Health Consultation

Health Implications of Students (& Faculty) Exposed

to Chemical Hazards at the

PHILLIPS COMMUNITY COLLEGE OF THE UNIVERSITY OF ARKANSAS

(ARKANSAS INSTITUTE FOR HISTORIC BUILDING TRADES)

415 OHIO STREET

HELENA, PHILLIPS COUNTY, ARKANSAS 72342

ARKANSAS FACILITY ID: 01-00162

MARCH 31, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

Arkansas Department of Health and Human Services
Arkansas Division of Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Atlanta, Georgia 30333

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Statement of Issues and Background

Statement of Issues

In July of 2004, Arkansas Department of Environmental Quality (ADEQ) personnel notified Arkansas Department of Health and Human Services, Division of Health (ADH) personnel of a complaint investigation. ADEQ reported that past operations and construction practices in the Arkansas Institute for Historic Building Trades (AIHBT) building located in Helena, Arkansas had resulted in some contamination (Appendix A, Figures 1-4). The building is part of the Phillips Community College of the University of Arkansas (PCCUA) campus and was used to train students to maintain, rehabilitate, and restore historic buildings [1]. Some documents refer to the AIHBT building as the Arkansas Institute for Building Preservation Trades. However, the 2001-2002 online PCCUA college catalog refers to the site as the AIHBT building, and it will be referred to as such throughout this document [2].

ADEQ asked ADH personnel to determine the public health significance of the contaminants identified at the AIHBT site. The site contaminants were detected in floor sweepings, a flooring wood chip, and bulk-building samples collected in July and August of 2004, by the Arkansas Department of Labor's Arkansas Occupational Safety and Health (ASOH) staff. The contaminants consisted of asbestos, dinoseb, and the pesticide DDT (dichlorodiphenyltrichloroethane) and its degradation products DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane). Sample results can be seen in Appendix B, Table 1. ADH evaluated the sample data and prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

The AIHBT building was formerly known as the McRae Brothers Hardware warehouse. Built in 1919, the three-story brick facade building has over 21,000 square feet of space and is located in the heart of Helena's downtown historic district at 415 Ohio Street [3]. The building is now owned and used by PCCUA for the AIHBT program.

The AIHBT program was created by collaboration between the Arkansas Historic Preservation Program of the Department of Arkansas Heritage and PCCUA to "address the need for artisans who are comprehensively trained in the traditional preservation trades. Students learn skills and methods to maintain, rehabilitate, and restore historic buildings in a curriculum that blends classroom theory and workshop practice [1]."

The college accepted its first students into the AIHBT program in the fall of 2000 [1]. An AOSH staff member informed ADH that the class size ranged between 5 – 10 students per semester. The program was in operation from Fall 2000 through Spring 2004, suggesting that as many as 60 students (plus faculty) may have taken part in the training.

In July 2004, an employee of PCCUA contacted AOSH to report a suspected air quality problem within the AIHBT building. The employee identified a yellow discoloration on some plastic surfaces (i.e., shop sink, electrical outlet cover, and vinyl wall covering behind the sink) and an area of the wooden floor of the building as a source of concern (See photos in Appendix A, Figures 2-4). It is believed that the discolored surfaces are confined to the first floor. Anecdotal information indicates that, as a former warehouse, agricultural pesticides had at some point been stored in the building. No information is available as to whether the storage of the pesticides was confined to the first floor, nor the period during which the building was used for this purpose.

On July 27, 2004, AOSH collected floor sweepings, a flooring wood chip, and a plastic electrical outlet cover for analysis. The materials were collected from the first floor of the AIHBT building. Test analysis revealed levels of dinoseb, DDT, DDE, and DDD. Subsequent sampling on August 19, 2004, found material containing 90-percent chrysotile asbestos partially behind wood planking on the wall located near the stairwell. Sample results are shown in Appendix B, Table 1.

Analysis of floor sweepings is a qualitative screening test performed to determine the presence of an analyte. The floor sweepings will contain impurities and larger particles with enough mass to have fallen to the floor. Floor sweepings aren't representative of dust that will be captured from the air and may, therefore, underestimate the true indoor air composition.

Due to the sample results, AOSH, in a letter to PCCUA dated September 28, 2004, stated that remediation of the AIHBT building must be done before *employees* could return to work in the building. AOSH set October 30, 2004, as the deadline for the remediation process to be completed [4]. In response to AOSH's request to remediate the building, PCCUA locked the doors to the AIHBT building to prevent entry by employees and/or students, and discontinued the AIHBT program in September 2004. No remediation has taken place to date.

ADH concurs with AOSH's decision to prevent employees from entering the building until remediation is satisfactorily completed [4]. ADH believes that this protective measure should apply to students as well. Additionally, ADH recommends that wipe samples be collected following remediation to insure the site was properly cleaned and safe for reoccupation.

