Appendix K—Area-Wide Soil Contamination Toolbox

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Area-Wide Soil Contamination Toolbox

Overview

This toolbox of information and materials is designed to help individuals and organizations answer questions about area-wide soil contamination in Washington, determine whether there is the potential for exposure to elevated levels of arsenic and lead in soil at specific properties, and identify actions they can use to reduce exposure to arsenic and lead. Area-wide soil contamination is low-to-moderate level soil contamination that is dispersed over large geographic areas, ranging from several hundred acres to many square miles. In many areas of Washington State, soil contains low-to-moderate levels of arsenic and lead from three main historical sources: emissions from metal smelters, use of arsenical pesticides, and combustion of leaded gasoline. The Area-Wide Soil Contamination Task Force developed this toolbox for consideration by the State Departments of Agriculture; Ecology; Health; and Community, Trade and Economic Development as they develop and implement a broad-based education and awareness building effort to respond to area-wide soil contamination in Washington.

In this toolbox, you'll find:

1. **Background information on area-wide soil contamination*.***

2. **Maps and contextual information describing the location and extent of area-wide soil contamination in Washington.** This information is organized according to the three main sources of area-wide soil contamination:
   - historical emissions from metal smelters located in Tacoma, Harbor Island, Everett, Northport, and Trail, BC;
   - historical use of lead arsenate pesticides on apple and pear trees; and
   - emissions from combustion of leaded gasoline.

3. **Tools for conducting individual property evaluations** to determine whether there is the potential for exposure to elevated levels of lead and arsenic in soil. These tools include:
   - *Individual Property Evaluation Flowchart* – to determine whether arsenic and lead soil contamination is likely to be present in soil on a property using information about the property's location and its land-use and development history,
   - *Qualitative Evaluation Checklist for Understanding Potential Exposures to Arsenic and Lead in Soil* – to determine whether there is potential exposure on the property and inform decisions about whether to test soils and/or implement protection measures to reduce potential exposure, and
   - *Sampling Guidance* – to provide instructions for how to collect and analyze soil samples for arsenic and lead at three types of land uses: child-use areas, residential properties, and commercial properties*.*

4. **Information on health risks** from exposure to low-to-moderate levels of arsenic and lead in soil*.*

5. **Examples of individual protection measures** that individuals can use to limit potential exposure to arsenic and lead in soil. In particular, individual protection measures are designed to minimize the potential for exposure of children, gardeners, and other adults who frequently work in soil. This toolbox contains four sets of example practices:
    - Personal hygiene practices and other guidelines for how residents may reduce potential exposure, developed by Public Health – Seattle & King County
    - Actions that schools may use to reduce potential exposure of schoolchildren, developed by the Tacoma-Pierce County Health Department
    - Worker protection guidelines, developed by the Snohomish Health District for the Everett smelter area
    - Guidelines for gardening on soils that may contain elevated levels of arsenic and lead, developed by the Washington State University, Agricultural Extension

6. **Information describing the range of protective measures** that might be taken to respond to area-wide soil contamination and providing guidance on how to implement those protective measures in an effective, practical, and affordable manner.

7. **Contact information** for Federal, State, and local agencies that are available to answer questions and provide additional help.

[Note: Cover sheets could be appended to this toolbox and the contents modified to address the concerns and needs of specific audiences (e.g., childcare providers, gardeners, etc.).]

1. What is Area-Wide Soil Contamination?

Area-wide soil contamination is low-to-moderate level soil contamination that is dispersed over large geographic areas, ranging in size from several hundred acres to many square miles. These areas generally have arsenic and lead levels that are higher than both naturally occurring concentrations and state soil cleanup levels established under the Model Toxics Control Act (MTCA). Area-wide soil contamination is different from most cleanup sites, which are typically smaller and have higher levels of contamination. Area-wide soil contamination was caused by a number of historical activities, including past air emissions from metal smelting operations, the use of lead-arsenate pesticides in the early to mid-1900s, and combustion of leaded gasoline.

What is "Low-to-Moderate" Level?

In general, arsenic concentrations of up to 100 parts per million (ppm) and lead concentrations of up to 500 – 700 ppm are "low-to-moderate" levels of contamination for schools, childcare centers, and residential land uses. For properties where exposure of children is less likely or less frequent, such as commercial properties, parks, and camps, arsenic concentrations of up to 200 ppm and lead concentrations of up to 700 – 1,000 ppm are within the low-to-moderate range. For comparison, the unrestricted site use cleanup levels for arsenic and lead under MTCA are 20 ppm and 250 ppm, respectively. Arsenic occurs naturally in Washington State soils at approximately 5 - 9 ppm and lead at 11 - 24 ppm. Ecology plans to ask the Science Advisory Board to review these values and their use in implementing the Task Force recommendations.

What Concentrations Have Been Observed?

Concentrations of arsenic and lead within areas affected by area-wide soil contamination are highly variable and the range of concentrations is quite broad. Arsenic concentrations range from natural background levels to over 3,000 ppm in smelter areas. Average concentrations of arsenic in soil at developed properties are generally less than 100 ppm. Lead concentrations range from natural background levels, to over 4,000 ppm in orchard top soils. Average concentrations of lead in soil at developed properties are generally less than 700 ppm. The higher concentrations were observed in smelter areas and in areas where lead arsenate pesticides likely were mixed in preparation for application. Soil concentrations tend to be greater around the Tacoma smelter than in the other smelter areas, because the Tacoma smelter operated for a longer period and specialized in the processing of high-arsenic ore.

Where found, arsenic and lead soil contamination tends to be relatively shallow. In undisturbed soils, most of the arsenic and essentially all of the lead from historical smelter emissions and historical use of lead-arsenate pesticides typically are concentrated in the upper 6 to 18 inches of soil.[1] While some downward movement of arsenic occurs in most soils, substantial downward movement has been observed on occasion and appears to be restricted to heavily leached sandy soils and medium-textured soils with very uniform soil profile characteristics. There are a few anecdotal reports of elevated arsenic concentrations in shallow drainage water

[1] Data in this paragraph from Landau Associates, *Preliminary Estimates Report, Area-Wide Soil Contamination Strategy, Washington State,* prepared for the Washington State Department of Ecology, Olympia, WA, 2003 (pending).

derived from heavily irrigated land containing lead arsenate pesticide residues; however, currently there does not appear to be evidence of ground water contamination.

Where is Area-Wide Soil Contamination Likely to be Found?

Areas affected by smelter emissions in King, Pierce, Snohomish, and Stevens counties have a higher likelihood of arsenic and lead soil contamination than other areas of the State due to historical emissions from metal smelters located in Tacoma, Harbor Island, Everett, Northport, and Trail, BC. Areas where apples and pears were historically grown have a higher likelihood of arsenic and lead soil contamination than other areas of the State because of past use of lead arsenate pesticides. Chelan, Spokane, Yakima, and Okanogan counties have a higher likelihood than other counties for elevated levels of lead and arsenic in soil based on the greater numbers of apple and pear trees in production there between 1905 and 1947. Combustion of leaded gasoline produces lead-enriched particulates and aerosols that are emitted from exhaust pipes and deposited onto nearby soils. The full extent of area-wide soil contamination from past use of leaded gasoline in Washington is not known; however, in general, land adjacent to any road constructed prior to 1995 and land in the center of highly populated urban areas has some likelihood of elevated levels of lead in soil from leaded gasoline.

For more information about whether area-wide soil contamination is likely to be present on a specific locality, see the maps and accompanying information in section 2 and the tools and guidance for individual property assessments in section 3 of this toolbox.

How Much Land is Potentially Affected?

Preliminary Estimates of Area-Wide Soil Contamination in Washington

Area-Wide Soil Contamination Source	***Estimated Land Area Affected***
Smelters (Tacoma, Everett, Harbor Island, Northport, and Trail, B.C.)	489,000 acres
Orchard Land	188,000 acres
Roadsides	Unknown at present
Total Area-Wide Sources	677,000 acres
Notes: The extent of affected area has not been fully characterized. The total area of land in Washington is about 42.6 million acres.	

What Are Other Sources of Arsenic and Lead Soil Contamination?

Other sources of arsenic contamination include wood treated with chromated copper arsenic (often called “pressure-treated” wood), emissions from coal-fired power plants and incinerators, and other industrial processes. Other sources of lead contamination include lead-based paint, lead-soldered water pipes, home remedies or health-care products that contain lead, hobbies that use lead (e.g., staining glass or sculpturing), foods and beverages, combustion of coal or oil, waste incinerators, and mining and industrial processes (such as battery and ammunitions manufacturing). Both arsenic and lead also occur naturally in the environment at varying concentrations.

2. Maps of Area-Wide Soil Contamination

Soil in many areas of Washington State has elevated levels of arsenic and lead from historical smelter emissions, historical use of lead arsenate pesticides, and past combustion of leaded gasoline. Areas where elevated levels of arsenic and lead are more likely to be present may be identified based on their proximity to these historical sources. Maps show a greater or lesser probability of encountering elevated levels of arsenic and lead in soil based on proximity to historical sources. For certainty, individual property evaluations are needed.

The Task Force recommends a tiered approach to maps, as follows.

- Tier 1: The first tier of maps identifies the general areas in the state where elevated levels of arsenic and lead soil contamination are more likely to be present based on historical smelter emissions and historical use of lead arsenate pesticides. The maps do not show areas that have been found to be contaminated, but simply show where contamination is more likely relative to other places. Tier 1 maps are designed to raise general awareness about area-wide soil contamination in the widest possible audience and to help users decide whether to look at the second tier of more detailed maps and informational tools for more information.

- Tier 2: Tier 2 maps allow individuals to refine their understanding of where area-wide soil contamination is likely to be present based on more detailed, smaller scale maps of smelter plumes and historical orchard areas. For sources such as leaded gasoline and lead arsenate pesticides where local maps may not exist, information and the individual property evaluation flowchart (see Section 3) are provided to help individuals determine whether elevated levels of arsenic and lead contamination are likely to be present based on the location and land-use history of specific properties.

Care should be taken to avoid misinterpretation of the maps. The maps do not show where properties have been sampled and area-wide soil contamination found. The maps only communicate where elevated levels of arsenic and lead in soil are more likely, relative to other areas in Washington State. Due to the variability of the distribution of area-wide soil contamination, properties outside of areas identified on maps may contain elevated levels of arsenic and lead, while properties inside areas identified on maps may not, in fact, have elevated levels of arsenic and lead. The maps include disclaimers to explain these limitations so that individuals are not given a false sense of assurance or concern about whether their property is affected by area-wide soil contamination.

Areas Affected by Smelter Emissions

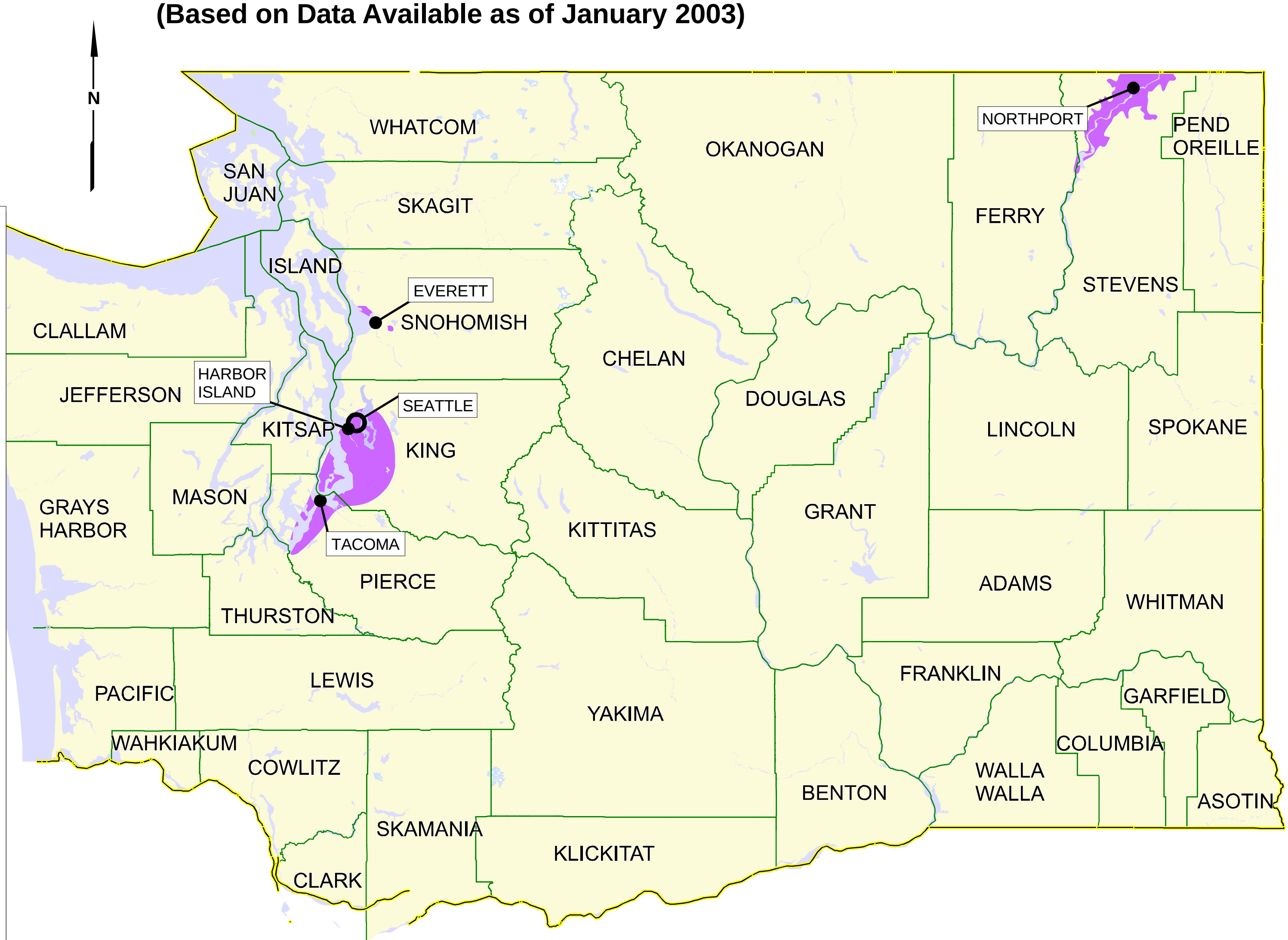
Tier 1 Smelter Map

The tier 1 smelter map (*Figure 3: Estimate of Areas Potentially Affected by Historical Smelter Emissions [Based on Data Available as of January 2003]*) shows the portions of counties where area-wide soil contamination is likely to be present based on the historical emissions from four former smelter areas in Washington, based on information currently available. Metal smelters were historically located in the Tacoma, Harbor Island, Everett, and Northport areas of

Washington, and a lead smelter currently operates in Trail, BC near Stevens county. This figure identifies the historical locations of smelters in Washington and shows the portions of counties potentially affected by smelter emissions in a darker color.

The areas indicated as potentially affected by smelter emissions do not necessarily include all affected areas, because the complete extent of effects has not been determined. The areas shown were derived from actual soil sampling results for the Tacoma and Harbor Island smelters, sampling and air modeling for the Everett smelter, and maps of sulfur dioxide injury to vegetation from the Northport and Trail, BC smelters. These regions include areas where arsenic and lead levels are likely to exceed cleanup levels based on soil sampling studies that have been conducted (as shown in the Tier 2 smelter maps for most of the smelters described below) as well as other areas where air modeling or other information indicated that some level of impact from smelter emissions exists.

Figure 3: Estimate of Areas Potentially Affected by Historical Smelter Emissions (Based on Data Available as of January 2003)



Legend

Area potentially affected by smelter emissions

● Smelter locations

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical smelter emissions, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination. The areas potentially affected by smelter emissions in these maps were derived from actual soil sampling results for the Tacoma and Harbor Island smelters, sampling and air modeling for the Everett smelter, and maps of sulfur dioxide injury to vegetation from the Northport and Trail, BC smelters. The areas indicated as potentially affected by smelter emissions do not necessarily include all affected areas, because the complete extent of effects has not been determined.

Tier 2 Smelter Maps

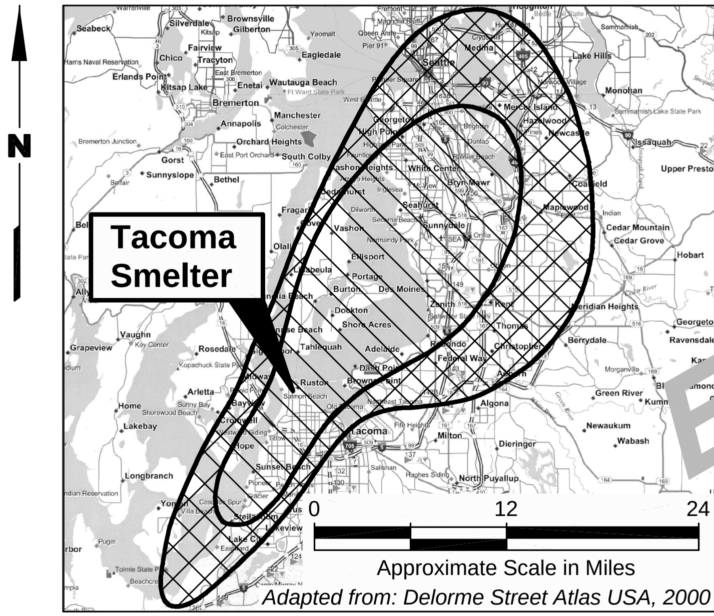
More detailed, local maps have been developed to delineate the potential extent of arsenic and lead soil contamination from smelter emissions for the following smelter areas:

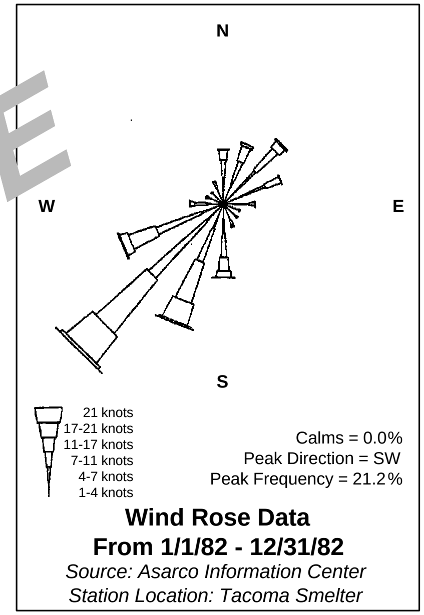
- *Figure I-1: Estimate of Area Affected by Historical Tacoma Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)*
- *Figure I-2: Estimate of Area Affected by Historical Everett Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)*
- *Figure I-3: Estimate of Area Affected by Historical Harbor Island Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)*
- *Figure I-4: Estimate of Area Potentially Affected by Emissions from the Northport and Trail, BC Smelters (Based on Data Available as of January 2003)*

Tacoma, Harbor Island, and Everett Smelters

For the Tacoma, Harbor Island, and Everett smelters, the figures show the extent of area known to be likely to contain elevated levels of arsenic and lead (above 20 mg/kg for arsenic or above 250 mg/kg for lead) based on soil sampling results. The Tacoma and Everett smelter plume maps also show the larger areas potentially affected by smelter emissions (including areas where arsenic and lead levels may occasionally exceed cleanup levels). All three Westside smelter figures include wind-rose diagrams illustrating the predominant wind patterns around the smelters.

