples as (a) logs that permitted core sampling did not have splinters and (b) logs that required splinter sampling could not be core sampled. Furthermore, it is not very useful to compare measured splinter and core concentrations within a treatment category as concentrations probably vary widely even when measured by the same technique. In any case, the results of the analyses of these samples are presented as Table 25.

PCP was detected in the wood core samples from all 21 houses in the study population. Detected concentrations ranged from 44 ng PCP/g wood to 438,500 ng PCP/g wood. The wood core PCP concentrations appeared to be distributed in a manner which corresponded with the different methods of PCP treatment which had been used in the study houses as stated by the homeowner. As a result, the six categories of house PCP treatment indicated earlier were used in further analysis rather than the treated/not treated categorizations which had been originally planned. The never treated homes had PCP concentrations as a possible result of the logging industry spraying stockpiled logs with PCP to prevent mold and mildew.

Table 23. Summary of PCP Concentrations (ng/L) in Air by House Treatment Category

Treatment category	N	Median	Range	Geometric mean	95% Confidence interval
T	4	0.421	0.090 - 0.810	0.314	0.116 - 0.850
TS	4	0.433	0.185 - 0.758	0.383	0.195 - 0.751
TN	3	0.068	0.062 - 0.083	0.071	0.060 - 0.084
TSN	1	0.209	0.209 - 0.209	0.209	-
XT	4	0.072	0.028 - 0.113	0.064	0.036 - 0.112
NT	4	0.010	0.003 - 0.019	0.007	0.003 - 0.030
TU	1	0.016	0.016 - 0.016	0.016	-
ALL	21	0.083	0.003 - 0.810	0.080	0.040 - 0.162

Table 24. Results of ANOVA and Duncan's Multiple Range Test for Concentrations of PCP (ng/L) in Air[a] by House Treatment Category

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	41.7	8.34	12.99	0.0001
Error	14	9.0	0.64		
Corrected total	19	50.7			

Duncan's Multiple Range Test

Duncan grouping[b]	Geometric mean	N	Treatment category
A	0.383	4	TS
A B	0.314	4	T
A B	0.210	1	TSN
B	0.071	3	TN
B	0.064	4	XT
C	0.007	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

Table 25. Wood Core PCP Concentrations (ng/g) in Log Homes Arranged by House Treatment Category

House	Concentration (ng/g)[a]
Treated	
T-1	16,500
T-2	8,000
T-3	438,500
T-4	141,000
Treated & sealed	
TS-1	340,000
TS-2	132,000
TS-3	101,000
TS-4	247,500
Treated & neutralized	
TN-1	113,000
TN-2	8,000
TN-3	45,000
Treated & sealed & neutralized	
TSN-1	101,500
External treatment	
XT-1	14,000
XT-2	33,400
XT-3	6,000
XT-4	8,600
Never treated	
NT-1	44
NT-2	56
NT-3	1,600
NT-4	164
Treatment unknown	
TU-1	28,000

[a]Limit of detection = 0.9 ng/g.

Concentrations of PCP in wood are summarized by house treatment category in Table 26. The concentrations were found to have a log-normal distribution; medians and geometric means are, therefore, presented. The 95% confidence interval about the geometric mean was also calculated and is presented in this table. This information was used to construct Table 27 which shows the results of ANOVA. The ANOVA showed that there were significant differences among the treatment groups. Duncan's Multiple Range Test was used to determine which groups differed at the 0.05 level. As seen in the table, the mean wood PCP concentration in the Never Treated category was statistically significantly different from that of each of the treated categories. There were no statistically significant differences between those categories which had been treated with PCP. The number of houses in each treatment group was small, however, and it is quite likely that given the same geometric means from a larger study population, there may have been statistically significant differences between the treatment groups.

3. Surface Wipe Sampling Results

Two composited sets of from 12 to 21 individual surface wipe samples were collected from the interior surfaces of logs in every home, together with appropriate quality control duplicates in selected homes, according to the previously described protocol. One of these sets, designated as "adjacent" samples, was collected from logs immediately contiguous to wood core samples for the purpose of determining how accurately a surface wipe sample reflected the PCP concentration in the underlying wood. The second set, designated "exposure" samples, was collected from surfaces throughout the house which were thought to be frequently contacted by occupants of the home. This set was collected in order to help estimate the potential dermal exposure to PCP. The results of analysis of both sets of surface wipe samples are presented in Table 28.

PCP was detected in all 21 of the "adjacent" wipe samples and in 20 of the 21 "exposure" wipe samples. Detected concentrations ranged from 7 ng/100 cm^2 to 2,294 ng/100 cm^2 for the "adjacent" wipe samples and from 10 ng/100 cm^2 to 427 ng/100 cm^2 for the "exposure" wipe samples. The composited "adjacent" wipe samples usually showed greater PCP concentration than the composited "exposure" wipe samples for a given house. This result is expected as all "adjacent" wipe samples were taken from the source of PCP contamination in the house (the logs), while the "exposure" wipe samples were taken from frequently contacted surfaces which may or may not have been contaminated with PCP.

The distribution of PCP surface wipe concentrations was found to be log-normal. Tables 29 and 30 show the medians, geometric means and 95% confidence levels about the geometric means for PCP surface concentrations determined for "adjacent" and "exposure" wipe samples by house treatment category. This information was used to construct Tables 31 and 32, which show the results of Duncan Multiple Range Test analyses to determine whether there were statistically significant differences between geometric mean surface wipe concentrations in the various house treatment categories. Table 31 shows that for concentrations of PCP in "adjacent" wipe samples, Never Treated houses statistically differed from Treated, Treated and Sealed, and Treated and Sealed and Neutralized houses. In addition, houses which received External Treatment differed only from Treated and Sealed houses. Table 32 shows that for concentrations of PCP in "exposure" wipe samples, only the highest (Treated) and lowest (Never Treated) treatment categories were statistically different.

Table 26. Wood PCP Concentration (ng/g Wood) by House Treatment Category

Treatment category	N	Median	Range	Geometric mean	95% Confidence interval
T	4	78,800	8,000 - 438,000	53,600	8,650 - 330,000
TS	4	190,000	101,000 - 340,000	183,000	106,000 - 316,000
TN	3	45,000	8,000 - 113,000	34,400	7,510 - 157,000
TSN	1	102,000	102,000 - 102,000	102,000	-
XT	4	11,300	6,000 - 33,400	12,500	6,040 - 25,900
NT	4	110	44 - 1,600	159	32 - 496
TU	1	28,000	28,000 - 28,000	28,000	-
ALL	21	28,000	44 - 438,000	15,900	5,020 - 50,200

Table 27. Results of ANOVA and Duncan's Multiple Range Test for Concentrations of PCP in Wood (ng/g) by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	119.9	23.98	13.63	0.0001
Error	14	24.6	1.76		
Corrected total	19	144.5			

Duncan's Multiple Range Test

Duncan grouping[b]	Geometric mean	N	Treatment category
A	183,000	4	TS
A	102,000	1	TSN
A	53,400	4	T
A	34,400	3	TN
A	12,500	4	XT
B	159	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

Table 28. PCP Surface Concentrations (ng/100 cm^2) of Wipe Samples Taken Adjacent to the Site of Wood Core Sampling ("Adjacent" Samples) and Wipe Samples from Surfaces Contacted by Inhabitants of the House ("Exposure" Samples)

House	Concentration (ng/100 cm^2) "Adjacent" samples	"Exposure" samples
Treated		
T-1	345	244
T-2	350	309
T-3	2,294	327
T-4	453	400
Treated & sealed		
TS-1	1,200	427
TS-2	871	117
TS-3	184	82
TS-4	1,231	349
Treated & neutralized		
TN-1	276	147
TN-2	83	93
TN-3	214	192
Treated & sealed & neutralized		
TSN-1	227	172
External treatment		
XT-1	82	55
XT-2	112	12
XT-3	115	59
XT-4	198	233
Never treated		
NT-1	30	40
NT-2	7	ND[a]
NT-3	108	63
NT-4	56	48
Treatment unknown		
TU	48	10

[a]ND - Not detected at the limit of detection (0.3 ng/100 cm^2).

Table 29. Summary of Surface PCP Concentrations (ng/100 cm^2) Determined from Wipe Samples of Surfaces "Adjacent" to Sites of Wood Core Samples by House Treatment Category

Treatment category	N	Median	Range	Geometric mean	95% Confidence interval
T	4	402	345 - 2290	596	245 - 1450
TS	4	1040	184 - 1231	699	289 - 1690
TN	3	214	82.6 - 276	171	83.8 - 348
TSN	1	227	227 - 227	227	-
XT	4	113	82.1 - 198	121	84.9 - 173
NT	4	43	6.7 - 108	34.9	11.5 - 106
TU	1	48	48 - 48	48	-
ALL	21	198	6.7 - 2290	187	106 - 333

Table 30. Summary of Surface PCP Concentrations (in ng/100 cm^2) Determined from Wipes of "Exposure" Surfaces by House Treatment Category

Treatment category	N	Median	Range	Geometric mean	95% Confidence interval
T	4	318.0	244 - 400	316	259 - 386
TS	4	232.9	81.5 - 427	195	88.6 - 431
TN	3	147.0	92.9 - 192	139	92.1 - 210
TSN	1	172.0	172 - 172	172	-
XT	4	57.1	12.3 - 233	56.9	18.1 - 179
NT	4	43.9	ND - 62.5	18.2	2.7 - 130
TU	1	10.0	10.0 - 10.0	10.0	-
ALL	21	117	ND - 427	89.6	47.9 - 167

Table 31. Results of ANOVA and Duncan's Multiple Range Test for Concentrations of PCP (ng/100 cm^2) in "Adjacent" Surface Wipe Samples by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	24.3	4.86	6.85	0.002
Error	14	9.9	0.71		
Corrected total	19	34.2			

Duncan's Multiple Range Test

Duncan grouping[b]	Geometric mean	N	Treatment category
A	699	4	TS
A B	596	4	T
A B	228	1	TSN
A B C	171	3	TN
B C	121	4	XT
C	34.9	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

Table 32. Results of ANOVA and Duncan's Multiple Range Test for Concentrations of PCP (ng/100 cm^2) in "Exposure" Surface Wipe Samples by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	20.1	4.02	3.12	0.043
Error	14	18.1	1.29		
Corrected total	19	38.2			

Duncan's Multiple Range Test

Duncan grouping[b]	Geometric mean	N	Treatment category
A	316	4	T
A B	195	4	TS
A B	172	1	TSN
A B	138	3	TN
A B	56.9	4	XT
B	18.2	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

4. Drinking Water Sampling Results

Based on the previously described protocol, a single sample of drinking water was collected in every home in the study population, along with with appropriate quality control duplicates in selected homes. PCP was detected in only 4 of the 21 homes in the study population. The PCP residues detected in these four homes ranged from 0.2 ng/L to 1.0 ng/L. In all other homes the PCP concentration was below the analytical limit of detection, 0.2 ng/L.

Analysis of the presence of PCP in drinking water by house treatment category showed that all four of the homes in which PCP was detected had been treated. The distribution was across house treatment categories: one Treated and Sealed and Neutralized (0.2 ng/L), one Exterior Treatment (0.3 ng/L), one Treated and Sealed (1.0 ng/L), and one which was treated in an unknown manner (0.6 ng/L). Table 33 shows the presence of PCP in drinking water samples analyzed by water source. This table shows that in all cases, PCP contaminated drinking water came from a house that utilized a cistern as the source of water. Statistical analysis (Fisher's Exact Test) of this distribution by source of water showed this relationship between source of water and the presence of PCP contamination of that water to be significant ($p = 0.002$).

5. Association of Demographic and Environmental Variables With Wood Core Concentrations

The association between measured PCP concentrations in the wood core samples and demographic characteristics of the houses and the house inhabitants was examined to identify factors which might influence or be used to predict environmental PCP residue concentrations. The statistical association between these variables and the wood core PCP concentration of the home was explored.

For continuous variables, the Pearson correlation coefficient and p-value were calculated. The results of statistical analysis of the association between selected house variables and wood core PCP concentrations are presented as Table 34. As shown in this table, the length of current occupant residence and the age of the home had a significant positive correlation with the wood core PCP; the number of rooms in the house had a significant negative correlation. The floor area of the house showed no significant association with wood core PCP. Among the house features studied, only age of the home and length of residence in the home showed a significantly positive correlation. These findings all appear to result from the higher PCP concentrations in older homes, which arises in part because of the past practice of treating logs with PCP. The relationships between these "house variables" and the various house treatment categories were explored further.

As shown in Table 35, ANOVA showed significant differences in the length of current family residence in the home by house treatment category. Application of Duncan's Multiple Range Test, seen in Table 35, shows the distribution of significant differences among the groups.

Table 33. Detection of PCP in Drinking Water by Drinking Water Source

Water source	PCP detected in water[a]		Total
	No	Yes	
Well or city	15	0	15
Cistern	2	4	6
Total	17	4	21

[a]Analytical limit of detection - 0.2 ng/L.

Table 34. Summary of Associations Between Selected House Features and Wood PCP Concentrations Showing Pearson Correlation Coefficients (R) and Statistical Significance

House feature	Mean	Standard deviation	Range	R	P-value
Length of residence (in years)	4.00	2.32	1 - 8	0.51	0.017[a]
Age of home (in years)	4.67	2.87	1 - 10	0.54	0.012[a]
Number of rooms in house	6.95	1.20	5 - 9	-0.50	0.020[a]
Floor area of house (in sq ft)	1,783	333	1200 - 2480	-0.09	0.687

[a]Statistically significant at p = 0.05.

Correlations Among Selected House Features Pearson Correlation Coefficients (r) and Statistical Significance (p)

	Length of residence	Age of home	No. of rooms	Floor area of home
Length of residence	--	r = 0.930 p = 0.0001[b]	r = -0.322 p = 0.155	r = 0.018 p = 0.938
Age of home		--	r = -0.381 p = 0.088	r = -0.124 p = 0.392
No. of rooms			--	r = 0.375 p = 0.094

[b]Statistically significant at p = 0.01.

Table 35. Results of ANOVA and Duncan's Multiple Range Test for Length of Current Occupant Residency in Home (in Years) by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	80.9	16.18	9.88	0.0003
Error	14	22.9	1.64		
Corrected total	19	103.8			

Duncan's Multiple Range Test

Duncan grouping[b]	Mean	N	Treatment category
A	8.0	1	TSN
A B	6.3	3	TN
A B	5.8	4	T
B C	4.2	4	TS
C	2.0	4	XT
C	1.8	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

In Table 36, ANOVA showed significant differences in the age of homes by house treatment category. The Exterior Treatment and Never Treated categories, while not differing significantly from each other, were significantly newer than houses in the other categories.

As seen in Tables 37 and 38, ANOVA showed no significant differences among the treatment groups for the number of rooms in the house and the floor surface area of the houses. It is believed that these differences reflect changes in building styles and in PCP treatment practices in newer homes and that these associations would not seriously confound any planned statistical analysis.

For discrete and dichotomous variables, the significance of any association between house characteristics and wood core PCP concentration was evaluated by comparing the mean wood core PCP concentrations of houses by variable response and using a t-test for statistical significance. The results are shown on Table 39. None of the differences among the means for the tested responses were statistically significant at the 0.05 level.

In order to determine whether any personal characteristics of inhabitants might be correlated with wood PCP concentrations and might therefore confound the analysis of health parameters, the Pearson correlation coefficients between the household means for selected personal characteristics of the log home residents and wood core PCP concentrations were calculated. The results are given in Table 40. It is seen that neither resident age, years of school completed, nor time spent in the house in the previous 48 h were significantly associated with wood core PCP concentrations.

The mean wood core PCP concentrations of the homes compared to study participants by selected demographic characteristics are shown on Table 41. For smoking habits, alcohol intake and employment characteristics, only the responses of the 44 individuals over 16 yr of age are given. None of the examined characteristics of study participants were significantly associated with wood core PCP concentrations. It was concluded that the distribution of these characteristics among the house treatment groups would not confound the further analysis of the results.

C. Biological PCP Concentrations

1. Serum and Urine PCP Concentrations

The serum PCP residue for each individual is expressed in units of ng PCP/mL serum. Two urine PCP concentrations were measured for each individual; the concentration of free PCP in urine and the total PCP concentration after acid hydrolysis. Since after hydrolysis both free and conjugated urine PCP are measured, it is considered a more reliable indicator of PCP total excretion. Results are shown in Appendix IX. Urinary PCP concentrations were normalized for potential variations in urine concentration by expressing the excretion in terms of mg PCP/g of creatinine excreted. The results of serum and urine analysis for PCP residues are shown in Table 42.

Table 36. Results of ANOVA and Duncan's Multiple Range Test for Age in Home (in Years) by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	103.7	20.74	5.43	0.006
Error	14	53.5	3.82		
Corrected total	19	157.2			

Duncan's Multiple Range Test

Duncan grouping[b]	Mean	N	Treatment category
A	9.0	1	TSN
A	7.0	3	TN
A	6.2	4	T
A	6.0	4	TS
B	2.2	4	XT
B	2.0	4	NT

[a]The house of unknown treatment is excluded.
[b]Geometric means with the same letter are not significantly different at alpha = 0.05.

Table 37. Results of ANOVA and Duncan's Multiple Range Test for Number of Rooms in House by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	5.45	1.09	0.65	0.667
Error	14	23.50	1.68		
Corrected total	19	28.95			

[a]The house of unknown treatment is excluded.
Note: None of the treatment means are significantly different at p = 0.05 using Duncan's Multiple Range Test (not shown).

Table 38. Results of ANOVA and Duncan's Multiple Range Test for Floor Area of House (sq ft) by House Treatment Category[a]

ANOVA Table

Source	DF	Sum of squares	Mean square	F	P-value
Treatment	5	129,053	25,811	0.17	0.968
Error	14	2,090,042	149,289		
Corrected total	19	2,219,095			

[a]The house of unknown treatment is excluded.
Note: None of the treatment means are significantly different at p = 0.05 using Duncan's Multiple Range Test (not shown).

Table 39. Geometric Mean Wood Core PCP Concentrations (ng/g Wood) and Statistical Significance of Differences Between the Means for Selected House Characteristics

House characteristic	Response	N	Geometric mean	95% Confidence interval	P-value
Use of other preservatives	Yes	7	6,760	684 - 66,800	0.316
	No	14	24,300	6,640 - 89,200	
Smokers in home	Yes	12	31,600	8,660 - 116,000	0.182
	No	9	6,330	870 - 46,096	
Electric heat[a]	Yes	12	7,470	1,210 - 46,000	0.394
	No	3	42,400	4,890 - 368,000	
Heating stove	Yes	18	13,500	3,680 - 49,400	0.509
	No	3	42,400	4,890 - 368,000	
Ceiling fan	Yes	15	15,800	4,510 - 55,400	0.991
	No	6	16,100	1,030 - 251,000	
Fireplace	Yes	15	21,600	6,640 - 70,000	0.424
	No	6	7,390	421 - 130,000	
Kerosene space heater	Yes	5	11,700	1,210 - 113,000	0.779
	No	16	17,500	4,435 - 68,862	
Electric space heater	Yes	10	18,800	5,820 - 143,000	0.347
	No	11	9,240	1,770 - 48,000	
Interior pesticide use	Yes	14	41,500	17,390 - 98,800	0.071
	No	7	2,300	184 - 29,500	
Exterior pesticide use	Yes	16	26,900	8,880 - 81,700	0.109
	No	5	2,930	135 - 63,400	
Cathedral ceiling	Yes	9	14,000	2,870 - 67,800	0.854
	No	12	17,500	3,240 - 94,500	

[a]Homes with central heat.

Table 40. Pearson Correlation Coefficients and Statistical Significance of the Association Between Wood Core PCP Concentrations and Household Means for Selected Characteristics of Log Home Residents (N=20)[a]

Participant characteristic	Weighted Pearson correlation coefficient	P-value
Age	-0.065	0.786
School years completed	-0.418	0.067
Time in house in previous 48 h	-0.205	0.386

[a]The log home without the completed questionnaire was excluded.

