Health Consultation

Evaluation of Exposures to Soil
Taplett Farms
Omak, Okanogan County, Washington

March 30, 2012

Prepared by

The Washington State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substance and Disease Registry

Washington State Department of Health

DOH 334-299 March 2012

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous wastes. This report was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act through a cooperative agreement with ATSDR. It was completed in accordance with approved methodologies and procedures that existed at the time the health consultation was initiated. However, it has not been reviewed and cleared by ATSDR. Editorial review was completed by DOH. The glossary in Appendix A defines technical terms.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health assessor who prepared this document:

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For people with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TTY/TDD call 711).

For more information about ATSDR, contact the CDC Information Center at 1-800-CDC-INFO (1-800-232-4636) or visit the agency's Web site: www.atsdr.cdc.gov

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Introduction

Past releases of pesticides, petroleum hydrocarbons, and other chemicals at the former Taplett Farms located just outside the city of Omak in Okanogan County, Washington have resulted in contamination of soils at the site. At the request of the Washington State Department of Ecology (Ecology), the Washington State Department of Health (DOH) prepared this health consultation to evaluate the potential current and future human health hazard posed by the contaminants in the soil. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The former Taplett Farm located outside of Omak consists of a farmyard and former fruit tree orchard (referred to in this report as Taplett Farms) on 39 acres. The owner of the former Taplett Farms plans to subdivide the land into residential plats. For this Health Consultation, exposures within the existing one-acre farmyard (and residence) and exposures to potential residents of future homes that may be built on the former 38-acre orchard are considered. DOH identified chemicals of potential concern to include residual petroleum hydrocarbons from their use within the one-acre farmyard area, polycyclic aromatic hydrocarbons and other breakdown chemical residues from the burned down barn, and pesticides used on the former orchard including lead arsenate and organochlorine compounds.

Conclusions

DOH reached five conclusions in this health consultation:

Conclusion 1–DOH concludes that touching, swallowing, or breathing in dust containing metals from soils at the site for one year or longer at the existing residence within the one-acre farmyard area could harm children and adult health. This is a health hazard to current residents unless behavior changes reduce exposure.

Basis for Decision–Average arsenic and lead concentrations found in the farmyard soils were at levels, which may cause health effects if exposures are high enough. Children incidentally ingesting, having contact with, or breathing in dust with arsenic from the soil every day for one year or longer have the potential to lead to dermal effects and numbness in the hands or feet. Children and adults with these exposures have a mild increased risk for cancer. Similarly, soil lead concentrations may result in daily exposures of children to lead from soils for one year or longer may lead to increased blood lead levels associated with decreased cognitive function and other neurological impairments.

Conclusion 2–DOH concludes that the old appliances, left-over burned debris, piles of unidentified granular material, and containers with left-over oils in the farmyard present a physical hazard and should be removed or safely contained. This is a physical health hazard for current residents or trespassers onto the farmyard.

Basis for Decision–Old appliances and burned debris not properly disposed may present a physical danger to a child playing or adult present near the debris. Piles of granular material have not been identified, are not contained, or fenced in. Containers with left-over oils have been collected but not disposed of. These containers were still open to the environment and easily accessible to child or adult residents. No documentation has been provided describing how and where the previous leaking containers were located or disposed. After physical hazards are removed and documented, more information about the nature and extent of contamination in soils in these areas of the farmyard will be needed to reach a conclusion regarding exposures and harm to public health.

Conclusion 3– DOH cannot currently conclude whether exposure to soils containing heavy oils and diesel, organochlorine pesticides, or polycyclic aromatic hydrocarbons (PAHs) that have been tested for and identified within the one-acre farmyard may cause further harm to people's health.

Basis for Decision–More information on the nature and extent of non-metal chemicals is needed for DOH to reach a formal conclusion on farmyard exposures. Contamination of soils with heavy oils and diesel has been reported at four areas in the farmyard at concentrations of concern with undocumented efforts of remediation. Organochlorine pesticides were only tested at one location and have been identified at concentrations of concern at that location. Widespread use of these pesticides on the orchard was likely and areas with higher concentrations may still be unidentified. Limited samples were analyzed for PAHs. PAHs were detected near the burned barn area; the extent of these chemicals throughout the farmyard is not known and may be of concern. Because of limited sampling and testing for these chemicals, the current nature and extent of these chemicals is not known.

Conclusion 4– DOH cannot currently conclude whether exposure to contaminants not analyzed in soil within the one-acre farmyard may cause further harm to people's health.

Basis for Decision–More information on the nature and extent of chemicals not tested for is needed for DOH to reach a conclusion. Of particular concern is the potential deposition of dioxins and furans in the farmyard that may have formed when stored organochlorine pesticides, tires, and other debris were released during the barn fire. Additionally, other chemicals that were stored in the former barn may have been spilled or released from the former barn area such as herbicides, old oil-burning smudge pots, and old tractor batteries

Conclusion 5–DOH cannot currently conclude whether touching, swallowing, or breathing in dust from the former 38-acre orchard portion of the property could harm the health of future residents.

Basis for Decision–Information on the nature and extent of chemicals on the former orchard land is needed for DOH to reach a conclusion. No soil samples have been collected and analyzed for contaminants from the former orchard. However, it is very likely that the lead and arsenic concentrations are similar to, or higher than those found at the farmyard area, thus future residents would have similar or higher risks as current residents. Further, if residential development were to occur, construction workers on the site may also be at risk for high exposures during movement of soils or digging activities.

To estimate potential exposure and threat to the health of future residents at Taplett Farms, DOH will need additional samples collected and analyzed for metals, chlorinated pesticides, PAHs, and dioxin/furan compounds. DOH believes it would be prudent for the landowner to gather more site information and develop a sampling and analysis plan to perform an expanded investigation of the site. This recommendation is consistent and supports recommendations made by the Area Wide Soil Task Force in 2003. DOH recognizes that legacy soil contamination at former orchards and farmyards is not specific to Taplett Farms and similar situations likely exist throughout eastern and central Washington.

Next Steps

In brief, DOH recommends the following actions:

1. DOH and Ecology should educate current residents on how to reduce exposures. Discourage children from playing in areas that have bare soil or that are known to have higher concentrations of lead and arsenic.
2. Owner should dispose of discarded appliances, old farm equipment, buckets containing residues, and piles of granular material; retain documentation of disposal.
3. Owner should further characterize the farmyard with emphasis on areas where current or future residents may be exposed to uncovered soil.
4. Prior to development, owner/developer should characterize the former orchard and disclose the nature and extent of chemicals.
5. In general, DOH recommends that all owners and developers characterize former orchards before subdivision into school, child care center, recreational, or residential use areas.

In brief, the public action plan includes the following items:

1. DOH, Ecology, and the Okanogan Public Health Department will work to provide information to current residents and their children about reducing exposures.
2. DOH will provide a copy of this consultation to the current land owner to inform them of potential physical and chemical hazards and suggested mitigations.
3. DOH is and will continue to work with local health, the land owners, and the planning department of Okanogan County to prevent potential exposures on future subdivided and developed parcels. Ecology is aware of widespread contamination from the use of lead arsenate. Ecology is currently focusing cleanup efforts on schools, since that is where young children have the greatest exposures.

For More Information

If you have any questions about this health consultation contact Rhonda Kaetzel at 360-236-3357 or 1-877-485-7316.

Purpose and Statement of Issues

The Washington State Department of Health (DOH) conducted this health consultation at the request of the Washington State Department of Ecology (Ecology). The purpose is to determine if current and future residents of the 39-acre Taplett Farms are being exposed or will be exposed to contaminants identified in the soil and whether these potential exposures pose a human health threat. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

Site Description

Taplett Farms is located just northwest of the city limits of Omak in Okanogan County, Washington. Okanogan County Public Health (OCPH) visited and photographed the site in November 2008 after receiving a complaint from another agency stating there was potential soil contamination at the site (1;2). At that time, several county agencies were evaluating this 39-acre historical orchard parcel for a pending long plat application that would create 21 residential lots (see plat configuration in Appendix B). OCPH reported in Ecology's Site Hazard Assessment (September 10, 2010) that fruit orchards had been planted and maintained on the property since the early 1900s (3). Based on an aerial photo from 1940, this appears to be the case (see Figure 1). The current owners bought the property in 1957 and produced fruit from 38 acres until the mid 2000s when trees were cut down in preparation for future development.