Figure I-1: Estimate of Area Affected by Historical Tacoma Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)





Legend

Level 1: Area where shallow undisturbed soil likely exceeds 20 mg/kg Arsenic

Level 2: Area where shallow undisturbed soil occasionally exceeds 20 mg/kg Arsenic

Data Sources:
Ecology, 2002
Glass, 2002

Disclaimer

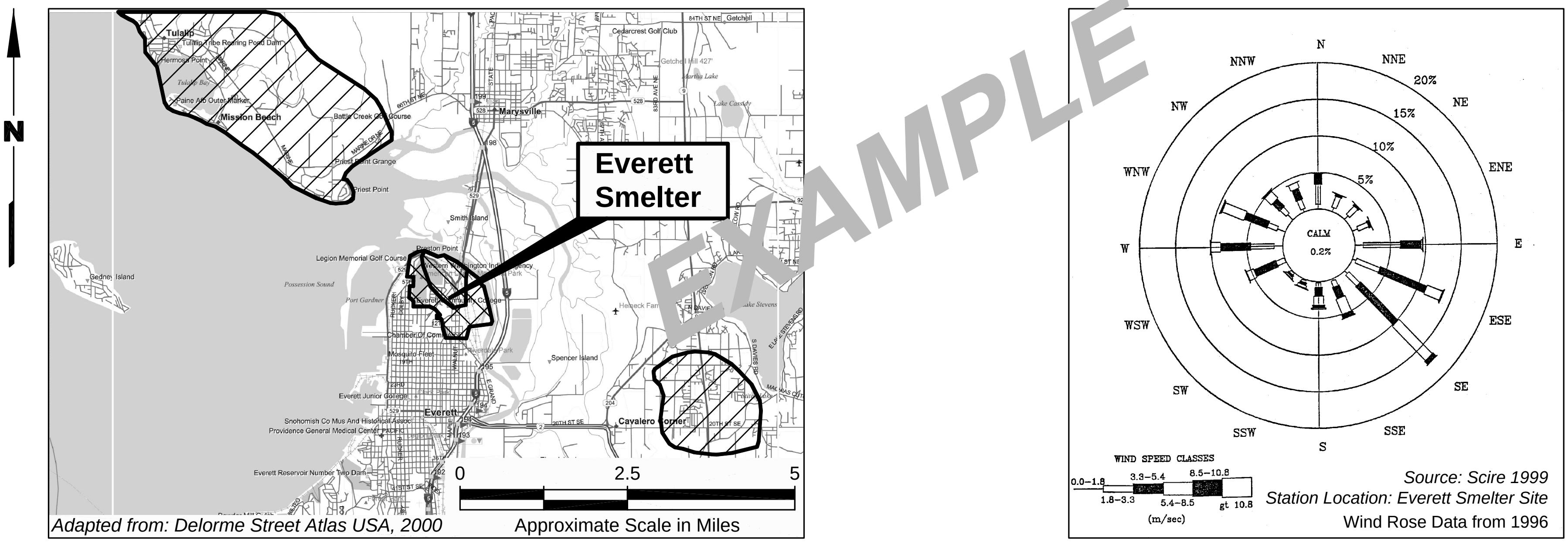
This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

The map of the area affected by smelter emissions was originally developed in 2003 for the report "Area-wide Soil Contamination Project, Task 3.4: Preliminary Estimates." They are based on information available at that time and are intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical smelter emissions, so individuals and communities can assess whether to look into additional information on area-wide soil contamination.

Interpreting a Wind Rose

A wind rose is a quantitative graphical summary of the wind direction and speed for a given time. The wind rose diagram shows the number of hours (expressed as a percentage) that the wind blew from a particular direction and speed. The wind rose spokes or arms represent 16 points of the compass. The length of each segment of a spoke represents the percentage of time the wind speed was within a specific speed interval for a particular direction (the longer the spoke, the greater the time that the wind blew from that direction). If summed for all wind directions, the result would provide the percentage of all hours the wind speed was measured within a specific interval. The percentage of time when the winds were light and variable is shown in the center of the rose.

Figure I-2: Estimate of Area Affected by Historical Everett Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)



Legend

Level 1: Area where shallow soil likely exceeds 20 mg/kg Arsenic

Level 2: Area where shallow soil occasionally exceeds 20 mg/kg Arsenic

Level 3: Area where modeling predicted most likely particulate deposition from former furnace stack

Data Sources:
Ecology, 1999
Scire, 1999

Disclaimer

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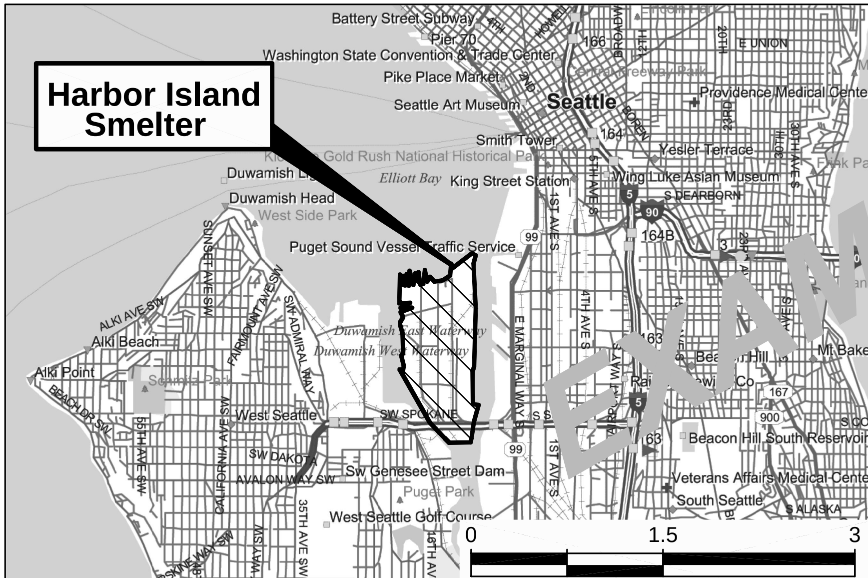
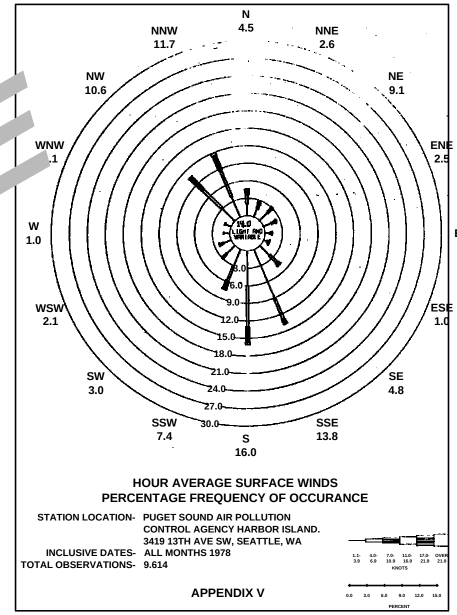
Figure I-3: Estimate of Area Affected by Historical Harbor Island Smelter Emissions with Wind Rose Diagram of Predominant Wind Directions at the Smelter Site (Based on Data Available as of January 2003)

N



Adapted from: Delorme Street Atlas USA, 2000



Source: PSAPCA 1980
Station Location: Harbor Island

Legend

Level 1: Area where shallow soil likely exceeds 250 mg/kg Lead

Data Source:
Weston, 1993

Disclaimer

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The map of the area affected by smelter emissions was originally developed in 2003 for the report "Area-wide Soil Contamination Project, Task 3.4: Preliminary Estimates." They are based on information available at that time and are intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical smelter emissions, so individuals and communities can assess whether to look into additional information on area-wide soil contamination.

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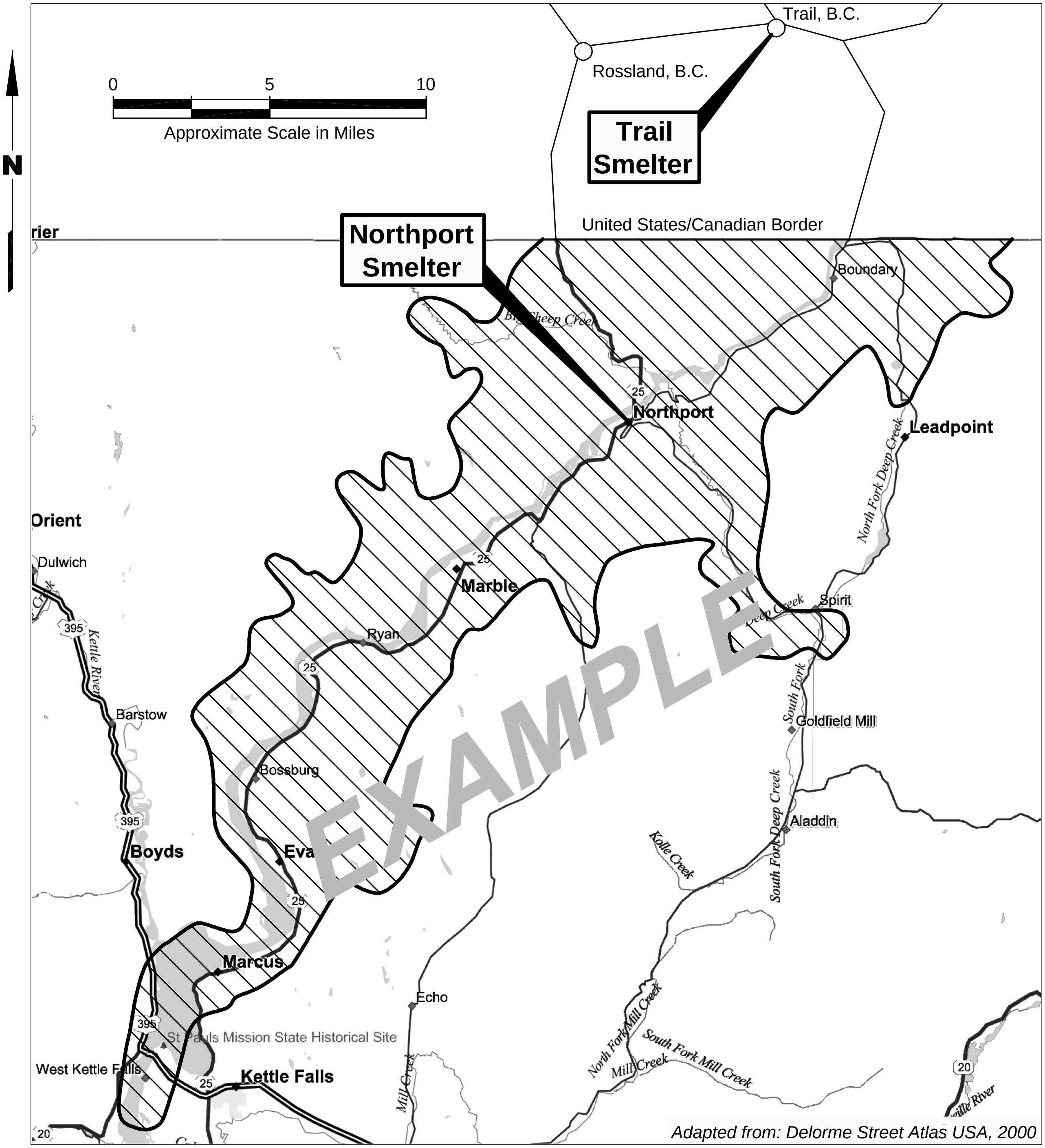
Northport and Trail, BC Smelters

For the Northport and Trail smelters (Figure I-4), the area potentially affected by smelter emissions has been estimated based on observed effects of sulfur dioxide emissions from the smelters, rather than soil sampling results for arsenic and lead, since soil sampling data do not exist for the area outside the Northport smelter property. The area of potential impact from Northport smelter emissions has been identified based on evaluation of another smelter emission contaminant, sulfur dioxide, and the maximum extent of injury to trees from this contaminant observed and documented in 1929. The area of arsenic and lead soil contamination from smelter emissions is assumed to approximate the same area as that affected by sulfur dioxide emissions, since the emissions occurred together.

Along with emissions from the Northport smelter, the area has also been affected by the Trail smelter, located approximately 18 miles upriver from the Northport smelter in the West Kootenay region of British Columbia. Smoke from Trail has reportedly been detected at Kettle Falls, Washington, 50 miles south along the river. As shown in Figure I-4, the defined area of potential impact from both smelters is influenced by the local topography. The deep valley of the Columbia River where the Northport and Trail smelters are located provides a channel which influences air dispersion, in part by limiting wind direction along the axis of the river, with the prevailing winds carrying smoke from Trail down the Columbia River valley past Northport.

Figure I-4: Estimate of Area Potentially Affected by Emissions from the Northport and Trail, BC Smelters (Based on Data Available as of January 2003)



Legend

Level 1: Area where smelter smoke damage to vegetation documented in 1929. Damage attributed to SO_2 emissions. Source: After Wirth, 2000

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

The map of the area affected by smelter emissions was originally developed in 2003 for the report "Area-wide Soil Contamination Project, Task 3.4: Preliminary Estimates." They are based on information available at that time and are intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical smelter emissions, so individuals and communities can assess whether to look into additional information on area-wide soil contamination.

The area potentially affected by smelter emissions is only shown for Washington State, not Canada.

Areas Affected by Lead Arsenate Pesticides

Tier 1 Lead Arsenate Pesticides Map

The location of areas affected by historical use of arsenical pesticides are not as well known or as extensively studied as areas affected by historical smelter emissions in Washington. Although data currently available do not permit the development of a state map of areas affected by lead arsenate contamination comparable to the tier 1 smelter map, agricultural and land-use data are available to provide a general indication of the distribution of lead arsenate pesticide contamination based on where apple and pear trees were located historically. The Task Force recommends that the following map be used to show the total acreage of land potentially affected by lead arsenate pesticide use in each county.

- *Figure 4: County Acreage Potentially Affected by Historical Use of Lead Arsenate Pesticide on Apple and Pear Orchards.* This map shows the area of land potentially affected by historical use of lead arsenate pesticide in each county based upon the peak-year acreage of apple and pear trees in each county over the period from 1905 to 1947, when lead arsenate pesticides were generally used. The table below lists these peak-year apple and pear tree acreages for each county and compares the total area potentially affected by lead arsenate pesticide use based on peak-year apple and pear tree acreages to the total area of each county and the total amount of private land in each county.

Figure 4: County Acreage Potentially Affected by Historical Use of Lead Arsenate Pesticide on Apple and Pear Orchards

Legend

1,948 Number of total acres in the county potentially affected by past use of lead arsenate pesticide on apple and pear orchards

Disclaimer

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical use of lead arsenate pesticides, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination.

Total Areas Potentially Affected by Lead Arsenate Pesticide Contamination by County and Proportions of Total Land and Private Land Potentially Affected by County

County	Total County Acreage	Public Land Acreage	Private Land Acreage	Total Apple & Pear Tree Acreage	Percent of County Affected	Percent of Private Land Affected
Adams	1,235,072	80,728	1,154,344	536	0.04%	0.05%
Asotin	409,262	108,814	300,448	501	0.12%	0.17%
Benton	1,122,809	352,563	770,246	7,738	0.69%	1.00%
Chelan	1,915,838	1,695,939	219,899	30,463	1.59%	13.85%
Clallam	1,141,042	719,834	421,208	331	0.03%	0.08%
Clark	410,999	75,462	335,537	2,676	0.65%	0.80%
Columbia	556,220	182,342	373,878	1,161	0.21%	0.31%
Cowlitz	731,478	128,115	603,363	1,139	0.16%	0.19%
Douglas	1,179,695	165,502	1,014,193	7,467	0.63%	0.74%
Ferry	1,450,915	1,246,545	204,370	322	0.02%	0.16%
Franklin	807,391	97,656	709,735	314	0.04%	0.04%
Garfield	459,852	113,200	346,652	749	0.16%	0.22%
Grant	1,786,503	425,765	1,360,738	4,928	0.28%	0.36%
Grays Harbor	1,235,289	490,589	744,700	425	0.03%	0.06%
Island	137,021	14,310	122,711	605	0.44%	0.49%
Jefferson	1,162,696	924,553	238,143	324	0.03%	0.14%
King	1,403,508	631,641	771,867	2,700	0.19%	0.35%
Kitsap	255,339	41,354	213,985	969	0.38%	0.45%
Kittitas	1,494,741	1,019,122	475,619	1,642	0.11%	0.35%
Klickitat	1,212,167	238,612	973,555	4,632	0.38%	0.48%
Lewis	1,564,211	669,023	895,188	1,954	0.12%	0.22%
Lincoln	1,496,674	127,984	1,368,690	1,819	0.12%	0.13%
Mason	620,305	235,033	385,272	416	0.07%	0.11%
Okanogan	3,402,402	2,630,253	772,149	10,608	0.31%	1.37%
Pacific	597,842	99,369	498,473	238	0.04%	0.05%
Pend Oreille	910,089	613,346	296,743	222	0.02%	0.07%
Pierce	1,080,110	462,343	617,767	2,139	0.20%	0.35%
San Juan	110,755	13,721	97,034	1,407	1.27%	1.45%
Skagit	1,127,231	657,007	470,224	941	0.08%	0.20%
Skamania	1,072,343	955,884	116,459	2,376	0.22%	2.04%
Snohomish	1,345,933	831,391	514,542	1,670	0.12%	0.32%
Spokane	1,138,013	74,600	1,063,413	19,455	1.71%	1.83%
Stevens	1,623,630	666,365	957,265	3,542	0.22%	0.37%
Thurston	471,338	95,381	375,957	1,075	0.23%	0.29%
Wahkiakum	165,146	44,341	120,805	195	0.12%	0.16%
Walla Walla	825,730	34,516	791,214	3,092	0.37%	0.39%
Whatcom	1,390,935	984,655	406,280	1,948	0.14%	0.48%
Whitman	1,393,456	43,240	1,350,216	6,819	0.49%	0.51%
Yakima	2,757,047	2,144,184	612,863	58,050	2.11%	9.47%
Statewide	**43,201,027**	**20,135,282**	**23,065,745**	**187,588**	**0.43%**	**0.81%**

Sources: Data on historical apple and pear tree acreages from the Washington State Agricultural Census for the period 1905-1947; data on public land areas from the Washington State Department of Ecology's database on state and federal public lands in Washington.