ADH visited the AIHBT building on April 7, 2005. The building was not in use and the doors remain locked. The adjoining buildings showed no signs of current use. During a follow-up telephone conversation with a representative for AOSH in June 2005, ADH was informed that the problem was considered abated because locking the building has prevented exposure to the contaminants. As of the date of this document, the AIHBT building remains closed.

Discussion

Potential exposure pathways to contaminants at the AIHBT building have been evaluated to determine if students (and faculty) could have been exposed to potentially unsafe levels of pesticides and asbestos. ADH considered dermal contact (absorption through skin), incidental ingestion (eating), and inhalation (breathing) as potential routes of exposure (Appendix A, Figure 5). Exposure pathways consist of the following five elements:

1. A source of contamination,
2. A release mechanism into soil, air, water, food chain (biota) or transfer between media (i.e., the fate and transport of environmental contamination),
3. An exposure point or area (e.g., public building, drinking water well, residential yard, etc.),
4. An exposure route (e.g., dermal contact, ingestion, inhalation), and
5. A receptor population (i.e., students, employees, etc.).

For a person to be exposed to a contaminant, the exposure pathway must contain all of the elements listed above, resulting in a completed exposure pathway. In some cases, a potential exposure pathway might exist in which at least one of the elements of the exposure pathway is missing, but could exist. Potential pathways indicate that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Potential exposure pathways refer to those pathways where (1) exposure is documented, but there is not enough information available to determine whether the environmental medium is contaminated, or (2) an environmental medium has been documented as contaminated, but it is unknown whether people have been, or may be, exposed to the medium, or may be exposed in the future. Additionally, an eliminated pathway is one where at least one element of the exposure pathway is missing, and therefore, exposure will never occur [5].

To assess the potential health risks associated with contaminants at this site, ADH compared contaminant concentrations to health comparison values. Health comparison values, such as ATSDR's Reference Dose Media Evaluation Guide (RMEG), are used to screen contaminants for further evaluation. RMEGs are concentrations of a contaminant in air, water, or soil that corresponds to the U.S. Environmental Protection Agency's (EPA) reference dose (RfD) for that contaminant when default values for body weight and intake rates are taken into account. EPA's RfD is an estimate of the daily exposure to a contaminant unlikely to cause non-carcinogenic adverse health effects.

The estimation of the daily exposure dose involves determining contaminant concentrations at points of potential human exposure and developing assumptions regarding the extent of human exposure in the completed exposure pathways. For this evaluation, the maximum concentration detected for the contaminants of concern in floor sweepings and wood flooring chip are considered as the concentration at the point of potential exposure.

An exposure pathway to the identified site contaminants potentially exists via the dermal contact and/or incidental ingestion of dust particles/soil contaminated with dinoseb, DDD, DDE, and DDT by the students and faculty. Dinoseb was detected in the floor sweepings at 17,000 milligrams per kilograms (mg/kg), and in the wood chip at 39,000 mg/kg. These levels are above the RMEG value of 700 mg/kg for dinoseb. Levels of DDE at 6 mg/kg, and DDD at 14 mg/kg were also above their comparison values of 2 mg/kg and 3 mg/kg, respectively. However, the highest concentration of DDT detected at the site was almost five times less than the RMEG value of 400 mg/kg. Table 1 of Appendix B provides a summary of these contaminants and their associated comparison values.

The inhalation exposure route is also a potentially completed pathway for volatilized contaminants, as well as through the inhalation of dust. Floor sweepings contain impurities and large particles with enough mass to have fallen to the floor and are not representative of dust that would be captured from the air during aggressive air testing. Aggressive air testing agitates settled contaminants, and is done to simulate living conditions. The lack of air sampling represents a data gap thus preventing ADH from conducting a complete exposure assessment for the site. ADH recommends aggressive indoor air testing be performed and is available to review the sampling results should this recommendation be undertaken.

Chemical Profiles

Dinoseb

Dinoseb is an herbicide used in soybeans, vegetables, fruits and nuts, citrus, and other field crops. It is also used as an insecticide in grapes. Dinoseb is a dark reddish-brown solid or dark orange thick liquid, depending on the temperature. It has a strong odor, is corrosive to steel in the presence of water, and toxic fumes are emitted upon decomposition of dinoseb [6].

In October 1986, the EPA issued an emergency suspension order prohibiting further sale, distribution, and use of pesticide products containing dinoseb in the U.S. This action was based on the significant risk of birth defects and other adverse health effects for persons with substantial dinoseb exposure. The product is no longer commercially available in the U.S. [6].

Dinoseb can be absorbed into the body by inhalation, through the skin (dermal), and by ingestion. Symptoms occurring in humans include fatigue, thirst, sweating, insomnia, weight-loss, headache, flushing of the face, nausea, abdominal pain, and occasional diarrhea. Inhalation of dusts and sprays may be irritating to the lungs and eyes, and may cause serious illness [6].