Table 41. Association of Household Distribution for Selected Demographic Characteristics of Study Participants[a] with Geometric Mean Wood Core PCP Concentrations (ng/g)

Participant variable	Response	N	Geometric estimated[b] mean	Log wood PCP concentration Estimated[b] mean	Standard error	P-value
Sex	Female	36	65,000	11.082	1.850	0.510
	Male	35	5,800	8.665	1.900	
Ever married	No	33	102,000	11.529	1.608	0.295
	Yes	38	4,760	8.468	1.421	
Ever smoke cigarettes	No	24	19,200	9.863	0.861	0.921
	Yes	20	16,600	9.718	0.964	
Currently smoke cigarettes	No	30	16,300	9.700	0.754	0.850
	Yes	14	22,100	10.004	1.217	
Ever smoke a pipe	No	35	7,210	8.883	0.691	0.066
	Yes	9	628,000	13.351	1.886	
Ever drink alcohol	No	8	14,500	9.585	1.534	0.884
	Yes	36	18,800	9.810	0.645	
Currently drink alcohol	No	15	17,600	9.773	1.144	0.981
	Yes	29	18,200	9.810	0.762	
Employed outside home	No	9	19,700	9.888	1.848	0.959
	Yes	35	17,600	9.774	0.721	
Employed part-time or volunteer	No	32	18,100	9.801	0.756	0.995
	Yes	12	17,800	9.788	1.461	
Ever worked with wood preservatives	No	37	23,400	10.062	0.617	0.292
	Yes	6	2,480	7.817	1.861	
Ever worked with pesticides	No	41	24,900	10.124	0.578	0.165
	Yes	3	206	5.327	3.134	
Hobby exposure to wood preservatives or pesticides	No	44	23,600	10.067	0.908	0.782
	Yes	26	13,600	9.516	1.344	
Pesticide use in home	No	63	18,000	9.798	0.606	0.809
	Yes	7	34,300	10.443	2.429	
Garden as hobby	No	37	17,900	9.792	0.880	0.920
	Yes	33	20,800	9.941	0.947	
Garden pesticide use in 1983	No	40	16,500	9.714	0.746	0.447
	Yes	26	50,200	10.823	0.994	
Garden pesticide use in 1982	No	41	20,900	9.992	0.843	0.842
	Yes	29	16,000	9.678	1.060	

[a]The one participant not completing a questionnair is excluded.
[b]Estimated from weighted least squares regression.

Table 42. Serum PCP Concentration (ng/mL) by House Treatment Category[a]

Treatment category	N	Range	Median	Geometric mean	95% Confidence interval
T	13	32.5 - 160	106	95.9	74.2 - 124
TS	12	21.7 - 151	111	81.1	55.9 - 118
TN	11	27.7 - 163	65.5	69.9	47.5 - 102
TSN	5	92.0 - 168	108	114	93.3 - 140
XT	12	9.4 - 55.7	23.0	22.8	17.9 - 29.1
NT	8	7.0 - 23.3	11.6	11.2	8.3 - 15.1
TU	4	16.0 - 25.1	18.3	19.1	13.1 - 27.9
ALL	65[b]	7.0 - 168	54.0	47.6	37.8 - 59.9

[a]Limit of detection = 0.25 ng/mL.
[b]Serum PCP concentration is unknown for seven participants because the specimen could not be collected.

Prior to further analysis, the distribution of serum PCP, free and total urinary PCP concentrations were examined. From skewness, box plots, normal plots, and normality test statistics, the distribution of log transformed serum and urinary PCP concentrations approximated a normal distribution than the untransformed data. Accordingly, median and geometric mean concentrations are presented, and log transformed values were used for further analysis.

The range, median, geometric means and 95% confidence intervals for serum PCP concentrations by house treatment category are given in Table 42. Table 43 shows the results of ANOVA of the mean serum PCP concentrations for all members of each household adjusted for the house age group distribution and weighted by the number of people in the household, by house treatment category. The ANOVA shows that there were significant differences among the groups. Pairwise comparisons of least squares means using the t-test at the 0.05 level indicated that the mean household serum PCP concentrations for the Exterior Treatment and Never Treated house treatment categories, while not differing significantly from each other, differed significantly from the means of the other four treatment categories. The geometric least squares mean serum PCP concentration in the Exterior Treatment category was almost twice as high as that in the Never Treated category, and those of the other four categories were from 4 to 7 times higher than the Never Treated category.

Table 44 provides summary statistics for total urinary PCP concentrations by house treatment category. Table 45 presents the results of ANOVA of the mean total urinary PCP concentrations for all members of each household, adjusted for the house age group distribution and weighted by the number of people in the household, by house treatment category. The ANOVA shows that there were significant differences among the groups. Pairwise comparisons of least squares means using the t-test at the 0.05 level indicated that the mean values for the Treated and Treated, Sealed and Neutralized categories were significantly higher than the mean for Exterior Treatment. The means for all other categories but the Exterior Treatment category were significantly higher than the mean for the Never Treated category. The geometric least squares mean total urinary PCP concentrations in the Exterior Treatment category were 3 times as high as those in the Never Treated category. Those of the other four categories were from 5 to 11 times higher than the Never Treated category.

Table 46 shows the summary statistics for free urinary PCP concentrations by house treatment category. For the population as a whole the median and geometric mean concentrations of urinary free PCP were, respectively, 48% and 43% lower than those found for urinary total PCP concentrations. Table 47 shows the results of ANOVA of the mean unhydrolyzed urine PCP concentrations for all members of each household adjusted for the house age group distribution and weighted by the number of people in the household by house treatment category. The ANOVA shows that there are significant differences among the groups. Pairwise comparisons of least squares means using the t-test at the 0.05 level indicated that the mean household unhydrolyzed urine PCP concentrations for the Treated category differed significantly from the Exterior Treatment category, and the Treated, Treated and Sealed, and Treated and Neutralized differed significantly from the Never Treated category. By analogy then, the Exterior Treatment and the Never Treated categories are not different from one another.

Table 43. Results of ANOVA of Mean Household Serum PCP Concentrations (ng/mL)[a] Adjusted for House Age Group Distribution by House Treatment Category

Treatment category	No. of houses	Geometric least squares mean	Log transformed data: Least squares mean	Log transformed data: Standard error	Overall P-value
T	4	87.6	4.472	0.243	0.0013
TS	3	87.5	4.472	0.263	
TN	3	54.4	3.996	0.271	
TSN	1	91.5	4.516	0.378	
XT	4	20.0	2.994	0.243	
NT	3	13.5	2.605	0.304	

[a]Means weighted by number of people in household.
Results of pairwise comparisons of least squares means using 0.05 level t-test: T, TS, TN, TSN differ from XT, NT.

Table 44. Total Urinary PCP Concentration (mg/g Creatinine) by House Treatment Category

Treatment category	N	Range	Median	Geometric mean	95% Confidence interval
T	13	0.012 - 0.179	0.036	0.044	0.026 - 0.074
TS	12	0.006 - 0.139	0.028	0.030	0.017 - 0.052
TN	12	0.008 - 0.082	0.026	0.026	0.018 - 0.038
TSN	5	0.028 - 0.134	0.056	0.060	0.035 - 0.100
XT	12	0.005 - 0.039	0.015	0.009	0.007 - 0.013
NT	8	0.000 - 0.013	0.004	0.004	0.003 - 0.006
TU	3	0.006 - 0.010	0.006	0.007	0.004 - 0.012
ALL	65[a]	0.000 - 0.179	0.021	0.021	0.016 - 0.028

[a]Total urinary PCP concentration corrected for creatinine is unkown for seven participants because no specimen was received.

Table 45. Results of ANOVA of Mean Household Total Urinary PCP Concentration (mg/g Creatinine)[a] Adjusted for House Age Group Distribution by House Treatment Category

Treatment category	No. of houses	Geometric least squares mean	Log transformed data: Least squares mean	Log transformed data: Standard error	Overall P-value
T	4	0.0417	-3.176	0.313	0.0116
TS	3	0.0317	-3.451	0.336	
TN	3	0.0235	-3.753	0.329	
TSN	1	0.0494	-3.008	0.493	
XT	4	0.0134	-4.316	0.332	
NT	3	0.0044	-5.428	0.403	

[a]Means weighted by number of people in household.
Results of pairwise comparisons of least squares means using 0.05 level t-test: T, TSN differ from XT
T, TS, TN, TSN differ from NT

Table 46. Free Urinary PCP Concentration (mg/g Creatinine) by House Treatment Category

Treatment category	N	Range	Median	Geometric mean	95% Confidence interval
T	13	0.007 - 0.120	0.034	0.031	0.018 - 0.052
TS	12	0.003 - 0.052	0.012	0.013	0.007 - 0.022
TN	12	0.006 - 0.101	0.016	0.017	0.011 - 0.026
TSN	5	0.011 - 0.028	0.018	0.018	0.013 - 0.025
XT	12	0.003 - 0.027	0.009	0.009	0.007 - 0.013
NT	8	0.002 - 0.006	0.005	0.004	0.003 - 0.005
TU	3	0.001 - 0.007	0.002	0.003	0.000 - 0.014
ALL	65[a]	0.001 - 0.120	0.011	0.012	0.009 - 0.016

[a]Free urinary PCP concentration corrected for creatinine is unknown for seven participants because no specimen was received.

Table 47. Results of ANOVA of Mean Household Free Urinary PCP Concentration (mg/g Creatinine)[a] Adjusted for House Age Group Distribution by House Treatment Category

Treatment category	No. of houses	Geometric least squares mean	Log transformed data: Least squares mean	Log transformed data: Standard error	Overall P-value
T	4	0.0292	-3.534	0.299	0.0454
TS	3	0.0135	-4.309	0.322	
TN	3	0.0160	-4.138	0.314	
TSN	1	0.0160	-4.138	0.471	
XT	4	0.0090	-4.714	0.318	
NT	3	0.0041	-5.490	0.385	

[a]Means weighted by number of people in household.
Results of pairwise comparisons of least squares means using 0.05 level t-test: T differs from XT
T, TS, TN differ from NT

These data clearly indicate that blood and urine PCP concentrations of residents in PCP-treated log homes were considerably higher than in residents of log houses not treated with PCP.

2. Influence of Age on Biological PCP Concentrations

In evaluating biological PCP concentrations it was considered that age was likely to be an important covariable. This is due to both behavioral and physiological differences between children and adults. Young children tend to spend more time than many adults in the house and have play activities which are likely to bring them into closer contact with potentially PCP contaminated surfaces such as floors. By the teenage years, more adult patterns of behavior in these respects are generally established. Physiologically there are differences with age in the absorption, distribution and possibly metabolism of xenobiotics like PCP. These differences include higher ventilation rates in children relative to body mass, larger relative surface area available in children for percutaneous absorption, higher metabolic rates in children, and differences in the relative proportions of different tissues into which xenobiotics might be distributed. Once puberty is reached these relationships tend to remain relatively stable throughout adult age.

The need to take the age of the individual into account in considering biological PCP concentration was also indicated by the results of the 1980 CDC/EPA study which found PCP concentrations in the urine of children to be higher than those of adults.

In order to account for possible differences in age, study participants were considered in three age groups: 4 to 7, 8 to 12 and over 12 yr old. As there were no individuals aged less than 4 or more than 65 yr, it was not necessary to consider the very young or very old in our analyses.

Table 48 shows the association of age group with biologic PCP concentrations, adjusted for household. The serum PCP concentration was slightly higher in the younger age group but the differences among the groups were not statistically significant. Highly significant differences among the groups were seen for urinary free and total PCP concentrations, with the highest values in the 4 to 7 age group and the lowest in the over 12 age group, whose mean values were less than half those of the youngest group. Plots of age against serum and urinary PCP concentrations are shown in Appendix X.

Because the data suggested different relationships with regard to age for serum and urinary PCP concentrations, the association of age group with urinary free and total PCP concentration adjusted for both serum PCP concentration and household was examined. The results are shown in Table 49. The differences between the urinary PCP concentrations are little changed and remain highly statistically significant indicating apparent differences between the age groups in rates of PCP excretion relative to creatinine excretion.

Table 48. Association of Age Groups with Biologic PCP Concentrations Adjusted for Household

Biological PCP measure	Age group	Number of participants in age group	Geometric least squares means	Ratio of means[a]	Overall P-value[b]
Serum PCP (ng/mL)	4-7	10	51.5	1.00	0.194
	8-12	11	38.0	0.74	
	> 12	50	41.1	0.80	
Urinary free PCP (mg/g creatinine)	4-7	10	0.027	1.00	0.0001
	8-12	11	0.019	0.70	
	> 12	50	0.010	0.37	
Urinary total PCP (mg/g creatinine)	4-7	10	0.036	1.00	0.004
	8-12	11	0.029	0.81	
	> 12	50	0.017	0.47	

[a]Compared with 4 to 7 yr old age group.
[b]P-value associated with F-test for differences among age groups. Results of pairwise comparison of age groups at the 0.05 level for urinary free and urinary total PCP: Age group > 12 differs significantly from age groups 4-7 and 8-12.

Table 49. Association of Age Groups with Urinary PCP Concentrations Adjusted for Serum PCP Concentrations and Household

Biological PCP measure	Age group	Number of participants in age group	Geometric least squares means	Ratio of means[a]	Overall P-value[b]
Urinary free PCP (mg/g creatinine)	4-7	10	0.028	1.00	0.0004
	8-12	11	0.023	0.82	
	> 12	50	0.011	0.39	
Urinary total PCP (mg/g creatinine)	4-7	10	0.039	1.00	0.0031
	8-12	11	0.033	0.85	
	> 12	50	0.017	0.44	

[a]Compared with 4 to 7 yr old group.
[b]P-value associated with F-test for differences among age groups. Results of pairwise comparison of age groups at the 0.05 level for urinary free and urinary total PCP concentrations: Age group > 12 differs significantly from age groups 4-7 and 8-12.

D. Relationships Between Selected PCP Measurements

1. Correlations Within Environmental Samples

Pearson and Spearman correlation coefficients between measured concentrations of PCP in air, wood cores, "adjacent" and "exposure" surface wipe samples are presented in Table 50. All values were highly correlated and all the correlations were statistically significant. PCP concentrations measured in the air of the log homes were highly correlated with the PCP concentration in the wood core samples. This suggests that PCP is continually vaporized from the logs to the air. Air concentrations were measured under a narrow range of temperatures and with closed windows defined by the study protocol to assess sample comparability; under other conditions the association may not be as strong.

PCP concentrations measured in "adjacent" wipe samples were also found to be highly correlated with the wood core PCP concentration and the air PCP concentration. These correlations are also presented in Table 50. This presumably reflects that the wood surface is the interface (i.e., site of vaporization) between the log and air.

PCP concentrations measured in "exposure" wipe samples were also significantly correlated with concentrations of PCP measured in air and wood samples, although the correlations were not as strong as in the case of the "adjacent" wipe samples. This is not unexpected since the "exposure" wipe samples reflect concentrations on various surfaces throughout the house rather than just the interface between logs and air. "Exposure" wipe samples were collected from both log and other surfaces thought to be frequently contacted by inhabitants of the house. Many of these surfaces may not have been PCP-treated, although they may have become PCP-contaminated through condensation. Other surfaces such as around light switches, door jabs, and window frames probably were touched and may have been treated with PCP. As a result, the correlation between "exposure" wipe samples and other environmental measures of exposure would be expected to be lower because of the sample being "diluted" with possible non-PCP treated surfaces.

The relationship between the presence of PCP in drinking water and the source of that water has already been discussed in Section X.B.4.

2. Relationship Between House Treatment History and Air PCP Concentrations After Adjustment for Wood Core PCP Concentrations

The effectiveness of the sealing and/or neutralizing PCP treated logs in reducing air PCP concentrations was explored. In order to permit comparisons, air PCP concentrations measured in log homes from the four manufacturer-treated categories (T, TS, TN, TSN) were adjusted to reflect equivalent wood core PCP concentrations utilizing least squares means regressions. Statistical analysis of the resulting adjusted air PCP concentrations utilized the factorial structure of the treatment categories and was performed using analysis of covariance to determine the effect of sealing, neutralization, and possible interactions between them.

Table 50. Pearson and Spearman Correlation Coefficients (r) and Statistical Significance (p) for Associations Between Various Environmental Concentrations of PCP[a]

Pearson Correlations

	Air PCP concentration	Wood core PCP concentration	"Adjacent" surface PCP concentration	"Exposure" surface PCP concentration
Air PCP concentration	--	r = 0.855 p = 0.0001	r = 0.828 p = 0.0001	r = 0.667 p = 0.001
Wood core PCP concentration		--	r = 0.835 p = 0.0001	r = 0.629 p = 0.002
"Adjacent" surface PCP concentration			--	r = 0.848 p = 0.0001

[a]All concentration data are log transformed.

Spearman Correlations

	Air PCP concentration	Wood core PCP concentration	"Adjacent" surface PCP concentration	"Exposure" surface PCP concentration
Air PCP concentration	--	r = 0.802 p = 0.0001	r = 0.881 p = 0.0001	r = 0.839 p = 0.0001
Wood core PCP concentration		--	r = 0.820 p = 0.0001	r = 0.670 p = 0.0009
"Adjacent" surface PCP concentration			--	r = 0.901 p = 0.0001

[a]All concentration data are log transformed.

Analysis of the four treatment categories did not detect any statistical interaction ($p = 0.174$) between the treatments. Since the test for interaction between sealing and neutralizing was not significant it was, therefore, appropriate to examine the tests for the individual effect of sealing or neutralization. The results of these analyses are presented in Table 51.

Table 51 demonstrates that, when air PCP concentrations were adjusted to compensate for differences in wood core PCP concentrations, sealing of the interior surface (with polyurethane or varnish) of the log homes included in the study population did not significantly reduce the air PCP concentration. Air concentrations were, in fact, slightly (although not statistically) elevated. Air PCP residues in homes constructed of treated logs which had subsequently been neutralized (with Permatox-Pentite) were found to be 44% of the expected concentration had the logs not been neutralized. This difference was statistically significant ($p = 0.039$).

3. Correlations of Serum and Urinary Free and Total PCP Concentrations

Partial correlation coefficients and associated significance levels among mean serum, free urinary and total urinary PCP concentrations for household (weighted by the number of people in the household) adjusted for age group distribution in the household are shown in Table 52. All three correlations were strong and highly significant.

4. Relationships Between Environmental and Biological PCP Concentrations

Table 53 shows the partial correlation coefficients and associated significance levels between various environmental PCP concentrations (wood core, air, "exposure" surface wipes) and biological PCP concentrations (serum, free urinary, and total urinary) for household (weighted by the number of people in the household) and adjusted for age group distribution in the household. All studied correlations were strongly positive and statistically significant.

E. Relationship Between Serum and Urinary PCP Concentrations and Clinical Findings

1. Questionnaire Responses

The significance of the age group adjusted association between estimated mean log serum PCP or log total urinary PCP concentrations and certain questionnaire responses was examined using a two-tailed t-test. The association was computed using mean household values for serum and total urinary PCP concentrations, and household distribution among categories for health responses and age groups, weighted by the number of people in the household. The results are shown on Table 54. It is seen that there were no significant differences for any of the health questions.

Table 51. Comparison of the Effects of Sealing and/or Neutralizing Logs Treated with PCP on Resultant Air Concentrations of PCP Using Analysis of Covariance

Treatment history	Adjusted[a] geometric mean PCP air concentration (ng/L)	Ratio	P-value
Not sealed	0.173	1.00 (reference)	
Sealed	0.218	1.13	0.737
Not neutralized	0.308	1.00 (reference)	
Neutralized	0.136	0.44	0.039[b]

[a]Adjusted for wood core PCP concentration.
[b]Significant at p = 0.05.

Table 52. Partial Correlation Coefficients (r) and Statistical Significance (p) for Associations Between Mean Serum and Urinary PCP Concentrations for Household[a] Adjusted for Age Group[a]

	Serum PCP concentration	Free urinary PCP concentration	Total urinary PCP concentration
Serum PCP concentration	--	r = 0.811 p = 0.0001	r = 0.893 p = 0.0001
Free urinary PCP concentration		--	r = 0.906 p = 0.0001

[a]Means weighted by number of people in household. All concentrations are log transformed.

Table 53. Partial Correlation Coefficients[a] for Associations Between Environmental and Mean Biologic PCP Concentrations for House[b] Adjusted for Age Group Distribution in House (N=19[c])

	Serum PCP concentration	Free urine PCP concentration	Total urine PCP concentration
Wood PCP concentration	r = 0.764 p = 0.0004	r = 0.507 p = 0.0377	r = 0.716 p = 0.0012
Air PCP concentration	r = 0.788 p = 0.0002	r = 0.772 p = 0.0003	r = 0.853 p = 0.0001
PCP "Exposure" surface wipes concentration	r = 0.677 p = 0.0028	r = 0.744 p = 0.0006	r = 0.643 p = 0.0053

[a]All data are log transformed.
[b]Means weighted by number of people in household.
[c]Paired blood and urine specimens could not be obtained for individuals in two houses.