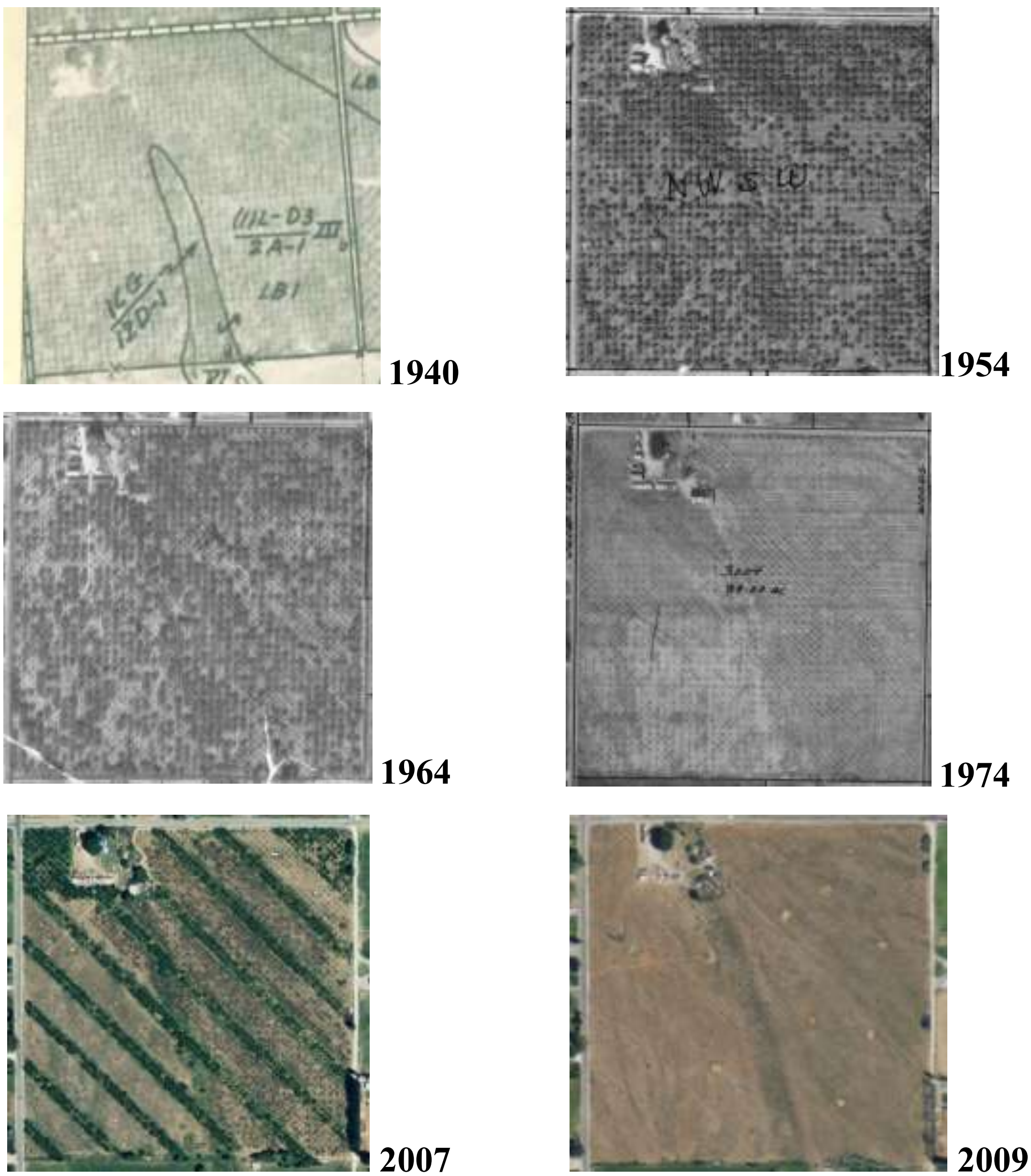
Drinking water at the current residence (and planned future residences) comes from Duck Lake Water Association, a Group A water system. This water system currently serves 206 people through 96 connections and can accommodate up to 200 connections. The water comes from a well field with three well sources: a permanent well, seasonal well, and emergency well. These wells draw from Okanogan Water Resource Inventory Area (WRIA 49) groundwater. The Taplett Farm property does not appear to fall within the default calculated 10-year time of travel draw area for these three wells, or any other wells in the area.

OCPH identified the following attributes on the remaining acre of the property identified as the farmyard:

- Single family residence.
- Abandoned worker sleeping, shower, and cooking buildings.
- Sheds near the residence.
- Diesel tank, mechanical maintenance equipment, and related materials (e.g., old buckets containing oil/hydraulic fluid and other liquids).
- Orchard-related equipment and debris (e.g., bins, irrigation pipes, discarded bags of pesticide/herbicides, etc.).
- An area containing numerous discarded appliances.
- A burned barn foundation and associated burned debris.

OCPH stated that the barn containing the orchard equipment and agricultural materials caught on fire and burned to the ground during the removal and disposal of the orchard trees. The burned debris included the barn, old tire rims, old tractor batteries, old smudge pots (i.e., oil-burning orchard heaters used to prevent frost on trees), and horticultural materials including bags that may have contained pesticides or herbicides. Piles of unidentified granular material were also present.

Figure 1. Aerial photographs from years 1940, 1954, 1964, and 1974 from the Okanogan County Assessor's Office and 2007 and 2009 from the National Agriculture Imagery Program, Taplett Farms, Omak, Okanogan County



The primary sources of chemicals include: 1) spilled petroleum hydrocarbons (diesel), hydraulic fluid, and/or motor oils; 2) pesticides use and preparation; and 3) residue from burning building materials, debris, chemicals, and/or pesticides (4). The main concern is related to lead arsenate, the primary insecticide used to control codling moth and other insects in Washington deciduous tree fruit (apple and pear) orchards between 1905 and 1947 (5) and other pesticides used subsequently.

Environmental Investigations

In April 2009, OCPH analyzed surface soil samples collected from eight hot-spot locations on the one-acre, non-orchard area suspected to be contaminated (Figure 2) (6;7). The remaining orchard portion of the property has not been characterized. The samples were analyzed for metals (samples 1–8); polycyclic aromatic hydrocarbons (PAHs) (samples 5, 6, and 7); and fuels (diesel and motor oil) (samples 1, 2, 3, 4, and 8). One sample was analyzed for organochlorine and organophosphate pesticides (sample 3). This sample was taken from what appeared to be the area that pesticides were formerly prepared for application.

Figure 2. Okanogan County Public Health soil sampling locations of Taplett Farms, Omak, Okanogan County, Washington (sampling area is approximately one acre, full extent of property not shown).

OCPH revisited the site in March 2010 and reported that at some point after the April 2009 sampling, the property owner removed visibly oil-stained top soils in several areas, including: near the former diesel tank location (samples 3 and 4), within the discarded appliance pile (sample 8), and near the burned barn foundation (possibly sample 5) (8;9). No verification of how or where the soils were disposed was provided. Additionally, no confirmation sampling was conducted at the soil removal locations to determine if any contaminants remain in these areas. The debris and orchard related material near the burned barn and worker housing areas were also reported removed and/or disposed of or collected into old fruit bins that remained on the site. OCPH reported that visible soil contamination was still present in the area where old buckets containing used oils were located.

Demographics

Taplett Farms is located on the northwestern edge of Omak, the largest city in Okanogan County. Omak became incorporated in 1911 and has a population of 4,845 people as of the 2010 U.S. census.[1] Over 12% of the population has a Hispanic or Latino ethnicity. The racial majority is 71.1% white, followed by 17.4% Native American.

Discussion

Exposure Evaluation

Exposure Pathways–This evaluation considered three routes of exposure: 1) swallowing (ingestion), 2) skin contact (dermal), and 3) breathing in (inhalation) dusts generated at the site.