Tier 2 Lead Arsenate Pesticide Maps

Although data are not available to precisely delineate areas affected by lead arsenate in all counties, certain general areas in the State may be assumed to have low probability of lead arsenate contamination based on their location or land use history. Two types of smaller scale maps of areas potentially affected by historical use of lead arsenate pesticide are provided:

- Maps of the general locations of areas potentially affected by lead arsenate contamination within individual counties, based on readily available land use information

- Maps showing the locations of historical orchards based on aerial photographs

Because of the limitations of the data sources used in these maps, it is important to conduct individual property evaluations (see section 3) to determine whether elevated levels of arsenic and lead are likely to be present in soil on specific properties.

A. Maps of Where Lead Arsenate May Have Been Used Based on Land Use Information

The Task Force recommends that local maps such as the following examples be developed to show the general locations of areas potentially affected by lead arsenate contamination within individual counties, based on available land-use information such as elevation and public lands.

- *Figures I-5, I-6, and I-7: Potential Historical Orchard Areas in Chelan, Okanogan, and Yakima Counties (Based on the Use of the Individual Property Evaluation Flowchart).* These maps show areas in Chelan, Okanogan, and Yakima counties show areas that are below 2,500 feet in elevation (2,000 feet for Yakima County) and that are not State, Federal, or tribal lands. With a few exceptions, fruit trees are not likely to have been grown on State and Federal public lands, or at elevations greater than 2,000 or 2,500 feet (based the highest elevation of historical orchard locations in Yakima and Chelan counties). On the Yakima County map (Figure I-7), an area west of Wapato where apple and pear trees were historically grown is shown as potentially affected, even though it is the property of the Yakama Indian Nation.

Figure I-5: Potential Historical Orchard Areas in Chelan County (Based on Use of the Individual Property Evaluation Flowchart)

Legend

- Areas where historical orchards may have been located
- Areas where historical orchards are not likely
- Cities
- Lakes
- Roads
- County line

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

The areas potentially affected by historical use of lead arsenate pesticides shown in this map were determined by excluding State, Federal and Tribal land and areas with elevations greater than 2,500 feet from the area of the county because these areas are unlikely to have had apple or pear trees grown on them.

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical use of lead arsenate pesticides, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination.

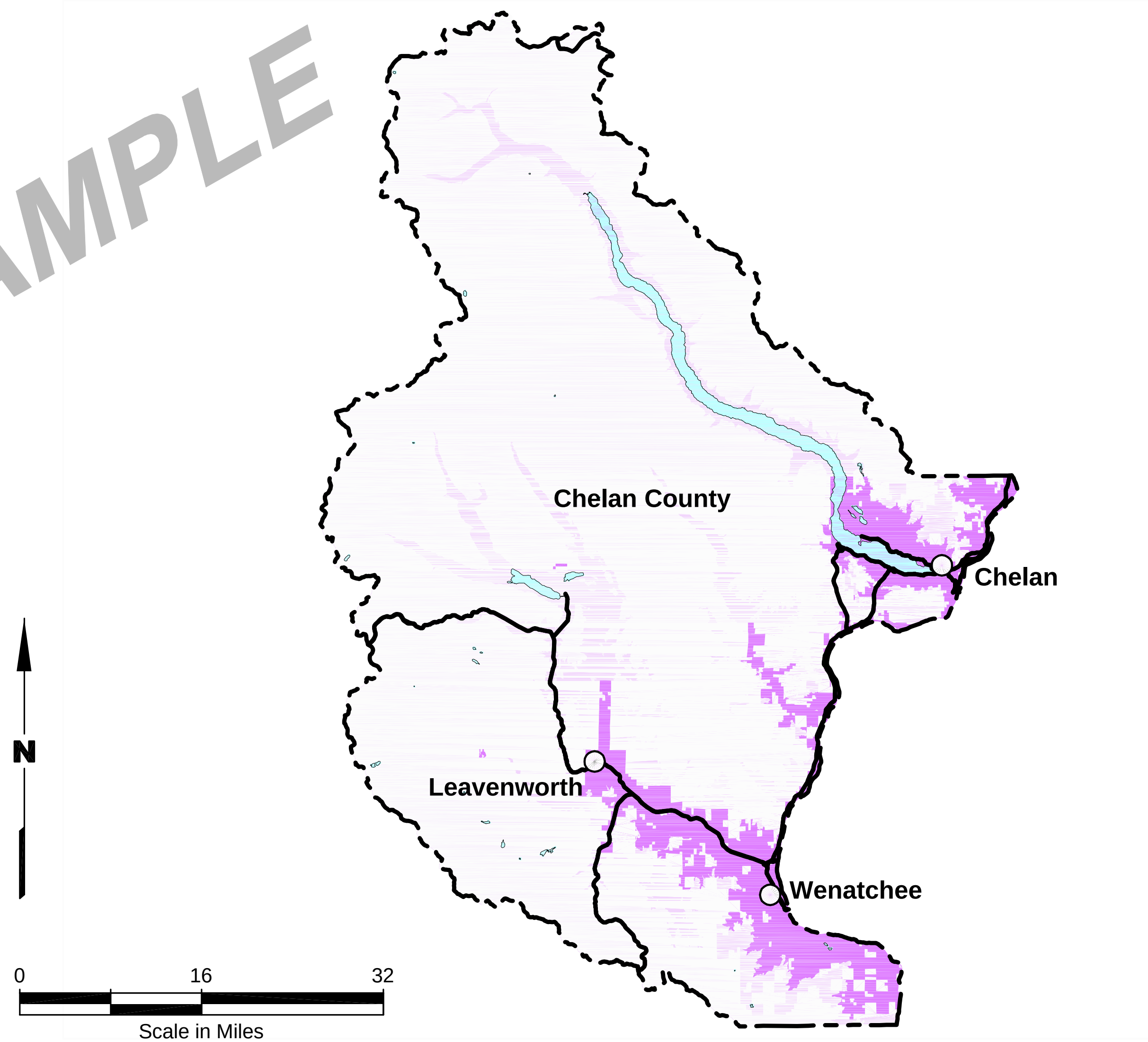


Figure I-6: Potential Historical Orchard Areas in Okanogan County
(Based on Use of the Individual Property Evaluation Flowchart)

Legend

- Areas where historical orchards may have been located
- Areas where historical orchards are not likely
- Cities
- Lakes
- Roads
- County line

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

The areas potentially affected by historical use of lead arsenate pesticides shown in this map were determined by excluding State, Federal and Tribal land and areas with elevations greater than 2,500 feet from the area of the county because these areas are unlikely to have had apple or pear trees grown on them.

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical use of lead arsenate pesticides, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination.

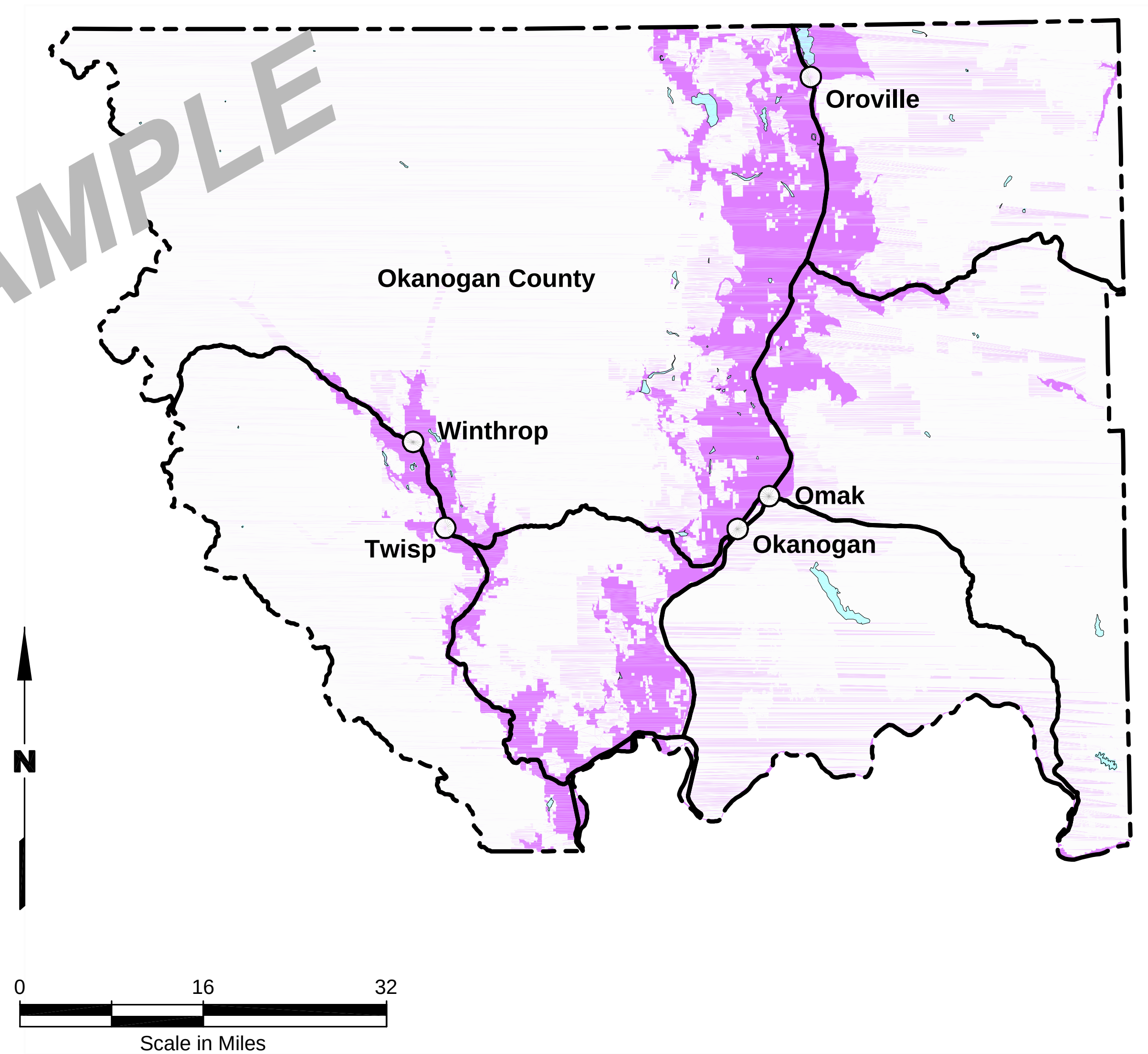


Figure I-7: Potential Historical Orchard Areas in Yakima County (Based on Use of the Individual Property Evaluation Flowchart)

Legend

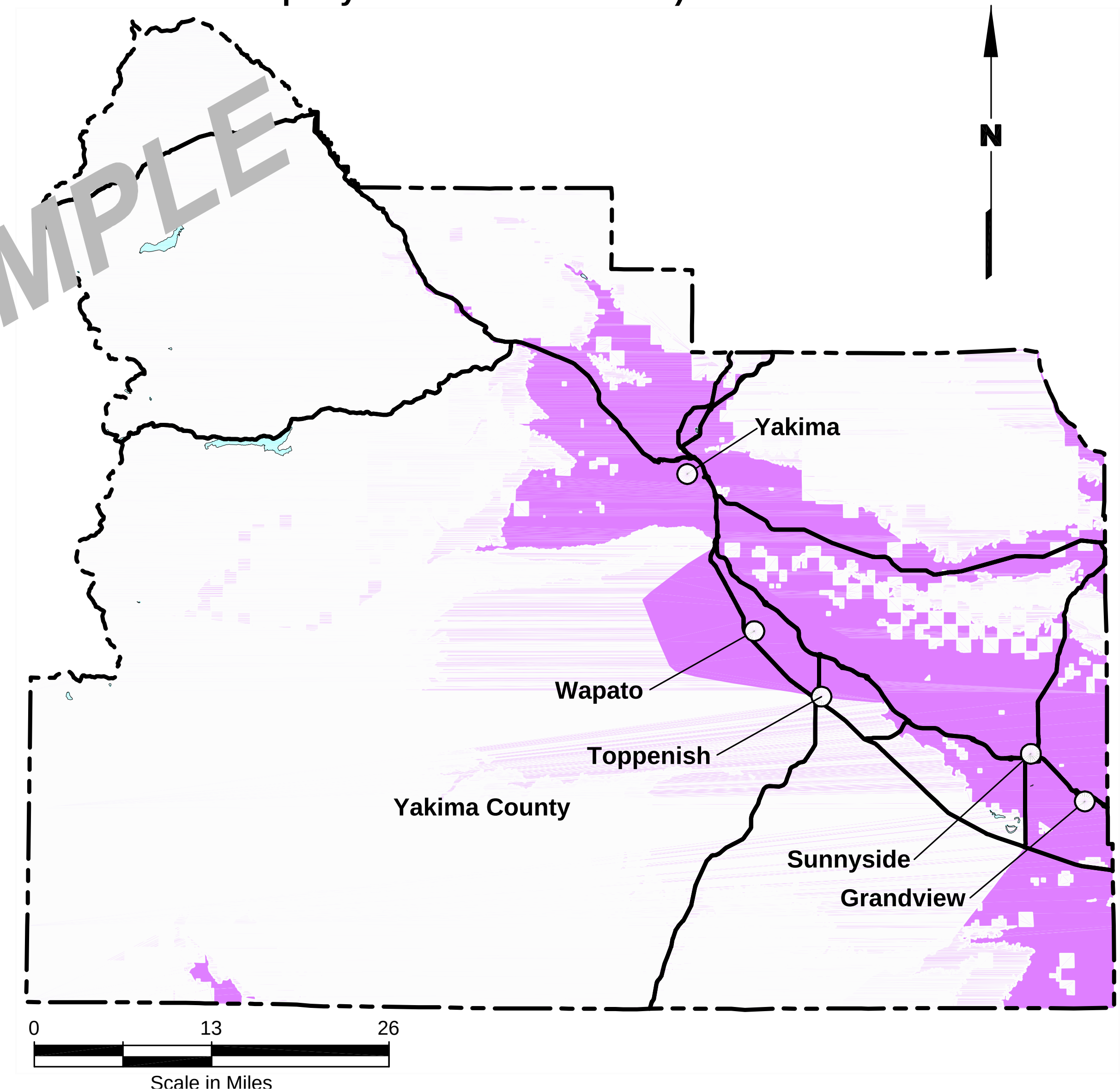
- Areas where historical orchards may have been located
- Areas where historical orchards are not likely
- Cities
- Lakes
- Roads
- County line

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

The areas potentially affected by historical use of lead arsenate pesticides shown in this map were determined by excluding State, Federal and Tribal land and areas with elevations greater than 2,000 feet from the area of the county because these areas are unlikely to have had apple or pear trees grown on them. An area west of Wapato where apple and pear trees have historically been grown is shown as potentially affected, even though it is Tribal property.

This map was developed in 2003 to support the Area-Wide Soil Contamination Task Force. It is based on information available at that time and is intended to provide a general indication of where elevated levels of arsenic and lead in soil may be present due to historical use of lead arsenate pesticides, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination.



B. Maps Showing the Locations of Historical Orchards Based on Historical Aerial Photographs

More detailed maps for lead arsenate pesticide contamination can be developed for counties or portions of counties to further delineate areas where elevated levels of arsenic and lead may be present based on using historical aerial photographs to roughly identify the former locations of orchards. These locations can then be matched with information known about the current uses of the property (e.g., whether the property is a school, park, or in a residential area). The following examples are included.

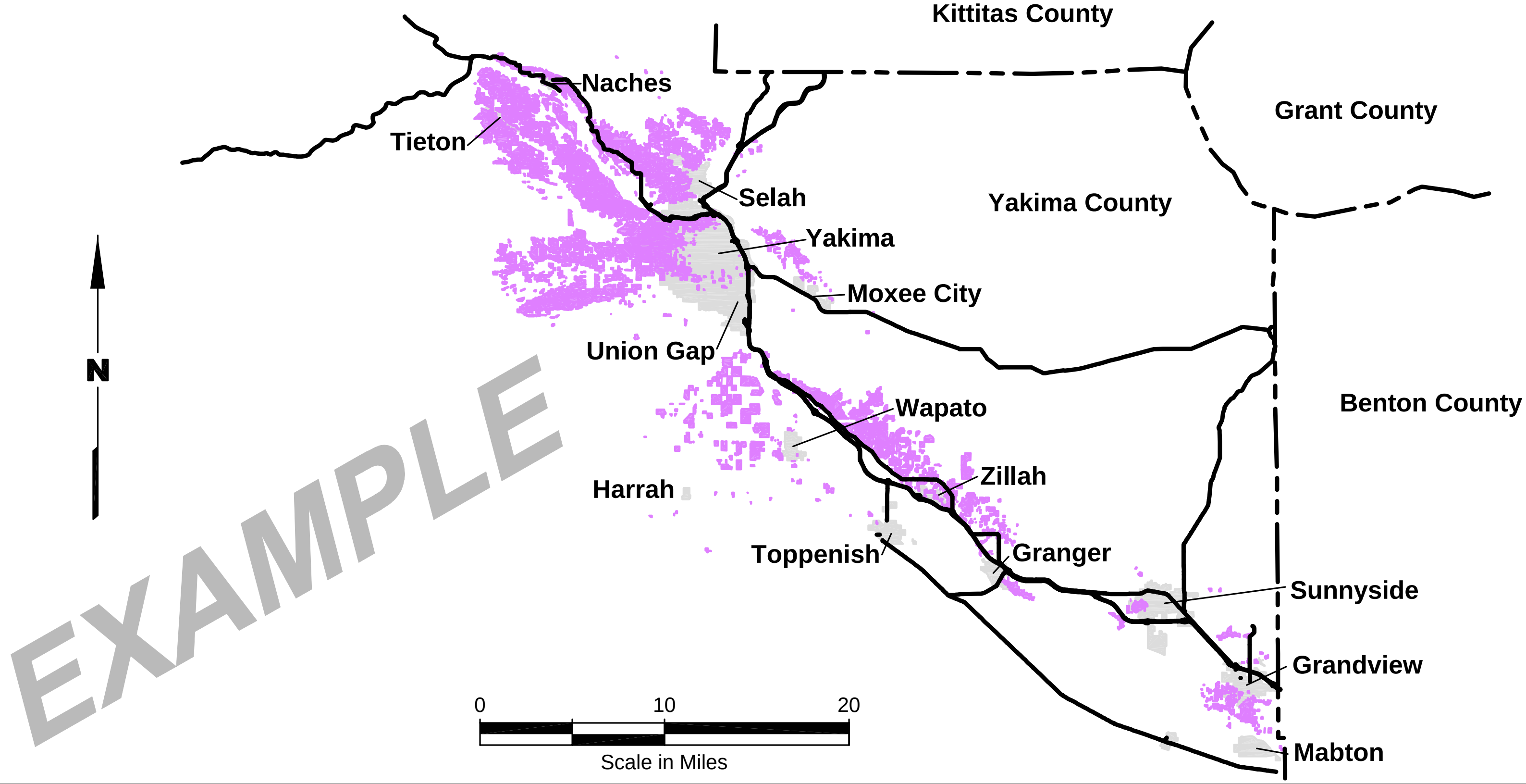
- *Figure I-8: Historical Orchards in Yakima County Circa 1947.* This figure shows areas in Yakima County that were orchards in 1947, as determined based upon an analysis of historical aerial photographs, along with the current locations of city boundaries and highways within Yakima County.
- *Figure I-9: Historical Orchards in the Lake Chelan/Manson Area of Chelan County Circa 1947*. This figure consists of black and white aerial photographs of the Manson area near Lake Chelan that have been overlain in purple with areas that used to be orchards in 1947, based on an analysis of aerial photographs.