At chronic and acute exposure levels, dinoseb interferes with a cell’s ability to convert food (such as glucose) into useable energy for the body. More specifically, it disturbs the

production of adenosine triphosphate, a chemical in the cell that provides energy for all cellular activities. This interference is the basis for most all toxic effects related to the compound [6].

DDT, DDE, and DDD

DDT is a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. DDT is a white, crystalline solid with no odor or taste. Its use in the U.S. was banned in 1972 because of damage to wildlife, but is still used in some countries [7].

DDE and DDD are chemicals similar to DDT that contaminate commercial DDT preparations. Both DDE and DDD enter the environment as contaminants or breakdown products of DDT. DDE has no commercial use. DDD was also used to kill pests, but its use has also been banned [7].

The EPA rates DDT, DDE, and DDD as probable human carcinogens. These ratings are based on liver tumors found in several strains of laboratory mice, hamsters, and rats fed DDT, DDE, and DDD in their diet. At high levels, damage to the nervous system can occur. Humans accidentally exposed to DDT suffered tremors, seizures and excitability [7].

Chrysotile asbestos

Chrysotile, also known as white asbestos, is the predominant commercial form of asbestos. Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate, and are resistant to heat, fire, chemical and biological degradation. Because of these properties, asbestos has been mined for use in a wide range of manufactured products, mostly in building materials, friction products, and heat-resistant fabrics. Since asbestos fibers may cause harmful health effects in people who are exposed, EPA has banned all new uses of asbestos in the U.S. [8].

Asbestos is a concern for the building occupants. Friable or airborne asbestos could be released and create serious health risks. Slivers of friable asbestos may look like particles from a tissue when it’s torn. It can remain suspended in the air for weeks, and if it’s inhaled, it can be extremely dangerous [8].

The U.S. Department of Health and Human Services (DHHS), the World Health Organization (WHO), and EPA have determined that asbestos is a human carcinogen. It is known that breathing asbestos can increase the risk of cancer in people. There are two types of cancer caused by exposure to asbestos: lung cancer and mesothelioma. Mesothelioma is a cancer of the thin lining surrounding the lung (pleural membrane) or abdominal cavity (the peritoneum). Cancer from asbestos does not develop immediately, but shows up after a number of years. Studies of workers also suggest that breathing asbestos can increase chances of getting cancer in other parts of the body (stomach, intestines, esophagus, pancreas, and kidneys), but this is less certain. Early identification and treatment of any cancer can increase an individual’s quality of life and survival [8].

Estimated Daily Exposures

In evaluating the toxicological significance of student (and faculty) exposure to contaminants of concern detected in the AIHBT building, ADH used standard assumptions. Students and faculty (adults only) are assumed to have had access to the site a maximum of 560 days. This represents the first day of class in January 2000 through the last day of class, held in May 2004. They are assumed to have an average body weight of 70 kg or 154 pounds and to ingest 100 mg of dust/soil per day. These assumptions were intended to represent the worst-case scenario.

To evaluate the potential health risks from contaminants of concern associated with the AIHBT site, ADH assessed the risks for cancer and noncancer health effects. Increased cancer risk was estimated using site-specific information on exposure levels and interpreting them using their respective cancer slope factors. Cancer slope factors are upper-bound estimates of cancer risk per increment of dose that can be used to estimate risk probabilities for different exposure levels. The calculated cancer risk for the contaminants of concern was determined to be within the EPA's target risk range [9]. See Appendix C for further information regarding the cancer risk estimates.

Noncarcinogenic health risk was estimated using the Hazard Quotient (HQ). An HQ is the average daily intake divided by the RfD [10]. HQ values greater than 1 indicates that exposure to the contaminant may result in harmful effects. The HQ for dinoseb was calculated to be 180 (Appendix B, Table 2). Using the assumptive values described in above, students and faculty were potentially exposed to levels of contamination through the combination of dermal contact and ingestion of dust/soil containing dinoseb in the AIHBT building that may cause adverse health effects.

The HQ for DDT was calculated to be 2.4 (Appendix B, Table 2). This value suggests that students and faculty were potentially exposed to levels of contamination through the combination of dermal contact and ingestion of dust/soil containing DDT in the AIHBT building that may cause adverse health effects.

Although inhalation exposures are thought to be insignificant compared to dietary sources of DDT, an assessment of risk associated with the inhalation of DDT was not done because of a lack of air sampling data [7]. Indoor air sampling is needed in order to assess inhalation risk associated with DDT.

Using EPA's HQ approach, a non-cancer risk was calculated for DDE of 0.16. A HQ of less than one indicates that harmful effects are not likely [10]. Therefore, adults have not been exposed to levels of contamination through the dermal contact and ingestion of dust/soil containing DDE within the AIHBT building that would be expected to cause adverse health effects.