Table 54. Significance of Age Group Adjusted Associations[a] Between Estimated Mean Log Serum PCP or Log Total Urinary PCP Concentrations and Certain Questionnaire Responses

Questionnaire variable	Response	Log serum PCP (ng/mL) concentration			Log urine total PCP (mg/g creatinine) concentration		
		Estimated mean	Standard error	P-value[b]	Estimated mean	Standard error	P-value[b]
Ever had eczema	No	3.87	0.227	0.933	-3.84	0.240	0.839
	Yes	4.06	2.128		-4.30	2.126	
Ever had acne	No	3.78	0.255	0.435	-3.78	0.285	0.734
	Yes	4.56	0.841		-4.15	0.922	
Acne since resident in present house	No	3.89	0.252	0.832	-3.81	0.254	0.802
	Yes	4.11	0.877		-4.08	0.960	
Rash or dermatitis in past year	No	4.45	0.373	0.110	-3.34	0.371	0.130
	Yes	3.08	0.521		-4.73	0.591	
Ever had a tumor or lump removed	No	3.79	0.250	0.429	-3.89	0.276	0.771
	Yes	4.66	0.951		-3.48	1.230	
Currently taking medication	No	3.23	0.513	0.174	-4.13	0.501	0.536
	Yes	4.56	0.498		-3.57	0.477	
Fever at least once within last 6 mo	No	3.29	0.383	0.082	-4.57	0.418	0.062
	Yes	4.85	0.535		-2.65	0.605	
Fever more than once in past 6 mo	No	3.95	0.220	0.679	-3.75	0.225	0.637
	Yes	2.82	2.589		-5.03	2.564	
Irritation of eyes since resident in present house	No	3.66	0.318	0.339	-3.93	0.321	0.697
	Yes	4.51	0.642		-3.56	0.748	
Tearing of eyes since resident in present house	No	4.02	0.250	0.453	-3.72	0.247	0.371
	Yes	3.17	0.973		-4.82	1.086	
Swelling of eyelids since resident in present house	No	3.77	0.214	0.166	-3.91	0.244	0.573
	Yes	5.06	0.818		-3.36	0.857	
Unexplained weight loss of greater than 5 lb in last 6 mo	No	3.95	0.209	0.421	-3.84	0.227	0.994
	Yes	2.16	2.121		-3.87	4.301	

[a]Computed using mean household values for serum and total urinary PCP concentrations, and household distribution among categories for health responses and age groups, weighted by the number of people in the household.
[b]Two-tailed t-test.

2. Clinical Laboratory Evaluations

In spite of planning, transportation delays did occur where more than 48 h elapsed between time of blood collection and laboratory processing. The delay did not affect biochemistries or PCP analysis; however, hematology specimens are sensitive to the time factor and results become unreliable after 48 h. No statistical analysis of hematology results was performed for this reason.

The association between serum biochemical results and serum, or total urinary PCP concentrations was evaluated. The association with total urinary PCP was examined both with and without correction for the urinary excretion of creatinine. Partial correlation coefficients were calculated between mean serum or mean total urinary PCP concentrations for households and mean biochemical variables for the household (weighted by the number of people in the household), adjusted for age group distribution in the household. The results are shown on Table 55. Most values, including various serum liver function tests (albumin, bilirubin, alkaline phosphatase, glutamic oxaloacetic transferase, glutamic pyruvate transaminase, lactic dehydrogenase and gamma glutamyl transpeptidase), a test of microsomal enzyme induction (ratio of urinary 6-beta-hydroxycortisol to free cortisol), and a renal function test (blood urea nitrogen) were not different among the groups.

There was a statistically significant negative association between the serum total protein concentration and both the serum PCP and the urine total PCP concentrations. The total serum protein concentrations measured a large number of proteins and the data did not allow determination of what fraction or fractions of proteins might be responsible for this association. The reason, if any, for this apparent association remains obscure and needs further exploration. Serum albumin, however, which constitutes the bulk of serum protein, was not statistically significantly associated with serum PCP or urinary PCP concentration.

There was a curious and not readily explained strong negative association between both the serum PCP and urinary PCP concentrations with the serum creatinine concentration. Both associations were highly statistically significant. The serum creatinine is an indicator, among other things, of renal function. If PCP nephrotoxicity were occurring the creatinine level would be expected to rise with increasing PCP concentrations, but the reverse is the case here so that nephrotoxicity is not a tenable explanation. Because creatinine adjustment of urine total PCP concentrations may have affected the association between the urinary PCP concentration adjusted for creatinine and the urine creatinine, the analysis was repeated using the total urinary PCP concentrations unadjusted for urinary creatinine. These results are also displayed in Table 55. It is seen that the correlation coefficient between the urinary PCP concentration and the serum creatinine is little changed and the negative correlation remains highly significant. All associations between PCP concentrations and serum creatinine were also adjusted for sex since this might affect serum creatinine levels.

Table 55. Partial Correlation Coefficients Between Mean Serum and Urinary PCP Concentrations for Household and Mean Biochemical Variables for Household[a] Adjusted for Age Group Distribution in Household

Biochemical variable	Serum PCP concentration (ng/L)		Total urinary PCP concentration (mg/g creatinine)		Total urinary PCP concentration (ng/L)	
	Partial correlation coefficient	P-value	Partial correlation coefficient	P-value	Partial correlation coefficient	P-value
Log serum protein	-0.484	0.049[b]	-0.502	0.040[b]	-0.476	0.046[b]
Serum albumin	-0.164	0.530	-0.265	0.305	-0.277	0.365
Log serum total bilrubin	-0.265	0.304	-0.048	0.856	-0.021	0.934
Log serum alkaline phosphatase	-0.150	0.565	-0.147	0.575	-0.161	0.523
Log serum glutamic oxaloacetic transferase	0.414	0.099	0.269	0.296	0.246	0.325
Log serum glutamic pyruvate transaminase	-0.300	0.241	-0.139	0.594	-0.184	0.466
Log serum lactic dehydrogenase	0.193	0.459	0.250	0.333	0.261	0.295
Blood urea nitrogen	-0.252	0.328	-0.187	0.472	-0.218	0.385
Serum creatinine[c]	-0.636	0.008[b]	-0.548	0.028[b]	-0.702	0.002[b]
Serum gamma glutamyl transpeptidase	-0:027	0.919	-0.133	0.611	-0.022	0.932
Log ratio urinary 6-beta-hydroxycortisol to free cortisol	0.167	0.538	-0.013	0.959	0.082	0.754
Urinary creatinine[c]	-0.189	0.499	-	-	-	-

[a]Weighted by number of people in household.
[b]Statistically significant at p = 0.05.
[c]Also adjusted for sex distribution in household.

The production of creatinine and therefore its concentration in serum, given normal urinary function, is a function of body muscle mass. It is conceivable that the negative correlation between PCP concentrations and serum creatinine reflects some alteration in distribution of PCP within the tissues of exposed individuals, but this explanation remains conjectural.

3. Physical Examination

The significance of the age group adjusted association between estimated mean log serum PCP or log total urinary PCP concentrations and abnormalities in the physical examination (skin examination, lymphadenopathy, neurologic examination) was examined using a two-tailed t-test. The association was computed using mean household values for serum and urinary PCP concentrations, and household distribution among categories for physical examination responses and age groups, weighted by the number of people in the household. The results are shown on Table 56.

No significant difference was seen for the neurologic examination or for lymphadenopathy. However, both the estimated mean PCP serum and estimated mean total urinary PCP concentration for those with abnormal skin examinations were statistically significantly higher than for those with normal skin examinations. It could not be determined whether there may have been more absorption of PCP through the skin as a result of pre-existing skin abnormalities, whether the PCP might have caused skin abnormalities, or whether there was some other factor accounting for both skin abnormalities and increased biologic PCP concentrations.

F. Comparison of Results for Participants in the 1980 and 1984 Studies

It is possible to compare biochemical indicators of organ functions between 1980 and 1984 in those participants who were studied at both times. Because of substantial variations in these indicators with age in children and changes in age which occur over a 4-yr period such comparisons will only be valid in adults. Further, the comparisons may be affected in undeterminable ways by possible sample storage, processing differences and by interlaboratory variations.

A summary of the results of the repeated measures analysis for the serum and urinary unhydrolyzed PCP concentrations and the serum biochemistries is given in Table 57. It is seen that the log serum PCP concentrations were significantly higher in 1980 than 1984. However, no significant differences were seen for the other values. An example analysis of variance result for serum PCP is given in Table 58. The remaining individual urinary PCP and biochemistry variables were studied in the same manner. Since the results were not statistically significant, only summary data are provided in Table 57.

Table 56. Significance of Age Group Adjusted Association[a] Between Estimated Mean Log Serum PCP or Log Total Urinary PCP Concentrations and Physical Examination Results for Households

Physical examination result	Serum PCP (ng/mL)			Total urine PCP (mg/g creatinine)		
	Estimated mean	Standard error	P-value[b]	Estimated mean	Standard error	P-value[b]
Skin examination:						
Abnormal	4.73	0.386	0.036[c]	-2.73	0.397	0.009[c]
Normal	3.33	0.315		-4.46	0.275	
Lymphadenopathy:						
Present	4.86	0.601	0.127	-3.19	0.649	0.330
Absent	3.65	0.257		-3.98	0.267	
Neurologic examination:						
Abnormal	4.45	0.824	0.532	-3.33	0.846	0.568
Normal	3.88	0.220		-3.87	0.235	

[a]Computed using mean household values for serum and urinary PCP concentrations, and household distribution among categories for health responses and age groups, weighted by the number of people in the household.
[b]Two-tailed t-test.
[c]Statistically significant difference at p = 0.05.

Table 57. Summary of Repeated Measures Analysis for Serum and Urinary PCP Concentrations and Serum Biochemistries

Variable	Number of replicates	Mean value[a] 1980	Mean value[a] 1984	Repeated measures analysis p-value
Log serum PCP ng/mL	19	313.5	64.1	< 0.001
Log unhydrolyzed urine PCP ng/mL	20	10.5	16.5	0.109
BUN mg/dL	19	12.1	13.3	0.132
Serum creatinine mg/dL	19	0.89	0.97	0.103
Log SGOT mu/mL	19	15.3	15.1	0.772
Log LDH mu/mL	19	156.5	155.7	0.760
Log alkaline phosphatase mu/mL	19	51.4	57.6	0.161
Log SGPT mu/mL	19	13.7	15.7	0.891
Log total bilirubin mg/dL	19	0.37	0.32	0.212
Log total protein g/dL	19	6.59	6.86	0.611
Albumin g/dL	19	4.19	4.59	0.095

[a]Geomtric means are given for log transformed variables.

Table 58. Analysis of Variance Table for Repeated Measures Analysis of Log Serum PCP ng/mL

Source	Degrees of freedom	Sum of squares	Mean square	F	P-value
Between subjects					
Family	7	8.6437	1.2348		
Subjects within family	11	2.1026	0.1911		
Within subjects					
Year	1	21.1540	21.1540	288.99	< 0.001
Family x year	7	0.5124	0.0732		
Subjects within family x year	11	2.6904	0.2446		
Total	37				

The results of longitudinal analysis showed that the serum PCP concentrations are significantly lower by a factor of almost 5 in 1984 compared with 1980. However, the urinary unhydrolyzed PCP concentrations are somewhat higher in 1984, although the differences are not statistically significant. A ready explanation for these differences is not apparent. Both the collection of specimens and the laboratory analysis were performed by different groups in the two studies so that differences in sampling and analysis cannot be excluded as responsible for the variations. It is also possible that substantial reduction in PCP exposure has occurred over the 4-yr interval but that for some unaccountable reason, it is not reflected in the urinary unhydrolyzed PCP concentrations. The results of serum biochemistries did not differ between the two years and the mean values obtained were quite similar on both occasions.

G. Quality Assurance and Quality Control Results

1. Method Optimization

The results of the method variables experiment are shown in Table 59. The major variables, as evidenced in the "effect" and "t variable columns," occur in the 2,4,6-tribromophenol (TBP) side of the results and specifically with the sample size, amount of acid, and acetylating reaction time. The significance of these three variables, as shown by the results of a t-test (specifically 80%, 70% and 70%, respectively), is minor. It is important to note that the endogenous PCP variables are quite low. However, the results for the dummy variables indicated that the precision of the method may be a problem. A benefit from conducting this simple experiment is that several changes in the original method could be made to improve the operating efficiency and increase sample throughput without compromising the method. Table 60 compares the conditions of the original versus updated method.

The most significant changes are the decrease in time for mixing the urine after surrogate addition and the time for analyte extraction. A combined total savings of almost 3 h was achieved. No changes were made in the gas chromatographic conditions.

2. Method Performance

The performance of the updated method was determined by analyzing spiked aliquots of the same urine sample used in the method variables. The samples were prepared as follows:

Method blank (reagents only)
Urine spiked in triplicate at 0 ppb
Urine spiked in triplicate at 4.72 ppb
Urine spiked in triplicate at 23.6 ppb
Urine spiked in triplicate at 236 ppb

These samples were then analyzed according to the updated method for the acetates of TBP and PCP. The results of the method validation are shown in Table 61. In general, the percent recoveries are acceptable for all three spike levels. Hence, the method was accepted for use in the current study.

Table 59. Results Method Variables Determination

Code	Variable	Level		Effect		t Variable	
		Low (-)	High (+)	TBP[a]	PCP[b]	TBP	PCP
A	Amount of sample	2 mL	4 mL	18.8	4.2	1.82	.32
B	Dummy	-	-	7.6	11.1		
C	Mixing time	15 min	1 h	-7.8	4.5	-.76	.34
D	Amount of H_2SO_4	120 µL	500 µL	-12.6	-3.9	-1.22	-.30
E	Solvent extraction	4 mL	10 mL	-6.9	-3.7	-0.66	-.28
F	Extraction time	1 h	2 h	3.9	-1.1	0.37	-.08
G	Dummy	-	-	12.5	7.0		
H	Acetylating reagent	0.1 mL	0.5 mL	4.9	-7.0	0.48	-.53
I	Reaction temperature	45°C	60°C	-2.1	0.7	-0.20	.05
J	Reaction time	5 min	15 min	12.7	5.1	1.22	.38
K	Amount of buffer	6 mL/2 mL	10 mL/5 mL	-6.8	-5.6	-0.66	-.43

1) $\text{Effect}_{(\text{variable})} = \frac{\Sigma \text{ R at (+)}}{n} - \frac{\Sigma \text{ R at (-)}}{n}$

2) Variance dummy effect $= \frac{\Sigma \text{ (dummy effects)}^2}{n} = \frac{E(B)^2 + E(G)^2}{2}$

3) Standard error (S.E.) effect $= \sqrt{\text{Variable dummy effect}}$

4) $t_{\text{variable}} = \frac{\text{effect}_{(\text{variable})}}{\text{S.E. effect}}$

[a] 2,4,6-Tribromophenol added as a surrogate.
[b] Pentachlorophenol added as a standard.

Table 60. Urine Method Parameters

Parameter	Needham method	Updated method
Amount of urine	2 mL	2 mL
Mixing time after addition of surrogate	2 h	15 min
Amount of conc. H_2SO_4	120 µL	150 µL
Amount of hexane	6 mL	4 mL
Extraction time	2 h	1 h
Amount of acetylating reagent	100 µL	100 µL
Reaction time	15 min	15 min
Reaction temperature	45°C	45°C
Amount of buffer wash	6 mL then 2 mL	6 mL then 2 mL

Table 61. Urine Method Validation Results

Spiking level		Results - unhydrolyzed urine					Results - hydrolyzed urine				
			Tribromophenol		Pentachlorophenol			Tribromophenol		Pentachlorophenol	
TBP (ng/mL)	PCP (ng/mL)	Sample I.D.	ng/mL	% rec ave	ng/mL	average[b] % recovery	Sample I.D.	ng/mL	% rec ave	ng/mL	average[b] % recovery
18.6	0	B1	19.4[a]	103	2.8	- -	HB1	17.7	98	4.9	- -
			19.3		2.9			18.3		4.9	
			18.8		2.9			18.5		5.0	
18.6	0	B2	13.7	75	2.3	- -	HB2	19.3	105	5.1	- -
			14.3		2.4			19.8		5.3	
			13.7		2.3			19.5		5.2	
18.6	0	B3	16.1	86	4.0	- -	HB3	19.1	103	5.9	- -
			16.0		3.9			19.4		6.0	
			15.8		4.9			19.0		5.8	
		Average % recovery = 88					Average % recovery = 102				
18.6	4.72	L1	18.2	97	10.9	6.9 147	HL1	19.7	106	9.3	4.1 87
			18.3		10.8			19.8		9.2	
			17.9		8.6		HL2	16.9	91	10.2	5 106
18.6	4.72	L2	16.3	88	6.7	3.7 79	HL3	16.5	88	12.9	7.6 161
			16.5		7.1			16.3		12.7	
			15.9		6.9		Average % recovery = 95			Average % recovery = 118	
18.6	4.72	L3	17.9	95	7.6	4.4 92					
			17.8		7.6						
			17.1		7.4						
		Average % recovery = 93			Average % recovery = 106						
18.6	23.6	M1	17.0	91	32.1	28 119	HM1	17.7	97	34.5	29 124
			17.0		30.2			17.8		34.2	
			16.8		32.1		HM2	16.1	86	32.3	27 114
18.6	23.6	M2	19.7	105	32.8	29 123		16.2		31.5	
			19.4		31.7		HM3	17.3	94	31.7	27 114
			19.6		32.7			17.7		32.4	
18.6	23.6	M3	17.9	96	29.2	26 110	Average % recovery = 92			Average % recovery = 117	
			17.9		29.0						
			17.9		29.8						
		Average % recovery = 97			Average % recovery = 117						
18.6	236	H1		c	297	292 124	HH1	c		279	281 119
					295					293	
					295		HH2			303	290 123
18.6	236	H2			244	238 101				286	
					243		HH3			275	267 113
					237					269	
18.6	236	H3			258	255 108	Average % recovery = -			Average % recovery = 118	
					257						
					258						
		Average % recovery = -			Average % recovery = 111						

[a]Triplicate injections of the extract.
[b]Average equals ng/mL PCP found minus the ng/mL PCP in the blank.
[c]The analyte was not observed because of the dilution of the sample to obtain the PCP concentration within working range of the instrument.
TBP = 2,4,6-Tribromophenol.
PCP = Pentachlorophenol.

3. QCC/QAM Report

Performance Audit

Performance samples were prepared by the QCC from EPA standards (derivatized to acetates by project staff) and analyzed by project staff. The results are reported to three significant figures; accuracy ranged from 85.6% to 183% (for PCP) and 86% to 203% (for TBP).

Analyzed	No.	PCP (ng/mL) Known	Found	Accuracy[a] (%)	TBP (ng/mL) Known	Found	Accuracy (%)
05/07/84	5	16.5	15.9	97	10.2	13.3	130
05/07/84	6	11	9.68	88	6.8	7.66	113
05/07/84	7	23.6	24.4	103	14.6	20.5	140
05/07/84	8	23.6	25.4	108	14.6	21.4	147
05/07/84	9	18.7	19.5	104	11.6	16.3	141
05/07/84	10	9.35	8.02	85.8	5.78	6.16	107
05/07/84	11	11.1	9.54	85.9	10.9	10.2	93.6
05/07/84	12	8.88	8.1	91.2	8.72	8.32	95.4
05/07/84	13	8.88	7.75	87.3	8.72	7.82	89.7
05/07/84	14	5.1	4.92	96.5	5.01	4.31	86
05/09/84	7	23.6	30.7	130	14.6	28	192
05/09/84	10	9.35	8	85.6	5.78	6.4	111
05/09/84	12	8.88	8	90.1	8.72	8.4	96.3
07/10/84	14	5.11	4.4	86.1	5.01	4.5	89.8
07/10/84	11	11.1	18.1	163	10.9	15.8	145
07/10/84	13	8.88	9.1	102	8.72	10.2	117
07/10/84	6	11	20.1	183	6.8	13.8	203

[a] $\text{Accuracy (\%)} = \frac{\text{Measured Value - Background Value}}{\text{Spike Equivalent Value}} \times 100.$

Systems Audit

Audits were conducted by the QCC and QAM; the results for facilities, staff credentials, documentation procedures, and internal quality control are summarized below.

The GC Facility was inspected for general QA complicance on 03/13/84, 06/12/84, and 06/12/84. No major problems were detected; instrument records were considered to be satisfactory.

Project staff credentials were examined during 01/07/85; credentials were considered to be satisfactory.

Project records were examined on 01/07/85 for documentation and the report was reviewed for data integrity on 02/25/85. The following items were traceable: standards, reagents, samples, instrumental parameters, and data calculations. Notebooks were reviewed and signed-off by the supervisor. Documentation was considered to be satisfactory.

The internal QC program was audited; no major discrepancies were noted. Table 61, Urine Method Validation Results, shows internal quality control results; accuracy as percent recovery ranged from 79% to 161% for (PCP) and 75% to 106% (for TBP).

XI. REFERENCES

Beckman ASTRA (Automated Stat/Routine Analyzer Systems) operating and service instruction: creatinine chemistry module. Revised March 1982.

Chau ASY, Coburn J. 1974. Determination of pentachlorophenol in natural waters and wastewater. Journal of the AOAC 57(2).

Chronic Diseases Division, Centers for Disease Control. 1981 (September). Internal memo to Director of Centers for Disease Control. Pentachlorophenol wood preservative exposure in residents of log homes. Louisville, Kentucky, Public Health Service-CDC-Atlanta. EPI 80-60-2.

Duncan DB. 1955. Multiple range and multiple F tests. Biometrics 11:1-42.