These maps were developed by analyzing 1947 aerial photographs to identify the locations of historical orchards, entering this information into a geographic information system (GIS) database, and overlaying the locations of the historical orchards onto aerial photographs or other geographic data, such city and county boundaries and highways. These maps have two important limitations:

- They include all orchard areas from 1947, not simply apple and pear orchard locations, where lead and arsenic contamination from lead arsenate pesticide use is more likely.
- Because apple and pear acreage was lower in these counties in 1947 than in previous years, these maps may fail to show lands that may be impacted by lead arsenate use.

The Individual Property Evaluation Flowchart (see section 3) and the tier 2 lead arsenate pesticide maps provide additional information and a guide for determining whether individual properties are likely to have lead arsenate contamination.

Figure I-8: Historical Orchards in Yakima County Circa 1947



Legend

State or federal roads

1947 Orchard lands

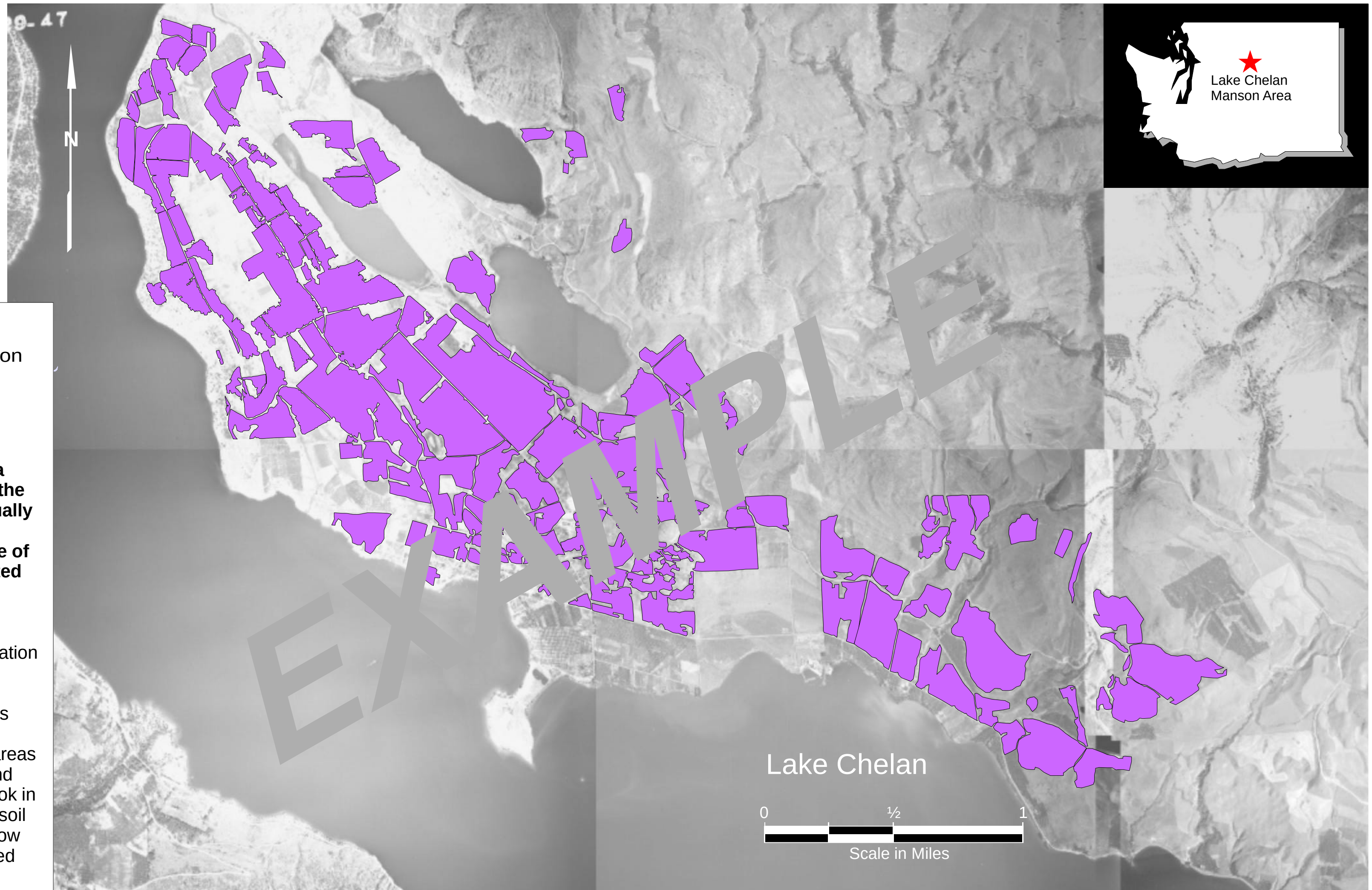
Cities

Disclaimer:

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

This figure was originally developed in 2000 by the Yakima County Geographic Information Services. It is based upon an analysis of historical aerial photographs and is intended to provide a general indication of where historical orchard areas were located in 1947, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination. This figure does not show the location of all orchards that operated during the period when lead arsenate pesticides were used, 1905-1947.

Figure I-9: Historical Orchards in the Lake Chelan/Manson Area of Chelan County Circa 1947



Legend

Historic orchards, based on 1947 aerial photographs

Disclaimer

This map should not substitute for a site-specific assessment. Not all of the areas identified on the map will actually have elevated levels of arsenic and lead in soil. Some properties outside of the identified areas may have elevated levels of arsenic and lead in soil.

This figure was originally developed in 2003 for the "Area-wide Soil Contamination Project, Task 3.12: Manson Area Data Analysis" report. It is based upon an analysis of historical aerial photographs and is intended to provide a general indication of where historical orchard areas were located in 1947, so individuals and communities can assess whether to look in to additional information on area-wide soil contamination. This figure does not show the location of all orchards that operated during the period when lead arsenate pesticides were used, 1905-1947.

Areas Affected by Combustion of Leaded Gasoline

Many factors can influence the concentration of lead in soil adjacent to roadways from historical use of leaded gasoline. These factors include distance from the road, soil depth, traffic volume, traffic speed, whether the soil has been disturbed, and physical features of the location such as degree of vegetation, topography, average wind speed, and prevailing wind direction. In general, any road constructed before 1995 has potential for some contribution of lead to roadside soil. For any land parcel adjacent to a road that was present before 1995, the top foot of soil (soil surface to one foot below ground surface) within 25 feet of the edge of the road has the highest potential for containing soil lead contamination from past leaded gasoline emissions (assuming the soil bordering the road has not been disturbed). In highly populated urban areas, elevated lead soil concentrations have the potential to be elevated throughout the city core due to high road density and traffic volume. If the soil near the road edge or within an urban area has been disturbed, elevated levels of lead in soil may also be present below the top foot of soil or in areas where contaminated soil was moved.

[Note: Additional information on the nature and extent of soil contamination in Washington from combustion of leaded gasoline should be incorporated into this toolbox, based on the results of the study of roadside lead contamination recommended by the Task Force.]

3. Individual Property Evaluation Tools

Because of the variability in the distribution of arsenic and lead from area-wide soil contamination sources, individual property evaluations are important to understand whether there is the potential for exposure to elevated levels of arsenic and lead in soil at a particular property. Three types of evaluation tools and guidance are provided in this toolbox:

- **Individual Property Evaluation Flowchart**

This flowchart describes how individuals or organizations can use information about a property's location and land-use and development history to evaluate whether elevated levels of arsenic and lead in soil are likely to be present. Based on this information, individuals may choose to conduct soil sampling to determine whether elevated levels of arsenic and lead are actually present, and/or to implement protection measures to reduce any potential for exposure.

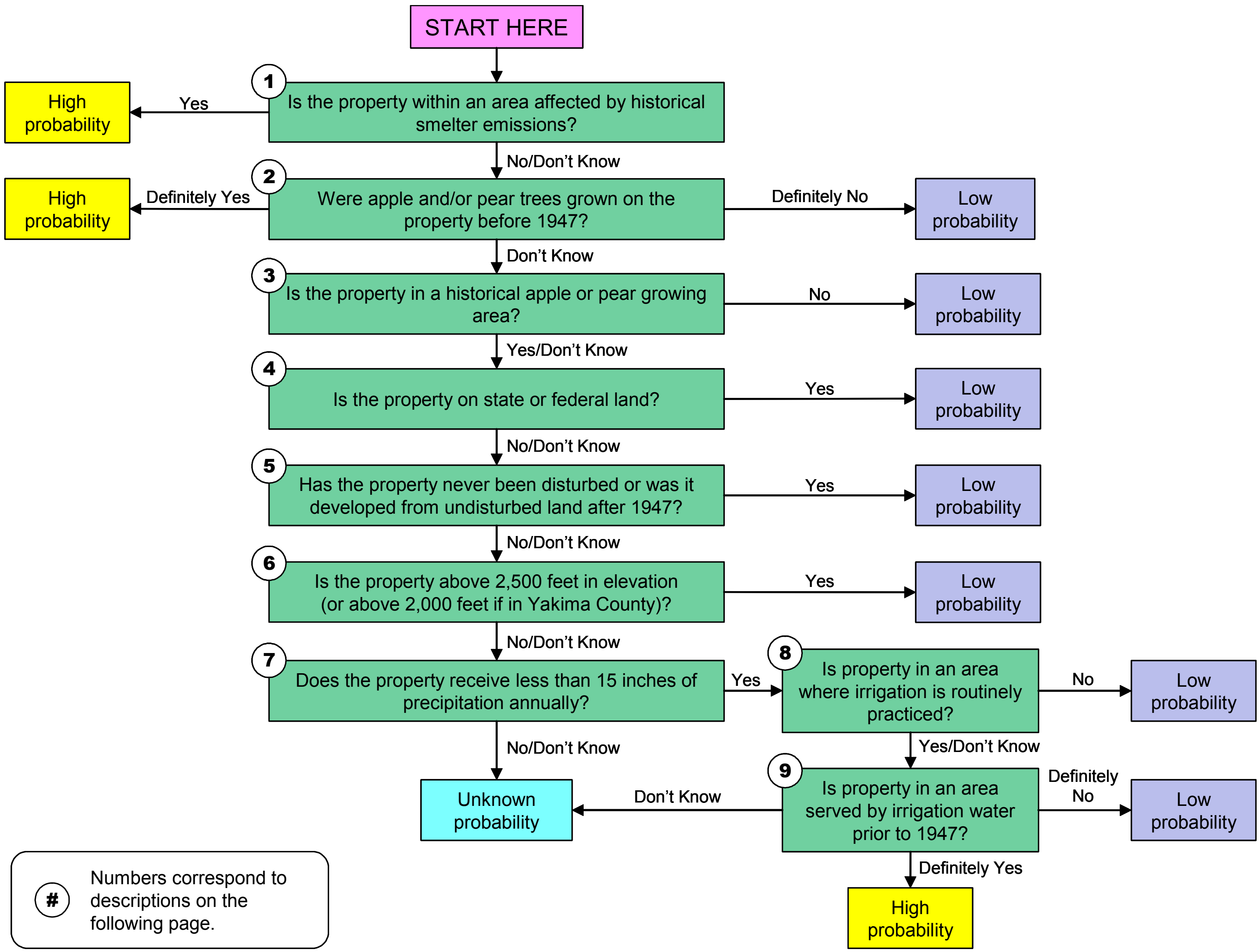
- **Qualitative Evaluation Checklist for Understanding Potential Exposures to Arsenic and Lead in Soil**

This checklist is designed to help individuals or organizations use easily observable features of a property (such as the presence or absence of bare dirt) to identify situations where there is or could be direct, frequent contact with contaminated soil over a period of months.

- **Sampling Guidance**

Where qualitative evaluations indicate that lead and/or arsenic contamination is likely, individuals or organizations may choose to conduct soil sampling to determine if elevated levels of arsenic and lead are actually present in soil on a property. Guidance on how to collect and analyze soil samples is provided for three typical types of properties: child-use areas, residential yards, and commercial properties.

Individual Property Evaluation Flowchart



1 **Is the property within an area affected by historical smelter emissions?** Parts of King, Pierce, Snohomish, and Stevens counties have a high probability of having elevated levels of arsenic and lead in soil based on historical emissions of metal smelters located in Tacoma, Harbor Island, Everett, Northport, and Trail, B.C. See associated smelter plume maps to determine which parts of these counties are affected or potentially affected by historical smelter emissions based on information currently available.

2 **Were apple and/or pear trees grown on the property before 1947?** Lead arsenate was used as a pesticide to control the codling moth from about 1905 to 1947 in Washington State. It was used most heavily on apple and pear trees, but was also applied to other tree fruit crops in smaller quantities. Properties that had apple or pear trees on them during the period when lead arsenate was used (i.e., before 1947) have a high probability of having elevated levels of arsenic and lead in soil, while properties that did not contain apple or pear trees have a low probability. Local planning and zoning departments, former property owners, and/or long-time residents of an area may have information about whether a particular property used to be an apple or pear orchard in the early to mid-1900s. The flowchart continues with additional questions if it is unclear whether apple or pear trees were grown on a property during the period when lead arsenate was used.

3 **Is the property in a historical apple or pear growing area?** Properties within historical apple or pear growing areas in the state—including but not limited to the Yakima valley, the Wenatchee valley, areas near Lake Chelan, areas in Okanogan and Spokane Counties, areas along the Columbia River, and in small commercial or "backyard" orchards in western Washington—are more likely to have contained apple and/or pear trees during the time when lead arsenate was used. If the property is not within a historical apple or pear growing area, the probability that it has elevated levels of arsenic and lead in soil from lead arsenate pesticide use is low. As with the first flowchart question, local planning and zoning departments, former property owners, and/or long-time residents of an area may have information about whether a particular property is within a historical apple or pear growing region.

4 **Is the property on state or federal land?** State and federal land is not likely to have been cultivated with apple or pear trees historically and therefore properties on state or federal land are less likely to be contaminated from lead arsenate pesticide use than are other properties.

5 **Has property never been disturbed or was it developed from undisturbed land after 1947?** Properties that have never been disturbed or that were developed from undisturbed land after 1947 would not have been cultivated with tree fruit crops during the time that lead arsenate pesticide was used, and therefore these properties have a low probability of having elevated levels of lead and arsenic in soil from historical use of lead arsenate. Former property owners, developers, and local officials may have information about the development history of properties.

6 **Is property above 2,500 feet in elevation (or above 2,000 feet if in Yakima County)?** Apple and pear trees tend to be grown in river valleys and other lower elevation areas in Washington. If a property is at a relatively high elevation, it is less likely to have had apple and pear trees grown on it during the early to mid 1900s, when lead arsenate was used as a pesticide, and therefore there is a low probability that elevated levels of arsenic and lead are present from historical lead arsenate use.

7 **Does the property receive less than 15 inches of precipitation annually?** This question is designed to separate the areas of the state that generally need irrigated water to grow apple and pear trees productively from those that do not. Information about average annual rainfall may be obtained from the National Weather Service.

> In general, areas receiving more than 15 inches of precipitation annually, such as in much of western Washington, would not have needed to rely on irrigation to grow apple and pear trees; the flow chart ends for these properties with a determination of unknown probability of lead and arsenic contamination from lead arsenate use.
>
> Areas in Washington that receive less than 15 inches of precipitation annually, however, would generally need irrigation to cultivate apple and pear trees productively; these areas are most often in eastern Washington. Information on current and historical irrigation practices, therefore, could help determine the likelihood of lead arsenate pesticide contamination. The flow chart continues for these properties with the following two additional questions about irrigation.

8 **Is the property in an area where irrigation is routinely practiced?** If the property is not located within a general area where irrigation has been routinely practiced, it is not likely to have been irrigated in the past. Since irrigation would have been necessary to grow apple or pear trees on the property because of its low annual precipitation, this implies that there is a low probability that elevated levels of arsenic and lead are present due to lead arsenate use. If, however, the property is in an irrigation area, the flow chart continues with the following question:

9 **Is the property in an area served by irrigation water prior to 1947?** If the property is in an area where irrigation is routinely practiced currently, information on whether the property was served by irrigation water before 1947, when lead arsenate pesticide use ended, can help determine whether there is high or low probability for arsenic and lead soil contamination from this source. Information on whether a property had been served by irrigated water historically may potentially be obtained by contacting local irrigation districts; County or City governments may also have maps or other historical references with this information.

> If the property definitely was not served by irrigated water prior to 1947 yet (from question 6) is in an area needing irrigation to cultivate apple and pear trees, it is unlikely that apple and pear trees were grown on the property and therefore there is a low probability that there is lead arsenate contamination present.
>
> If the property, however, was definitely irrigated in this period and (from question 2) is in a historical apple or pear growing area, there is a high probability that lead arsenate contamination is present.