The HQ for DDD was calculated to be 0.36. Therefore, adults have not been exposed to levels of contamination through the dermal contact and ingestion of dust/soil containing DDD within the AIHBT building that would be expected to cause adverse health effects.

No toxicological effects of chrysotile asbestos exposure in humans could be calculated because of the absence of a complete asbestos characterization, including aggressive indoor air sampling. Furthermore, the condition of the asbestos was not noted (i.e., damaged, disturbed, etc.); only the location and proportion of asbestos in the sample collected were described. ADH suggests an asbestos characterization survey of the AIHBT building, and aggressive indoor air sampling to be conducted prior to the building being reopened for use. ADH is available to review any additional sampling data.

Community Health Concerns

Currently, there are no community health concerns associated with this site. As of the date this document was completed, the building was not in use and the doors remain locked.

Child Health Considerations

ADH and ATSDR recognize that the unique vulnerabilities of children demand special attention. Critical periods exist during development, particularly during early gestation, but also throughout pregnancy, infancy, childhood and adolescence [11]. Children may exhibit differences in absorption, metabolism, storage, and excretion of toxicants, resulting in higher biologically effective doses to target tissues. Depending on the affected media, they also may be more exposed than adults because of behavior patterns specific to children.

PCCUA's AIHBT building is an adult learning facility. Children have not been reported to be in the building while under its current ownership, and therefore not expected to be at any risk for exposure.

Conclusions

ADH evaluated floor sweepings, a flooring wood chip, and bulk building samples collected from the first floor of the AIHBT building in July and August of 2004, by AOSH staff. Test analysis detected the presence of asbestos, dinoseb, DDT, DDE, and DDD (Appendix B, Table 1).

ADH has determined this site to represent an *Indeterminate Public Health Hazard* for past, current, and future exposures. Although calculation scenarios indicate possible health risks could exist, definitive conclusions are limited because of the uncertainty regarding the possible length of completed exposures to site contaminants, and lack of sampling data.

Specifically, the HQ for dinoseb was calculated to be 180, and the HQ for DDT was calculated at 2.4 (Appendix B, Table 2 and Appendix C); a HQ of greater than 1 indicates that exposure to the contaminant is likely to result in harmful effects. However, actual length of completed exposure is unknown. (The parameters used to calculate the HQ included dermal contact and incidental ingestion of dust/soil.) Inhalation of air and dust

was not definitive because of a lack of aggressive indoor air sampling that would be assumed to strengthen ADH's finding. DDE and DDD were detected at levels well below thresholds that would be expected to be of a public health concern. However, because of the lack of aggressive indoor air sampling a complete assessment of the risk posed by these contaminants cannot be determined.

Asbestos was detected in the bulk sample collected at the site. The condition of the asbestos was not noted (i.e., damaged, disturbed, etc.); only the location and proportion of asbestos in the sample collected were described. Usually it is best to leave asbestos material that is in good condition alone. Generally, asbestos material in good condition will not release asbestos fibers [12]. There is no danger unless fibers are released and inhaled into the lungs. ADH recommends an asbestos characterization survey and aggressive indoor air sampling be performed. ADH is available to review sampling results.

Recommendations

- ADH concurs with AOSH's recommendation that remediation of the contamination in the AIHBT building be done following all applicable State and Federal regulations before the building can be reoccupied.
- ADH suggests that PCCUA, prior to the remediation and reoccupation of the AIHBT building, obtain the services of an ADEQ certified company/laboratory to conduct aggressive indoor air sampling to test for the contaminants of concern (asbestos, dinoseb, DDT, DDE, and DDD). The test results should be provided to ADH for review. Aggressive indoor air sampling prior to remediation will help ADH better quantify possible health risk scenarios.
- ADH suggests that PCCUA have an asbestos characterization survey of the AIHBT building conducted prior to its remediation and reoccupation. The asbestos survey shall be conducted by a person that is trained, certified, and meets all other requirements of Arkansas Pollution Control and Ecology Commission regulation 21. The survey results should be provided to ADH for review.
- ADH suggests wipe samples of hard surfaces (flooring, countertops, and any other hard surface work areas) be collected in the AIHBT building as a post-remediation test. The test results should be provided to ADH for review. Test results for the contaminants (asbestos, dinoseb, DDT, DDE, and DDD) should be below appropriate screening values.

Public Health Action Plan

The purpose of the Public Health Action Plan (PHAP) is to ensure that this health consultation not only identifies any public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The PHAP implemented for the AIHBT building is as follows:

Completed Actions

- AOSH collected environmental samples on July 27 and August 19, 2004.
- ADEQ personnel notified ADH personnel of contamination detected in the AIHBT building July 30, 2004.
- AOSH provided ADH with additional information related to the site consultation inspection on January 26, 2005.
- ADH evaluated sample data collected by AOSH in July and August 2004.
- ADH conducted a site visit on April 7, 2005. As of the date of this document completion, the AIHBT building remains closed.