Kream J et al. 1978. A rapid competitive protein binding assay of urinary cortisol. Clin Chem 24:994.

Lakings D et al. 1980. Determination of pentachlorophenol and hexachlorobenzene residues. Final Report, EPA Contract 68-01-5915, Task 12.

Needham LL, Cline RE, Head SL, Liddle JA. 1981. Determining pentachlorophenol in body fluids by gas chromatography after acetylation. J Anal Tox 5, Nov/Dec.

Saenger P. 1983. Measurement of 6-beta-hydroxycortisol excretion in random urine samples as indicator of enzyme induction. Clin Pharmacol Ther 34:818-822.

Shapiro SS, Wilk MB. 1965. An analysis of variance test for normality (complete samples). Biometrika 52:591-611.

Stowe RA, Mayer RP. 1966 (February). Efficient screening of process variables. Industrial and Engineering Chemistry 58(2).

Voccia E et al. 1979. 6-Beta-hydroxycortisol excretion in hypercortisolemic states. J Clin Endocrinol Metab 48:467-471.

Winer BJ. 1971. Statistical principles in experimental design, 2nd ed. New York: McGraw-Hill Book Comapny, pp. 518-539.

PCP Used as a Wood Preservative in Log Homes

PRELIMINARY CONTACT QUESTIONNAIRE

FACE SHEET

Interviewer_____ Date_____

Person Interviewed_____

House Study#_____ 1 — —

Street Address_____

City & ZIP_____

Mailing Address_____

City & ZIP_____

Area Code & Telephone#_____

Occupants:

Names_____ Study #_____ 3 —

_____ _____ 5 —

_____ _____ 7 —

_____ _____ 9 —

_____ _____ 11 —

_____ _____ 12 —

Attempted contacts: (date/time)

_____

_____

_____

_____

_____

_____

1. How many persons regularly reside in your log home? _____ 19

2. How old and of what sex are each of them?

	SEX		AGE IN YEARS	
a.	(1)M _____	(2)F _____	_____	10
b.	(1)M _____	(2)F _____	_____	13
c.	(1)M _____	(2)F _____	_____	16
d.	(1)M _____	(2)F _____	_____	19
e.	(1)M _____	(2)F _____	_____	22
f.	(1)M _____	(2)F _____	_____	25

3. Do the residents of your home consider themselves to be
(1)white _____ (2)Black _____ (3)Hispanic _____ 34
(4)other(specify) _____

4. Do you live in your log home all year?
(1)YES _____ (2)NO _____ – 35

5. In what year was your home built? _____ 36

6. What year did you move in? _____ 38

7. Who was the manufacturer and/or distributor of the pre-cut logs used to build your home? _____ 40
_____

8. To your knowledge, have the logs in your home been treated with a wood preservative or something to stop the wood from darkening? 43
(1)YES _____ (2)NO _____ (3)DK _____

IF NO SKIP TO #15

9. If yes, who did the treatment? (1)manufacturer _____ 46
(2)builder _____ (3)previous owner _____
(4)self or family member _____ (5)DK _____

10. When was the preservative applied? (year) _____ 47

11. What chemical preservative was used? _____ 49
_____

12. Has the home been retreated with wood preservative? 51
(1)YES _____ (2)NO _____ (3)DK _____

IF NO OR DK SKIP TO #15

13. If yes, when was the preservative applied? (year) 52
_____

14. What chemical preservative was used? _____ 54
_____

15. Has any part of your house ever been sealed with a chemical sealer such as varnish, polyurethane, or any other material? (1)YES _____ (2)NO _____ (3)DK _____

16. What chemical sealer was used? _____
_____

17. When was the chemical sealer applied? (year)_____

18. Have you previously lived in a log home?
(1)YES _____ (2)NO _____ (3)DK _____

IF NO OR DK SKIP TO #23

19. If yes, where was this home located? _____
_____

20. When did you live there? _____ to
_____

21. Was a chemical preservative used on the wood of that home? (1)YES _____ (2)NO _____ (3)DK _____

IF NO OR DK SKIP TO #23

22. What was the preservative used? _____
_____

23. During what hours of the day, Monday through Friday, can the male or female head of household be contacted at home?_____
_____
_____
_____

24. If no adults are at home during the day, is it possible to contact one at work? Y____ N____
IF YES, what is the telephone number there?
_____

25. Do male or female head of household work nights, evenings or weekends? Y____ N____
IF YES, FIND OUT HOURS.
_____
_____
_____

26. What time of day are most of the people in your family at home? (Get specific hours.)_____
_____
_____
_____

27. What hours and days of the week does the male head of household work outside the home?

28. What hours and days of the week does the female head of household work outside the home?

29. Will you be home (vs. on a trip) between:
(if Louisville) February 14 and February 18? Y____ N____
(if Danville) February 19 and February 22? Y____ N____
(if Cincinatti) February 23 and February 25? Y____ N____
IF NO, FIND OUT WHEN THEY WILL BE IN TOWN.

COMMENTS & QUESTIONS

APPENDIX II

MEDICAL INFORMED CONSENT FORM

Evaluation of Clinical Field Methodologies
Study of Log Home Residents Exposed to Pentachlorophenol
The Johns Hopkins School of Hygiene and Public Health
and
Midwest Research Institute

CONSENT FORM I

You have been asked to participate in a study of persons living in log homes. Many log homes have wood preservatives applied to them, and the purpose of this study is to find out more about if and how these wood preservatives are released into the environment and if they find their way into the body. Every effort will be made to keep confidential the information collected for this study. Any information that could identify you individually will not be revealed to anyone outside of the Johns Hopkins personnel conducting this study.

Prior to the main part of the study the head of the household will be asked to complete a preliminary contact questionnaire which will ask about the home and its occupants.

You will then be asked to complete a questionnaire about yourself and your health and work habits. Some of the questions about your medical status may be of a sensitive nature, including whether you are currently under treatment for any illness. You will be asked to collect a sample of your first urine specimen of the morning into a container which we will provide. A physician will draw about 25 milliliters of blood from your arm with a needle. This is about one fluid ounce. The risks of this procedure are the discomfort of the needle prick and possible bleeding from the needle prick site. If you have problems with bleeding and bruising, you should not have blood taken. A limited physical examination will be performed by a doctor, including an examination of your skin and your blood pressure. This examination will be performed at your home. The questionnaire and examination should take about 30 minutes to complete.

The head of the household will be asked further questions about the home by an environmental hygienist. Several samples will be collected in the home. These will be from 2 to 4 samples of air collected for eight hours, a number of samples collected by wiping surfaces of the home, and a drinking water sample. A number of small pieces of wood, less than 1/4" in diameter, will be taken from inconspicuous locations. The hygienist will show you in advance the sites from which these samples will be taken. No samples will be taken from parts of the house without your permission.

Benefits to you of this study include free environmental, blood and urine tests, and limited physical examination, which can be expensive if performed elsewhere. If there are abnormalities detected in your tests, we will inform you and discuss the resources available to you. Benefits to society include improved knowledge of the effects of long term contact with commonly used wood preservatives in homes.

Please indicate by your signature below that the research procedures described to you have been explained to you and that any questions that

you have asked have been answered to your satisfaction. You may ask now, or in the future, any questions that you have about the study. You are free to withdraw from the study at any time. If you do not join the study or if you decide to withdraw from it at any time, confidentiality of study records, reporting results from blood and urine tests, and the availability of resources to you will not be jeopardized.

In the event that you believe participation in this research study has led to injury, contact Edward A. Emmett, M.D. (principal investigator) at 301-338-3501, or the Office of the Committee on Human Volunteers of the Johns Hopkins University School of Hygiene and Public Health at 301-955-3795 to identify the resources which may be available to you and to assist you in obtaining appropriate medical care. You should understand that The Johns Hopkins University and the Federal Government do not have any program to provide compensation for persons who may experience injury while participating in research projects when the injury is not due to the fault of the investigators.

Date	Signature of Participant
Signature of Witness	Signature of Investigator

You have my permission for my child _____, age _____ also to participate in the study as outlined above. The nature of the study and requirements for participation as outlined above have been explained to him/her.

Date	Signature of Participant
Signature of Witness	Signature of Investigator

Evaluation of Clinical Field Methodologies
Study of Log Home Residents Exposed to Pentachlorophenol
Johns Hopkins School of Hygiene and Public Health
and
Midwest Research Institute

Authority to Give Medical Report

In addition to notifying me whether my tests are normal or need further study, I agree to allow the Johns Hopkins Center for Occupational and Environmental Health (COEH) to inform my personal physician of any significant results of this study.

Yes, inform my personal physician.

NAME (of personal physician)_____

ADDRESS _____

City _____

SIGNATURE _____

No, do not inform my personal physician. _____

INFOMATION OBTAINED IN THIS STUDY WILL BE KEPT CONFIDENTIAL.

APPENDIX III

ENVIRONMENTAL SAMPLING CONSENT FORM

Evaluation of Clinical Field Methodologies
Study of Log Home Residents Exposed to Pentachlorophenol
The Johns Hopkins School of Hygiene and Public Health
and
Midwest Research Institute

Attachment to Consent Form I for Head of Household

As the head of the household I understand that prior to the main part of the study I will be asked to complete a preliminary contact questionnaire asking about the home and its occupants which should take less than ten minutes to complete.

I understand that at the time of the study I will be asked further questions about my home by an environmental hygienist. These should take less than twenty minutes to answer. Several samples will be collected in my home. These will be from 2 to 4 samples of air collected for eight hours, a number of samples collected by wiping surfaces of the home, and a drinking water sample. A number of small pieces of wood, less than 1/4" in diameter, will be taken from inconspicuous locations. The hygienist will show me in advance the sites from which these samples will be taken. No samples will be taken from parts of the house without my permission.

I understand that all other considerations of the study including the voluntary nature and freedom to withdraw at any time apply to this part of the study.

Date	Signature of Participant
Signature of Witness	Signature of Investigator

APPENDIX IV

PHYSICAL EXAMINATION FORM

CLINICAL FIELD METHODOLOGIES

Medical Exam Form

Examiner _____

Date _____

Name _____

MEDICAL HISTORY

Present illnesses:

Past major illnesses:

Hospitalizations:

Operations:

Accidents:

Allergies (meds and others):

Family History:

CLINICAL FIELD METHODOLOGIES

Medical Exam Form

Examiner _____

Date _____

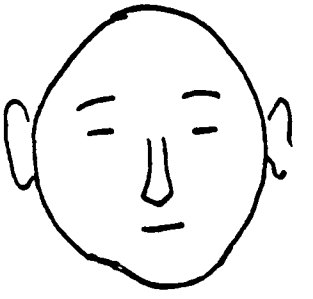
Name _____

PHYSICAL EXAMINATION

Vital Signs: P _____ reg _____ BP _____ R _____ Weight _____ Height _____

Skin: Facial Lesions

	Number of Lesions				
	0	1-5	5-10	10	Sites
a. Comedones					
b. Inflammatory Exam					
c. Pustules					
d. Cystic Acne					
e. Small Clear Cysts					



Lesions elsewhere: _____

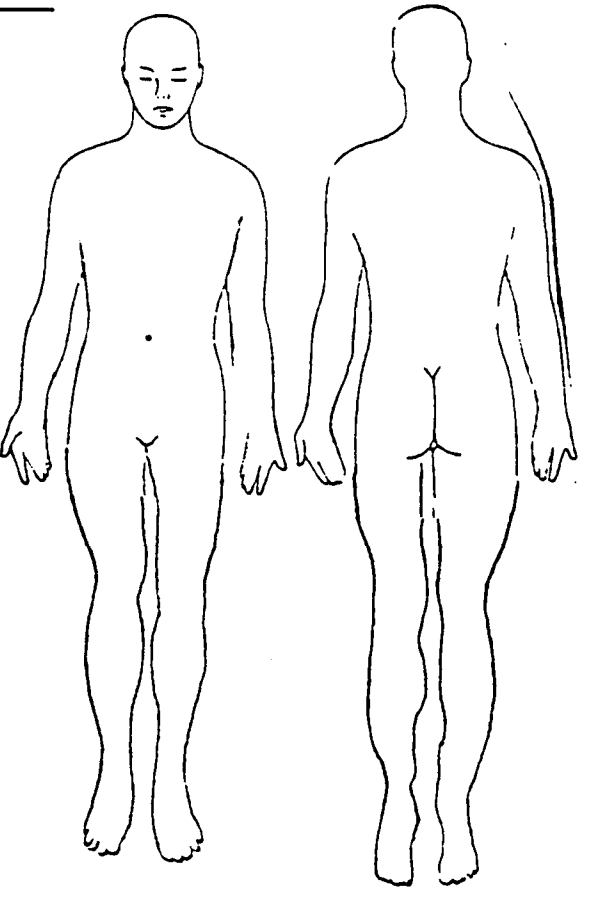
_____

Skin Exam: Normal Abnormal

If abnormal, state diagnoses: _____

_____

_____



HEENT:

Head: _____

Eyes: conjunctivitis:

refractive error:

pterygia:

cataract:

other: _____

Ears: _____

Nose: sinus tenderness

mucosa: nl red blue

Throat: nl red exudate

Other: _____

Chest: _____

Cor: _____

Abdomen: _____

Liver size _____ (cm, midclavicular line, quiet respiration)

Nodes: _____

Musculoskeletal: _____

_____

NAME_____

PHYSICIAN-EXAMINER_____

NEUROLOGICAL EXAMINATION

		Right		Left	
REFLEXES:	Knee	present	absent	present	absent
	Ankle	present	absent	present	absent
VIBRATION	Thumb	_____sec		_____sec	
(time in seconds for disappearance of sensation)					
	Big toe	_____sec		_____sec	

		Right: II	III	V	Left: II	III	V
PINPRICK (2-pt discrim: fingertip)		____ mm	____ mm	____ mm	____ mm	____ mm	____ mm
TINEL's	Right:	normal	abnormal		normal	abnormal	

		Right		Left	
MOTOR	Abd poll brevis (median)	normal	abnormal	normal	abnormal
	Adductors (ulnar)	normal	abnormal	normal	abnormal
	Abductors (ulnar)	normal	abnormal	normal	abnormal
	Dorsiflex foot	normal	abnormal	normal	abnormal
	Plantarflex foot	normal	abnormal	normal	abnormal

COMMENTS:

Neurological Physical Exam: Normal Abnormal

CLINICAL FIELD METHODOLOGIES

Medical Exam Form

Examiner _____

Date _____

Name _____

MEDICAL SUMMARY

Diagnoses and Comments	ICDA	ICDA Code
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Plan: _____

Immediate letter to MD needed? ____ Yes ____ No

Local physician's NAME _____

ADDRESS _____

_____

PHONE _____

Request lab records sent to family _____ physician _____

APPENDIX V

ENVIRONMENTAL QUESTIONNAIRE

THE JOHNS HOPKINS UNIVERSITY

WYMAN PARK HEALTH SYSTEM, INC.

CENTER FOR OCCUPATIONAL AND ENVIRONMENTAL HEALTH

3100 Wyman Park Drive, Bldg. 6
Baltimore, Maryland 21211-2895
(301) 338-3501

PCP Used as a Wood Preservative in Log Homes

ENVIRONMENTAL QUESTIONNAIRE

FACE SHEET

Revised 2/7/84

Interviewer _____ Person Interviewed _____ Date _____

Card # 0 1 (1-2)

House Study # _____

House # ___ (3-4)

Street Address _____

City & ZIP _____

Mailing Address _____

City & ZIP _____

Occupants:

Names	Study #	Occup #
_____	_____	___ (5-6)
_____	_____	___ (7-8)
_____	_____	___ (9-10)
_____	_____	___ (11-12)
_____	_____	___ (13-14)
_____	_____	___ (15-16)

My name is _____. I'm an industrial hygienist from _____ in _____. As you know, we will be collecting a number of environmental samples in your home today (tomorrow) as a part of our study of the health effects of PCP - pentachlorophenol - used as a wood preservative in certain log homes. I would like to ask you several questions about the history of your home which may help us to validate and interpret the results of our environmental sampling. Ready?

Card # 0 2 (1)
House # _ _ (3)

1. How many years have you and your family lived in this house? _____ years — _ _ (5)

2. Has anyone lived in this home prior to you and your family?
   (1) Yes ___ (2) No ___ (3) DK ___ — _ (7)

3. What year was this house built? _____ — 1 9 _ _ (8)

4. Who was the manufacturer of the logs used to build your house?
   _____

5. Where is the manufacturer located?
   _____

6. Who was the builder who assembled the pre-cut logs used to build your house?
   _____

7. Where is the builder located?
   _____

8. To the best of your knowledge, did the manufacturer of the logs used in building this house treat them with any type of wood preservative?

(1) Yes ___ (2) No ___ (3) DK ___ 10

IF NO OR DK SKIP TO #12

9. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____ 11

10. How was this preservative applied to the wood?

(1) pressure treated ___ (2) dipped ___

(3) brush ___ (4) roller ___ (5) spray ___

(6) other _____ (7) DK ___ 13

11. What parts of the house were treated with this preservative?

(1) logs ___ (2) beams ___ (3) posts ___

(4) roof ___ (5) floor ___ (6) other _____ 14

(7) DK ___ 17

12. At the time of construction was a preservative treatment applied to any part of this house?

(1) Yes ___ (2) No ___ (3) DK ___ 20

IF NO OR DK SKIP TO #17

13. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ 21 __

14. Who applied this preservative?

(1) builder ___ (2) previous owner ___

(3) self or family member ___ (4) DK ___ 23 _

15. How was this preservative applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ 24 _

16. What parts of the house were treated with this preservative?

(1) interior walls ___ (2) exterior walls ___

(3) interior roof ___ (4) exterior roof ___

(5) floor ___ (6) beams ___ (7) posts ___ 25 __

(8) other _____ (9) DK ___ 28 __

17. Has the any part of the house been treated with a preservative at any time after original construction and since 1980?

(1) Yes ___ (2) No ___ (3) DK ___ 31 _

IF NO OR DK SKIP TO #34

18. How many times has the house been retreated? ___ 32 _

Starting from the most recent treatment and working backwards in time, please tell me the following information about each treatment:

For the most recent retreatment:

19. What year was the house retreated? _____ 1 9 __ (33) __

20. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ __ __ (35)

21. Who applied this preservative?

(1) contractor ___ (2) previous owner ___

(3) self or family member ___ (4) DK ___ (37)

22. How was this preservative applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ (38)

23. What parts of the house were treated with this preservative?

(1) interior walls ___ (2) exterior walls ___

(3) interior roof ___ (4) exterior roof ___

(5) floor ___ (6) beams ___ (7) other _____ (39) __ __

(8) DK ___ (42) __ __

IF ONLY TIME RETREATED SKIP TO #34

For the retreatment immediately preceding the one we just discussed:

24. What year was the house retreated? _____ 1 9 __ (45) __

25. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ __ (47) __

26. Who applied this preservative?

(1) contractor ___ (2) previous owner ___

(3) self or family member ___ (4) DK ___ (49)

27. How was this preservative applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ (50)

28. What parts of the house were treated with this preservative?

(1) interior walls ___ (2) exterior walls ___

(3) interior roof ___ (4) exterior roof ___

(5) floor ___ (6) beams ___ (7) other _____ (51) __ __

(8) DK ___ (54) __ __

IF NO PREVIOUS RETREATMENTS SKIP TO #34

For the retreatment immediately preceding the one we just discussed:

29. What year was the house retreated? _____ 1 9 __ 57

30. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ __ 59

31. Who applied this preservative?

(1) contractor ___ (2) previous owner ___

(3) self or family member ___ (4) DK ___ 61

32. How was this preservative applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ 62

33. What parts of the house were treated with this preservative?

(1) interior walls ___ (2) exterior walls ___

(3) interior roof ___ (4) exterior roof ___

(5) floor ___ (6) beams ___ (7) other _____

(8) DK ___ 63 64

Card # 03

House # __ 3

34. Has any part of the interior of this house ever been sealed with a sealer such as polyurethane, paint, varnish or any other material?

(1) Yes ___ (2) No ___ (3) DK ___ 5

IF NO OR DK SKIP TO #40

35. What year was the house sealed? _____ 1 9 __ (6)

36. What sealer was used?

Name _____

Manufacturer _____

Address _____

Type _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ (8)

37. Who applied this sealer?

(1) contractor ___ (2) previous owner ___

(3) self or family member ___ (4) DK ___ (10)

38. How was this sealer applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ (11)

39. What parts of the house were treated with this sealer?

(1) interior walls ___ (2) exterior walls ___

(3) interior roof ___ (4) exterior roof ___

(5) floor ___ (6) beams ___ (7) other _____ (12) (13) (14)

(8) DK ___ (15) (16) (17)

40. Have there been any other uses of wood preservatives such as for fence posts, decks, additions to the house, etc. since the house was originally built?