Qualitative Evaluation Checklist for Understanding Potential Exposures to Arsenic and Lead in Soil

Please visit and walk around the site, preferably during daylight hours, before answering these questions.	
Q1. ***Is the property near a historical smelter location in Pierce, King, Snohomish, or Stevens counties?***	If YES or UNSURE, go to Q4. If NO, go to Q2.
Q2. ***Were lead arsenate pesticides used on the property historically (e.g., on apple or pear trees)?***	If YES or LIKELY, go to Q4. If NO, go to Q3.
Q3. ***Are portions of the property within 25 feet of a road built before 1995?***	If YES or UNSURE, go to Q4. If NO, elevated levels of arsenic and lead are not likely to be present in soil.
Q4. ***Do children routinely play in this area?***	If YES or UNSURE, go to Q7. If NO, go to Q5.
Q5: ***Do people spend a lot of time in this area (e.g., while gardening)?***	If YES or UNSURE, go to Q7. If NO, go to Q6.
Q6: ***Are there frequently used, unpaved paths or trails through this area?***	If YES or UNSURE, go to Q7. If NO, potential exposure to elevated levels of lead and arsenic in soil is less likely.
Q7: ***Is there any exposed dirt in play and high use/traffic areas (e.g., swing sets, gardens, sports fields, lawns, and paths)?*** Note: Asphalt, wood chips, grass cover, or other natural/synthetic barrier may help limit potential exposure to contaminated soil. The Consumer Product Safety Commission recommends that surfaces around playground equipment have at least 5-12 inches of wood chips, mulch, sand, or pea gravel, or are covered with mats made of safety-tested rubber or rubber-like materials.	If YES or UNSURE, there may be a higher potential for exposure to contaminated soils. Use individual protection measures to minimize potential exposure and determine whether to test soils. If NO, go to Q8.
Q8: ***Would you expect soils to be exposed at any time during the year (e.g., due to seasonal sports or other activities)?***	If YES, there may be a higher potential for exposure to contaminated soils. Use individual protection measures to minimize potential exposure and determine whether to test soils. If UNSURE, check with the landowner or organization responsible for maintaining the property to see whether a maintenance program is in place to ensure that play and high use/traffic areas remain thoroughly covered year round. If NO, the potential for exposure to contaminated soils is less likely.

Area-Wide Soil Contamination Sampling Guidance-Residential Areas

This Residential Soil Sampling Guidance is one of a series of guidance documents developed by the Washington State Department of Ecology (Ecology) to help homeowners, businesses, developers, and local governments characterize arsenic and lead concentrations in soil for the purposes of reducing exposure to these common soil contaminants.

1.1 Where do elevated levels of arsenic and lead in soil typically occur?

Ecology has identified soil in large areas of Washington State that have low to moderate levels of contaminants, principally arsenic and lead. The primary causes of this widespread or area-wide contamination are metal smelters, lead arsenate pesticide applications, and leaded gas emissions from automobiles. These historical practices released arsenic and or lead to the environment over hundreds of square miles in both eastern and western Washington through airborne particulate (smelters) and/or direct application (pesticides). Leaded automobile gas (used from 1923 to the mid-1970s) emissions released lead to the environment, particularly in high-traffic urban corridors. The consequence of these historical practices is that arsenic and lead concentrations in shallow soil may be elevated above natural background levels and exceed Ecology soil cleanup levels.

A potentially common source of localized lead in soil near older houses (pre-1978) is lead-based paint. Flaking and chipping of old lead-based paint due to weathering and maintenance activities can result in elevated lead concentrations surrounding the perimeter of a house. A potentially common source of localized arsenic in soil is outdoor wood structures that were treated with arsenic preservative (arsenic-treated wood is being phased out of use beginning in 2002). Lead-based paint and arsenic-treated wood impacts to soil are usually localized directly adjacent to a building or play structure where these products were used.

1.2 Purpose of this guidance.

This *Residential Property Soil Sampling Guidance* has been prepared for people who are interested in identifying ways to reduce exposure to arsenic and lead in soil at their home. This guidance provides a process explaining how homeowners, tenants, and landlords can collect and analyze soil samples from residential properties.

Soil sampling is presented as a three-step process. The first step is planning the sampling – deciding where and how to collect soil samples at your home. The second step is actual sample collection by you. The third step is getting the sample analyzed by a private laboratory.

The resulting laboratory data can be used by homeowners, tenants, and landlords to help manage potential exposure to soil arsenic and lead. This guidance is not intended to meet sampling requirements for State hazardous waste cleanups or real estate transactions.

State hazardous waste cleanups are administered by Ecology under the Model Toxic Control Act (MTCA), a state law that provides for investigation and cleanup of contaminated properties. MTCA is a formal program with specific procedures for addressing soil contamination. Compliance with MTCA may require additional sampling beyond recommendations in this guidance. Ecology Toxic Cleanup Program staff can provide additional information on MTCA requirements to interested individuals. Ecology maintains offices in different regions of the State. Appropriate Ecology contact phone numbers by region are presented on the attached map at the back of this guidance.

Organizations or individuals involved in real estate transactions (lenders, buyers, and real estate agents) may request soil sampling, especially in specific areas where area-wide contamination has been associated with historic smelter operation or pesticide use. In these situations, the involved individuals typically define the sampling requirements. Contact involved individuals for more information on sampling requirements for your real estate transaction.

1.3 Why should I be concerned about arsenic and lead in soil?

Arsenic and lead occur naturally in soil. However, exposure to elevated soil concentrations can affect a person's health. For low to moderate soil concentrations, typically associated with area-wide contamination, chronic or long-term effects are the primary health concern. Chronic exposure to arsenic and lead may lead to a variety of symptoms. Arsenic exposure is known to cause cancer; lead exposure is known to have toxic effect on the human nervous system. Young children are at greatest risk for a variety of reasons including the likelihood of increased exposure through normal hand-to-mouth activity and increased susceptibility to development impairment of the central nervous system.

More information on the toxicity of arsenic and lead can be found at the following web sites published by the Agency for Toxic Substances and Disease Registry (ATSDR):

Arsenic: http://www.atsdr.cdc.gov/tfacts2.html

Lead: http://www.atsdr.cdc.gov/tfacts13.html.

Various government agencies have been evaluating the extent of arsenic and lead soil impacts associated with the former Tacoma Smelter in Ruston, Washington. Three good general sources of information on soil arsenic and lead impacts are Ecology, the Seattle-King County Health Department, and the Tacoma-Pierce County Health Department:

Ecology: http://www.ecy.wa.gov/programs/tcp/sites/tacoma_smelter/ts_fs.htm

Ecology: http://www.ecy.wa.gov/programs/tcp/area_wide/area_wide_hp.html

King County: http://www.metrokc.gov/health/tsp/arsenic.htm

Pierce County: http://www.healthdept.co.pierce.wa.us/eh/arsenic.htm.

The State Department of Health (WDOH) is another source of information on lead in soil. The WDOH fact sheet discusses health effects and ways to minimize exposure specifically as it pertains to children. The WDOH web site is:

WDOH Fact Sheet:
http://www.doh.wa.gov/Topics/Childhood%20lead%20Poisoning.htm.

1.4 How will soil sampling help me?

There are a number of relatively simple actions that you can take to prevent exposure to arsenic and lead in soil. What actions you take may depend on the amount and location of arsenic and lead in soil on your property. Past studies have shown that the amount of arsenic and lead can be quite variable – that is, even samples taken close together can have very different results. This may be especially true in residential areas where landscaping, construction, gardening, or other actions have resulted in soil excavation or movement. Because soil testing results can be so variable, you cannot reliably predict soil concentrations on your property based on larger studies or even results from your neighbor's property. Sampling is the only reliable way to tell what soil concentrations are on your property. Once you know the location of any elevated arsenic and lead soil levels on your property, you and your family can take steps to reduce contact with those soils.

2.0 STEP 1: Planning the Sampling

2.1 Where do I collect the samples?

If your property is affected by arsenic and or lead contamination, the concentration of arsenic and lead in soil on your property will vary from one location to the next. The cause of the variability is due to a number of factors including the source of contamination (i.e., smelter, pesticide use, or automobile emission); topography; climate; and past land use practices that cause soil disturbance or mixing. Consequently, sampling in one area will not necessarily provide reliable information on another area. To characterize your property, you will need to collect samples from different parts of your property. An efficient way to do this is to divide your property into subareas prior to collecting samples. The purpose of defining subareas is to group soil samples together from areas of your property with similar characteristics.

Since the main concern is exposure to contaminated soil, you should divide your property into subareas based on exposure potential. The three most important criteria for defining exposure potential are:

- Where is exposed dirt?
- Where do children usually play?
- Where do people spend the most time?

Typical high exposure potential subareas are child play areas or gardens. Typical low exposure potential subareas are lawns or brushy/wooded areas. An example of a residential property segregated into subareas for soil sampling is shown on Figure 1.

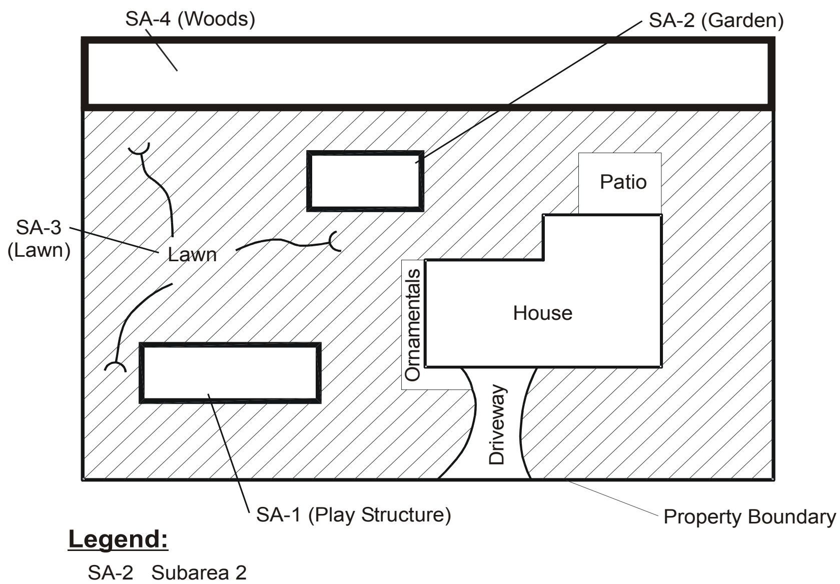


Figure 1 Example Subareas for a Residential Property

Each property will have different characteristics and be used in different ways. It is up to each homeowner, tenant, or landlord to make informed decisions about how to divide their property into representative subareas. Obviously, the maximum size of a subarea for a residential homeowner is the property boundary. For large parcels, a subarea should be limited to a maximum of 2 acres in size. The size of high exposure potential subareas (i.e., such as a child play area) should not be larger than about a tenth of an acre (equivalent to an area of about 40 ft by 100 ft). If you suspect lead-based paint has been used at your property, you may want to define the immediate area (approximately 10 ft from the house) around the perimeter of the house as a separate subarea. If you suspect arsenic-treated wood has been used at your house, you may want to define the immediate area around the treated wood structure as a separate subarea.

2.2 How many samples should I collect?

The average soil concentration over a subarea is the most important characteristic for evaluating potential long-term exposure. Because there can be wide variations in arsenic and lead soil concentrations, it is necessary to collect more than one sample from a subarea to get a reliable estimate of the average soil concentration. In general, more samples collected at different locations within a subarea will provide a better estimate of the average. Ecology recommends collecting a minimum of four samples per subarea for small subareas; the sample size should increase for large subareas. Also, more samples should be collected from high exposure subareas relative to low exposure subareas. As a general rule, it is important to prioritize sampling resources toward high exposure subareas. If your resources are limited, high exposure areas should be sampled first. Table 1 provides guidelines on how many samples to collect based on subarea size and exposure potential.

TABLE 1

GUIDELINES FOR DETERMINING THE MINIMUM NUMBER OF SAMPLES PER SUBAREA

	NUMBER OF SAMPLES/MANAGEMENT AREA	
Subarea Size (acres)	**Low Exposure Areas**	**High Exposure Areas**
0 – 0.01	4	6
0.01 – 0.1	4	6 – 8[(a)]
0.1 – 1	4 – 6[(a)]	8 – 12[(a)]
1 – 2	6 – 8[(a)]	12 – 16[(a)]

Note: 1 acre equals about 43,500 ft^2.
(a) Range based on characteristics of management area.

2.3 How do I decide where to collect samples within a subarea?

A minimum of four samples should be collected from each subarea. Sample locations should be selected to represent good geographic coverage within each subarea. A simple way to achieve this goal is to separate each subarea into approximately equal sized blocks. Collect a single sample from the approximate center of each block. Keep in mind that the sample location should generally be representative of the subarea as a whole. For example, if you sample near older buildings or wood play structures, your sample results could be influenced by lead-based paint or arsenic-treated wood impacts. An example of appropriate sampling locations for different residential property subareas is presented on Figure 2.

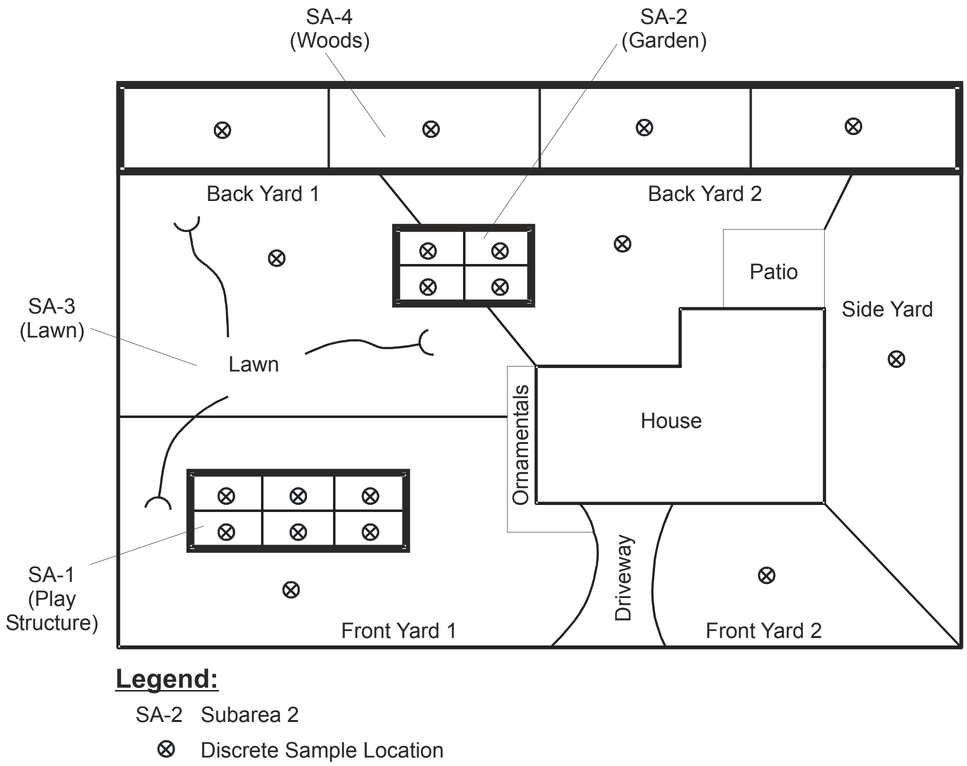


Figure 2 Example Sample Locations for a Residential Property

2.4 What are composite samples?

Increasing the number of samples collected from a subarea provides a better estimate of soil concentration, but has the disadvantage of increasing laboratory analytical cost. Laboratory analytical cost can be reduced by mixing individual samples together from different locations within a subarea into a single individual sample for analysis. This is called *compositing*, and gives an "average" result for all the soil that was mixed into the sample. For example, if four samples are collected to characterize a subarea, a reasonable estimate of the average concentration can be obtained at a reduced cost by compositing (mixing) the four samples into a single sample prior to laboratory analysis. Compositing is demonstrated schematically on Figure 3.

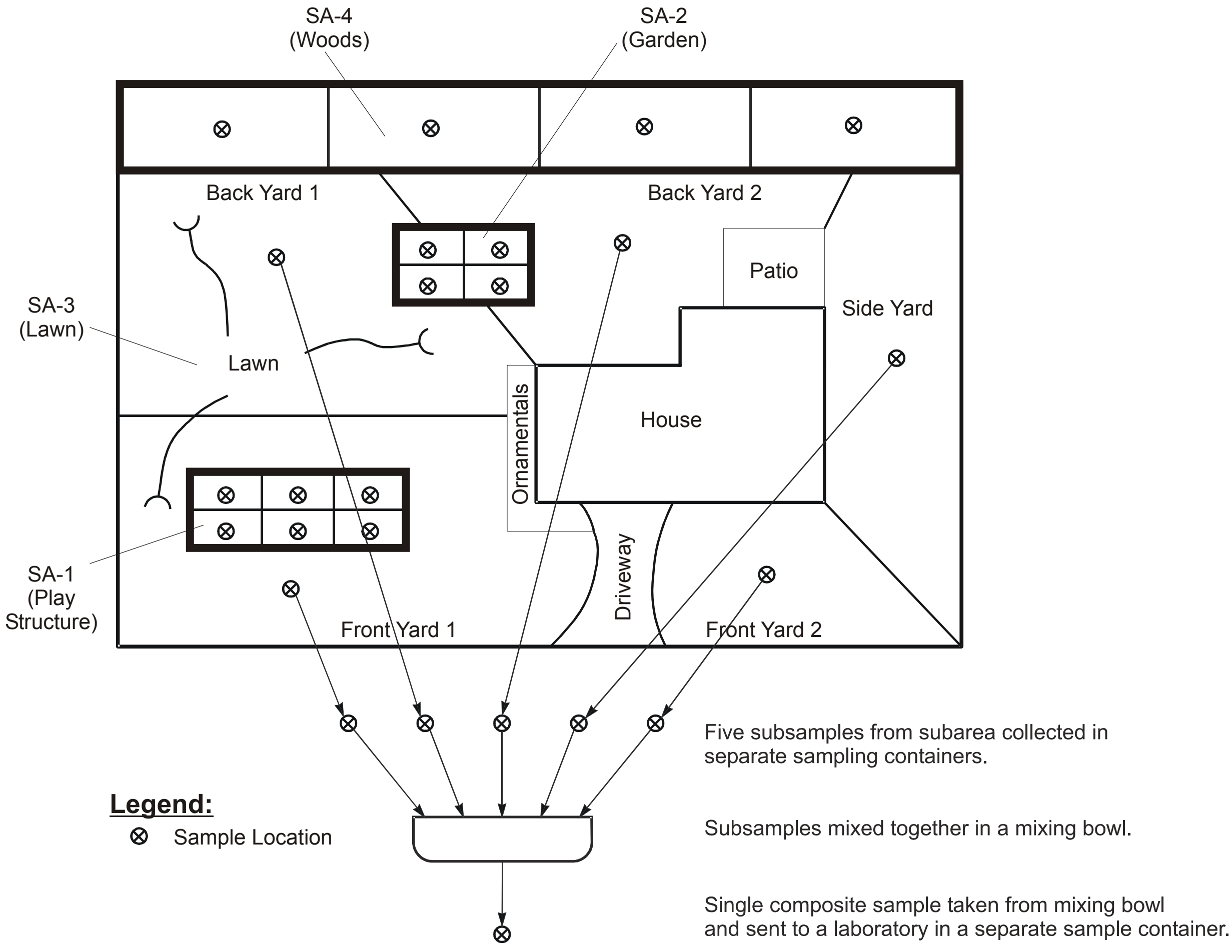


Figure 3 Example of a Composite Sample for Subarea 3: Lawn

The decision to composite is the choice of the property owner or user. The composite sample result provides an acceptable estimate of average soil concentration for evaluating exposure. It does not provide information on the variability of the contamination or whether some parts of an area have higher concentrations than other parts. If you are interested in a more comprehensive understanding of arsenic and lead concentrations on your property, you should analyze each sample individually. Also, discrete sample results may be required if the data are to be used for MTCA compliance.