Future Activities

- ADH will be available to assist and review remediation and air sampling plans for the building.
- ADH will continue to review available sampling data to better determine public health risk.
- ADH will conduct health education in the community as needed, and/or requested.

Authors, Technical Advisors

Health Assessor

Dan Seaton
Arkansas Department of Health and Human Services
Division of Health, Mail Slot H-32
P.O. Box 1437
Little Rock, AR 72203-1437

Designated Reviewer

Lori Simmons
Arkansas Department of Health and Human Services
Division of Health, Mail Slot H-32
P.O. Box 1437
Little Rock, AR 72203-1437

ATSDR Regional Representative

George Pettigrew
Division of Regional Operations
Agency for Toxic Substances and Disease Registry - Region 6
1445 Ross Avenue (6SF - L)
Dallas, TX 75202

ATSDR Technical Project Officer

Tammie McRae
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry
1600 Clifton Road, Mailstop E-29
Atlanta, Georgia 30333

Certification

This health consultation for Phillips Community College of the University of Arkansas site was prepared by the Arkansas Department of Health and Human Services, Division of Health, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedure existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner.

Tammie McRae, M.S.
Technical Project Officer
Division of Health Assessment and Consultation (DHAC)
ATSDR

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

Alan W. Yarbrough
Cooperative Agreement Team Leader, DHAC, ATSDR

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Appendices

Appendix A - Figures

Figure 1. Aerial photo of Helena, Arkansas. The red dot marks the location of the Arkansas Institute for Historic Building Trades site.

Figure 2. The Arkansas Institute for Historic Building Trades building is located in the center of this photograph.

Figure 3. Area of concern is the yellow stained floors.

Figure 4. Yellow staining was observed on the plastic sink, outlet cover, and wall surfaces.