Potentially Exposed Populations–As this is no longer an operating orchard, there are three exposure scenarios of concern for this property based on current and proposed future land use.

- *Current Residents*–Current residents may touch, breath in dust, or incidentally ingest soil containing chemicals found near or on the one-acre lot. DOH has not been able to identify specific areas where children may play near the house or within the farmyard; thus as a worst case scenario, it is assumed that a child would have access to the entire farm area. Exposure may also occur through yard activities such as gardening, landscaping, etc
- *Future Residents*–Potential future residents of the 21 lots of the former orchard planned for development may be exposed in the same manner. At this time, potential health threats for future residents cannot be fully assessed because soil data is not available for the remaining 38-acres of the former orchard property. However, potential exposures could be similar to, if not more than, that found within the one-acre lot depending on the chemicals that may be identified during any future, expanded sampling efforts.
- *Future Site Construction Workers*–If the former orchard property is developed into new homes, construction workers may be exposed by touching, breathing in dust or incidentally ingesting soil during construction activities. As with future residents, the potential health threat for future construction workers cannot be fully assessed because soil data is not available.

[1] www.census.gov

This analysis only considered the exposure route of the farmhouse resident to average (and 95% upper confidence limit of the average) farmyard metal soil concentrations calculated from locations throughout the farmyard. Until soil data for the former orchard portion of the property is available, assessment of future exposure routes cannot be assessed.

Screening Analysis

DOH screened the analytical results against health-based comparison values (CVs) to determine if contaminants in surface soils in this small area might pose a possible health threat to current and/or future residents and warrant further consideration. Soil concentrations above health-based CVs do not mean that people will get sick. However, it does tell us that additional evaluation is necessary. Contaminants with soil (or any other media) concentrations below the CV do not pose a health threat and further evaluation is not required. Of the available CVs for each chemical, the most conservative CV was used. The full screening is in Appendix C. The following points summarize concentrations of chemicals that exceeded their respective CVs and have been identified as potential chemicals of concern:

Arsenic and Lead–Given the historical use of this property as a fruit orchard, it was not surprising to find elevated arsenic and lead concentrations, especially within the apparent ends of the orchard tree tracts. No data are available from the orchard area itself. The following concentrations were found within the one-acre farm area:

- Arsenic concentrations ranged from 13.44 mg/kg up to 247.6 mg/kg, which is above ATSDR's cancer risk evaluation guide (CREG) of 0.5 mg/kg. Four samples exceeded the Model Toxic Control Act (MTCA) state clean up level for unrestricted land use screening value (20 mg/kg) with concentrations of 37.56 mg/kg (sample 6), 45.18 mg/kg (sample 2), 172.2 mg/kg (sample 7), and 247.6 mg/kg (sample 8). These four sample locations appear to be at the end of an old orchard tree tract.

  Two of the eight samples (samples 7 and 8) exceed Department of Ecology's interim action level for arsenic (100 mg/kg) that should trigger prompt action to reduce exposure to the soil. As these samples are proximal to the former orchard tract, these levels may be representative of those on the former orchard. For schools, child care centers, and residential land uses, Ecology considers total arsenic concentrations up to 100 mg/kg to be in the low to moderate range,

  Average concentration from the eight samples was 70 mg/kg. Because of the uncertainty associated with estimating the true average concentration at a site, the 95% upper confidence limit (95% UCL) of the arithmetic mean provides reasonable confidence that the true site average will not be underestimated. The 95% UCL for arsenic in soil was equal to 174 mg/kg based on gamma distribution (n=8).

- Lead was identified above the U.S. Environmental Protection Agency (EPA) screening level (400 mg/kg) at the same four locations. Concentrations at these locations ranged between 463 mg/kg and 1,680 mg/kg. These samples also exceeded the MTCA state clean up level for unrestricted land use screening value (250 mg/kg).

Two same two samples (samples 7 and 8) exceed Department of Ecology's interim action level for lead (700 mg/kg) that should trigger prompt action to reduce exposure to the soil. As stated above these samples are proximal to the former orchard tract, these levels may be representative of those on the former orchard. For schools, child care centers, and residential land uses, Ecology considers total lead concentrations up to 500–700 mg/kg to be in the low to moderate range.

The average concentration from the eight samples was 577 mg/kg. The 95% UCL of the mean was equal to 1,388 mg/kg based on gamma distribution (n=8).

Because the concentrations of arsenic and lead in the farmyard were highest in areas which appeared to be the ends of the tree tracts, it is possible that these areas are representative of the concentrations that might be found in the former orchard. These samples exceed the low to moderate range. Until further characterization of the former orchard occurs, the average concentrations found in the farmyard may underestimate the average concentrations in the orchard.

Diesel and Motor Oils These hydrocarbons were identified at 2–60 times higher than the MTCA Method A unrestricted land use screening value (2,000 mg/kg) in 4 of the 5 sampling locations. Two of the locations used for sampling have since been excavated. Visible evidence of other oil contamination in areas throughout the main yard has been documented, but concentrations and identification has not been measured or reported. It is clear that contamination was and is present; however, the extent has not been fully characterized.

Pesticides Pesticides (other than lead arsenate) were only sampled at one location (sample 3) presumed to be the pesticide staging area. No organophosphate pesticides were detected. Of the 21 organochlorine pesticides analyzed for, 16 were detected, and two exceeded their CV. Toxaphene (12 mg/kg) was 20 times higher than the CV (ATSDR CREG of 0.6 mg/kg). Dieldrin was measured (0.042 mg/kg) very close the CV (ATSDR CREG of 0.040 mg/kg). DDT was detected, but at levels below screening values (see Appendix C, Table C1). Topsoil from this area may have been removed since sampling. Because only one sample has been taken, it is possible that the highest concentrations within the farmyard have not been identified. Therefore, the extent of contamination has not been fully characterized.

Polycyclic Aromatic Hydrocarbons PAHs were only measured at three locations near the burned barn. The concentration of 2.8 mg/kg benzo(a)pyrene exceeded the CV (ATSDR CREG 0.1 mg/kg) at one location (sample 6). When combining benzo(a)pyrene with all the other PAHs known to have carcinogenic effects (cPAHs) and using the relative toxicity equivalency factors (TEFs), the elevated cPAH TEQ (toxic equivalency quotient of all cPAHs) was 3.9 mg/kg. The source and extent of this contamination is not known.

There is considerable uncertainty regarding the extent of contamination from the diesel fuels/motor oils, organochlorine pesticides, and cPAHs identified at the Taplett farmyard. Thus, until more data is available potential health threats cannot be quantified from these chemicals. According to the Area-Wide Contamination Task Force report (2003) on arsenic and lead, arsenic occurs naturally in Washington State soils at approximately 5–9 mg/kg and lead occurs at 11–24 mg/kg. Arsenic and/or lead were above their respective CVs, two samples were elevated above the low to moderate range for school, child care center, and residential land uses, and samples were found elevated above background levels in every sample across the farmyard site. Therefore, only these two chemicals have been identified for further evaluation.

Health Evaluation

Potential health risks were evaluated for current residents of the one-acre farm. It was assumed that adults and children live at the residence. Our efforts are focused on potential health threats to children, because they are believed to be the most sensitive population to elevated levels of lead and arsenic in the environment. Equations and parameters used to calculate potential risk to adults and children are described in Appendices D and E.

Arsenic–Appendix D describes the methods and assumptions DOH used to estimate human exposure doses and to determine potential health effects from ingestion of and contact with arsenic in soils. Note that behaviors such as washing hands after soil play, restricting access to elevated soil concentrations, and reducing soil and dust in the home reduce residential exposures substantially.