2.5 How deep should I sample?

Under most residential scenarios, exposure to soil arsenic and lead is primarily from the surface soil layer. Therefore, it is recommended that you collect your soil sample from the surface to a depth of 6 inches. Your sample should consist of soil; avoid collecting organic debris or gravel. Clear or cut away grass, gravel, wood chips, or other similar materials prior to collecting your sample.

Keep in mind that collecting and analyzing a soil sample from the upper 6 inches of the soil column will provide a good estimate of an individual's likely exposure to arsenic and lead.

The test result will not necessarily provide a good estimate of deeper soil contamination, should it also exist on your property.

2.6 Do I have to sample for both arsenic and lead?

A number of studies have been completed to evaluate the characteristics of area-wide soil contamination. If the source of contamination is from historical smelter discharges or lead arsenate pesticide application, soil with elevated arsenic concentrations will also likely have elevated lead concentrations, though arsenic tends to represent the greater health concern. If the source of contamination is automobile leaded gas emissions or lead-based paint, then only lead will be elevated. If the source is treated wood then only arsenic will be elevated.

It is recommended that soil samples be analyzed for both arsenic and lead to get a clearer picture of soil contamination impacts on your property. If costs are a concern, it may be acceptable to collect a sample just for arsenic if the suspected source is from historical airborne smelter deposition, lead arsenate pesticide application, or treated wood. In these circumstances, if arsenic concentrations are low, lead concentrations are also likely to be low.

2.7 Step 1 Summary:

- Divide your yard into subareas based on potential for exposure to soil.
- Collect a minimum of four samples from each small subarea – more for larger subareas.
- Composite the samples or keep them separate, depending on cost constraints, potential future use of the data (i.e., MTCA compliance), and level of detail you want.
- Collect samples evenly throughout the subarea.
- Sample to a depth of 6 inches.
- Sample for arsenic and lead.

3.0 STEP 2: Sample Collection Methods

Once you have planned your sampling, the soil samples are relatively easy to collect. The following steps provide a cost-effective way to get good quality and representative samples:

1. Mark your sample locations with a stake or flagging tape. It may also be useful to prepare a site diagram that shows where samples were collected.
2. Assemble the necessary equipment:
   - Shovel, trowel, or bulb planter
   - Clean stainless-steel or plastic spoon
   - Permanent marking pen
   - Small ZipLoc^{tm} plastic bags or glass sampling containers (about 4 ounces in size; you can get these from the laboratory)
   - Paper towels or wash bucket and scrub brush.
   - Large stainless-steel, plastic, or glass bowl (if compositing).
3. Collect the soil sample:
   - Using the permanent marker, label a ZipLoc^{tm} bag or glass container with the following minimum information:
     - Unique sample identifier (i.e., SS1A for soil sample A from subarea 1)
     - Your name
     - Date
     - What you want to be analyzed (arsenic and lead).
   - Clear away any surface debris or grass mat layer.
   - Dig a 6-inch deep hole with your shovel, trowel, or bulb planter.
   - Using the spoon, scrape fresh soil from the sides of the hole and fill up the plastic bag or the jar. Avoid or discard soil pebbles and rocks. Be sure to collect soil from throughout the entire depth interval.
   - Either discard the spoon or clean it using a paper towel or wash bucket and scrub brush. If the spoon is to be used again, it should be free from any visible dirt.
   - Securely seal the sample jar or ZipLoc^{tm} bag.
4. If you are compositing:
   - Collect all individual samples (as described above) from a subarea first. Then put equal amounts of soil from each sample directly into the large bowl.
   - Thoroughly mix the soil.
   - Using the spoon, fill up the plastic bag or the jar with the mixed soil.
   - Discard remaining soil.

5. Catalog all soil samples on a sheet of paper. Form 1 is included at the end of this guidance for this purpose. Indicate which samples are composites. Store the samples together in a large ZipLoc^{tm} bag, box, cooler, or similar container with a copy of the sample inventory sheet for reference.

4.0 STEP 3: Getting the Samples Analyzed

4.1 How are the samples analyzed?

The levels of arsenic and lead are determined by sending your soil samples to a laboratory that has the capability to perform metals analyses in soil. You should transport the samples to the laboratory as soon as convenient after the samples have been collected. The samples can be delivered to the laboratory or shipped using a parcel service. The samples should be stored in a cool, dark place. If you will not be able to get the samples to the laboratory for a week, it is suggested that the samples be refrigerated. Once the laboratory receives the samples, they should be able to perform the analysis and report the results to you within 3 to 4 weeks.

The laboratory can use a variety of methods to analyze for arsenic and lead. It is recommended that you request the samples be analyzed by either of two methods:

- the ICP/MS (inductively coupled plasma mass spectrometer) method, also known as U.S. Environmental Protection Agency (EPA) Method 6020A.
- the GFAA (graphite furnace atomic adsorption spectroscopy) method, also known as EPA Method 7010.

Prior to analysis, the laboratory should thoroughly mix each individual sample. The size of soil in the sample should be less than 2 millimeters (2 mm) or about a tenth of an inch. If the soil grain size appears to be greater than 2 mm, you should request the laboratory screen the samples to remove all soil and debris in the sample greater than 2 millimeters (2 mm). This may result in an extra cost.

The laboratory should report the sample concentrations in units of milligrams per kilogram (mg/kg) or parts per million (ppm) (these two are equivalent to each other). The samples should also be reported relative to the dry weight of the soil (e.g., “on a dry weight basis”). Instruct the laboratory to screen the samples (if necessary) and report the results on a dry weight basis, using the units noted.

Finally, the samples have to be analyzed so that very low concentrations can be determined accurately. When submitting the samples to the laboratory, they should be instructed that the analytical reporting limits should be no greater than 5 ppm arsenic and 10 ppm lead.

4.2 How do I find an appropriate analytical laboratory?

Analytical laboratories are listed in the yellow pages. You do not necessarily need to use a lab near to your home, however, because many labs can work with you through the mail.

Only a relatively small subset of laboratories is capable of analyzing metals in soil. When you talk to the laboratory you should ask the following questions:

- Do they have the capability to analyze arsenic and lead in soil by either of the methods listed above?
- Will they be able to screen the sample to 2 mm if necessary?
- Can you mail samples to them?
- How much will it cost?
- How long will it take?

If the answer to the first two questions is yes, the laboratory should have the capabilities of providing you with an accurate soil sample analysis. The cost of the analysis should be about $30 or $40 per sample, per analysis. There may be an additional fee if the samples need to be screened to 2 mm.

Ecology maintains a list of laboratories that are accredited by the state to perform soil analyses. This web site, http://www.ecy.wa.gov/programs/eap/labs/srchmain.htm, may be useful in helping you locate an appropriate laboratory to complete your sample analyses. For example, if you use this web site for arsenic, select "Chem II (Trace Metals)" as the general category and "Arsenic (6020)" as the parameter (method).

4.3 Step 3 Summary:

Instruct the laboratory to:

- Screen samples to 2 mm if necessary.
- Report on dry weight basis.
- Report in units of mg/kg or ppm.
- Use either of these methods: ICP/MS or GFAA.
- Analyze with analytical reporting limits no greater than:
    - arsenic, 5 ppm
    - lead, 10 ppm.

FORM 1

SAMPLE INVENTORY SHEET

Date ____________________
Page ________ of ________

Owner:

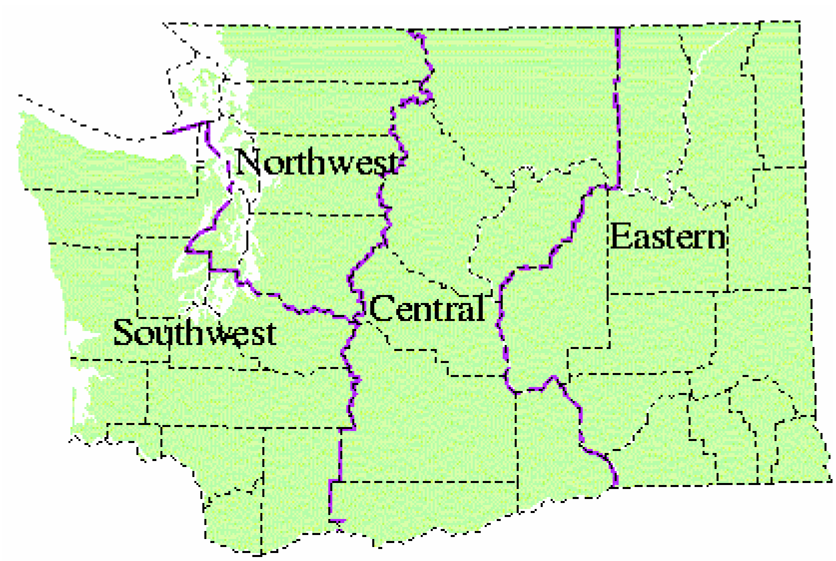
Property Address: ____________________

____

Phone No.: ____________________

				Testing Parameters				
Sample No.	Date	Time	**Composite (Y/N)**	**Arsenic**	**Lead**			Observations/Comments

Instructions to laboratory:
1) Sieve samples to 2 mm prior to analysis if requested
2) Report results on dry weight basis in ppm or mg/kg
3) Sample analytical reporting limits are 5 ppm arsenic; 10 ppm lead
4) Perform analysis by EPA Method 6020A (ICP/MS) or 7010 (GFAA)



Source: Washington State Department of Ecology website (http://www.ecy.wa.gov/org.html)

WASHINGTON STATE DEPARTMENT OF ECOLOGY CONTACT INFORMATION:

Headquarters:	360-407-6000
Northwest Region:	425-649-7000
Southwest Region:	360-407-6300
Central Region:	509-575-2490
Eastern Region:	509-329-3400

4. Health Risks Associated with Exposure to Low-to Moderate Levels of Arsenic and Lead in Soil

What is Known about Health Risks from Exposure to Low-to-Moderate Levels of Arsenic and Lead in Soil?

The risk of developing health problems from arsenic or lead depends on the amount of exposure and the concentrations to which a person is exposed. The greater the exposure or the greater the concentrations, the greater the risk. Most information about the health effects of arsenic and lead comes from studies where exposures were greater than those expected from living and working in places with low-to-moderate levels of arsenic and lead in soil. Health monitoring and research studies have not been carried out to the extent necessary to understand and document whether exposure to low-to-moderate level arsenic and lead in soil is causing or contributing to long-term health problems in Washington.

Evaluating health effects at lower levels of exposure is difficult, and it is unlikely that conclusive scientific information to determine the health risks from exposure to area-wide soil contamination will be available in the foreseeable future. In light of this uncertainty, there is disagreement among scientists about how the information that is available should be interpreted and used to assess the risks of exposure to low to moderate level soil contamination. Some members of the scientific community argue that federal and state efforts to address low to moderate level soil contamination are not scientifically justified because there is no information demonstrating that health problems are being caused by exposure to such contamination. Other members of the scientific community argue that arsenic and lead in soil have the potential to cause health problems at low levels of exposure—especially for people who are particularly sensitive to the effects of these contaminants. In recent years, the majority of scientific review committees formed to evaluate the available scientific information on arsenic and lead have concluded that there is a sufficient scientific basis to justify efforts to reduce exposure to these contaminants.

What are Health Risks from Exposure to* High *Levels of Arsenic and Lead?

Exposure to high levels of arsenic and lead can cause health problems in people. Arsenic can cause more than 30 distinct health effects, including nervous system damage, increased blood pressure, heart attack, stroke, and cancer of the bladder, lung, skin, and other organs. Lead can affect many parts of the body, causing health effects that include increased blood pressure, kidney damage, and brain damage. Although both children and adults can be adversely affected by lead poisoning, it is a particular concern for young children. Arsenic and lead are both considered persistent contaminants. This means that they bind strongly to soil and usually remain in the environment without breaking down or losing their toxicity, and thus can be a source of exposure for many decades.

How to Obtain Blood Lead Level Tests for Your Children

Children ages six and younger are at much higher risk of lead poisoning. Parents who wish to have their children tested for lead should contact a pediatrician or health care provider. For more information, please visit the Washington State Department of Health Childhood Lead Poisoning Prevention Program's website at:
http://www.doh.wa.gov/EHSPHL/Epidemiology/NICE/Lead/default.htm

The Washington State Department of Health Lead Information Hotline can be reached at 1-800-909-9898.

[Note: This information should be updated as the Agencies implement the expanded health monitoring for arsenic and lead as recommended by the Task Force]

5. Examples of Individual Protection Measures

Individual protection measures are simple, day-to-day things that individuals can do to limit or reduce exposure to soil contaminants. Examples include hand washing, removing shoes before entering homes, using gloves while gardening, scrubbing fruits and vegetables before eating them, wet mopping to clean surfaces indoors, bathing pets, and washing toddler toys.

This toolbox contains four sets of example practices:

- Personal hygiene practices and other guidelines for how residents may reduce potential exposure, developed by Public Health – Seattle & King County
- Actions that schools may use to reduce potential exposure of schoolchildren, developed by the Tacoma-Pierce County Health Department
- Worker protection guidelines, developed by the Snohomish Health District for the Everett smelter area
- Guidelines for gardening on soils that may contain elevated levels of arsenic and lead, developed by the Washington State University, Agricultural Extension

Public Health–Seattle & King County—Soil Safety Guidelines

Following these guidelines will help keep your house healthier and cleaner. Dirt has germs, bacteria, chemicals, and other unhealthy things in it. Dirt and dust can be breathed in or eaten, which can be harmful to your health. So encourage your family to follow the soil safety guidelines to reduce the amount of dirt and dust you inhale and ingest!

Inside your home:

- Take off your shoes before entering your home.
- Wash hands and face thoroughly after working or playing in the soil, especially before eating.
- Damp mop and wipe surfaces often to control dust.
- Wash toddler toys and pacifiers often.
- Scrub vegetables and fruits with soap and water.
- Wash clothes dirtied by contaminated soil separately from other clothes.
- Repair painted surfaces in homes. Homes built before 1980 may contain lead-based paint. Older paint flakes may be a source of lead.
- Eat a balanced diet. Iron and calcium help keep lead from becoming a problem in the body.
- Use water and soap to wash – avoid "waterless" soaps.

Outside your home:

- Keep children from playing in contaminated dirt.
- Cover bare patches of dirt with bark, sod or other material, or fence off area.
- Dampen dusty soils before gardening.
- Wear gardening gloves.
- Do not eat or drink in contaminated areas.
- Keep vegetable gardens away from old painted structures and treated wood.
- Do not plant food crops under the roof overhang of your home.
- Keep pets off of exposed dirt so they don't track it into the house.

More information and resources:

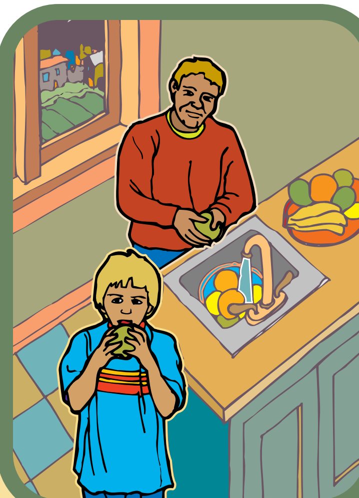
Some soils in King County are contaminated with chemicals such as arsenic and lead. These chemicals have come from many places, including industrial emissions, leaded gasoline, and pesticides. Arsenic and lead can cause illness, especially in children. If you have young children, talk to their pediatrician about a simple blood-lead test. For more information, visit our website at: http://www.metrokc.gov/health/tsp/arseniclead.htm or contact Bonnie Meyer at 206-205-1150.

Soil Safety Guidelines

to reduce your risk from contaminated soil

WASH your hands well after playing in the dirt.

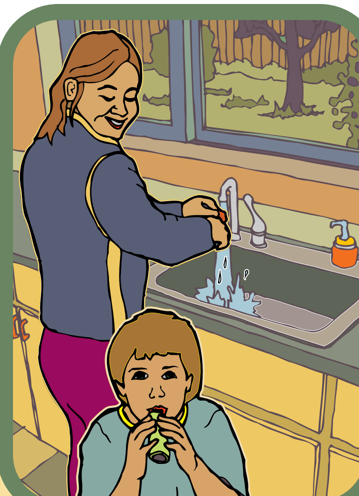
Keep dust down — DAMP-MOP regularly.



Eat fruits and vegetables — but WASH them first.

WEAR GLOVES while you garden.

Take your shoes off! DON'T TRACK DIRT in the house.



WASH toys and pacifiers often.

Funded by a grant from the Washington State Department of Ecology.
Available in alternative formats

FOR MORE INFORMATION visit our web site at http://www.metrokc.gov/health/tsp/arseniclead.htm

Tacoma Smelter Plume Project
Environmental Health Division
Questions about lead and arsenic?
Contact the Public Health Hazline
at 206-296-4692

Public Health
Seattle & King County
HEALTHY PEOPLE. HEALTHY COMMUNITIES.

King County

City of Seattle

Printed on recycled paper.

Tacoma Pierce County Health Department—Healthy Actions at School

What's on your shoes?

Did you know that most soil and dust enters your home and work place via shoes, clothing and pets? Dust contains numerous contaminants including arsenic, lead, bacteria, PCBs, pesticides, and dust mites. It settles on windowsills, bookcases, and other hard surfaces, as well as upholstery and curtains. This dust is then inhaled or ingested in the air we breathe and the food we eat, making it a contributor to poor health.

The good news? Many things can be done to minimize the health risk from dust. By limiting contact with dust and soil and following these simple Healthy Actions, the risk of exposure to contaminants found in dust can be greatly reduced.

Healthy Actions

- **Use plenty of soap and water.** Encourage students to wash their hands with soap and warm water before eating and after playing in the soil. A scrub brush is a good way to clean dirt from under nails.
- **Stay in the play areas.** Designate a "play area" for your students. Providing clean soil or sand is a good alternative for those kids who like to dig in the dirt.
- **Wipe off your shoes.** Place a large "wipe-off" mat outside all entrances to the school and remind everyone to wipe off their shoes before coming inside. This will significantly reduce the amount of soil and dust brought into your school.
- **Throw it away.** Remind students to throw away candy, food, straws, and other items that fall to the ground (inside and outside.)
- **Pick up your stuff.** Keep rooms free of general clutter. Remove clutter from shelves and under the sink. Cluttered areas tend to be dusty places.
- **Mop, dust and vacuum.** Damp-mop and damp-dust floors, windowsills, bookcases and other surfaces frequently. Once a week is suggested.
- Vacuum carpeted areas and upholstered furniture several times a week. Using a bag designed to filter "allergens" or a HEPA filter (High Efficiency Particulate Arrestor) will reduce the amount of dust redistributed by the vacuum cleaner.
- Launder curtains if possible.
- **Keep rooms easy to clean.** Minimize hard to clean surfaces such as carpets, upholstered furniture, stuffed animals, fuzzy room dividers and similar objects made with plush materials.
- **Maintain school grounds.** Cover bare patches of soil with a ground cover such as grass, gravel or a wood/mulch product.