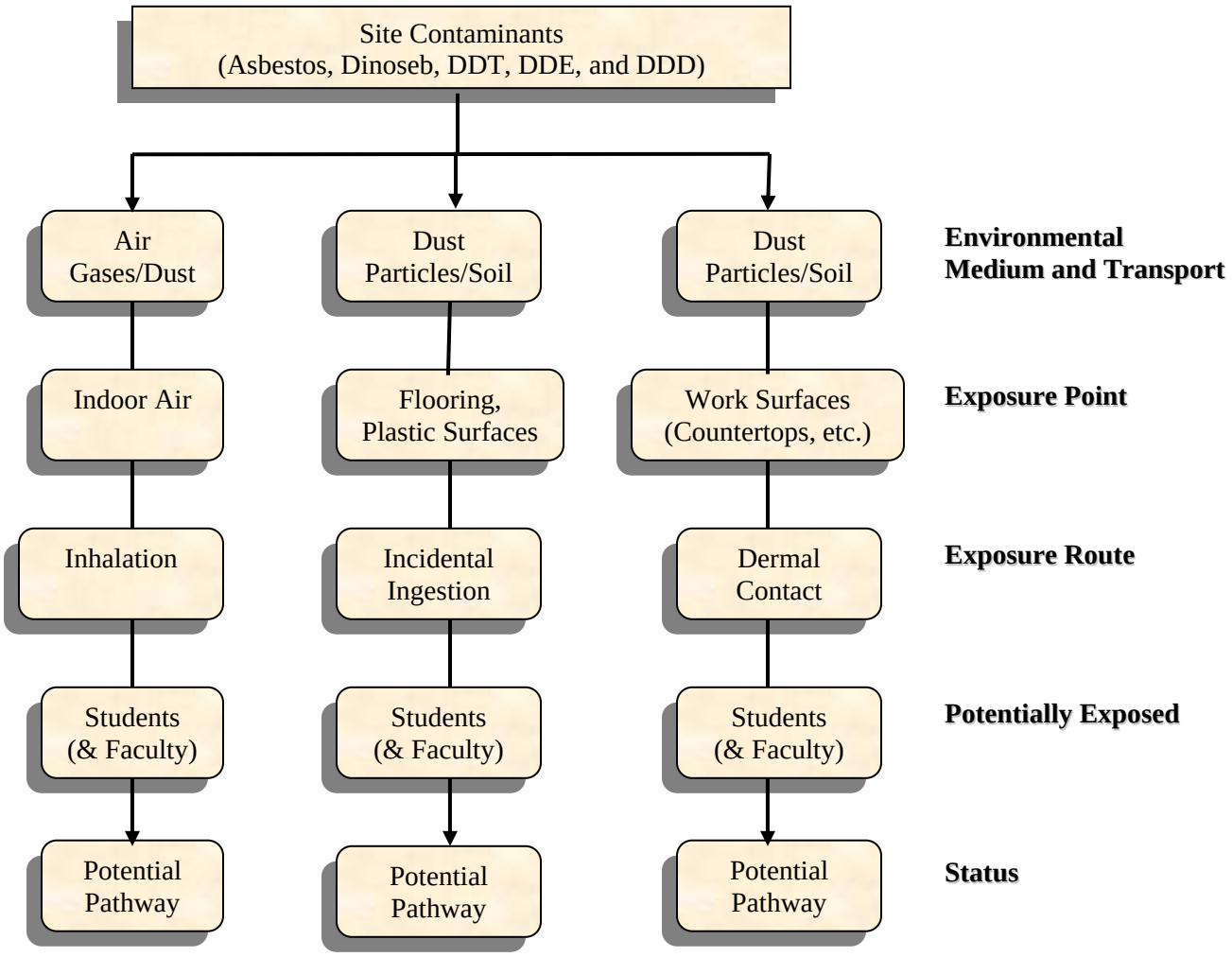

Figure 5. Exposure Pathway Evaluation

Appendix B - Tables

Table 1. Arkansas Institute for Historic Building Trades sample lab results

Chemical	Floor Sweepings (mg/kg)*	Wood Chip (mg/kg)*	Bulk Sample Media	Comparison Value (mg/kg)*
Dinoseb	17,000	39,000	NA	700†
DDT	87	34	NA	400†
DDE	6	6	NA	2‡
DDD	14	14	NA	3‡
Asbestos (Chrysotile)	NA	NA	90%¶	0.23§

Note: samples collected by Arkansas Department of Labor's Arkansas Occupational Safety and Health (ASOH) personnel (7/27/04 & 8/19/04)
* mg/kg = milligram per kilogram
† RMEG = Reference dose media evaluation guide
‡ CREG = Cancer risk evaluation guide
§ Unit of measurement is micrograms per cubic meter $(\mu g/m^3)^{-1}$
¶ The units for the asbestos inhalation unit risk are fibers per milliliter
NA = Not Applicable

Table 2. Summary of estimated risk for exposure to contaminants detected at the Arkansas Institute for Historic Building Trades site

Chemical	Estimated Theoretical Risk for Cancer	Cancer Slope Factor	Hazard Quotient (Noncancer Risk)	Tolerable Daily Intake* (mg/kg/day)†	Estimated Exposure Dose (mg/kg/day)
Dinoseb	NA	NA	180	1.0×10^{-3}‡	1.8×10^{-1}
DDT	4.1×10^{-4}	0.34	2.4	5.0×10^{-4}‡	1.2×10^{-3}
DDE	2.7×10^{-5}	0.34	0.16	5.0×10^{-4}*	8.0×10^{-5}
DDD	4.3×10^{-5}	0.24	0.36	5.0×10^{-4}*	1.8×10^{-4}
Asbestos (Chrysotile)	NA§	NA	NA	NA	NA

Note: a cancer risk of 6×10^{-6} means 6 excess cancers in 1,000,000 (one million) exposed people.
*Tolerable Daily Intake is an estimate of the amount of a substance in air, food or drinking water that can be taken in daily over a lifetime without appreciable health risk [13].
† mg/kg/day = milligram per kilogram
‡ RfD = Reference Dose = an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful effects during a lifetime.
§ NA = Not Applicable

Appendix C - Calculations

Students and faculty are assumed to have had access to the site a maximum of 560 days from the first day of class in January 2000 through the last day of class, held in May 2004. Adults are assumed to have a body weight of 70 kg or 154 pounds and to ingest 100 mg of dust/soil per day. These assumptions were intended to represent the worst-case scenario. Assumptive values were used to estimate the maximum cancer and non-cancer risk for the contaminants detected in the AIHBT building (asbestos, dinoseb, DDE, and DDD). The source of the exhibits used in Appendix C is obtained from ATSDR's Public Health Assessment Guidance Manual [5].

Calculation of Incidental Ingestion

Exhibit 1. Exposure Dose Equation

Exposure doses from ingestion of soil can be calculated as follows:

$$D = (C \times IR \times EF \times CF) / BW$$

where,

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated soil (mg/day)
EF = exposure factor (unitless)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg)

Default Soil Intake Rates

100 mg/day – adult average soil ingestion rate

Note:
mg/day – milligrams per day

mg – milligrams; kg – kilograms

Exhibit 2. Exposure Factor Equation

$$EF = (F \times ED) / AT$$

where,

EF = exposure factor (unitless)
F = frequency of exposure (days/year)
ED = exposure duration (years)
AT = averaging time (ED x 365 days/year)

EF = (F x ED) / AT
EF = ([5 days/week x 16 weeks/year] x 3.5 years) / (3.5 years x 365 days/year)
EF = 0.22

Dinoseb (floor sweepings)
D = (C x IR x EF x CF) / BW
D = (17,000 mg/kg x 100 mg/day x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 5.0 x 10^{-3} mg/kg/day