(1) Yes ___ (2) No ___ (3) DK ___ (18)

IF NO OR DK SKIP TO #46

41. What was treated with a preservative?

(1) deck ___ (2) fence ___ (3) other _____ 19 ___

42. What year was this done? _____ 1 9 ___ 22

43. What preservative was used?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____ 24

44. Who applied this preservative?

(1) manufacturer ___ (2) contractor ___

(3) previous owner ___ (4) self or family member ___ (5) DK ___ 26

45. How was this preservative applied to the wood?

(1) dipped ___ (2) brush ___ (3) roller ___

(4) spray ___ (5) other _____ (6) DK ___ 27

46. Does this house have double glazed or storm windows?

(1) Yes ___ (2) No ___ (3) DK ___ 28

IF NO OR DK SKIP TO #49

47. What type of windows are used?

(1) aluminum storm ___ (2) wooden storm ___

(3) double glazed ___ (4) other _____ 29

48. What year were these windows installed? _____ 1 9 ___ 30

That completes the questions about the house itself. Now I have several other questions to ask you about personal living patterns and various features of your home that may help us to explain unusual environmental or medical findings, if there are any.

49. Do any of the residents of this home currently smoke any tobacco products?

(1) Yes ___ (2) No ___ (3) DK ___ 32

IF NO OR DK SKIP TO #54

50. How many persons smoke tobacco products? _____ 33 —

51. How many total cigarettes are smoked per day in this house? _____ 35 —

52. How many total pipes are smoked per day in this house? _____ 37 —

53. How many total cigars are smoked per day in this house? _____ 39 —

54. Does this house have a central heating unit other than solar?

(1) Yes ___ (2) No ___ (3) DK ___ 41

IF NO OR DK SKIP TO #58

55. What fuel is used in the central heating unit?

(1) natural gas ___ (2) LPG ___ (3) coal ___
(4) oil ___ (5) wood ___ (6) electric ___
(7) other _____ (8) DK ___ 42

56. How is the heat transmitted to the individual rooms?

(1) hot water or steam radiators or baseboard ___

(2) forced hot air ___ (3) natural draft ___

(4) radiant ___ (5) other _____ (6) DK ___ 43

57. How many hours has it been since the central heating unit was last used?

(1) 0-1 hour ___ (2) 1-6 hours ___

(3) 6-12 hours ___ (4) 12-24 hours ___

(5) 24+ hours ___ 44

58. Does this house have any stoves used only for heat?

(1) Yes ___ (2) No ___ (3) DK ___ 45

IF NO OR DK SKIP TO #61

59. What fuels are used in these heating stoves?

(1) wood ___ (2) coal ___ (3) other _____ 46

60. How many hours has it been since any heating stove was last used?

(1) 0-1 hour ___ (2) 1-6 hours ___

(3) 6-12 hours ___ (4) 12-24 hours ___

(5) 24+ hours ___ 47

61. Does this house have a ceiling fan to circulate the air in the house?

(1) Yes ___ (2) No ___ (3) DK ___ 48

62. Does this house have any fireplaces?

(1) Yes ___ (2) No ___ (3) DK ___ 49

IF NO OR DK SKIP TO #66

63. How many fireplaces are in this house? _____ 50

64. What fuels are used in these fireplaces?

(1) wood ___ (2) natural gas ___

(3) coal ___ (4) DK ___ 51

65. How many hours has it been since any fireplace was last used?

(1) 0-1 hour ___ (2) 1-6 hours ___

(3) 6-12 hours ___ (4) 12-24 hours ___

(5) 24+ hours ___ 52

66. Do you ever use space heaters, including individually controlled electric baseboard units, in this house?

(1) Yes ___ (2) No ___ (3) DK ___ 53

IF NO OR DK SKIP TO #69

67. How many of each type space heater is used?

(1) natural gas ___ 54

(2) LPG ___ 55

(3) coal ___ 56

(4) oil ___ 57

(5) kerosene ___ 58

(6) electric ___ 59

(7) DK ___ 60

68. How many hours has it been since any space heating unit was last used?

(1) 0-1 hour ___ (2) 1-6 hours ___

(3) 6-12 hours ___ (4) 12-24 hours ___

(5) 24+ hours ___ 61

69. Does this house have a stove/oven used only for cooking?

(1) Yes ___ (2) No ___ (3) DK ___ 62

IF NO OR DK SKIP TO #72

70. What fuel is used in this cooking stove/oven?

(1) electric ___ (2) wood ___ (3) LPG ___

(4) natural gas ___ (5) microwave ___

(6) coal ___ (7) other _____ (8) DK ___ 63

71. How many hours has it been since the cooking oven/stove was last used?

(1) 0-1 hour ___ (2) 1-6 hours ___

(3) 6-12 hours ___ (4) 12-24 hours ___

(5) 24+ hours ___ 65

72. Does this house have a hot water heater?

(1) Yes ___ (2) No ___ (3) DK ___ 66

IF NO OR DK SKIP TO #74

73. What fuel is used in this hot water heater?

(1) gas ___ (2) oil ___ (3) LPG ___

(4) electric ___ (5) solar ___ (6) DK ___ 67

74. What is the source of drinking water for this house?

(1) city water from any source ___

(2) own well on property ___ (3) DK ___ 68

IF CITY WATER OR DK SKIP TO #80

75. What is the depth of your well? _____ feet 69 — —

76. How far is your well from your house? _____ feet

77. How far is your well from the nearest garden from which your family eats food?

_____ feet

78. Is your well water treated through the use of a conditioning system (such as a Culligan system) which serves the entire house?

(1) Yes ___ (2) No ___ (3) DK ___

79. Is your well water purified through the use of traps or filters (such as a Waterpik system) which are attached to individual faucets in the house?

(1) Yes ___ (2) No ___ (3) DK ___

Card # 0 4

House # ___

80. Has urea formaldehyde foam insulation been used to insulate any part of this house?

(1) Yes ___ (2) No ___ (3) DK ___

IF NO OR DK SKIP TO #83

81. What year was it installed? _____

82. What parts of the house are insulated with this urea formaldehyde foam insulation?

(1) walls ___ (2) floor ___ (3) roof ___

(4) ceiling ___ (5) other ___ (6) DK ___

83. In the past three years, have you used any pesticides or insecticides <u>inside</u> this house?

(1) Yes ___ (2) No ___ (3) DK ___ 9

IF NO OR DK SKIP TO #92

I have several questions about the three pesticides most frequently used <u>inside</u> your home.

84. What pesticide/insecticide do you use most frequently inside your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____ 10

85. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___ 12

86. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___ 13

IF ONLY PESTICIDE/INSECTICIDE USED SKIP TO #92

87. What pesticide/insecticide do you use second most frequently <u>inside</u> your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ 14 __

88. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___ 16 __

85. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___ 17 __

IF NO OTHER PESTICIDE/INSECTICIDE USED SKIP TO #92

89. What pesticide/insecticide do you use third most frequently <u>inside</u> your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

→ Percent PCP _____ 18 __

90. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___

20

91. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___

21

92. In the past three years, have you used any pesticides or insecticides outside of this house, for instance in a garden or on the lawn?

(1) Yes ___ (2) No ___ (3) DK ___

22

IF NO OR DK SKIP TO #102

I have several questions to ask you about the three pesticides most frequently used outside your home.

93. What pesticide/insecticide do you use most frequently outside of your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____

23

94. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___

25

95. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___

26

IF ONLY PESTICIDE/INSECTICIDE USED OUTSIDE HOME SKIP TO #102

96. What pesticide/insecticide do you use second most frequently outside of your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____

27 28

97. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___

29

98. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___

90

IF NO OTHER PESTICIDE/INSECTICIDE USED OUTSIDE THE HOME SKIP TO #102

99. What pesticide/insecticide do you use third most frequently outside of your home?

Name _____

Manufacturer _____

Address _____

QUESTION TO BE COMPLETED AFTER INTERVIEW BY INSPECTING LABEL OR CONTACTING MANUFACTURER

Percent PCP _____

91

100. Which of the following words best describes the frequency of use of this pesticide/insecticide?

(1) daily ___ (2) weekly ___ (3) monthly ___

(4) bi-monthly ___ (5) quarterly ___

(6) semi-annually ___ (7) annually ___

(8) DK ___

93

101. How long has it been since last used?

(1) 1 day ___ (2) 1 week ___ (3) 1 month ___

(4) 3 months ___ (5) 6 months ___

(6) 1 year ___ (7) DK ___

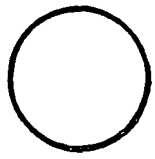
94

Thank you. That concludes the questionnaire. Now all I have to do is (1) take a look at cans of preservative or sealer to find PCP content and (2) sketch floorplans and sample locations.

STOP

102. Provide Sketch of Floor Plan

FIRST (GROUND) FLOOR



Indicate North

Show dimensions, doors, windows, and treated/sealed areas.

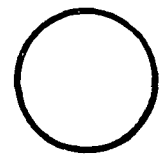
Indicate additions to house since 1980.

Indicate sampling locations using following symbols:

A = air C = wood core S = surface wipe (exposure only) W = water

103. Provide Sketch of Floor Plan

SECOND FLOOR



Indicate North

Show dimensions, doors, windows, and treated/sealed areas.

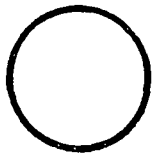
Indicate additions to house since 1980.

Indicate sampling locations using the following symbols:

A = air C = wood core S = surface wipe (exposure only) W = water

104. Provide Sketch of Floor Plan

THIRD FLOOR



Indicate North

Show dimensions, doors, windows, and treated/sealed areas.

Indicate additions to house since 1980.

Indicate sampling locations using the following symbols:

A = air C = wood core S = surface wipe (exposure only) W = water

APPENDIX VI

MEDICAL QUESTIONNAIRE

PCP Used as a Wood Preservative in Log Homes

WOOD PRESERVATIVE QUESTIONNAIRE

FACE SHEET

Interviewer _____ Date _____

Person Interviewed _____

House Study # _____ Resident # _____ _ _ _ _

Street Address _____

City & ZIP _____

Mailing Address _____

City & ZIP _____

Area Code & Telephone # _____

Note: Study participants 16 years of age and over will be administered this questionnaire. For study participants less than 16, a parent will be asked the following questions about the child:

Demographic Information (questions: face sheet - 5)

Leisure Activity Information (questions: 14-21)

Health Information (questions: 22-30)

Coding instructions: Before coding mark individual number in the upper right corner of each page of questionnaire.

Card # ___ ___ (1)

Individual # ___ ___ ___ ___ (3)

1. Date of birth ___ ___ ___ (7)
   M D Y (11)

2. Sex: (1)male ____ (2)female ____ (13)

3. Marital status
   (1)married ____ (2)widowed ____
   (3)separated ____ (4)cohabitating____
   (5)never married____ (14)

4. Do you consider yourself: (1)white ____ (2) Black ____
   (3)Asian ____ (4)Hispanic ____
   (5)American Indian ____
   (6)other (specify) _____ (15)

5. What was the last year of school you completed? ____ (16)
   (e.g. 12 years is completion of high school)

> Participants 16 years or younger skip to #14

TOBACCO SMOKING INFORMATION (ATS-DLD-78-A)

6A. Have you ever smoked cigarettes? (18)
(No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette per day for one year.) (1)YES____ (2)NO____
(8)Does not apply ____

> IF NO SKIP TO #7

Individual # _____

B. Do you now smoke cigarettes (as of one month ago)? 19
(A current smoker is a person who was a regular smoker up to one month ago.) (1)YES _____ (2)NO _____
(8)Does not apply _____

C. How old were you when you first started regular cigarette smoking? Age in years _____ (8)Does not apply _____ 20

D. is asked only if respondent answered "no" to B.

D. If you have stopped smoking completely, how old were you when you stopped? Age stopped _____ 22
(77)check if still smoking _____ (88)Does not apply _____

E. How many cigarettes do you smoke per day now? 24
cigarettes per day _____ (88)Does not apply _____

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day? 26
cigarettes per day _____ (88)Does not apply _____

G. Do or did you inhale the cigarette smoke? 28
(1)never smoked _____ (2)not at all _____
(3)slightly _____ (4)moderately _____ (5)deeply _____

I. During all the time you have smoked cigarettes, would you say you smoked filter tips: 29
(0)never _____ (1)less than half the time _____
(2)about half the time _____
(3)more than half the time _____
(4)always _____ (8) Does not apply _____

Individual # _____

7A. Have you ever smoked a pipe regularly? (Yes means more than 12 oz. of tobacco in a lifetime.) 30
(1)YES ____ (2)NO ____ (8) Does not apply ____

IF NO SKIP TO #8

B1. How old were you when you started to smoke a pipe regularly? Age in years _____ 31-32
(88)Does not apply ____

2. If you have stopped smoking a pipe completely, how old were you when you stopped? Age stopped _____ 33-34
(77)check if still smoking a pipe ____(even if occasionally)
(88)Does not apply ____

C. On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week? 35-36
oz. per week _____ (a standard pouch of tobacco contains 1.5 oz.)
(88)Does not apply ____

D. How much pipe tobacco are you smoking now? 37-38
oz. per week _____
(88)not currently smoking a pipe, does not apply ____

E. Do you or did you inhale the pipe smoke? 39
(1)never smoked ____ (2)not at all ____
(3)slightly ____ (4)moderately____ (5)deeply ____

8A. Have you ever smoked cigars regularly? (Yes means more than one cigar per week for a year.) 40
(1)YES ____ (2)NO ____ (8) Does not apply ____

Individual # _____

IF NO SKIP TO #F

B1. How old were you when you started smoking cigars regularly? Age in years_____ 41

2. If you have stopped smoking cigars completely, how old were you when you stopped? Age when stopped _____ 43
(77)check if still smoking cigars _____
(88)Does not apply _____

C. On the average, over the entire time you smoked cigars, how many cigars did you smoke per week? 46
cigars per week _____
(88)Does not apply _____

D. How many cigars are you smoking per week now? 47
cigars per week _____
(88)Not currently smoking cigars, does not apply _____

E. Do or did you inhale the cigar smoke? 49
1)never smoked _____ (2)not at all _____
(3)slightly _____ (4)moderately _____ (5)deeply _____

F. Have you ever chewed tobacco regularly? 50
(1)YES _____ (2)NO _____ (8) Does not apply _____

G. Have you ever used snuff regularly? 51
(1)YES _____ (2)NO _____ (8) Does not apply _____

H. Have you ever smoked nontobacco products regularly? 52
(1)YES _____ (2)NO _____ (8) Does not apply _____

Individual # _____

DRINKING INFORMATION

9A. Have you ever drunk beer, wine, or liquor? (No means less than one case of beer or six bottles of wine or two bottles of liquor in a lifetime.) 53
(1)YES ____ (2)NO ____ (8) Does not apply ____

IF NO SKIP TO #10

B1. Do you now drink, even if occasionally? (No means less than one glass of beer or wine or less than one ounce of liquor per month.) (1)YES ____ 54
(2)NO ____ (8)Does not apply ____

B2. How old were you when you started drinking? 55 56
Age in years ____ (88) Does not apply ____

B3. If you stopped drinking, how old were you when you stopped? Age stopped ____ 57 58
(77) check if still drinking ____
(88)Does not apply ____

C. On the average over the entire time you have drunk alcoholic beverages, how many drinks did you have per week? 59 60
1. glasses of beer (12 oz. per glass, can, or bottle) ____
2. glasses of wine (4 oz. per glass) ____
3. drinks (hard liquor, 1 oz. per drink) ____
(88) Does not apply ____

D. Did you ever drink more heavily than you do now? 61
(1)YES ____ (2)NO ____ (8)Does not apply ____

Individual # _____

E1. Did you have anything containing alcohol to drink in the last 12 hours? 62

(1)YES ____ (2)NO ____ (8)Does not apply ____

IF NO SKIP TO #10

E2. If yes, what and how much? 63

a. glasses of beer _____

b. glasses of wine _____

c. drinks (oz. of liquor) _____

(00) if E1. is answered "No"

(88) Does not apply _____

OCCUPATIONAL INFORMATION

10A. Are you currently employed outside your home either full-time, part-time or as a volunteer? 65

(1)YES ____ (2)NO ____

(3)check if housewife or has office in home as primary place of business _____

IF NO SKIP TO #12

B. If yes, where (name of company & address)?

_____

_____

_____

C. When did you begin working at this position? 66

_____ 19___

Individual # _____

D. What is your job title?_____

E. What do you do there?_____

F. What sort of materials do you come in contact with there? _____

G. How are you in contact with them? 70

(0)does not apply or no contact _____

(1)skin _____ (2)air _____ (4)ingestion _____

(8)individual less than 16 years, or not employed outside home, does not apply _____

11A. Have you been employed in your present position less than six months? 71

(1)YES _____ (2)NO _____ (8)DOES NOT APPLY _____

IF NO SKIP TO #12

B. Where were you previously employed? _____

C. When did you begin working at this position?_____ 72 _ _ _ _

_____ 19____ [(8888) if 11A. answered "No"]

D. What was your job title? _____

E. What did you do there? _____

F. What sort of materials did you come in contact with there? _____

G. How were you in contact with them? 76
(0) does not apply or no contact ____
(1)skin ____ (2)air ____ (4)ingestion ____
(8)individual 16 years or less or not employed outside the home, does not apply____

12A. In addition to this position, do you work part-time or as a volunteer? (1)YES ____ (2)NO ____ 77
(8)Does not apply ____

IF NO SKIP TO # 13

Card # 1 — —

Individual # 3 — — — —

B. If YES, where (name of company, address)?

C. When did you begin working at this position? 7 — — — —
____ 19____ [(8888)if 12A. answered "No"]

D. What is your job title?_____

Individual # _____

E. What do you do there? (general job activities)

_____

_____

_____

F. What sort of materials do you come in contact with there? _____

_____

_____

G. How are you in contact with them? 11

(0)does not apply or no contact ____

(1)skin ____ (2)air ____ (4)ingestion ____

(8)individual less than 16 years, or not employed outside home, does not apply ____

13. Have you ever been employed part-time, full-time or as a volunteer in a position where you came in contact with any of the following:

A. Wood preservatives? (1)YES ____ (2)NO ____ 12

(8)Does not apply ____

IF NO SKIP TO #13B

A1. When did you work in this position? 13 ___ ___ ___

____19 ____ to ____ 19____ 17 ___ ___ ___

(8888)if 13A answered "No"

A2. How did you come in contact with the chemical? 21

(0)does not apply or no contact

(1)skin ____ (2)air ____ (4)ingestion ____

(8)individual less than 16 years or not employed outside home, does not apply ____

Individual # _____

13B. Pesticides? (1)YES _____ (2)NO _____ 22
(8)Does not apply _____

IF NO SKIP TO #14

B1. When did you work in this position? 23 — — — —
_____ 19____ to _____ 19____ 27 — — — —
(8888)if 13B answered "No"

B2. How did you come in contact with the chemical? 31
(0)does not apply or no contact _____
(1)skin _____ (2)air _____ (4)ingestion _____
(8)individual less than 16 years, does not apply _____

LEISURE ACTIVITY INFORMATION

14A. Do you have any hobbies which bring you in contact with wood preservatives or pesticides? 32
(1)YES _____ (2)NO _____

IF NO SKIP TO #15

B. If yes, what are the hobbies?_____

C. What are the wood preservatives or pesticides?_____

Individual # _____

15A. Have you sprayed or applied any pesticides or bug killer (such as RAID) to your home within the past three weeks? (1)YES ____ (2)NO____ 33

IF NO SKIP TO # 16

B. If yes, type of pesticide sprayed or applied? _____

_____

16A. Do you garden? (1)YES ____ (2)NO ____ 34

IF NO SKIP TO #22

B. In 1983, did you use any pesticides in your garden? 35
(1)YES ____ (2)NO ____ (9)DK ____
(8)Does not apply____

C. In 1982, did you use any pesticides in your garden? 36
(1)YES ____ (2)NO ____ (9)DK ____
(8)Does not apply ____

IF NO SKIP TO #22

IF YES FOR EITHER 1982 or 1983 ASK:

17A. Which pesticide did you use most often?
second most often? third most often?
(Record in column A below)

FOR EACH PESTICIDE NAMED ASK:

B. How often during a single year do you apply this pesticide? (Record in column B below)

C. When was the last time you used (name the pesticide)?
(Specify month and year, record in column C below)

Individual # _____

	A. name of pesticide	B. # applications	C. last used
MOST OFTEN			
2nd MOST			
3rd MOST			

18A. In addition to the pesticides you just mentioned, have you applied any others? (1)YES _____ (2)NO _____ (8)Does not apply _____ 37

IF NO SKIP TO #19

B. What were they? (Record in column B below.)

C. How often did you apply (name of pesticide)? (Record in column C below.)

D. When was the last time you used (name of pesticide)? (Specify month and year, record in column D below.)

B. Name of Pesticide	C. # of Applications	D. Last Used

19A. Do you eat what you grow in your garden? (1)YES _____ (2)NO _____ (8)Does not apply _____ 38

Individual # _____

IF NO SKIP TO #20

B. What do you grow in your garden that you eat? (Record in column B below.)

C. How many (name) plants do you put in? (Record in column C below.)

D. How often do you eat (name) from your garden? (Record in column D below.)

E. How much (name) that you grow do you eat canned? Number of pounds. (Record in column E below.)

B. NAME	C. # PLANTS	D. OFTEN EATEN	E. CANNED

20. How far is the garden from the house? (distance in yards) _____ 39

21. What is the primary source of water for your garden? 42
(1)well water _____ (2)public water supply _____
(3)pond on property _____ (4)rainfall _____
(5)other (specify) _____
(8)does not apply _____

Individual # _____

HEALTH INFORMATION

22. Have you ever had or ever been diagnosed by a doctor as having any of the following (place an x in appropriate column):

	(1)YES	(2)NO	(9)DK	
A. hepatitis				45
B. liver cirrhosis				47
C. jaundice				48
D. any liver disease				49
E. cancer				47
F. eczema				48
G. acne				49
H. psoriasis				50
I. tumor or lump removed from your skin				51

23A. Are you currently taking any pills or medication? This includes vitamins, birth control pills, diet pills, and aspirin. (1)YES ____ (2)NO ____ 52

IF NO SKIP TO #24

B. If yes, what pills or medications are you taking? (Record in column B below.)

C. How often do you take (name)? (Record in column C below.)

D. When did you last take (name)? (Record in column D below.)

Individual # _____

B. NAME OF PILL/MED	C. HOW OFTEN	D. LAST TAKEN

24A. Have you had any type of skin rash or dermatitis within the last year? 53

(1)YES _____ (2)NO _____ (9)DK _____

IF NO OR DK SKIP TO #25

B. If yes, please describe the type, how long it lasted, if you saw a doctor for it, what treatment did you receive if any?