For more information, please contact the Tacoma-Pierce County Health Department:

www.tpchd.org/eh/arsenic.htm

(253) 798-3503

Email: arsenicproject@tpchd.org

TACOMA-PIERCE COUNTY HEALTH DEPARTMENT ENVIRONMENTAL HEALTH PROGRAM

Guidelines for Reducing Potential Exposure
Everett Smelter Site

The highly contaminated soil over the original smelter has been covered, fenced or removed and **there is no immediate danger to human health**. However, it is uncertain what minimum level of long-term exposure to soil contaminated with arsenic, lead or cadmium poses a significant health risk. Therefore, **it is prudent to follow the precautionary health guidelines** outlined below.

Note that this advisory is not specific to any property. Concentrations of arsenic, lead, and cadmium in soil vary from location to location. Generally, higher levels of metals are found in the soil near the original smelter site and lower levels are found in outlying areas. Arsenic is the metal of most concern. Also note that large chunks of smelter slag found in the area are less hazardous than dust particles because dust can enter into the body more readily.

1. Children are more likely than adults to be exposed to arsenic, lead, and cadmium in soils and dust. Their exposure should be limited as much as practical.

- Children should not play in dirt. Play areas covered with grass or some other material will reduce a child’s exposure.
- Encourage your children to wash their hands and faces after playing outdoors.
- Damp mop and dust your house frequently to reduce your child’s contact with dust.

2. Avoid eating vegetables and fruit grown within the affected area.

- Lead and cadmium are known to accumulate in leafy vegetables such as lettuce, spinach, carrots, endive, cress, and beet greens. Onions, mustard, potatoes, and radishes have a moderate ability to uptake heavy metals from the soil.
- It is not known if these metals accumulate in blackberries or other fruit, so avoid eating them until more information is available. Metals were not found above the laboratory detection limits in apples tested from the site.
- If vegetables or fruit are consumed from local gardens, wash thoroughly before eating.

3. Use caution while working in the soil.

- Avoid all unnecessary exposure to soil or dust in the affected area.
- Spray the soil with water before and during the project to minimize dust. Do not saturate the soil or allow water to run off the site.
- Wear clean, full body protective clothing (coveralls or long sleeve shirt and pants), shoes and gloves. For maximum protection wear a dust mask or other respiratory protection. Wash work clothes separately from other clothing.
- Don't eat, drink, smoke, or chew any material while in the work area.
- Clean surfaces by wet mopping, spraying with water, or vacuuming with a HEPA filter. Don't sweep or blow the surface.

4. Avoid other sources of metal exposure.

- Minimize children's exposure to hobbies that use lead (e.g., hobbies that involve the use of lead solder or paint).
- Make sure your child eats a well-balanced diet. Children who have acceptable iron and calcium intake, and low fat intake are less likely to absorb lead from their environment.
- Homes built before 1980 could have lead-based paint. Maintain the painted surfaces in your home to avoid exposure to lead paint chips and dust.
- If your job involves lead or lead compounds, shower and change clothes before returning home.

5. Construction activity.

- Employees of companies who are required to work in soil within the study area should refer to Good Practice Guidelines, and WAC 296-62 (the General Occupational Health Standard), or consult the Department of Labor and Industries for assistance on how to reduce work-related exposure to contaminated soil.
- Use heavy equipment that have enclosed cabs whenever possible.
- Soil removal from any site in the study area must be carried out in consultation with the Snohomish Health District. Soils in the area may have the potential to be designated as Dangerous Waste due to high metals content.

6. Pet precautions.

- Pets can come in contact with contaminated soil, which may then be carried into the home. If possible, keep pets out of areas of exposed soil. Inspect your yard and look for exposed soil your pet may have access to. Fill any holes where dogs may be digging as soon as it is noticed. If possible, restrict pet access from your house. Bathe your pets frequently. Wash your hands after handling your pet, and before preparing or eating food.

Good Practice Guidelines for Employers and Employees

The Good Practice Guidelines for Employers and Employees Working within the Everett Smelter Study Area" was developed by Washington State Department of Labor for the Everett Smelter Study Area. These guidelines address the hazards of arsenic, lead, cadmium and other metals as related to the hazardous waste site. They do not address other safety and health hazards or programs that are required by Washington Industrial Safety and Health Administration. These guidelines were not developed to protect young children or residents who live on the site. See the Public Health Advisory for the residential guidelines and other recommendations for reducing residents' personal exposure.

How to use the Good Practice Guideline Decision Boxes For workers in the Smelter Area.

1. Determine whether the task is above or below ground level. Ground level is the plane of the earth. If the task is both above and below ground level, use the below ground decision box.
2. Determine the soil arsenic concentration (see map or sources for additional information). Use the highest soil level if there are different values.
3. Evaluate whether dust is going to be generated. Dust generation is interpreted to be dust suspended in the air. If you can see it, you are generating dust.
4. Determine which box and quadrant fits your task. Use the letter guidelines in the selected quadrant.
5. Compare your activities/conditions with the exception items. Follow the exceptions where they apply.

ppm = parts per million (mg/kg or ug/g)

Above Ground Tasks

Arsenic in soil ≥ 200 ppm?

Dust Generating?	No	Yes
No	**AB**	**AB**
Yes	**AB**	**ABC**

Below Ground Tasks

Soil will be disturbed

Arsenic in soil ≥ 200 ppm?

Dust Generating?	No	Yes
No	**AB**	**ABC**
Yes	**ABC**	**ABCD**

Letter guidelines used by employees

A	**Hazard communication**: Know the arsenic levels in the soil. Know arsenic and other metals in the soil cause health problems. Know appropriate methods to minimize dust exposure. Know that arsenic and other metals can be taken home if precautions are not taken.
B	**Personal hygiene**: No eating or smoking while doing tasks on location. Wash hands and face before eating or smoking. Wash hands and face before breaks, at the end of the day or task, and when leaving location.
C	**Work clothing**: Wear coveralls and hat while doing task. When leaving site, remove coveralls and clean hat and shoes. Prevent transfer of hazardous materials by placing removed clothing in a bag for transporting. Launder coveralls separately and carefully.
D	**A work site-specific safety plan**: A plan is recommended and may be required. See WAC 296-62-3010 for details. **Workers may need additional training**, at least 24 or up to 80 hours, before entering the work site.

Exceptions

Crawling under houses or in similar circumstances is a special situation. The space is enclosed and airborne concentrations of dust can climb rapidly. Add the next letter guideline to the selected decision box.

A site-specific safety plan is recommended and may be required when undertaking large scale site development, or building activities that involve excavation soils. See WAC 296-62-300 (Part P).

All work activity in the current fenced area requires following WAC 296-62-300 (Part P).

COOPERATIVE EXTENSION
WASHINGTON STATE UNIVERSITY

EB1884

GARDENING ON LEAD- AND ARSENIC-CONTAMINATED SOILS

BY
FRANK J. PERYEA

A

The chemical elements lead and arsenic are potentially toxic to people. Although lead and arsenic occur naturally in the environment, their concentrations have increased, and they have become more widely distributed because of human activities. Societal concerns about excessive human exposure to lead and arsenic prompted development of new products and practices to reduce or eliminate the many industrial and residential uses of the two elements. The principal historical sources of lead (leaded gasoline, lead-based paint) and arsenic (arsenical pesticides) are now outlawed in the United States. As a result, overall human exposure to lead and arsenic is much lower than in the past; however, the legacy of environmental contamination because of past lead and arsenic use is taking on renewed importance. Recent scientific research suggests that human health, especially for infants and small children, may be adversely affected by exposure to lower levels of lead and arsenic than previously believed. Hence, taking additional steps to reduce human exposure to the remaining sources of lead and arsenic may be warranted.

Soil is a major repository for lead and arsenic released by human activities. Some soils are naturally high in lead or arsenic, but many have been artificially enriched through a variety of means. *Contaminated* soils contain total concentrations of elements exceeding the natural background level for local soils. Contamination is an intrinsic property of soil, and contaminated soils are easy to identify by chemical testing. They may or may not pose a health hazard, depending on the amount and type of contamination. *Polluted* soils contain concentrations of an element exceeding some regulatory level associated with impaired human or environmental health. The defining criteria for polluted status can change for scientific, social, economic, or political reasons. This bulletin focuses on lead- and arsenic-*contaminated* soils, based on the premise that reducing exposure to soil lead and arsenic, regardless of their concentrations, will help protect human health.

Home gardening is one of the most popular forms of recreation. Gardening puts people in intimate contact with soil and plants grown in soil. Gardening on lead- or arsenic-contaminated soil increases the likelihood of exposure to these two potentially toxic elements. This bulletin provides general information on

- Why some soils contain elevated amounts of lead and arsenic,
- How to tell if a soil contains elevated lead and arsenic concentrations, and
- How to minimize risk of exposure if one chooses to garden on such soils.

This bulletin addresses home gardening on lead- and arsenic-contaminated soils. Ingestion of lead and arsenic in drinking water or meat and fish foodstuffs, and exposure through household dust are other important routes for human exposure. Specific information about the effects of lead and arsenic on human health and reducing exposure in industrial settings and within the home can be obtained from the following:

U.S. Centers for Disease Control and Prevention, Atlanta, GA 30333 (http://www.cdc.gov), the U.S. Environmental Protection Agency (http://www.epa.gov), and from state and local public health agencies.

Lead and arsenic in the environment

Lead is a metallic element found everywhere in the human environment because of industrialization. Humans have used it in some form since prehistoric times. While lead has a multitude of beneficial uses, it has no known physiological value in humans. High levels of lead exposure can adversely affect human health.

Arsenic is classified as a metalloid (having some properties of a metal) and, like lead, occurs everywhere in the environment. Arsenic also has many beneficial uses but can cause human health problems if exposure is sufficient. Environmental contamination with arsenic because of human activities is less widespread than contamination from lead but can be of regional and local importance.

Lead and arsenic occur naturally in all soils and waters. Plants absorb soil lead and arsenic through their roots; hence, all plants contain small amounts of both elements. The relationship between soil and plant lead varies so much it is impossible to predict accurately how much lead a plant will take up when grown on a soil containing a particular amount of lead. Plant arsenic concentrations tend to increase with increasing soil arsenic, then stabilize at some maximal value at higher concentrations in soil. The exact relationships between plant and soil lead and arsenic vary with factors ranging from chemical forms of the elements in soil, soil properties, climate, soil and plant management practice, to plant species and varieties.

Sources of lead and arsenic

People in residential settings are exposed to lead from many sources. These include natural background soil lead, lead-based paint, leaded gasoline, lead-based pesticides, drinking water, aerosols and dusts from smelters and mines, hobby activities (e.g., pottery glazes; soldering; casting ammunition, fishing weights, toy soldiers and other metal objects), leaching from containers (e.g., improperly glazed ceramic ware; leaded crystal; lead-soldered cans), some food supplements, and "traditional" medicines. Industrial workers also may bring home lead-contaminated work clothes or wash such clothing with the family laundry.

In most cases, high lead contamination in home garden soils originate from four sources: paint, gasoline, insecticide, and industrial fallout.

- Lead-based paint (containing up to 50% lead) was widely used up to the mid-1940s because it was more durable than the non-lead-based paint of the day. Estimates indicate that 90% of homes built before 1940 contain lead paint. Use of lead-based paints declined during the 1950s and was banned for home use in 1978. Industrial uses of high-lead paint are still allowed. Flaking, chalking or other disturbance of lead-based paint on exterior surfaces of buildings and other structures create lead-rich dusts that fall onto nearby soil and increase soil lead content.
- Oil companies added lead to gasoline because it was an inexpensive and effective octane-booster and anti-knock compound. Combustion of leaded gasoline produced tiny lead-rich particles. About 75% of gasoline lead was emitted from exhaust pipes; oil or internal surfaces of the engine and exhaust system trapped 25%. The lead-rich exhaust dust fell directly onto soil near the road or blew a short distance first. Gasoline-derived soil lead is highest adjacent to roadways, parking areas, and driveways. Lead particle size

and soil lead concentrations drop off quickly with increasing distance from driving surfaces; however, gasoline lead often has accumulated in more distant soils near structures that interfere with wind patterns. The wind-transported lead particles struck and stuck to houses, trees, and other barriers, and eventually were washed into the soil by rain. As a result, soil lead can be high around houses not painted with lead-based paint or those not adjacent to roads. Soil lead concentrations typically are higher near heavily used roads than near less traveled roads. Some states banned leaded gasoline as early as 1986. Washington continued to allow leaded gasoline until the end of 1995, when it was banned nationwide.

- Lead arsenate was a popular insecticide during the first half of the 20th century because of its low toxicity to plants and great effectiveness for controlling insect pests. The most common use was for control of codling moth in commercial apple orchards. Ranchers also used large quantities for grasshopper control baits. Smaller but still substantial amounts were used on deciduous tree fruits other than apple, in home gardens and orchards, for mosquito control, and on lawns and golf greens. Applicators used other arsenic-based pesticides for agricultural crops, turfgrass, gardens, and rights-of-way.

- Repeated applications of lead arsenate over time caused lead and arsenic to accumulate in soil. Soil lead and arsenic concentrations vary considerably in former orchard sites because applicators using hand-held sprayers applied lead arsenate individually to trees. Higher concentrations tend to occur where the former trees stood; lower concentrations appear between the former tree sites. Use of lead arsenate in apple orchards in Washington ended about 1947 when a more effective replacement pesticide was introduced. Use continued in some other states and countries through the 1960s. Lead arsenate was banned on most food crops in the U.S. in 1988 and on all food crops in 1991. Growing garden crops on soils containing lead arsenate residues raises potential problems when pre-1947 orchard land is converted to residential use.

- Soil lead and soil arsenic often are high around existing metal ore smelters and former smelter sites due to lead- and arsenic-rich ash emitted from smokestacks, or lead- and arsenic-rich dusts blown off ore and slag piles. Metal ores frequently contain arsenic, which is released during smelting as arsenic-rich gases. Soil lead and arsenic concentrations typically decrease with increasing distance from the source and are highest in the predominant downwind directions. Smelter-derived lead dust also may accumulate at the bases of structures obstructing wind flow patterns. Particulate- and gas-trapping devices and ore pile covers are now required to reduce uncontrolled releases of lead and arsenic from operating smelters. Use of smelter slag for construction and landscaping may have distributed lead and arsenic into residential areas. Soils formed on metal ore mine tailings also may be high in lead and arsenic.

Arsenic is present in coal and at much smaller concentrations in oil. Like ore smelting, combustion of fossil fuels in electrical power plants releases arsenic, which can be deposited onto nearby soil. Trapping devices now used to minimize arsenic release from fossil fuel-fired power plants may not have been used in the past. Arsenic dusts and gases also are released during cement manufacture.

- Leaching of arsenic from treated lumber can increase soil arsenic near the wood. Lumberyard use of arsenicals as wood preservatives is a specific, legal treatment.

- Soils can be naturally high in arsenic, as reported at the upper ends of some valleys in Washington's Cascade Mountains. Rocks high in arsenic release this element as the rock weathers, causing arsenic enrichment of local soil and groundwater. Volcanic emissions and hot springs associated with volcanic activity are another natural source of arsenic. Surface runoff or percolating groundwater from springs having high concentrations of arsenic can increase the soil arsenic content of nearby soils.

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IDENTIFYING LEAD and ARSENIC CONTAMINATION in SOILS

Soil lead typically occurs as minerals of very low solubility or as positively charged ions strongly bound to soil particle surfaces. Lead solubility is particularly low at high soil pH and in the presence of high soil phosphorus. Lead normally has very poor mobility in soil. Most surface-deposited lead resides in the top few inches of soil unless the soil profile has been physically mixed due to tillage, digging, or some other disturbance. In this case soil lead redistribution can occur throughout the depth of mixing.

Soil arsenic normally occurs as negatively charged ions bound to soil particle surfaces or making up part of their structure. Soil arsenic is more soluble and more mobile than soil lead. Arsenic solubility and mobility usually increase in very wet or flooded soils. Soil arsenic also is redistributed in the soil by tillage. Most surface-deposited arsenic remains in the topsoil, but considerable amounts may have leached into the subsoil, particularly in sandy soils.

Former and existing land uses

Knowledge of current and past land use offers clues about possible lead and arsenic soil contamination. Most unrestricted releases of lead and arsenic from human activities occurred before the 1960s. Because land use may have changed substantially since then, current use may not accurately reflect historical use.

- Suspect soil lead contamination if the garden is within 20 feet of older buildings or other structures once painted with lead-based paints.
- Suspect soil lead contamination if the garden is within 100 feet of roadways and parking areas, particularly near high-traffic routes.
- Suspect soil lead and arsenic contamination if the garden is within 1 mile of existing or former smelters, fossil fuel-fired electrical power plants, or cement manufacturing facilities.
- Suspect soil lead and arsenic contamination if the garden is planted on a pre-1947 orchard site.
- Suspect soil lead and arsenic contamination if the garden is planted on or near tailings from current or former metal ore mines.

Soil testing

Chemical analysis of soil will confirm the presence of elevated concentrations of lead or arsenic.

Locate a soil testing laboratory and discuss requirements for soil sample size and containers before collecting samples. Washington State University Cooperative Extension can help you find suitable laboratories.

Using a nonmetal tool, such as a plastic trowel or scoop, collect samples from the top 8 inches of the garden soil at several locations within the garden. Dump them all into a plastic bucket, mix the soil samples using a nonmetal tool until they are uniformly combined. Collect a subsample or composite sample from the soil mixture (usually about one cup volume) and place it in a plastic bag or other nonmetal sample container (often provided by the testing laboratory). Label the sample with your name, date, location, and depth of sample, using a permanent marker. Deliver the composite soil sample to a testing laboratory and request analyses for *total* lead and *total* arsenic concentrations.

Collect more than one composite sample from different areas within the garden if the garden is very large or if you expect contamination patterns to vary greatly. Use common sense when devising sampling plans. For example, if a garden is adjacent to an old building where lead paint might have been used, collect one composite sample from the garden area next to the building, where soil lead might be high, and one from farther away in the garden, where soil lead might be low. Map the sampling sites so you can relate the test results to the specific locations.

Testing laboratories normally report the lead and arsenic concentrations in units of milligrams per kilogram (mg/kg) or parts per million by mass (ppm). These units are numerically identical; that is, 10 mg/kg of a substance in a soil sample is the same as 10 ppm by mass of that substance.