Non-carcinogenic Effects– Estimated exposures occurring for a long time (more than one year) to arsenic in children and adults living at the farmhouse approached levels where observable non-cancerous effects have been reported in human studies. Exposure doses for children were found to be 17 times higher than those for adults (Appendix D). This difference results from children's higher soil ingestion rate and lower body weight. Ingestion of soils contributes the most to a person's exposure, with relatively minor amounts contributed from touching soil or breathing in particles of soil from the air. Short term exposures (< 14 days) from soils in the farmyard will not lead to acute non-cancerous health effects. Estimated doses for children and adults were below the acute minimal risk level (MRL) (0.005 mg/kg-day). Most chronic (> 1 year) studies of arsenic toxicity have examined people exposed to arsenic in water, which is usually better absorbed than arsenic from soil. Non-carcinogenic effects have not been found in some studies where people are exposed to arsenic in drinking water at chronic doses of 0.0004 to 0.01 mg/kg-day. Other studies found effects as low as 0.0043 mg/kg-day. Estimated dose for children ages 1 to 5 years old, 0.00097 mg/kg-day was slightly above the chronic MRL (0.0003 mg/kg-day). This estimated exposure dose was slightly above the no observed adverse effect level (NOAEL) (0.0008 mg/kg-day) and 14 times below the lowest observed adverse effects level (LOAEL, 0.014 mg/kg-day). Older child and adult exposures were below the chronic MRL. Non-cancer effects may potentially occur in children exposed to arsenic in soil at the farmyard. Long term oral exposure to arsenic may cause dermal effects (e.g., hyperpigmentation, hyperkeratosis, corns, and warts) and peripheral neuropathy characterized by numbness in the hands and feet.

Carcinogenic Effects–In some of these same studies arsenic has been shown to cause cancer at high enough doses; however, much uncertainty exists about what levels of intake might lead to increased cancer risk. Long term oral exposure to arsenic results in an increased risk of skin, bladder, and lung cancer. The calculated theoretical increased cancer risk for a child over a five year exposure period is estimated to be about 3-4 additional cancers in a population of 10,000 persons. If a person were to live in the household for a lifetime, exposures may result in an increase of 5-6 additional cancers in a population of 10,000 persons. Because of uncertainties regarding the behavior of arsenic at low doses and the consistent detections of arsenic in soils throughout the property, prudent public health practice calls for reducing exposures by limiting behaviors leading to the ingestion of soils (e.g., washing hands after playing or working in the yard, washing toys often, not eating outside, etc.).

Lead–Since the toxicokinetics (the absorption, distribution, metabolism, and excretions of toxins in the body) are well understood, lead is regulated based on blood lead concentration. EPA and Centers for Disease Control and Prevention (CDC) have determined that childhood blood lead concentrations at or above 10 micrograms of lead per deciliter of blood (10 μg/dL) present risks to children's health. Blood lead concentration can be correlated to both exposure and adverse health effects. More recently, multiple studies have established the link between blood lead levels less than 10 μg/dL and adverse health effects such as cognitive impairment and decreased cardiovascular and renal function. A scientific advisory panel to the CDC has made a formal recommendation that CDC acknowledge that there is no known safe level of exposure in children. The panel recommended that prevention steps be put into place to prevent child blood lead levels exceeding 5 μg/dL.

Exposure was estimated using the EPA-developed Integrated Exposure Uptake and Biokinetic (IEUBK) model. Results from modeling are described in Appendix E. Using the average soil lead concentration of the samples taken across the one-acre farmyard (577 mg/kg), the model predicted that blood lead levels of children less than seven years old would range from 4.0 to 7.5 μg/dL. The model also predicted that 17.8% of a population of children less than seven years old exposed under these conditions would have a blood lead level that exceeded 10 μg/dL.

Child Health Considerations

Average arsenic and lead concentrations in soils around the farmyard pose a chronic health threat to residents, particularly children that may live at the farmhouse. Individual exposure will depend on the location and frequency of outdoor interactions with soil. Children are particularly susceptible because of frequent hand-to-mouth behaviors and putting soil in their mouths. Levels of arsenic and lead on the orchard land are likely to be elevated and similar to the maximum concentrations found in the farmyard (samples 7 and 8). Children living at future residences built on orchard lands will likely have exposures similar to, or more than, the exposures identified for the current residents.

Community Health Concerns

Currently, exposure from known soil contamination is limited to residents who may be living at the farmyard residence. Additionally, community members have expressed concerns to OCPH about potential exposures to current residents or trespassers to hazardous substances that may be located on the property.

Exposure to pesticides on former orchards has been addressed in Washington State. In 2003, a 17-person panel chartered by the Washington State Departments of Agriculture, Ecology, Health, and Community, Trade and Economic Development offered advice about a statewide strategy to respond to arsenic and lead soil contamination in Washington State (10). The task force recommended that developers incorporate appropriate additional protection measures into site development and construction plans to reduce the potential for exposure to area-wide soil contamination after properties are developed. For many on the Task Force, development was seen as a low-cost opportunity to make the site less hazardous because dirt was going to be moved around anyway. In addition, the task force recommended that construction workers on former orchards implement individual protection measures to reduce their potential for exposure to contaminated soil, consistent with U.S. Occupational Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Act (WISHA) requirements.

Regardless of how agencies track or record sampling data, individual property owners who have information about the presence of elevated levels of arsenic, lead, or other contaminants on a property are required under existing real estate disclosure laws to disclose this information to buyers during real estate transactions. Failure to disclose may potentially present larger costs to the developer (11).

Conclusions

In summary, DOH reviewed the analytical results of soil samples taken throughout the one-acre farmyard at Taplett Farms. DOH identified the following chemicals of potential concern: pesticides used historically on the former orchard including lead arsenate and organochlorine compounds, residual petroleum hydrocarbons from their use within the one-acre farmyard area, PAHs, and other breakdown chemical residues from the burned down barn. The former orchard (38 acres) was not sampled.

DOH estimated exposures for current residents living at the farmyard and came to the following five conclusions about current residents living within the farmyard and future use of the former orchard.

Conclusion 1–DOH concludes that touching, swallowing, or breathing in dust containing metals from soils at the site for one year or longer at the existing residence within the one-acre farmyard area could harm children and adult health. This is a health hazard to current residents unless behavior changes reduce exposure.

Conclusion 2–DOH concludes that the old appliances, left-over burned debris, piles of unidentified granular material, and containers with left-over oils in the farmyard present a physical hazard and should be removed or safely contained. This is a physical health hazard for current residents or trespassers onto the farmyard. After physical hazards are removed and documented, more information about the nature and extent of contamination in soils in these areas of the farmyard will be needed to reach a conclusion regarding exposures and harm to residents.

Conclusion 3– DOH cannot currently conclude whether exposure to soils containing heavy oils and diesel, organochlorine pesticides, or PAHs that have been tested for and identified within the one-acre farmyard may cause harm to people's health. Because of limited sampling and testing for these chemicals, more information on the extent of these chemicals within the farmyard is needed for DOH to reach a conclusion.

Conclusion 4– DOH cannot currently conclude whether exposure to contaminants not analyzed in soil within the one-acre farmyard may cause further harm to people's health. More information on the nature and extent of chemicals not tested for is needed for DOH to reach a conclusion. Of particular concern is the potential deposition of dioxins and furans in the farmyard that may have formed when stored organochlorine pesticides, tires, and other debris were released during the barn fire.

Conclusion 5–DOH cannot currently conclude whether touching, swallowing, or breathing in dust from the former 38-acre orchard portion of the property could harm the health of future residents. Information on the nature and extent of chemicals on the former orchard land is needed for DOH to reach a conclusion.

Recommendations

DOH recommends the following actions be taken to protect public health:

1. DOH recommends that actions be taken to reduce or eliminate exposure of current residents to contaminants, especially if children currently live at the residence. DOH will work with Ecology to complete the following actions:

    - Current residents will receive health education on how to reduce exposures.
    - Children will be discouraged from playing in areas that have bare soil or that are known to have higher concentrations of lead and arsenic.
    - DOH will communicate with the owner to discuss potential actions to eliminate exposures

2. DOH recommends the following actions be taken by the owner within the one-acre farmyard:

    - Work with Ecology and DOH to determine the best direction in characterizing the extent of contamination; future soil sampling should include at minimum analysis for metals, PAHs, organochlorine pesticides, and dioxin/furan compounds.
    - Soil should be tested in specific areas where child or adult residents may be exposed to uncovered soil.

- Properly dispose of discarded appliances and old farm equipment, which present a physical hazard.
- Properly dispose of buckets and debris containing oil residues and retain documentation of disposal.
- Identify nature and extent of contamination from piles of granular material; contain or properly remove piles to prevent access and further release to the environment; and retain documentation of disposal.