_____

_____

_____

C1. Have you had any other skin rash or dermatitis within the last year? 54

(1)YES _____ (2)NO _____ (9)DK _____

Enter "No" if 24A. is "No"

IF NO SKIP TO #25

Individual # _____

C2. If yes, please describe the type, how long it lasted, etc., if different from previous incidence. _____

25A. Have you had any type of fever within the last six months? (1)YES ____ (2)NO ____ (9)DK ____ 55

IF NO OR DK SKIP TO #26

B. If yes, please describe how long it lasted, if you saw a doctor for it, if you had any treatment prescribed.

C1. Have you had any other occurrence of fever in the last six months? (1)YES ____ (2)NO ____ (9)DK ____ 56
Enter "No" if 25A. is "No"

IF NO SKIP TO #26

C2. If yes, please describe how long it lasted, etc., if different from above. _____

Individual # _____

26. Do you or did you ever have any of the following (place an x in the appropriate column):

	NOW (1)	BEFORE IN HOME (2)	LIVING IN HOME (3)	NEVER (4)	
A. eye irritation					57
B. increased tearing or discharge					58
C. swelling of eyelids					59
D. acne					60

27A. In the past 6 months, have you experienced any sudden unexplained loss of weight totally 5 pounds or more?
(1)YES ____ (2)NO ____ (9)DK ____ 61

B. If yes, have you been dieting to lose this weight?
(1)YES ____ (2)NO ____ (8) Does not apply ____ 62
(9) DK ____

28. ADULT FEMALES ONLY:
A. How many pregnancies have you had? _____ 63
B. How many live births? _____ 64
C.1. Have you experienced any miscarriages or spontaneous abortions? (1)YES ____ (2)NO ____ 65
(8) Does not apply ____ (9) DK ____
IF YES,
2. How many? _____ 66
3. When did they occur?
____ 19____ ____ 19____
____ 19____ ____ 19____

All other individuals question does not apply; all blanks enter "8"

Individual # _____

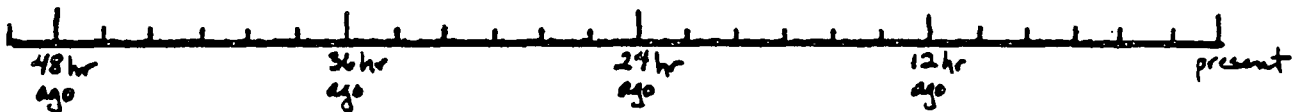
29A. Do you have any health problems that these questions have not covered? (1)YES ____ (2)NO ____ (9)DK____ 67

IF NO OR DK SKIP TO # 30

B. If yes, please tell me about it:_____

30. To help give us an idea of how much time you spend in your home we would like to complete a time line as a record of your coming and going from the house. Starting two days ago, were you at home, outdoors, or at work and away from home? (A parent will answer for each child under 16 years of age.)

Time: _____



Add the number of hours spent in the house and enter to nearest half-hour.

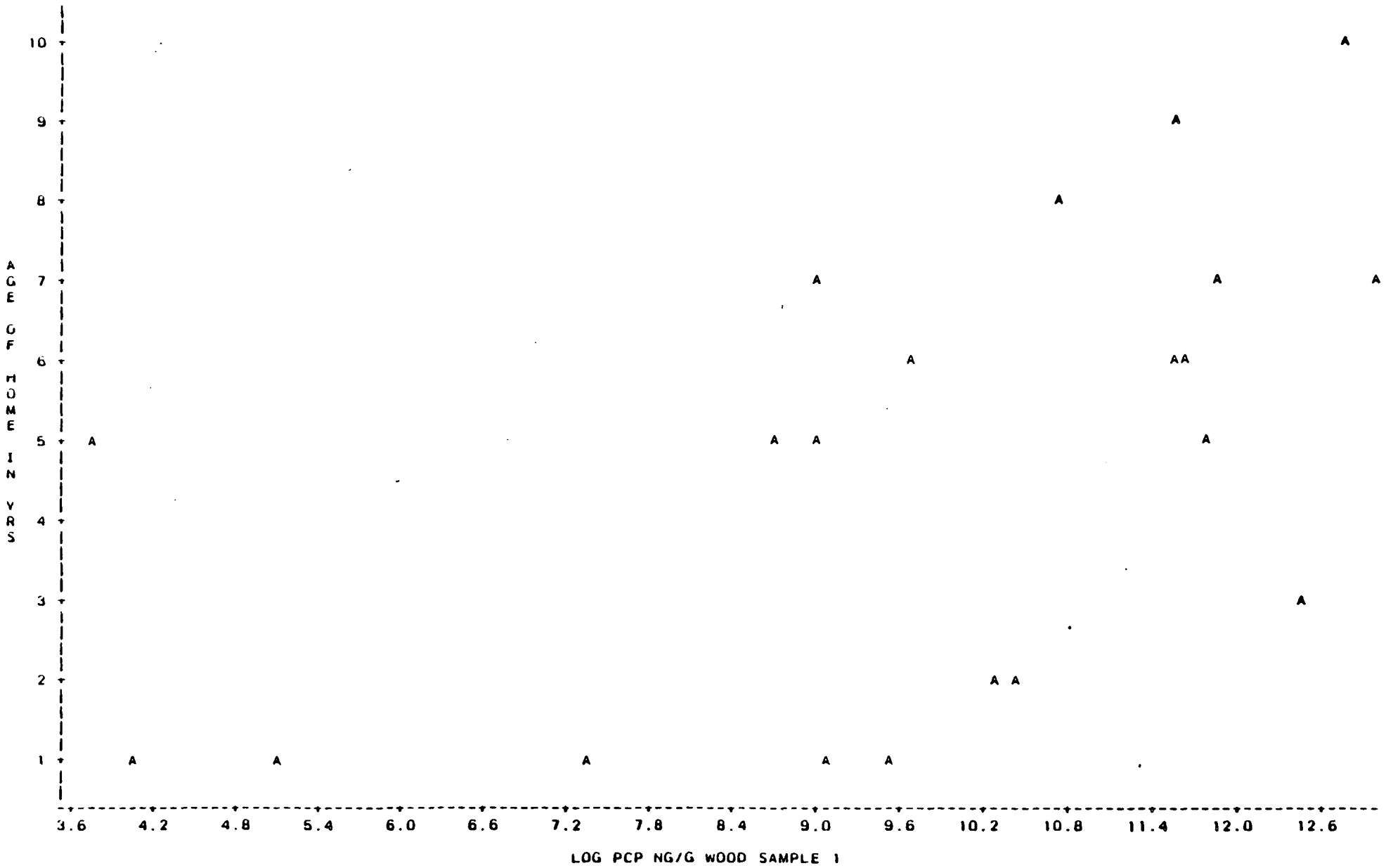
68 __ . __

APPENDIX VII

PLOTS OF HOUSE DEMOGRAPHICS AND WOOD CORE PCP CONCENTRATION

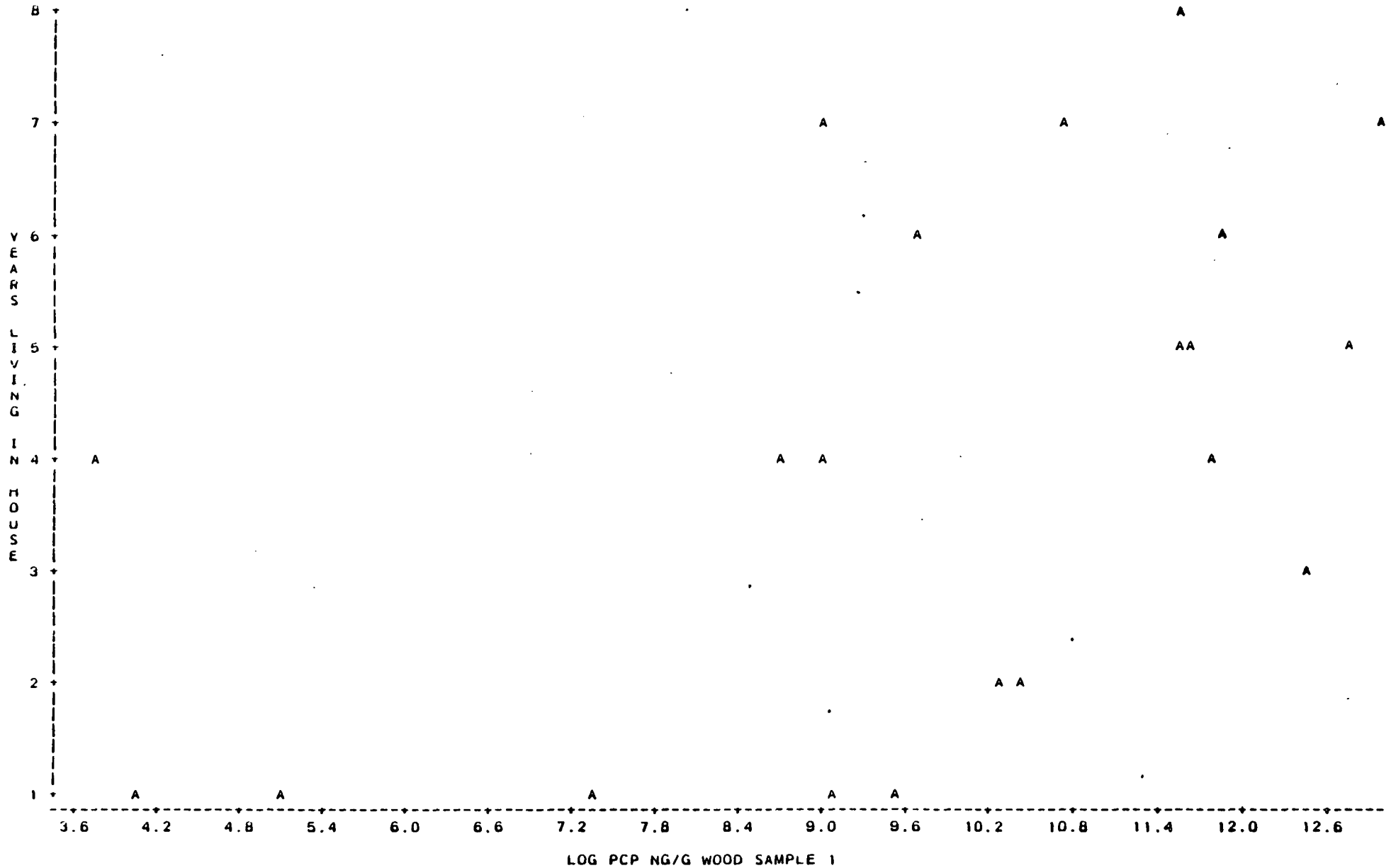
PLOTS OF HOUSE DEMOGRAPHIC VS. WOOD CORE PCP CONCENTRATION

PLOT OF AGEHOME*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.



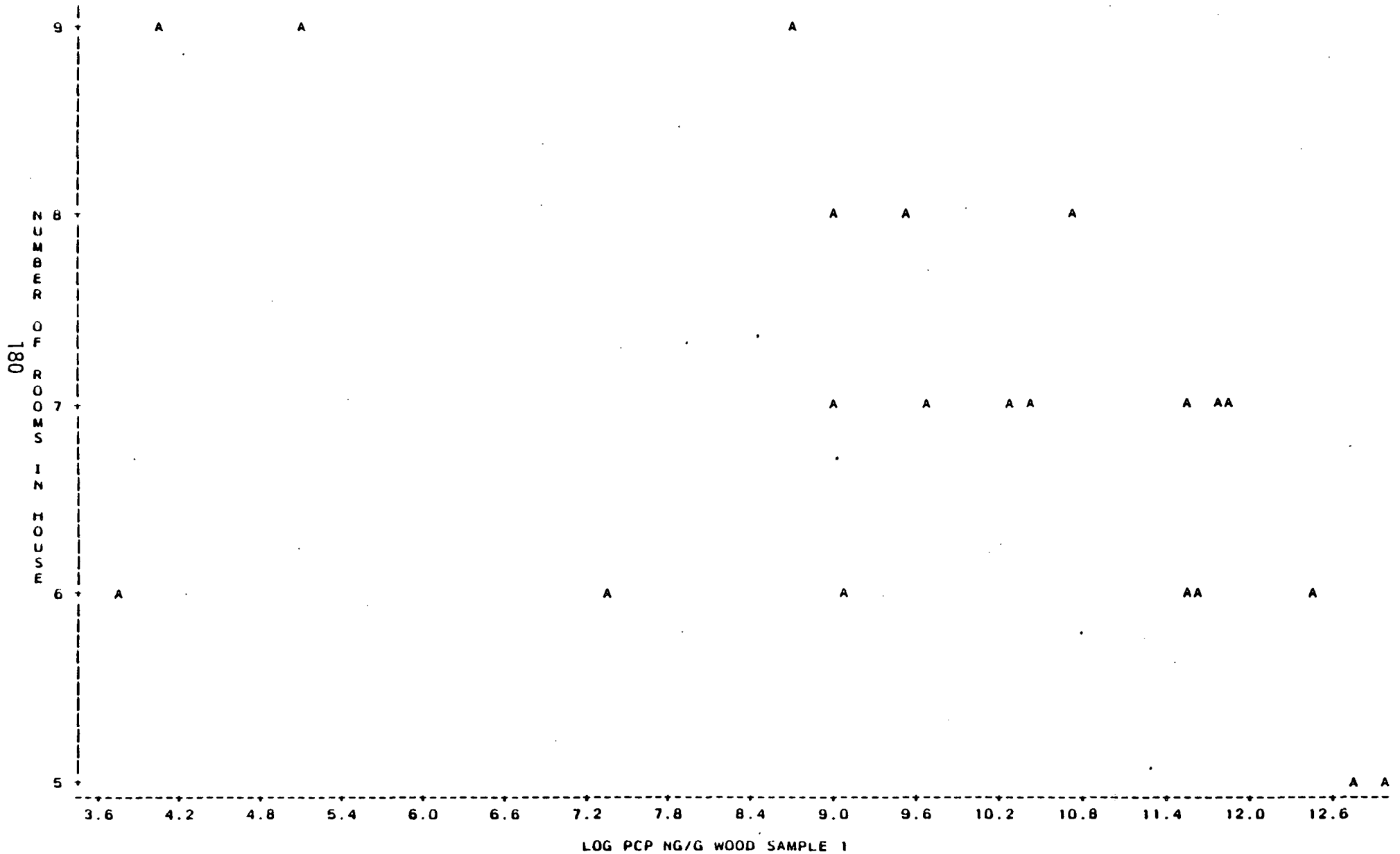
PLOTS OF HOUSE DEMOGRAPHIC VS. WOOD CORE PCP CONCENTRATION

PLOT OF X3*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.



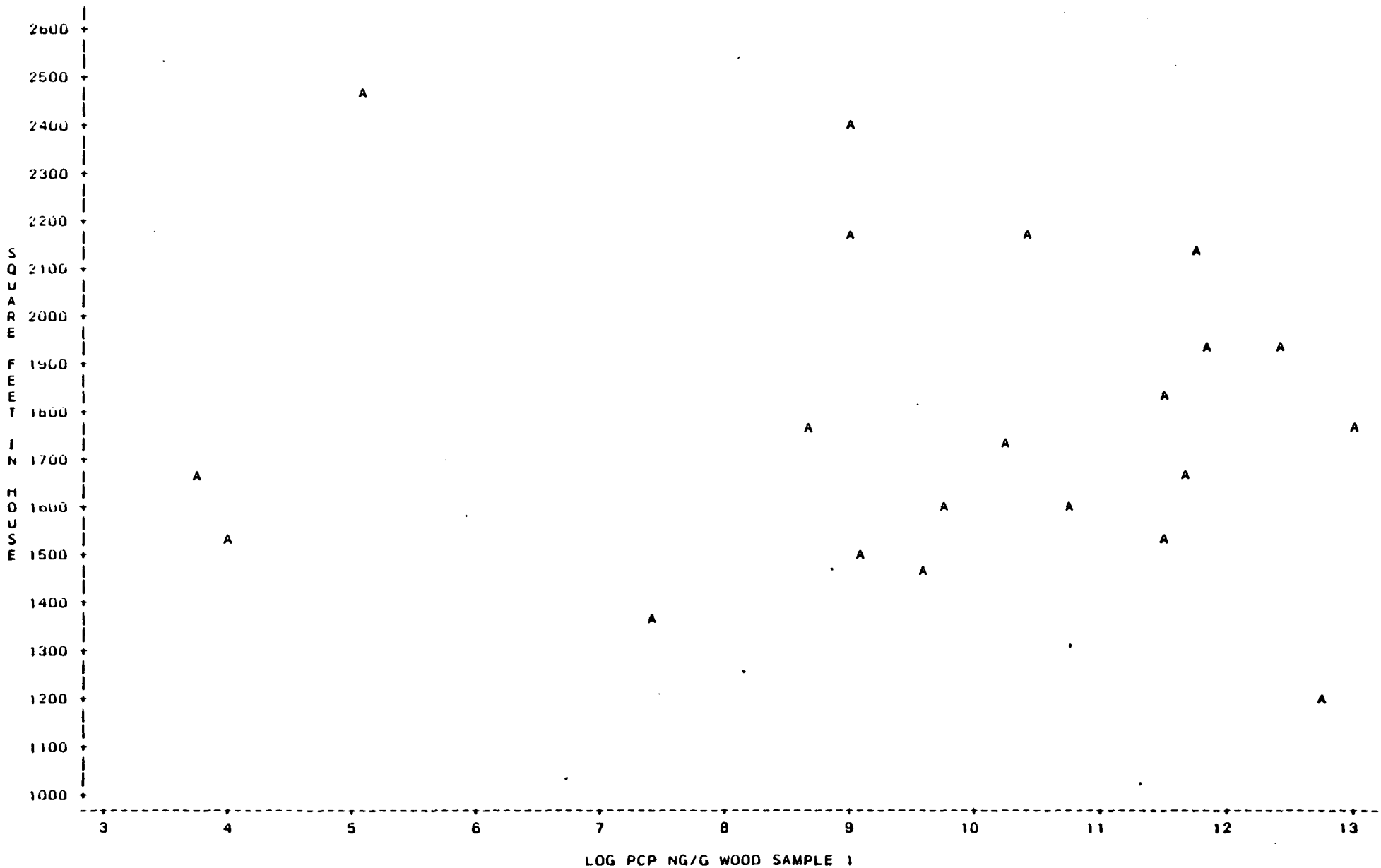
PLOTS OF HOUSE DEMOGRAPHIC VS. WOOD CORE PCP CONCENTRATION

PLOT OF X156*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.