DDT (floor sweepings)
D = (C x IR x EF x CF) / BW
D = (87 mg/kg x 100 mg/day x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 2.7 x 10^{-4} mg/kg/day

DDE (floor sweepings)
D = (C x IR x EF x CF) / BW
D = (6 mg/kg x 100 mg/day x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 1.9 x 10^{-5} mg/kg/day

DDD (floor sweepings)
D = (C x IR x EF x CF) / BW
D = (14 mg/kg x 100 mg/day x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 4.4 x 10^{-5} mg/kg/day

Calculation of Soil Dermal Contact Dose

Dermal absorption of contaminants from soil or dust depends on the area of contact, the duration of contact, the chemical and physical attraction between the contaminant and the soil, and the ability of the contaminant to penetrate the skin. Chemical specific factors, such as lipophilicity, polarity, volatility, molecular weight, and solubility also affect dermal absorption.

Dinoseb is absorbed through the skin. The chemical is excreted in the urine and feces and is metabolized in the liver. Breakdown products are found in the liver, kidneys, spleen, blood and urine. Dinoseb can also pass through the placenta into the fetus of experimental animals [6]. Dermal absorption of DDT and its breakdown products of DDE and DDD in humans and animals are considered to be limited [7]. As for asbestos, there are no indications in available data that dermal absorption of asbestos fibers may occur to any significant extent [8].

In the equation used in Exhibit 3 (below), the bioavailability factor represents, as a percent, the total amount of a substance ingested, inhaled, or contacted that actually enters the bloodstream and is available to possibly harm a person. Typically, the bioavailability factor is assumed to be 1 (100%) for screening purposes—that is, all of a substance to which a person is exposed is assumed to be absorbed.

Exhibit 3. Soil Dermal Contact Dose Equation

Doses from dermal contact with soil can be calculated as follows:

$$D = (C \times A \times AF \times EF \times CF) / BW$$

where,

D = dose (mg/kg/day)
C = contaminant concentration (mg/kg)
A = total soil adhered (mg)
AF = bioavailability factor (unitless)
EF = exposure factor (unitless)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg)

Default Dermal Exposure Values

Age (yrs)	Body Weight (kg)	Total Surface (cm^2)	% Area Exposed	Exposed Area (cm^2)	Total Soil Adhered (mg)
18-70	70	19,400	24	4,656	326

Total soil adhered (A) is estimated by multiplying the exposed area by the default soil adherence concentration of 0.07 mg/cm^2 for adults.

mg – milligrams; kg – kilogram; cm^2 – square centimeter

Dinoseb (floor sweepings)
D = (C x A x AF x EF x CF) / BW
D = (17,000 mg/kg x 326 mg x 1 x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 1.7 x 10^{-1} mg/kg/day

DDT (floor sweepings)
D = (C x A x AF x EF x CF) / BW
D = (87 mg/kg x 326 mg x 1 x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 8.9 x 10^{-4} mg/kg/day

DDE (floor sweepings)
D = (C x A x AF x EF x CF) / BW
D = (6 mg/kg x 326 mg x 1 x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 6.1 x 10^{-5} mg/kg/day

DDD (floor sweepings)
D = (C x A x AF x EF x CF) / BW
D = (14 mg/kg x 326 mg x 1 x 0.22 x 10^{-6} kg/mg) / 70 kg
D = 1.4 x 10^{-4} mg/kg/day

To estimate the total exposure to a specific contaminant from dermal contact and incidental ingestion the dose values are summed.

Dinoseb (floor sweepings)
Total Exposure $_{Dinoseb}$ = Dermal Exposure $_{Dinoseb}$ + Incidental Ingestion $_{Dinoseb}$
Total Exposure $_{Dinoseb}$ = 1.7 x 10^{-1} mg/kg/day + 5.0 x 10^{-3} mg/kg/day
Total Exposure $_{Dinoseb}$ = 1.8 x 10^{-1} mg/kg/day

DDT (floor sweepings)
Total Exposure $_{DDT}$ = Dermal Exposure $_{DDT}$ + Incidental Ingestion $_{DDT}$
Total Exposure $_{DDT}$ = 8.9 x 10^{-4} mg/kg/day + 2.7 x 10^{-4} mg/kg/day
Total Exposure $_{DDT}$ = 1.2 x 10^{-3} mg/kg/day

DDE (floor sweepings)
Total Exposure $_{DDE}$ = Dermal Exposure $_{DDE}$ + Incidental Ingestion $_{DDE}$
Total Exposure $_{DDE}$ = 6.1 x 10^{-5} mg/kg/day + 1.9 x 10^{-5} mg/kg/day
Total Exposure $_{DDE}$ = 8.0 x 10^{-5} mg/kg/day

DDD (floor sweepings)
Total Exposure $_{DDD}$ = Dermal Exposure $_{DDD}$ + Incidental Ingestion $_{DDD}$
Total Exposure $_{DDD}$ = 1.4 x 10^{-4} mg/kg/day + 4.4 x 10^{-5} mg/kg/day
Total Exposure $_{DDD}$ = 1.8 x 10^{-4} mg/kg/day

Calculation of Hazard Quotient

Risk can be estimated using the Hazard Quotient (HQ). An HQ is the average daily intake divided by the reference dose (RfD) [10]. RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful effects during a lifetime.