3. In alignment with the recommendations made by the Area-Wide Task Force, DOH recommends that the developers building residences on former orchards incorporate appropriate additional protection measures into the site development and constructions plans to reduce the potential for exposure after properties are developed. At Taplett Farms, DOH recommends that the developer:

    - Perform an expanded site assessment of the former orchard. At a minimum, this would be a full description of the property, former use and activities, future use and activities, location of old orchard tracts, and recording of field observations (e.g., soil disturbances, burned areas, prior excavations, etc.).
    - Determine the distribution of metals, organochlorine pesticides, petroleum hydrocarbons, PAHs, and dioxin/furan compounds in soils across each lot.
    - Consider future site development and construction plans to reduce the potential for exposures to potential future residents and constructors.

4. In general, DOH recommends that owners should characterize former orchards before subdivision into school, child care center, recreational, or residential use areas.

Public Health Action Plan

1. DOH, Ecology, and the Okanogan Public Health Department will provide information to current adult and child residents about reducing exposures.

2. DOH will provide a copy of this consultation to the current owner to inform them of potential physical and chemical hazards and suggested mitigations.

3. DOH is working with local health, the land owners, and the planning department of Okanogan County to prevent potential future exposures on future parcels. Ecology is aware of widespread contamination from the use of lead arsenate. Ecology is currently focusing cleanup efforts on schools, since that is where young children have the greatest exposures.

4. A copy of this health consultation report will be provided to Ecology, Okanogan County Public Health, and the Okanogan Public Library in Omak.

5. A copy of this health consultation report will be placed on the DOH site assessment website: http://www.doh.wa.gov/consults.

Report Preparation

This Health Consultation for the Taplett Farms site in Omak, Washington was prepared by the Washington Department of Health (DOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner (DOH).

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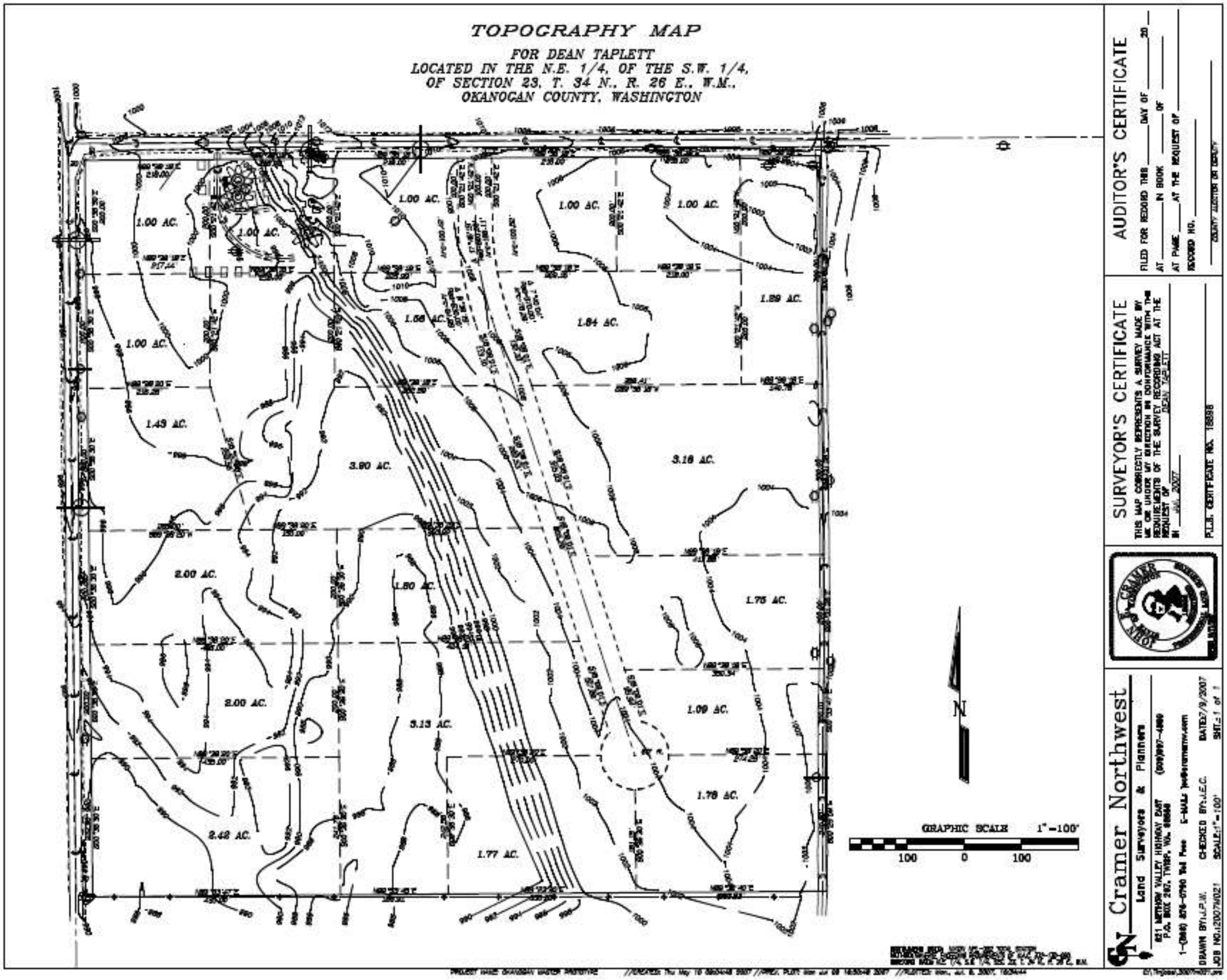
Appendix A–Glossary

Acute	Occurring over a short time [compare with **chronic**].
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor (CSF)	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin [see **route of expo**sure].
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a comparison value used to select contaminants of potential health concern and is based on ATSDR's minimal risk level (MRL).
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Epidemiology	The study of the occurrence and causes of health effects in human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. The investigators try to determine if any factor (i.e., age, sex, occupation, economic status) is associated with the health effect.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [see **acute exposure**], of intermediate duration, or long-term [see **chronic exposure**].
Hazardous Substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].
Ingestion Rate (IR)	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts Per Billion (ppb)/Parts Per Million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [see **inhalation**], eating or drinking [see **ingestion**], or contact with the skin [see **dermal contact**].

Appendix B–Proposed Plat Schematic for Taplett Farms



Appendix C–Screening Analysis

Washington State Department of Health (DOH) compiled results from samples taken at Taplett Farms by Okanogan County Public Health (OCPH) in 2009. DOH screened these data with appropriate health-based comparison values (CVs) to determine if the chemical concentrations pose a potential health threat. Media concentrations above health-based CVs do not mean that people will get sick. However, it does tell us that additional evaluation is necessary. Contaminants with media concentrations below the CV do not pose a health threat and further evaluation is not required. Of the available CVs for each chemical, the most conservative CV was chosen.