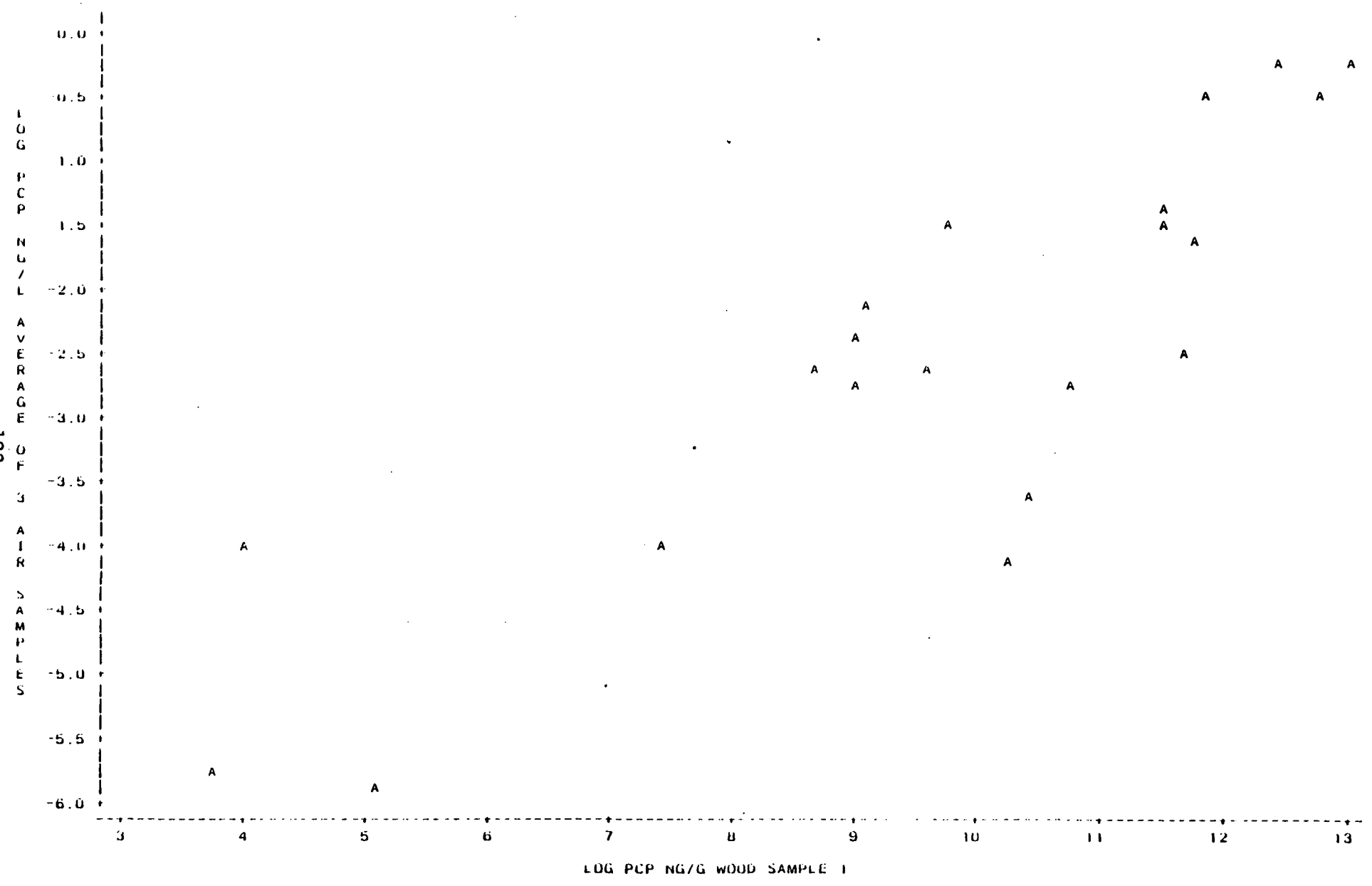
PLOTS OF HOUSE DEMOGRAPHIC VS. WOOD CORE PCP CONCENTRATION

PLOT OF X157*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.



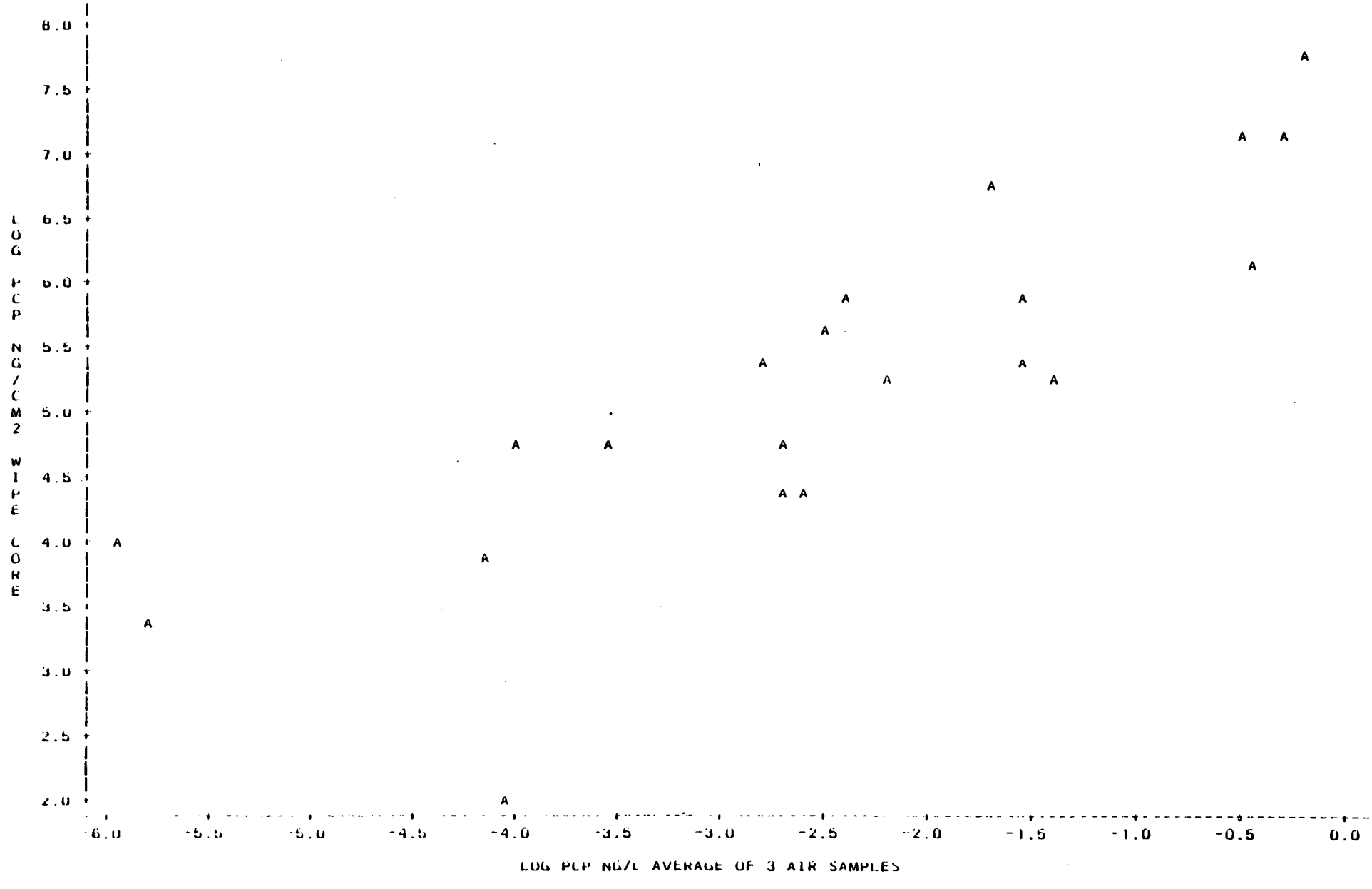
APPENDIX VIII

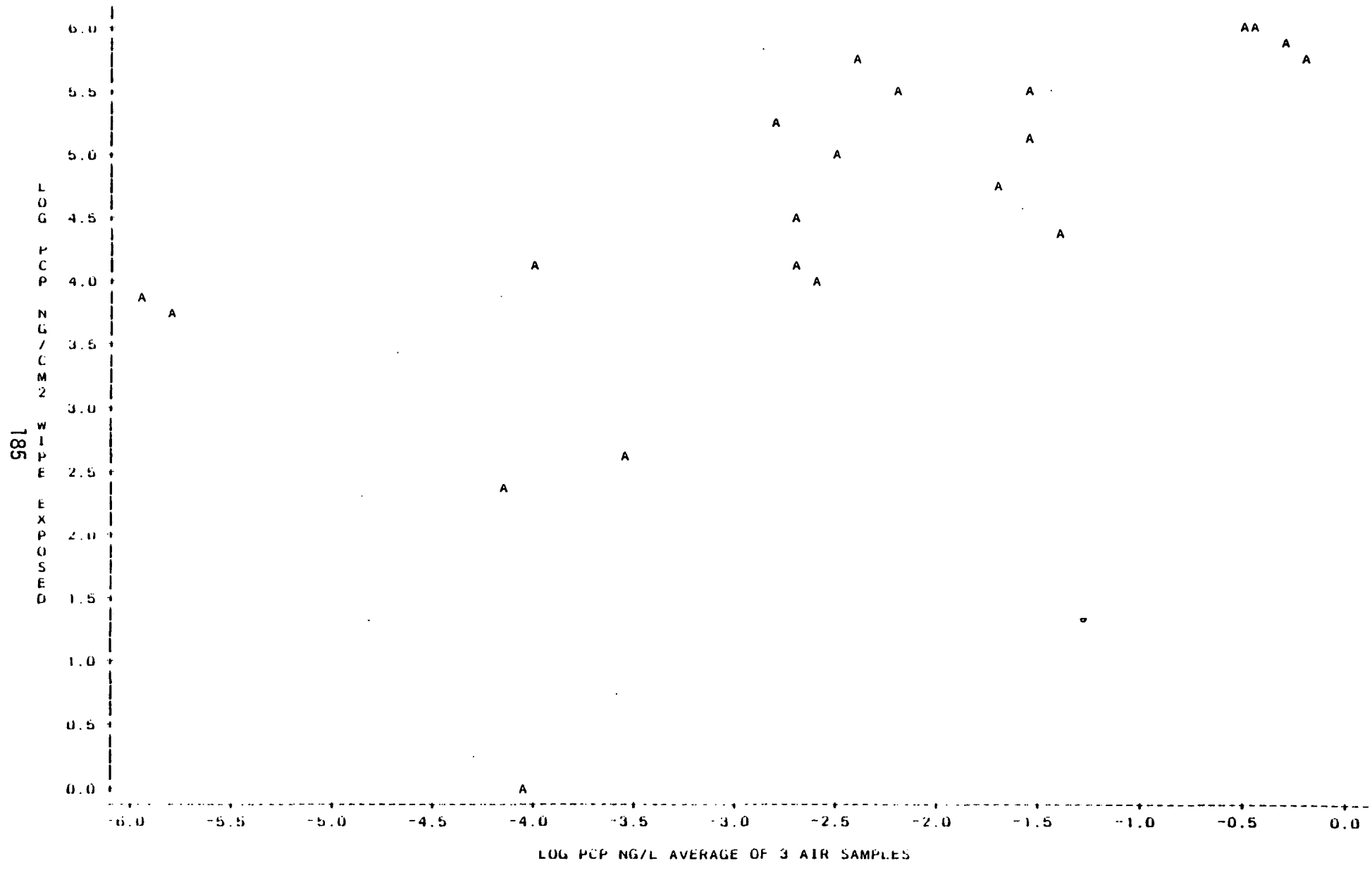
PAIRWISE PLOTS BETWEEN ENVIRONMENTAL PCP CONCENTRATIONS

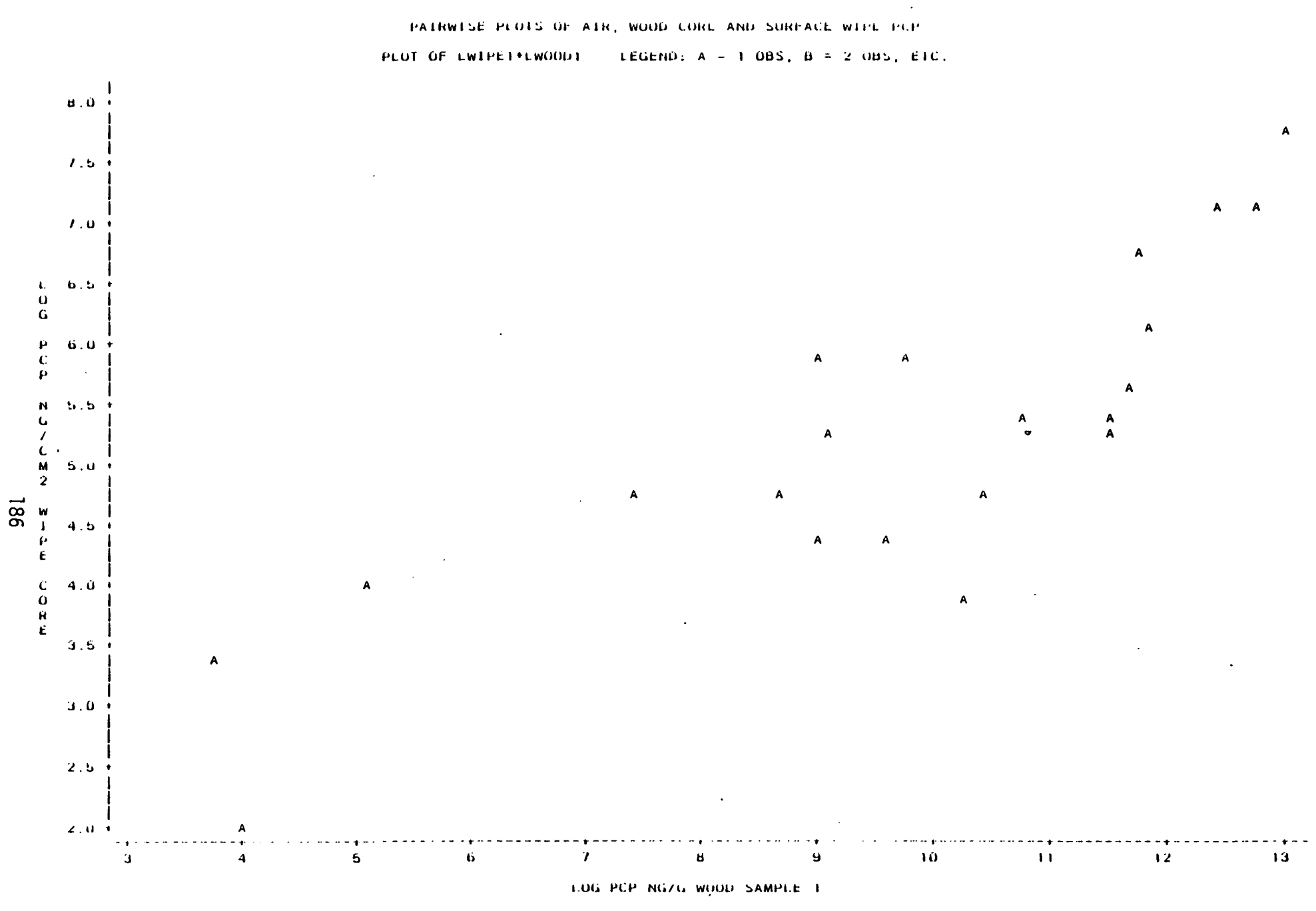

PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP
PLOT OF LAIR*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
LOG PCP NG/L AVERAGE OF 3 AIR SAMPLES
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-5.5
-6.0
3
4
5
6
7
8
9
10
11
12
13
LOG PCP NG/G WOOD SAMPLE 1

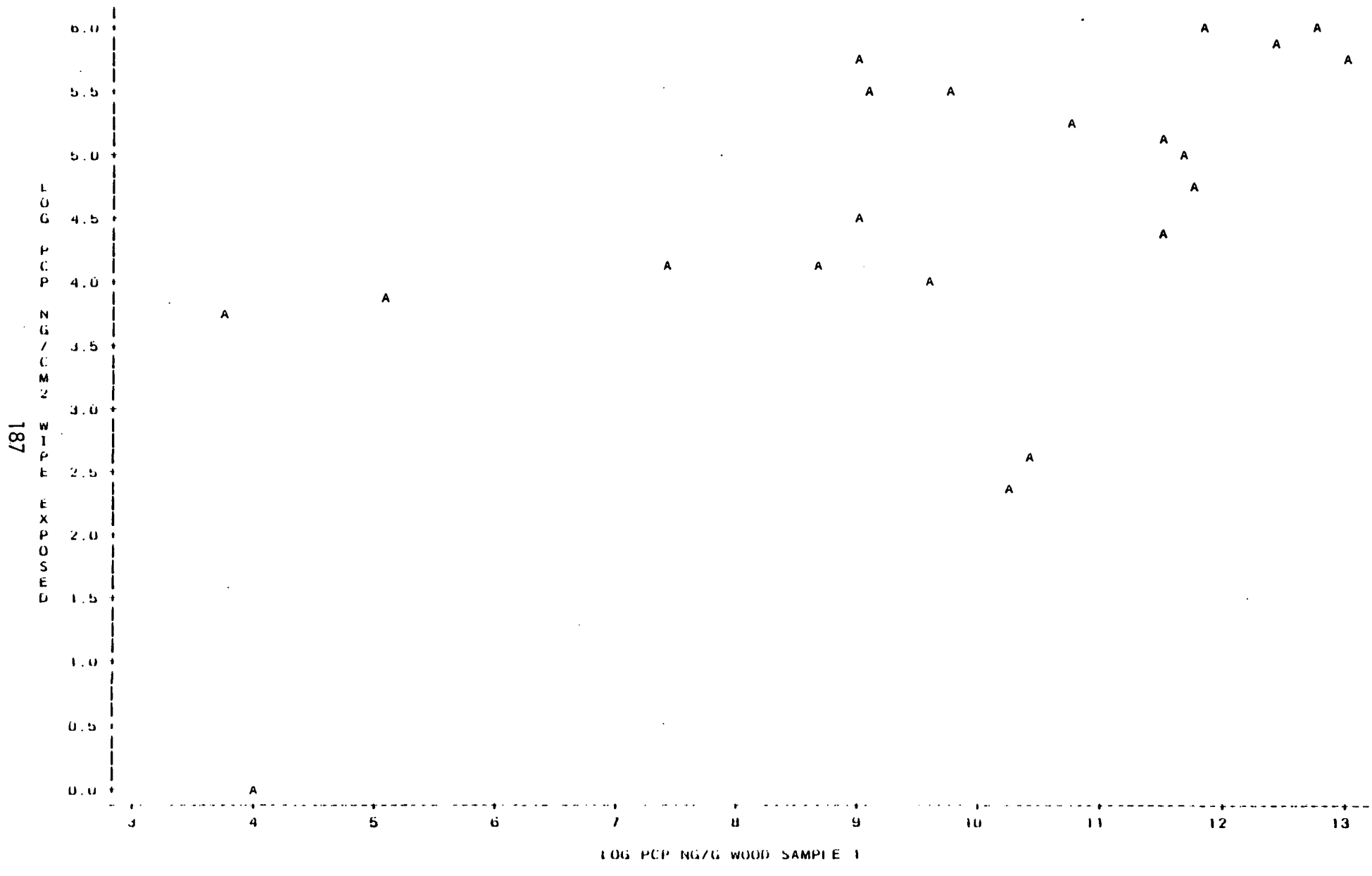
PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP

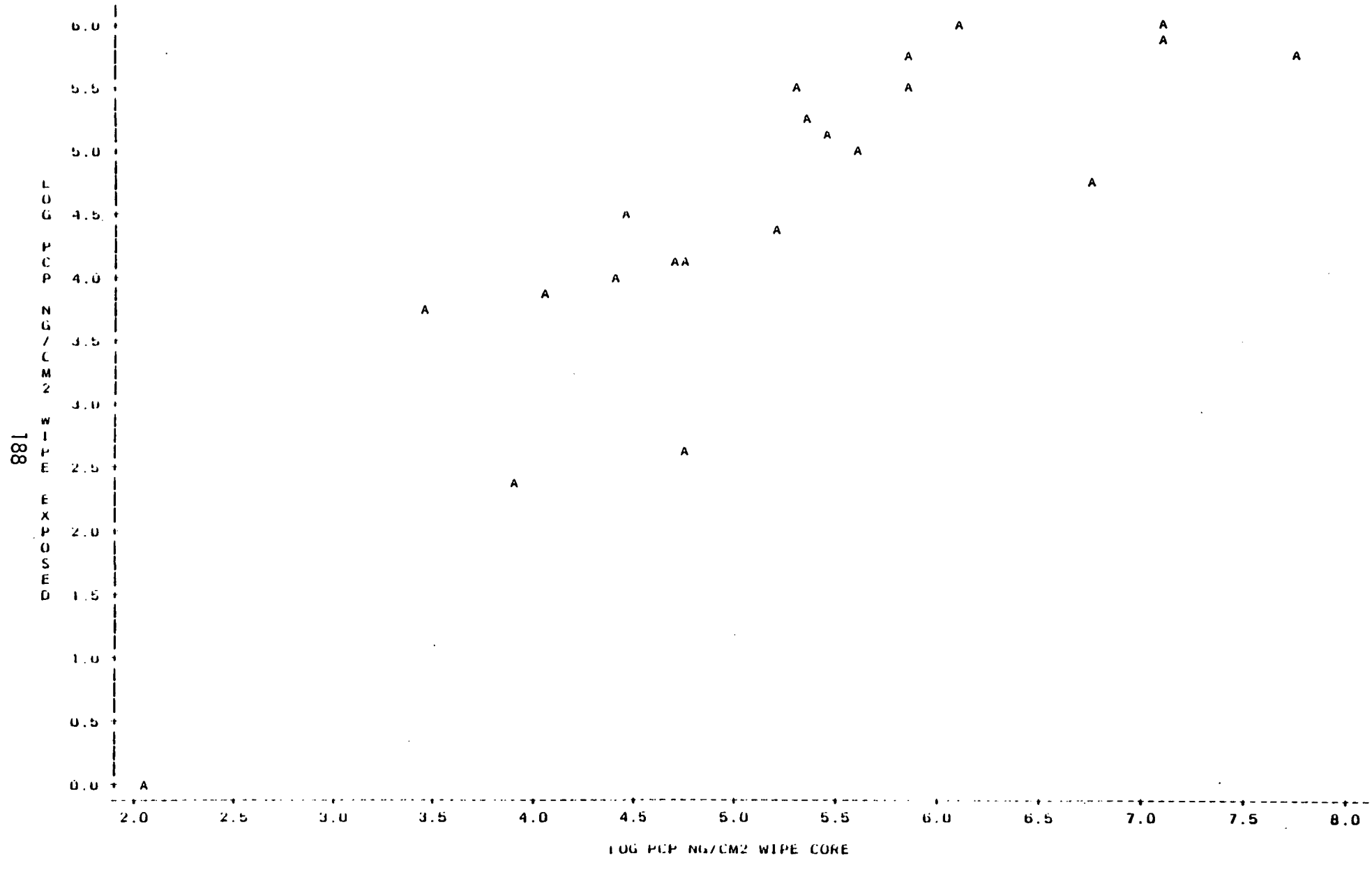
PLOT OF LWIPE1*LAIR LEGEND: A = 1 OBS, B = 2 OBS, ETC.




PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP
PLOT OF LWIPE2*LAIR LEGEND: A = 1 OBS, B = 2 OBS, ETC.
LOG PCP NG/CM2 WIPE EXPOSED
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-6.0
-5.5
-5.0
-4.5
-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
LOG PCP NG/L AVERAGE OF 3 AIR SAMPLES


PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP
PLOT OF LWIPE*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
LOG PCP NG/CM2 WIPE CORE
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
3
4
5
6
7
8
9
10
11
12
13
LOG PCP NG/G WOOD SAMPLE 1


PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP
PLOT OF LWIPE2*LWOOD1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
LOG PCP NG/CM2 WIPE EXPOSED
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3
4
5
6
7
8
9
10
11
12
13
LOG PCP NG/G WOOD SAMPLE 1


PAIRWISE PLOTS OF AIR, WOOD CORE AND SURFACE WIPE PCP
PLOT OF LWIPE2*LWIPE1 LEGEND: A = 1 OBS, B = 2 OBS, ETC.
LOG PCP NG/CM2 WIPE EXPOSED
LOG PCP NG/CM2 WIPE CORE
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0

APPENDIX IX

PCP IN BIOLOGICAL SAMPLES

PCP in Biological Samples

House no.	Participant	Treatment category	PCP serum (ng/mL)	Unhydrolyzed urine (mg/g creatinine)	Hydrolyzed urine (mg/g creatinine)
1	1	TN	113.6	0.007	0.021
1	2		102.2	0.008	0.027
1	3		125.5	0.040	0.038
1	4		151.0	0.019	0.023
2	1	NT	-	0.001	0.004
2	2		-	0.002	0.006
3	1	XT	12.6	0.007	0.011
3	2		-	0.004	0.030
3	3		26.8	0.008	0.016
3	4		20.7	0.008	0.014
4	1	TU	15.7	0.000	0.004
4	2		13.9	0.001	0.004
4	3		-	-	-
4	4		17.8	0.009	0.013
4	5		14.9	-	-
5	1	XT	32.0	0.001	0.002
5	2		20.7	0.008	0.036
5	3		68.5	0.024	0.037
6	1	XT	17.8	0.005	0.007
6	2		16.4	-	-
7	1	NT	9.0	-	-
7	2		9.0	-	-
8	1	T	107.1	0.016	0.008
8	2		118.5	0.022	0.033
8	3		113.6	0.009	0.021
8	4		125.8	0.033	0.028
8	5		128.4	0.085	0.246
9	1	NT	20.9	0.001	0.004
9	2		17.7	0.002	0.001
10	1	T	32.1	0.003	0.009
10	2		41.7	0.009	0.016
10	3		-	0.008	0.013
10	4		-	-	-
11	1	T	115.1	0.008	0.008
11	2		114.3	0.090	0.094
12	1	NT	12.8	0.001	0.000
12	2		9.0	0.003	0.002
12	3		11.2	0.000	0.000
12	4		7.5	0.001	0.004
13	1	TS	63.5	-	-
14	1	TS	22.1	0.002	0.011
14	2		131.1	0.000	0.007
14	3		37.0	0.001	0.004
14	4		70.0	0.001	0.009
14	5		25.5	0.002	0.014
15	1	TS	113.8	0.007	0.021
15	2		126.8	0.007	0.014

PCP in Biological Samples (concluded)

House no.	Participant	Treatment category	PCP serum (ng/mL)	Unhydrolyzed urine (mg/g creatinine)	Hydrolyzed urine (mg/g creatinine)
16	1	TSN	125.4	0.003	0.010
16	2		151.2	0.011	0.066
16	3		110.1	0.004	0.038
16	4		140.2	0.013	0.047
16	5		113.1	0.014	0.079
17	1	TS	115.5	0.005	0.017
17	2		120.9	0.005	0.023
17	3		133.2	0.010	0.062
17	4		130.1	0.020	0.079
17	5		130.1	0.020	0.079
18	1	T	115.0	-	-
18	2		118.5	0.006	0.035
18	3		119.7	0.049	0.097
18	4		130.5	0.088	0.144
19	1	TN	-	0.009	0.003
19	2		33.0	0.016	0.018
19	3		40.2	0.011	0.014
20	1	TN	67.4	0.002	0.005
20	2		30.7	0.003	0.016
20	3		41.0	0.013	0.021
20	4		46.1	0.008	0.014
20	5		72.1	0.002	0.012
21	1	XT	23.5	0.001	0.015
21	2		29.0	0.012	0.011
21	3		23.4	0.011	0.007
21	4		31.1	0.005	0.010

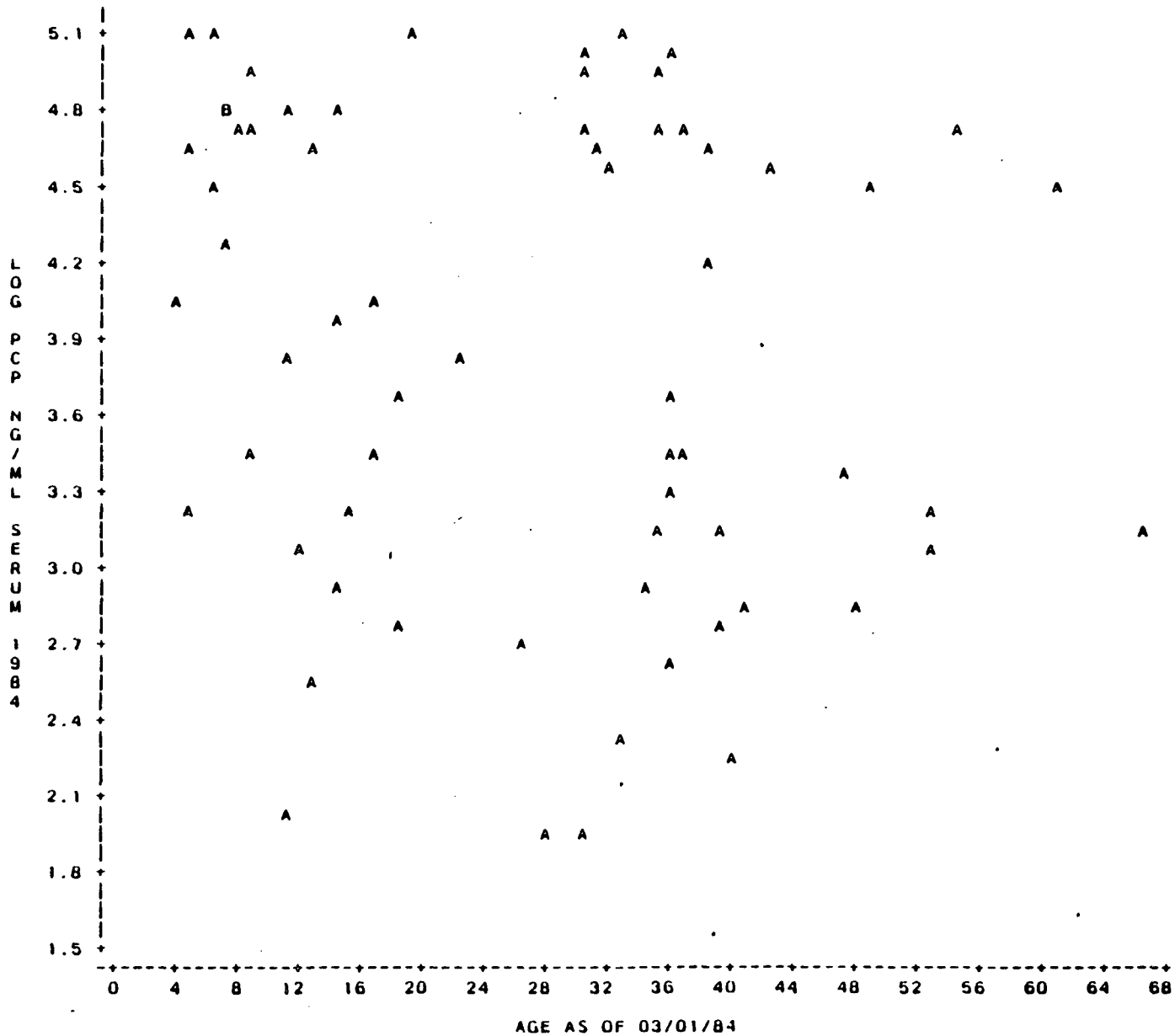
Note: T = treated; TS = treated and sealed; TSN = treated, sealed, and neutralized; TN = treated and neutralized; XT = exterior treated; NT = never treated; TU = treatment unknown.

APPENDIX X

PLOTS OF AGE AND BIOLOGIC PCP CONCENTRATION

PLOTS OF BIOLOGIC PCP CONCENTRATION VS. AGE

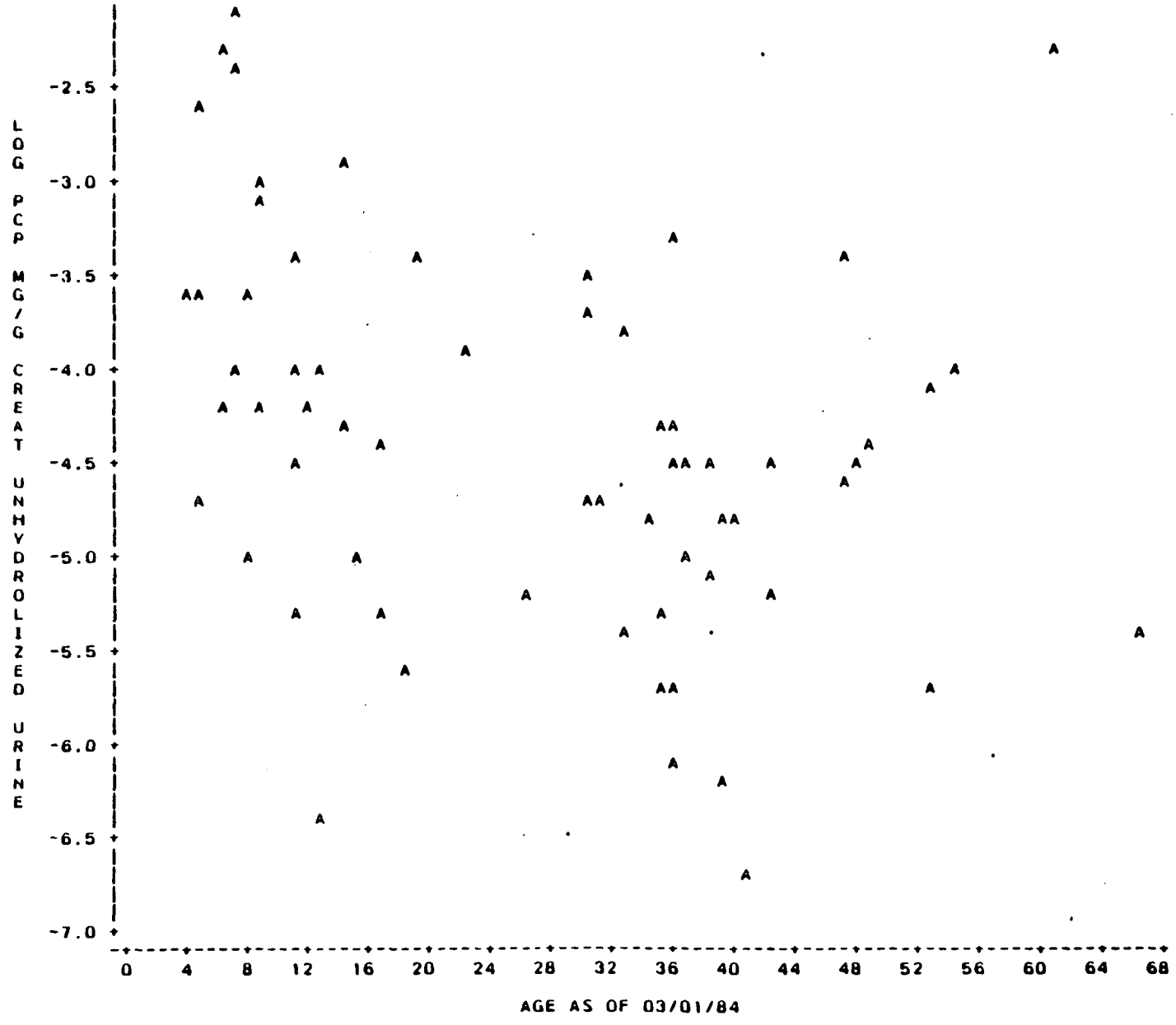
PLOT OF LX333*AGE LEGEND: A = 1 OBS, B = 2 OBS, ETC.



NOTE: 7 OBS HAD MISSING VALUES

PLOTS OF BIOLOGIC PCP CONCENTRATION VS. AGE

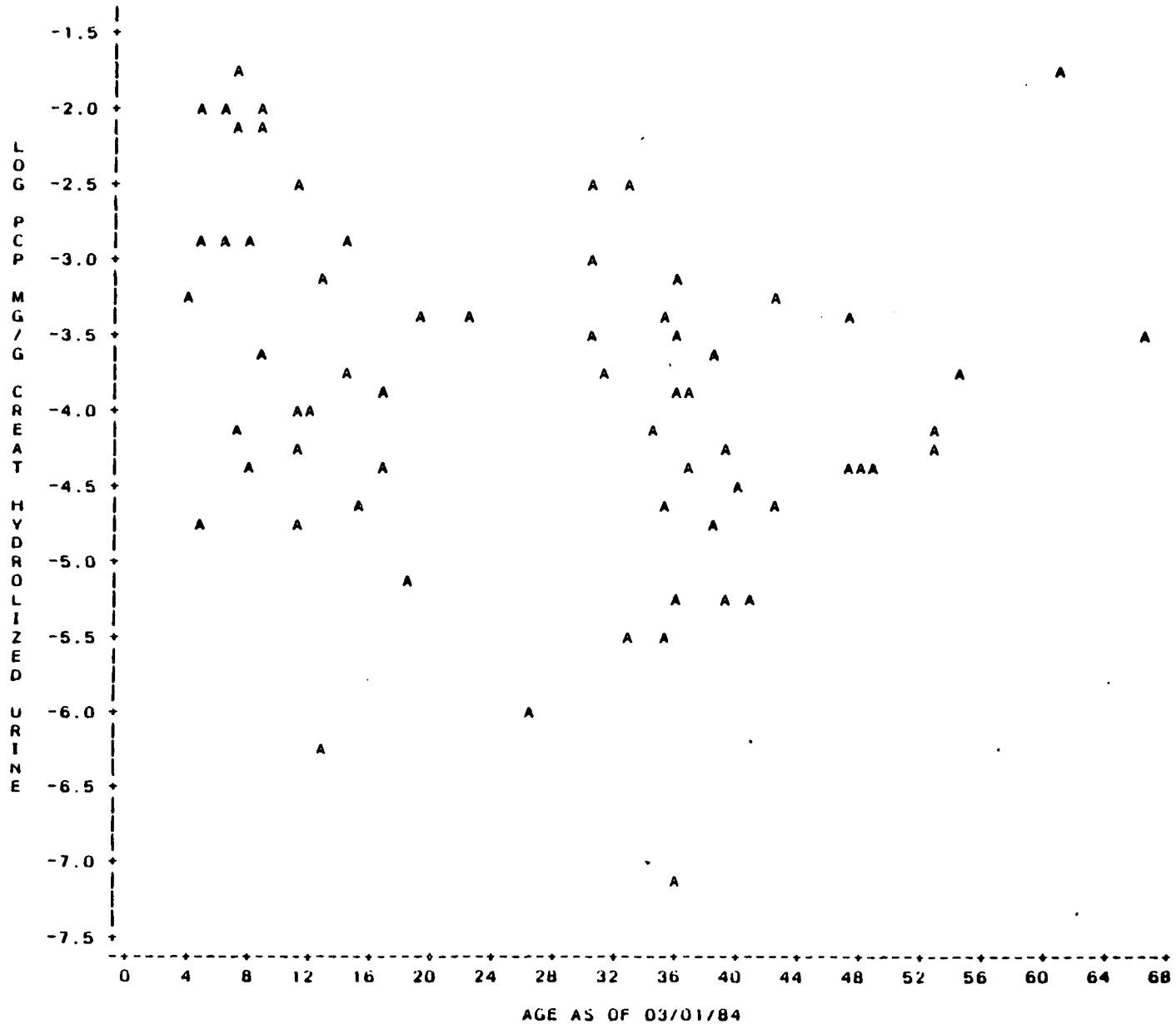
PLOT OF LUNHYDRO*AGE LEGEND: A = 1 OBS, B = 2 OBS, ETC.



NOTE: 8 OBS HAD MISSING VALUES

PLOTS OF BIOLOGIC PCP CONCENTRATION VS. AGE

PLOT OF LHYDRO*AGE LEGEND: A = 1 OBS, B = 2 OBS, ETC.



NOTE: 8 OBS HAD MISSING VALUES

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December 1986

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7. Author(s)
Hosenfeld, John M.;[a] Moody, Leslie A.;[a] Gabriel, Marilyn J.;[a] Emmett, Edward A.;[b] Lees, Peter S. J.;[b] Friesem, Robin M.;[b] Jeffervs, Joan L.;[b] Fox, Robin;[b] Bascom, Rebecca;[b] Bennett, Diane[b]

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9. Performing Organization Name and Address
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[b] Center for Occupational and Environmental Health, 3100 Wyman Park Dr., Baltimore, MD 21211

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16. Abstract (Limit: 200 words)
A survey of pentachlorophenol (PCP) treated log homes was conducted to determine environmental levels and the extent of biological exposure and to examine the relationships of biological PCP concentrations and selected health variables. A directed survey was conducted in 21 log homes that were subsequently found to be in six treatment categories. The highest levels of PCP were found in the category manufacturer treated homes; next highest in the manufacturer treated and subsequently sealed homes; next in the manufacturer treated and subsequently sealed and neutralized homes; next in the manufacturer treated and subsequently neutralized homes; next in exterior treatment only; and lowest levels in "never treated" homes. Concentrations of PCP in air, wood core, and surface-wipe samples were highly correlated with each other. PCP was detected in all 66 occupants sampled, and spanned a wide range, but levels were generally considerably higher in occupants of treated homes than untreated homes. The biological levels of PCP concentrations (serum, free, and total urinary) were highly correlated with the environmental PCP concentrations. In general, no significant associations were seen between biological PCP concentrations and liver function, microsomal enzyme induction, or renal function tests. Comparison of results from some of the occupants who participated in this survey and the survey conducted in 1980 showed no biochemical differences although serum PCP was lower in the present survey. Urinary PCP levels were the same for both studies.

17. Document Analysis a. Descriptors
Pentachlorophenol, log homes air sampling, wood sampling, wipes, drinking water, blood, urine, clinical biochemistry, hepatic examinations, neurologic examinations, dermatologic examinations, questionnaires, indoor exposure, health effects.

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c. COSATI Field/Group

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