Exhibit 4. Hazard Quotient Equation

Hazard Quotient approach:

HQ = DI / RfD

where,

HQ = Hazard Quotient (unitless)
DI = Daily Intake (mg/kg/day)
RfD = Reference Dose (mg/kg/day)

After the calculation…	
If…	Then…
HQ > 1.0	Harmful effects are likely
HQ = 1.0	Not likely to cause harmful effect
HQ < 1.0	Harmful effects not likely

mg/kg/day – milligrams per kilograms per day

Dinoseb (floor sweepings)
HQ = DI / RfD
HQ = 1.8 x 10^{-1} mg/kg/day / 1.0 x 10^{-3} mg/kg/day
HQ = 180

DDT (floor sweepings)
HQ = DI / RfD
HQ = 1.2 x 10^{-3} mg/kg/day / 5.0 x 10^{-4} mg/kg/day
HQ = 2.4

DDE (floor sweepings)
HQ = DI / RfD
HQ = 8.0 x 10^{-5} mg/kg/day / 5.0 x 10^{-4} mg/kg/day
HQ = 0.16

DDD (floor sweepings)
HQ = DI / RfD
HQ = 1.8 x 10^{-4} mg/kg/day / 5.0 x 10^{-4} mg/kg/day
HQ = 0.36

Calculation of Estimated Theoretical Risk for Cancer

Excess lifetime cancer risk is the additional or extra risk of developing cancer due to exposure to a toxic substance incurred over the lifetime of an individual (70 years). It is expressed in terms such as one in one million (one additional case of cancer per 1,000,000 people). This can also be written as 1 x 10^{-6}. Any excess cancer risk that is less than one in one million is not considered to be important and, thus, is considered an *acceptable* risk. Risks greater than one in one million (1 x 10^{-6}) but less than one in ten thousand (one additional case of cancer per 10,000 people or 1 x 10^{-4}) are within the EPA's target risk range. If the additional lifetime cancer risk is greater than one in ten thousand, it is generally considered *unacceptable*. Thus, calculated risks greater than 1 in 10,000 generally warrant a remedial action [9].

To characterize potential carcinogenic effects, estimated risks are calculated from projected intakes and the cancer slope factor (CSF). The CSF converts estimated daily intakes directly to an estimate of incremental risk [5]. The following calculation estimates a theoretical excess lifetime cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a *lifetime* of exposure. Because of the uncertainties and conservatism inherent in deriving the CSFs and inhalation unit risks (IURs), this is only an estimate of risk; the true risk is unknown and could be as low as zero. EPA has given dinoseb a "D" classification meaning that it is not classifiable as to human carcinogenicity [14]. Because of this classification no CSF is available for the chemical dinoseb.

ER = CSF (or IUR) x dose (or air concentration)

where,

ER	=	estimated theoretical risk (unitless)
CSF/IUR	=	cancer slope factor [$(mg/kg/day)^{-1}$ or inhalation unit risk $[(\mu g/m^3)^{-1}]$
dose	=	estimated exposure dose (mg/kg/day) [or ($\mu g/m^3$)]

mg/kg/day – milligrams per kilograms per day
$\mu g/m^3$ – microgram per cubic meter

DDT (floor sweepings)
ER = CSF x dose
ER = 0.34 $(mg/kg/day)^{-1}$ x 1.2 x 10^{-3} mg/kg/day
ER = 4.1 x 10^{-4} [B2]

DDE (floor sweepings)
ER = CSF x dose
ER = 0.34 $(mg/kg/day)^{-1}$ x 8.0 x 10^{-5} mg/kg/day
ER = 2.7 x 10^{-5} [B2]

DDD (floor sweepings)
ER = CSF x dose
ER = 0.24 $(mg/kg/day)^{-1}$ x 1.8 x 10^{-4} mg/kg/day
ER = 4.3 x 10^{-5} [B2]

Excess cancer risk calculation results based on a lifetime exposure (70 years) to contaminants of concern – not the more probable 560 days exposure period – are as follows:

- DDT – a risk of 4 excess cancers in 10,000 exposed people represents some risk of cancer, as compared to 1 in 1,000,000 that represents no risk of cancer.
- DDE – a risk of 3 excess cancers in 100,000 exposed people represents some risk of cancer, as compared to 1 in 1,000,000 that represents no risk of cancer.
- DDD – a risk of 4 excess cancers in 100,000 exposed people represents some risk of cancer, as compared to 1 in 1,000,000 that represents no risk of cancer.