Table C1. Screen of chemicals (mg/kg) measured in soil samples at Taplett Farms, Omak, Okanogan County, Washington with comparison values

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	Average (95%UCL)	CV	Type of CV
Total metals[a] (mg/kg)											
Arsenic	**15.75**	**45.18**	**13.44**	**15.43**	**13.64**	**37.56**	**172.2**	**247.6**	70.10 (175)	**0.5**	CREG
Barium	82.4	169	164	210	107	76.0	116	160	136	10000	cEMEG
Cadmium	1.00	1.93	1.39	1.51	1.57	1.35	1.56	1.63	1.49	5 (2)	cEMEG (MTCA)
Chromium	9.40	12.7	14.4	16.1	18.0	17.6	23.2	15.3	15.8	50[b]	cEMEG
Lead	117	**473**	138	124	88.8	**463**	**1,680**	**1,530**	577 (1388)	**400 (250)**	EPA SL (MTCA)
Mercury	<0.0183	0.0391	<0.0199	0.0440	<0.0155	<0.0165	0.0279	0.0432	0.0281[c]	5[d]	RMEG
Selenium	<3.05	<2.74	<3.31	<2.96	<2.58	<2.75	<2.84	<3.03	<2.91[c]	300	cEMEG
Silver	4.81	3.15	2.73	1.38	3.62	3.44	3.78	4.33	3.41	300	RMEG
Fuel oils[e] (mg/kg)											
#2 Diesel (C10-C24)	**12,000**	**12,000**	**120,000**	54				**3,800**	**29,571**	2,000	MTCA
Motor Oil (> C24-C36)	**70,000**	**93,000**	**11,000**	1,000				**20,000**	**39,000**	2,000	MTCA
Non-carcinogenicPAHs[f] (mg/kg)											
Acenaphthylene					<0.0016	0.022 J	0.67			-	-
Acenapthene					<0.0016	<0.0085	0.047			3,000	RMEG

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	Average (95%UCL)	CV	Type of CV
Anthracene					<0.0014	0.012 J	0.51			20,000	
Benzo[g,h,i]perylene					<0.0015	0.16	1.8			-	-
Fluoranthene					0.0055 J	0.11	5.5			2,000	RMEG
Fluorene					<0.0012	<0.0064	0.19			2,000	RMEG
1-Methylnapthalene					0.0025 J	<0.0096	0.028 J			4,000	cEMEG
2-Methylnapthalene					<0.0022	<0.012	0.031 J			200	RMEG
Naphthalene					<0.0021	<0.012	0.062			1,000	RMEG
Phenanthrene					0.018 J	0.038 J	2.2			-	-
Pyrene					<0.0014	0.11	4.5			2,000	RMEG
Carcinogenic PAHs[f] (mg/kg)											
Total cPAH TEQ[g]					0.0033*	0.067*	**3.9**			0.1	BaP CREG
Benzo[a]anthracene					<0.0017	0.085 J	3.1			-	-
Benzo[a]pyrene					<0.002	<0.011	**2.8**			0.1	CREG
Benzo[b]fluoranthene					<0.004	0.17	4.1				-
Benzo[k]fluoranthene					<0.0013	0.077 J	1.4			-	-
Chrysene					<0.0014	0.14	2.9			-	-
Dibenzo(a,h)anthracene					<0.0021	<0.012	0.59			-	-
Indeno[1,2,3-cd]pyrene					<0.0041	0.2 J	1.8			-	-
Organochlorine pesticides[h] (mg/kg)											
Aldrin			0.0081 J							0.04	CREG
alpha-Chlordane			<0.0017							2[i]	CREG
gamma-Chlordane			0.020 p							2[i]	CREG
4,4'-DDD			0.44							3	CREG
4,4'-DDE			0.69							2	CREG
4,4'-DDT			0.15							2	CREG
Dieldrin			**0.042**							0.040	CREG
Endosulfan I			<0.0013							100[j]	cEMEG
Endosulfan II			0.17							100[j]	Endosulfan I CREG
Endosulfan sulfate			0.025 Jp							100[j]	Endosulfan I CREG
Endrin			0.017 J							20	cEMEG,

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	Average (95%UCL)	CV	Type of CV
											RMEG
Endrin aldehyde			0.10							20	Endrin cEMEG
Endrin ketone			0.066							20	Endrin cEMEG
Heptachlor			<0.006							0.2	CREG
Heptachlor epoxide			0.015							0.08	CREG
alpha-Hexachlorocyclohexane[k]			<0.0036							0.1	CREG
beta-Hexachlorocyclohexane[k]			0.017							0.4	CREG
delta-Hexachlorocyclohexane[k]			0.0033 J							0.1	α-BHC CREG
gamma-Hexachlorocyclohexane (lindane)[k]			<0.0010							20	RMEG
Methoxychlor			0.094 Jp							300	RMEG
Toxaphene			**12**							0.6	CREG
Organophosphate Pesticides[l] (mg/kg)											
Azinphos methyl			<0.058							100	cEMEG
Bolstar			<0.090							-	-
Chlorpyrifos			<0.090							50	cEMEG
Coumaphos			<0.220							-	-
Demeton-O			<0.160							2[m]	RMEG
Demeton-S			<0.059							2[m]	RMEG
Diazinon			<0.090							40	cEMEG
Dichlorvos			<0.042							2	CREG
Dimethoate			<0.055							10	RMEG
Disulfoton			<0.220							2	RMEG
EPN			<0.067							0.5	RMEG
Ethoprop			<0.220							-	-
Famphur			<0.096							-	-

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	Average (95%UCL)	CV	Type of CV
Fensulfothion			<0.075							-	-
Fenthion			<0.090							-	-
Malathion			<0.059							1000	cEMEG, RMEG
Merphos			<0.130							2	RMEG
Mevinphos			<0.220							-	-
Momochrotophos			<2.200							-	-
Naled			<0.200							100	RMEG
Parathion, ethyl			<0.070							-	-
Parathion, methyl			<0.036							10	RMEG
Phorate			<0.090							-	-
Ronnel			<0.220							-	-
Stirophos			<0.220							-	-
Sulfotepp			<0.095							30	RMEG
Thionzin			<0.100							-	-
Tokuthion			<0.090							-	-
Trichloronate			<0.090							-	-

Notes:
Bold values exceed CV
[a] Samples taken by OCPH in 2009 and analyzed by Cascade Analytical, Inc. using Method SW846 6010 (Mercury analyzed by SW846 7471).
[b] The cEMEG is for chromium VI in soil; analyte was total chromium.
[c] Average included half of non-detect values.
[d] The RMEG is for methyl mercury in soil; analyte was total mercury.
[e] Samples taken by OCPH in 2009 and analyzed by Test America using Northwest Total Petroleum Hydrocarbon method and prepared by SW846 3550B.
[f] Sample taken by OCPH in 2009 and analyzed by Test America using Method SW846 8270C and prepared by SW846 3550B.
[g] cPAH TEQ is the sum of each cPAH multiplied by the respective TEF (used detection limit for non detects).
[h] Sample taken by OCPH in 2009 and analyzed by Test America by Method SW846 8081A and prepared by SW846 3550B.
[i] Chlordane isomer not specified by the ATSDR soil CV table.
[j] Endosulfan isomer not specified by the ATSDR soil CV table.
[k] Hexachlorocyclohexane listed as benzene hexachloride (BHC) on laboratory data package.
[l] Sample taken by OCPH in 2009 and analyzed by Test America by Method SW846 8041A and preparation SW846 3550B.
[m] Demeton-O or Demeton-S not specified by ATSDR soil Comparison Value table.

Abbreviations:

BaP	– benzo (a)pyrene
cEMEG	– Chronic environmental media evaluation guide developed by ATSDR
cPAH	– Polycyclic aromatic hydrocarbons associated with carcinogenic effects
CREG	– Carcinogenic Risk Evaluation Guide based on EPA's cancer slope factor
CV	– ATSDR Comparison Value or other identified criterion
EPA SL	– U.S. Environmental Protection Agency Screening Level
J	– Analyte concentration between method detection limit and practical quantitation limit
MTCA	– Washington State Model Toxic Control Act cleanup level
p	– The relative percent difference (RPD) between the primary and confirmatory analysis exceeded 40%. The lower value was reported because of apparent chromatographic interference.
RMEG	– Reference dose Media Evaluation Guide developed by ATSDR based on EPA's reference dose value
TEF	– Toxic equivalency factor is the potency factor for cPAH compounds relative to BaP
TEQ	– Toxic equivalency quotient (sum of each cPAH concentration × TEF)
<	– Analyte concentration below method detection limit listed on laboratory data package
-	– CV not identified

Appendix D – Exposure Calculations for Arsenic

This appendix provides the assumptions and calculations used to estimate daily intakes for exposure to chemicals in the one-acre farmyard area at Taplett Farms in Omak, Okanogan County, Washington. Two exposure scenarios were developed to model exposures that might occur at the site. These scenarios were devised to represent exposures to: 1) a younger child resident (0–6 years old) and 2) an adult resident. The total dose for estimating harm from chemicals is determined by adding the exposure dose calculated for incidental ingestion, skin contact, and inhalation of particulates together.

Calculations

Equation D1: Total Exposure Dose (mg/kg-day) calculation

$$Total\ Exposure\ Dose = Dose_{ingestion} + Dose_{dermal} + Dose_{inhlation}$$

The following exposure dose equations were used to estimate exposures to chemicals in soil through incidental ingestion, dermal contact, and inhalation of particulates. Exposure estimates were calculated for all age groups (child, older child, and adult) then added together. The averaging time is calculated differently for chemicals with non-carcinogenic or carcinogenic effects; see specific parameters in table C1. Specific parameters are defined in Table B1.

Incidental Ingestion

Equation D2: Calculation of daily intake from incidental ingestion of soil

$$Dose_{ingestion} = \frac{C_{soil} \times IR_{soil} \times ET \times EF \times ED \times CF}{BW \times AT}$$

Skin Contact

Equation D3: Calculation of daily intake of chemical in soil through the skin

$$Dose_{dermal} = \frac{C_{soil} \times SA \times AF \times ABS_{dermal} \times EF \times ED \times CF}{BW \times AT}$$

Inhalation of Particulates

Equation D4: Calculation of daily intake of chemical through inhalation of particulates or dust

$$Dose_{inhlation} = \frac{EPC \times IR_{inh} \times EF \times ED \times SMF \times 1/PEF}{BW \times AT}$$

Equation D5: Calculation of the particulate emission factor (assuming 50% grass cover)

$$PEF = \frac{Q/C \times CF}{RF \times \ 1 - V \ \times (Um/Ut)^3 \times F(x)}$$

Table D1. Exposure assumptions for exposure to arsenic in soil at Taplett Farms, Omak, Okanogan County, Washington

Parameter	Abb.	Value	Unit	Comments
Absorbance factor (24-hour)	ABS	0.03	unitless	Dermal absorbance factor from soil specific for arsenic (EPA RAGS E Exhibit 3-4 (2004)
Adherence factor of soil to skin [2]	AFa	0.07	mg/cm^2	Based on geomean of adult gardeners EPA RAGS E Exhibit 3-3 (2004)
	AFoc	0.2	mg/cm^2	Based on geomean of children playing in wet soil (8-12 year olds) EPA RAGS E Exhibit 3-3 (2004)
	AFc	0.2	mg/cm^2	Based on older child value (similar to 95th percentile for daycare children playing outdoors) EPA RAGS E Exhibit 3-3 (2004)
Averaging time	Ata_{nc}	5475	days	Number of days as an adult at one residence (15 years, for a total of 30 years per EFH Table 1-1 (US EPA 1997)
	$AToc_{nc}$	3650	days	Number of days as an older child at one residence (10 years) 6 to < 16 years old

[2] For the purposes of this calculation, the surface of the face may be assumed to be 1/3 that of the head, forearms maybe assumed to represent 45% of the arms, and lower legs may be assumed to represent 40% of the legs (U.S. EPA 2004).

Parameter	Abb.	Value	Unit	Comments
	$AT_{c_{nc}}$	1825	days	Number of days during childhood at one residence (5 years) 1 to < 6 years old
	AT_{cancer}	27375	days	Number of days during lifetime (75 years × 365 days/year)
Body weight	BWa	72	kg	Adult mean body weight EFH 1997
	BWoc	41	kg	Ages 6 to < 11 years old EFH 1997
	BWc	15	kg	Combined mean for ages 1 to < 6 years old EFH 1997
Cancer slope factor[3]	CSF	5.7	$(mg/kg\text{-}day)^{-1}$	Oral cancer slope factor
Concentration in soil	C	70.1 175	mg/kg	Site-specific, Mean and 95% UCL of the Mean (as calculated by ProUCL 4.1)
Conversion Factor	CF	0.000001	kg/mg	Converts soil concentration from milligrams to kilograms
Exposure Duration	ED	30 (5,10,15)	years	Residential occupancy period 95% combined for child, older child, adult, EPA EFH 1997)
Exposure Frequency	EF	350	days/year	Number of days per year in contact with soil
Ingestion rate (soil)	IRa	50	mg/day	EPA EFH Table 5-1 (2011) adults
	IRoc	100	mg/day	EPA EFH Table 5-1 (2011) 6 to < 11 years old
	IRc	200	mg/day	EPA EFH Table 5-1 (2011) 3 to < 6 years old high-end
Inhalation rate	IHRa	15.2	m^3/day	EPA EFH 1997 mean for adults (maximum of adults at ages 21 to <51 years old)
	IHRoc	14	m^3/day	EPA EFH 1997 mean for 6 to <11 years old
	IHRc	8.3	m^3/day	EPA EFH 1997 mean for 3 to <6 years old
Oral route adjustment factor	ORAF	1	unitless	EPA 2004
Particulate emission factor	PEF	calculated	m^3/kg	Equation D5

[3] cancer slope factor - ORAF

Parameter	Abb.	Value	Unit	Comments
Surface Area	SAa	5700	cm^2	Skin surface area available for contact during adult EPA RAGS E Exhibit 3-5 (2004)
	SAoc	2900	cm^2	Skin surface area available for contact for an older child (based on ages 1-6 from EPA RAGS E Exhibit 3-5 and equation 3.21 (2004)
	SAc	2900	cm^2	Skin surface area available for contact during ages 1-6 from EPA RAGS E Exhibit 3-5 (2004)
Soil matrix factor	SMF	1	unitless	EPA 2004
Q/C	Q/C	82.7		Inverse of mean concentration at center of a 0.5 $acre^2$ source
Conversion factor	CF	3600	second/hour	Converts seconds to hours in PEF equation
Respirable fraction	RF	0.036	g/m^2-hour	Respirable fraction of dust
Fraction of vegetative cover	V	0.5	unitless	Fraction of vegetative cover (0.5 indicated 50% grass)
Wind speed	Um	4.69	m/s	Mean annual wind speed for the region (based on Seattle data)
Relative wind speed	Ut	11.32	m/s	Equivalent threshold value of wind speed at 10 meters per second
Function dependent on Um/Ut	F(x)	0.194	unitless	Function dependent on Um/Ut (scenario specific)

EFH – U.S. EPA Exposure Factors Handbook (1997, 2011) (12;13).
RAGS E – U.S. EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (2004) (14).

Non-carcinogenic Effects

To evaluate harm from chemicals with non-carcinogenic effects, a hazard quotient (HQ) is calculated by dividing the total exposure dose by the MRL for arsenic.

Table D2. Hazard calculations for non-carcinogenic effects resulting from residential exposure to arsenic in soil at the Taplett Farms homestead, Omak, Washington

Age	**Concen-tration (mg/kg)**	**Estimated Dose (mg/kg-day)**			**Total Dose (mg/kg -day)**	**MRL**	**Hazard Quotient**
		Incidental Ingestion	Dermal Contact	Inhalation of Particulates			
Child 1 to <6 years old	70.1	8.96E-4	7.8E-5	3.10E-8	9.74E-4	0.0003	**3.2**
Older child (6 to 11 years old)		1.64E-4	2.85E-5	1.91E-8	1.92E-4		0.64
Adult		4.67E-5	1.12E-5	1.18E-8	5.79E-5		0.19
Child 1 to <6 years old	175	2.24E-3	1.95E-4	7.74E-8	2.43E-3	0.0003	**8.1**
Older child (6 to 11 years old)		4.09E-4	7.12E-5	4.78E-8	4.81E-4		**1.6**
Adult		1.17E-4	2.79E-5	2.95E-8	1.44E-4		0.48

Carcinogenic Effects

To evaluate harm from chemicals with carcinogenic effects the exposure dose is multiplied by the cancer slope factor. This calculation estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime of exposure. This risk is calculated separately for each route (incidental ingestion and dermal contact) and age group (child, older child, and adult) then added together for lifetime cancer risk.

Table D3. Cancer risk resulting from residential exposure to arsenic in soil at the Taplett Farms homestead, Omak, Washington

Age	Concen-tration (mg/kg)	Cancer Slope Factor	Cancer Risk			Total Cancer Risk	Lifetime Cancer Risk
			Incidental Ingestion	Dermal Contact	Inhalation of Particulates		
Child 1 to <6 years old			3.41E-4	2.96E-5	1.18E-8	3.70E-4	
Older child (6 to 11 years old)	70.1	5.7	1.25E-4	2.17E-5	1.46E-8	1.46E-4	5.82E-4
Adult			5.32E-5	1.27E-5	1.35E-8	6.60E-5	
Child 1 to <6 years old			8.50E-4	7.40E-5	2.94E-8	9.24E-4	
Older child (6 to 11 years old)	175	5.7	3.11E-4	5.41E-5	3.63E-8	3.65E-4	1.45E-3
Adult			1.33E-4	3.18E-5	3.37E-8	1.65E-4	

Uncertainty– Although there is some uncertainty surrounding the magnitude of the carcinogenic potential of arsenic, there is a strong scientific basis for choosing a slope factor that is different from the 1.5 per mg/kg-day currently listed in the EPA Integrated Risk Information System (IRIS) database (15). Several recent reviews of the literature have evaluated bladder and lung cancer endpoints instead of skin cancer (which is the endpoint used for the current IRIS value):

- National Research Council (2001) (16).
- EPA Office of Drinking Water (2001) (17) .
- Consumer Product Safety Commission (2003) (18).
- EPA Office of Pesticide Programs (2008) (19).
- California Office of Environmental Health Hazard Assessment (2004) (20).
- Toxicological Review of Inorganic arsenic for IRIS (review draft for the Science Advisory Board) (2005) (21).
- Report of the Science Advisory Board for EPA's assessments of carcinogenic effects of organic and inorganic arsenic (2007) (22).
- Toxicological Review of Inorganic arsenic for IRIS (External Review Draft) (2010) (23).

Information provided in these reviews allows the calculation of slope factors for arsenic which range from 0.4 to 27 per mg/kg-day (but mostly greater than 3.7 mg/kg-day). The EPA IRIS review draft for the Science Advisory Board presented a slope factor for combined lung and bladder cancer of 5.7 per mg/kg-day (21). The slope factor calculated from the work by the National Research Council is about 21 per mg/kg-day (16). The revised external review draft of the EPA IRIS toxicological review presented revised cancer slope factors for these cancers– 16.9 and 25.7 per mg/kg-day for men and women respectively (24). Until EPA officially implements these values in IRIS and ATSDR recommends using these values, DOH will employ apply a slope factor of 5.7 per mg/kg-day, which reflects EPA's 2005 assessment.

Appendix E–Exposure Calculations for Lead

Since the toxicokinetics (the absorption, distribution, metabolism, and excretions of toxins in the body) are well understood, lead is regulated based on blood lead concentration. EPA and Centers for Disease Control and Prevention (CDC) have determined that childhood blood lead concentrations at or above 10 micrograms of lead per deciliter of blood (µg/dL) present risks to children's health. Blood lead concentration can be correlated to both exposure and adverse health effects.

The EPA-developed Integrated Exposure Uptake and Biokinetic (IEUBK) model (Version 1.1 Build 11) was used to predict blood lead concentration and the probability of a child's blood lead concentration exceeding 10 µg/dL based on the specific scenario at Taplett Farms. The model was run with both the average concentration of lead in soil found across the site (577 mg/kg) and with the 95% upper confidence limit on the mean (1388 mg/kg).

Summary of IEUBK Results

Using default parameters, the following results were obtained from the IEUBK model:

- Average soil lead concentrations resulted in a prediction of blood lead levels ranging from 4.0 to 7.5 µg/dL for ages of six months to six years old.
- Average soil lead concentrations resulted in a prediction of 12.987% of the population of children under seven years old to have a blood lead level of greater than 10 µg/dL.
- 95% UCL of mean soil lead concentrations resulted in a prediction of blood lead levels ranging from 8.1 to 12.3 µg/dL for ages six months to six years old.
- 95% UCL of mean soil lead concentrations resulted in a prediction of 60.888% of the population of children under seven years old to have a blood lead level of greater than 10 µg/dL.

Note that soil lead data used in this assessment represent levels throughout the farmyard, including farm worker areas. It does not necessarily represent specific areas that a child may play in.

EPA recommends using the arithmetic mean for soil concentration in the IEUBK model to represent the central point estimate for risk of an elevated blood lead. The 95% UCL of the mean can be used; however, it is interpreted as a more conservative estimated of the risk of an elevated blood lead.

Model Output (1)

Model Version: 1.1 Build 11

Date: **12/14/2011**

Site Name: **Taplett Farms**

Operable Unit: **Average of 8 samples**

Run Mode: Research

*****Air*****

Indoor Air Pb Concentration: 30.000 percent of outdoor

Other Air Parameters:

Age (year)	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (percent)	Outdoor Air Pb Concentration (µg Pb/m^3)
0.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

*****Diet*****

Age (year)	Diet Intake (µg/day)
0.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

*****Drinking Water*****

Age (year)	Water Consumption (L/day)
0.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking water concentration: 4.000 µg/L

*****Soil and Dust *****

Multiple Source Analysis Used

Average multiple source concentration: 413.90 µg/g

Soil concentration: 577.000 µg Pb/g

Mass fraction of outdoor soil to dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Used alternate indoor dust Pb sources? No

*****Alternate intake*****

Alternate intake (µg/day): 0.000

*****Maternal Contribution: Infant Model*****

Maternal Blood Concentration: 1.000 µg/day

*******CALCULATED BLOOD LEAD AND LEAD UPTAKES*******

Age (year)	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
0.5-1	0.021	0.982	0.000	0.348
1-2	0.034	0.831	0.000	0.848
2-3	0.062	0.923	0.000	0.901
3-4	0.067	0.901	0.000	0.936
4-5	0.067	0.896	0.000	1.011
5-6	0.093	0.956	0.000	1.082
6-7	0.093	1.043	0.000	1.109

Age (year)	Soil and Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
0.5-1	10.800	12.151	6.5
1-2	16.739	18.452	7.5
2-3	17.100	18.986	7.0
3-4	17.429	19.333	6.7
4-5	13.431	15.404	5.5
5-6	23.268	14.399	4.6
6-7	11.680	13.926	4.0

*******PERCENT POPULATION GREATER THAN 10 µg/dL*******

Percentage of population expected to have blood lead level greater than 10 µg/dL: 12.987 percent

Model Output (2)

Model Version: 1.1 Build 11

Date: **12/14/2011**

Site Name: **Taplett Farms**

Operable Unit: **95% UCL on the mean of 8 samples**

Run Mode: Research

*****Air*****

Indoor Air Pb Concentration: 30.000 percent of outdoor

Other Air Parameters:

Age (year)	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (percent)	Outdoor Air Pb Concentration (μg Pb/m^3)
0.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

*****Diet*****

Age (year)	Diet Intake (μg/day)
0.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

*****Drinking Water*****

Age (year)	Water Consumption (L/day)
0.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking water concentration: 4.000 µg/L

*****Soil and Dust *****

Multiple Source Analysis Used

Average multiple source concentration: 981.600 µg/g

Soil Concentration: 1388.000 µg Pb/g (95% UCL)

Mass fraction of outdoor soil to dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Used alternate indoor dust Pb sources? No

*****Alternate intake*****

Alternate intake (µg/day): 0.000

*****Maternal Contribution: Infant Model*****

Maternal Blood Concentration: 1.000 µg/day

*******CALCULATED BLOOD LEAD AND LEAD UPTAKES*******

Age (year)	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
0.5-1	0.021	0.855	0.000	0.303
1-2	0.034	0.708	0.000	0.723
2-3	0.062	0.800	0.000	0.781
3-4	0.067	0.793	0.000	0.824
4-5	0.067	0.819	0.000	0.924
5-6	0.093	0.887	0.000	1.004
6-7	0.093	0.997	0.000	1.038

Age (year)	Soil and Dust (µg/day)	Total (µg/day)	Blood Pb (µg/dL)
0.5-1	22.471	23.650	12.3
1-2	34.093	35.559	14.3
2-3	35.420	37.063	13.5
3-4	36.654	38.338	13.1
4-5	29.335	31.144	10.9
5-6	27.213	29.197	9.2
6-7	26.132	28.241	8.1

*******PERCENT POPULATION GREATER THAN 10 µg/dL*******

Percentage of population expected to have blood lead level greater than 10 µg/dL: 60.888 percent

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