The Washington State Department of Ecology reported natural background soil lead and arsenic concentrations in Washington to be 17 and 7 mg/kg, respectively (*Natural background soil metals concentrations in Washington State,* Washington State Department of Ecology, Publ. #94-115, Olympia, WA, October 1994). Soil test reports indicating soil lead and arsenic concentrations above these values suggest enrichment due to human activities. Landowners offering property for sale are required by law to disclose information about known environmental contamination to prospective buyers.

Numerous interpretive standards exist for soil lead and arsenic. They often are contradictory because they reflect the varying objectives of the originating organizations and regulatory agencies. Most standards currently are undergoing review and therefore are subject to revision.

Tolerances for soil lead and arsenic concentrations associated with optimal plant growth and "safe" plant lead and arsenic levels have not been established. An out-of-print WSU extension bulletin cites a soil arsenic standard of 25 mg/kg and lower as "probably" not affecting plant growth (*Interpretation of special orchard soil tests,* Cooperative Extension Bulletin FG-28d, Washington State University, Pullman, WA, January 1983).

The Washington State Department of Ecology established residential soil cleanup standards of 250 mg/kg for lead and 20 mg/kg for arsenic (*Model Toxics Control Act Cleanup Regulation*, Chapter 173-340 Washington Administrative Code). The Washington State Department of Health estimates soil arsenic concentrations below 37 mg/kg should protect the health of children having frequent exposure to contaminated soils, and regards 175 mg/kg as safe for adults having occasional exposure to contaminated soil (*Hazards of short-term exposure to arsenic contaminated soil*, Washington State Department of Health, Olympia, WA, January 1999).

The U.S. Environmental Protection Agency final rule established soil lead concentrations of 400 mg/kg as the level of concern in play areas and 1200 mg/kg as the hazard standard for bare soil in residential areas based on soil samples (Lead; Identification of dangerous levels of lead; Final Rule, 40 Congressional Federal Register Part 745.65(c), January 5, 2001)

GARDENING ON LEAD- OR ARSENIC-CONTAMINATED SOILS

General considerations

People who garden on lead- and arsenic-contaminated soils are unlikely to have high enough exposure to become suddenly ill. The rare cases of acute toxic responses to soil arsenic involve a combination of atypical circumstances: highly susceptible individuals, exceptionally high-contact exposure, or the presence of highly soluble forms of arsenic in the soil. Chronic exposure to soil lead and arsenic is the principal concern. People exposed to environmental sources of lead and arsenic over long periods of time are more likely to have elevated body burdens of these elements and, consequently, increased risk of developing adverse health effects.

The potential toxicity of either lead or arsenic in plants and soils depends on many factors. People vary in susceptibility to lead and arsenic, due to genetic makeup, type and amount of exposure, general health, and age. Lead and arsenic in plants and soils occur in a variety of chemical forms, called chemical species, which have different toxicological properties. Most studies of lead and arsenic in plants and soils report only total concentrations of these elements because it is difficult to accurately and inexpensively quantify the distribution and amount of chemical species. The inherent variation among people, plants, soils, and behavioral factors greatly complicates predicting the relative lead or arsenic hazard of food plants and contaminated soils.

Lead and arsenic enter the human body primarily by ingestion. Preschool-age children are the most vulnerable segment of population for exposures to soil lead and arsenic. Factors contributing to this sensitivity include: 1) a greater likelihood for children playing in soil to place their hands and other objects into their mouths; 2) greater lead and arsenic absorption by children than by adults; and 3) greater likelihood of children having nutrient deficiencies that may facilitate lead and arsenic absorption.

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People are exposed daily to lead and arsenic from a wide variety of sources, including contact with soil and home garden produce. It is not realistic for most people to quantify the contribution home gardening makes to their overall exposure. By adopting specific practices and behaviors that reduce exposure, people can reduce possible health impacts caused by gardening on lead- and arsenic-contaminated soils.

Lead and arsenic in garden crops

Lead and arsenic concentrations in crop plants grown on lead- and arsenic-enriched soils are too low to cause acute poisoning in humans. The health concern is that extra lead and arsenic in or on plants grown on lead- and arsenic-enriched soils add to total intake of these elements. Because lead and arsenic occur naturally in all soils, it is impossible to grow plants completely free of lead or arsenic.

Concentrations of lead and arsenic in soil may be 10 to 1000 times greater than their concentrations in plants growing on that soil. Because of this, failure to remove soil particles that adhere or become trapped on the outside surfaces of garden crops can substantially increase dietary lead and arsenic obtained by eating garden plants.

- Wash garden crops grown on lead- and arsenic-enriched soils with water before bringing them into the house. This removes most soil particles, reduces the lead and arsenic content of the crops, and reduces the transport of soil lead and arsenic into the home.

- Once you have brought the produce inside, wash it again carefully, using edible soap or detergent (sold at many supermarkets), water, and a scrub brush to remove remaining soil particles. Pay particular attention to crops like broccoli having rough exposed exteriors that can trap soil. Leafy plants having large surface areas (such as lettuce and swiss chard) can trap and retain large quantities of dust.

- Pare root and tuber crops (such as potatoes, carrots and radishes) and discard the parings.

- Do not compost unused plant parts, peelings, and parings for later use in the garden.

These practices will reduce the lead and arsenic content of harvested home garden produce to the lowest possible levels.

Garden plant selection

Crops respond differently to soil lead and arsenic depending on plant species and variety. Unfortunately not enough data are available to reliably rank plant species and varieties for growth, yield, and lead and arsenic uptake responses. A few general guidelines can be abstracted from the scientific literature.

The quantities of lead found in most lead-contaminated soils typically are not high enough to reduce plant growth and yield. Elevated concentrations of soil arsenic can stunt plants and reduce yields. If sufficiently high, soil arsenic can cause plant death. Arsenic in plants bonds irreversibly with energy transport molecules, interfering with their activity. Plants containing excessive arsenic effectively “run out of energy.”

Green beans and other legumes appear to be most sensitive to soil arsenic contamination. They often fail to grow at soil arsenic concentrations which cause no deleterious effects on other plant species. Growth patterns of stone fruit trees such as peaches and apricots are very sensitive to elevated soil arsenic; apples and pears are less sensitive, and cherries are intermediate. Information about growth sensitivity of other crop species is sparse. The stunting effect of soil arsenic may have horticultural benefits. Although the results are difficult to predict, arsenic stunting can control the size of ornamental plants and fruit trees.

The distribution patterns of lead and arsenic among various plant parts is highly variable. Seeds and fruits typically have lower lead and arsenic concentrations than do leaves, stems or roots. Roots and tubers usually have the highest lead and arsenic concentrations, with the skin having higher lead and arsenic concentrations than does the inner flesh. The lead content of roots correlates more closely to soil lead than does lead in leaves or stems, possibly because roots tend to retain absorbed lead and not transport it higher up into the plant. Tree fruits such as apples and apricots contain very low lead and arsenic concentrations. Contamination of plant parts by lead- and arsenic-rich soil or dust can increase the apparent lead and arsenic content of that plant.

Organic arsenic compounds may be less toxic than inorganic arsenic compounds. Although comprehensive data about the distribution of chemical species in food plants are not available, preliminary reports suggest organic arsenic is predominant in fruits and vegetables, while inorganic arsenic is more common in grains. Plants grown on sands and sandy loams have higher total arsenic contents than those grown on heavier-textured soils at equivalent total soil arsenic concentrations.

Land use practice

Home gardeners can control the amount of their exposure to soil lead and arsenic by adopting different land use practices.

- Grow Only Ornamental Plants. Cease raising food plants to eliminate the contribution of edible garden crops to dietary lead and arsenic. Remember that contaminated soil adhering to the outside of cut plants brought inside can introduce lead and arsenic into the home.

- Build Containers or Raised Beds. Construct container or raised bed gardens using low lead and arsenic soil. Make sure to test the new container or bedding soil for lead and arsenic content before using it.

- Place a barrier between the uncontaminated topsoil and any underlying contaminated soil to reduce mixing and to remind you how deeply you can till the bedding soil without incorporating underlying contaminated soil. Impermeable barriers such as a concrete slab or thick plastic sheeting between the new soil and the underlying contaminated soil keep plant roots from penetrating into buried soil to absorb lead and arsenic. Provide for bed drainage if you use an impermeable barrier. Permeable barriers are less effective at isolating the bedding and underlying soils. Examples include porous herbicide-impregnated fabric or geotextile plant root barriers or a layer of flat concrete tiles placed on top of the subsoil and butted against each other before the replacement topsoil is placed on top. Plant roots likely will grow through the cracks between the tiles, permitting plants to absorb subsoil lead and arsenic and eventually to redistribute some lead and arsenic into the topsoil.

Cover the walkways between the raised beds with concrete, boards, new soil, and similar barriers to further reduce the likelihood of contact with contaminated topsoil remaining within the garden area.

Do not use arsenic-treated lumber to construct raised beds.

- Replace Contaminated Soil. Dig up and replace existing contaminated garden soil with soil containing low lead and arsenic levels. Test the replacement soil for lead and arsenic concentrations. If you remove all of the contaminated soil, you will not need to place barriers between the new topsoil and old subsoil. Install barriers to reduce the likelihood of recontaminating the new topsoil if the old subsoil still contains elevated levels of lead or arsenic. If you install an impermeable barrier underneath the new topsoil, you may need a drainage system.

  Depending on its lead and arsenic content, excavated topsoil may meet criteria designating it as a dangerous waste by the Washington State Department of Ecology (*Dangerous Waste Regulations*, Chapter 173-303 Washington Administrative Code) and, therefore, may require special handling for disposal. The criteria for determining if contaminated soil is a dangerous waste are complex and may require technical assistance for interpretation.

- Isolate Contaminated Garden Areas. Fence off the garden area using a lockable gate if infants or small children might enter the area and play, or otherwise come in contact with lead- or arsenic-contaminated soil.

Personal hygiene

Certain personal hygiene practices help minimize exposure to soil lead and arsenic while gardening and reduce transport of contaminated garden soil into the home. Which ones you choose to adopt depends on how much control you wish to have over exposure. Use common sense—walking in your garden to harvest some tomatoes for dinner does not require the same level of protection and cleanup as would spending a day on hands and knees weeding. Important factors to consider include how high the concentrations of lead and arsenic are in the garden soil, how dirty you get while gardening, and if young children live in the home.

- While gardening, do not eat unwashed produce or any other foods. Do not drink, smoke, or engage in other activities that may introduce soil into the mouth.

- Wear a dust mask or respirator in dusty environments to minimize both inhalation and ingestion of airborne soil particles.

- Keep soil moist while gardening to control dust.

- Wash all exposed body surfaces, preferably by showering, as soon as possible after gardening.
- Wash soil particles from gardening tools and supplies outside after each use and store tools outside. Tools, supplies and clothing used for gardening may pick up and transport lead- and arsenic-enriched soil particles.
- Designate certain clothing, including footwear, shirts, pants, and tight-fitting disposable gloves for gardening use only.
- Remove gardening footwear—every time—before entering the house.
- Store used garden clothing outdoors.
- Launder garden clothing outside by hand to remove adhering soil.
- Wash the garden clothing as a separate load in the general household washing machine. Running the washing machine through a subsequent clothing-free rinse cycle will further flush the inside of the machine and help reduce possible carry-over of lead and arsenic residues into the next batch of clothing.

Helpful soil amendments

Soil acidity is reported in units of pH. A pH value of 7.0 is defined as neutral. Values above 7 are termed alkaline, and values below 7 are acidic. The pH range found in natural Washington soils is about 4 to 9.

Plant lead concentrations typically decrease with increasing soil pH. Plants tend to take up the least amount of soil arsenic at neutral soil pH. Amend acidic soils contaminated with lead but not arsenic with agricultural lime (calcium carbonate or dolomite) to pH 7 or greater. Lime acid soils containing elevated arsenic concentrations but not lead to pH 7. Maintain soils containing both lead and arsenic at pH 7 to minimize plant uptake of both elements. It is difficult to reduce the pH of soils that contain free lime (also known as caliche), which have a pH of 8 or greater. Using an acidic fertilizer formulation such as one containing nitrogen as ammonium or urea will help reduce soil pH over time.

Increase soil organic matter by adding compost, manures, and other organic soil amendments. Normally, this will reduce plant uptake of soil lead and arsenic. Part of this effect appears to be simple dilution of soil lead and arsenic concentrations. Beyond some maximal amount of added organic material increases have no further beneficial effect. Test all composts and other organic amendments or choose those certified low in lead and arsenic. Avoid preparing compost using plant materials grown on lead- and arsenic-contaminated soils.

Use of phosphate-containing soil amendments such as triple superphosphate sometimes can reduce plant uptake of soil lead, by causing lead phosphate minerals of very low solubility to form. This approach does not work if soil lead already occurs as lead phosphate minerals, as it may on soils that have a history of phosphorus fertilizer application.

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Adding phosphate amendments to high arsenic soils can increase plant uptake of soil arsenic. Apply phosphorus-containing fertilizers to high arsenic soils only when plant growth is restricted by lack of phosphorus. In this case the phosphorus-stimulated increase in plant biomass will dilute any extra absorbed arsenic and reduce plant arsenic concentration.

Other proposed techniques for reducing soil lead and arsenic concentrations and phytoavailability are still in the testing stage. Specific recommendations are not yet available.

SUMMARY

Lead and arsenic occur naturally in soils. Both elements are potentially toxic if present at high concentrations. Past human activities have increased the lead and arsenic content of some soils used for home gardens, sometimes to levels that create concern about human health. Geographical and historical factors give clues about the possibility of soil contamination with lead and arsenic. Soil testing can confirm higher than natural background concentrations.

Ingestion is the principal route by which lead and arsenic enter the human body. Human health is best protected by minimizing total dietary intake of these elements. People ingest lead and arsenic in water, food, soil, and housedust. Because lead and arsenic concentrations in soil are much higher than in plants, home gardeners and their families are likely to have greater exposure to lead and arsenic in soil directly or in soil particles adhering to the outside of plants than to lead and arsenic actually within garden produce. The lead and arsenic contents of plants and most soils are not high enough to be acutely toxic to people; however, they contribute to overall lead and arsenic exposure. The amount of lead and arsenic ingested increases with increasing exposure to lead and arsenic in soil. Young children generally have greater likelihood of exposure to soil lead and arsenic than do older children and adults. Children also are more likely to be harmed by lower doses of lead and arsenic.

Home gardeners can reduce the potential hazard of gardening on lead- and arsenic-contaminated soils by combining appropriate land use, horticultural, and personal hygiene practices. These practices reduce the amount of lead and arsenic in or on garden produce, and minimize direct exposure of gardeners and their families to contaminated soil.

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COOPERATIVE EXTENSION
WASHINGTON STATE UNIVERSITY

College of Agriculture and Home Economics

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6. Range of Possible Actions to Address Area-Wide Soil Contamination

Types of protection measures to reduce potential exposure to arsenic and lead in soil include:

- **Education programs** refer to broad-based, community-wide efforts to inform individuals and businesses of the presence of contamination and changes in behavior that can be taken to limit or reduce exposure to the contamination. Such programs use a wide range of techniques to distribute information and increase public awareness.

- **Public health programs** generally involve activities designed to identify and focus protection measures on specific populations within a community considered to be at high risk. They often include health monitoring activities (e.g., blood lead testing or urinary arsenic screening), one-on-one education on steps to reduce exposure, and intervention activities to address sources contributing to elevated exposures.

- **Individual protection measures** are simple, day-to-day things that individuals can do to limit or reduce exposure to soil contaminants. Examples include hand washing, removing shoes before entering homes, using gloves while gardening, scrubbing fruits and vegetables before eating them, wet mopping to clean surfaces indoors, bathing pets, and washing toddler toys.

- **Land-use controls** are actions by government or private agreements that provide information on the presence of contamination on a property and/or that limit or prohibit activities that could result in exposure to contaminants or harm to a physical barrier on the property. Examples include zoning, permits and licenses, covenants, easements, deed and plat notices, and real-estate disclosure.

- **Physical barriers** prevent or limit exposure to contaminated soil or unauthorized access to a property. They may be used in combination with excavation to consolidate contaminated soil on a particular part of a property. Examples include fences, grass cover, wood chips, clean soil cover, and pavement.

- **Contamination reduction** involves reducing the concentration of contaminants in soil or removing the contamination for disposal at another location or in a contained area on a property. Examples include soil blending or tilling, soil removal and replacement, and phytoremediation.

[Placeholder for information on specific protection measures, including information on effectiveness, cost, and practicality, and guidance on how to implement the protection measures, in particular, how to maintain and establish good soil cover and how to locate soil for use in gardens or play areas.]

7. Area-Wide Soil Contamination Contact List

Note: Contact information was correct as of the date of publication, but is subject to change.

State Agencies

Department of Agriculture
Pesticide Management Division
P.O. Box 42560,
Olympia, WA 98504-2560

- http://www.wa.gov/agr/PestFert/default.htm
- By Phone: 360-902-2010

Department of Community, Trade and Economic Development
Office of Community Development
906 Columbia St. S.W.
Olympia, WA 98504-8300
General Information

- http://www.ocd.wa.gov/
- By Phone: (360) 725-2800

Department of Ecology
Headquarters
P.O. Box 47600
Olympia, WA 98504-7600

- http://www.ecy.wa.gov/org.html
- By Phone: (360) 407-6000

Northwest Regional Office
3190 - 160th Ave. SE
Bellevue, WA 98008-5452

- By Phone: (425) 649-7000

Southwest Regional Office
PO Box 47775
Olympia, WA 98504-7775

- By Phone: (360) 407-6300

Central Regional Office
15 West Yakima Ave -- Suite 200
Yakima, WA 98902-3452

- By Phone: (509) 575-2490

Eastern Regional Office, Spokane
N. 4601 Monroe
Spokane, WA 99205-1295

- By Phone: (509) 329-3400

Tacoma Smelter Plume Environmental Cleanup Information

- http://www.ecy.wa.gov/programs/tcp/sites/tacoma_smelter/ts_hp.htm

Area-Wide Soil Contamination Homepage

- http://www.ecy.wa.gov/programs/tcp/area_wide/area_wide_hp.html

Department of Health
1112 SE Quince Street, P.O. Box 47890
Olympia, Washington, 98504-7890

- http://www.doh.wa.gov
- By Phone: (800) 525-0127

Environmental Health Programs

- http://www.doh.wa.gov/ehp/default.htm
- By Phone: (360) 236-3380

Federal Agencies

Environmental Protection Agency
Region 10
U.S. EPA, Region 10
1200 Sixth Avenue
Seattle, WA 98101
- http://www.epa.gov/region10
- By Phone: 1-800-424-4372

Region 10 Office of Waste & Chemical Management
- http://yosemite1.epa.gov/R10/OWCM.NSF/webpage/homepage?opendocument
- (206) 553-8511

National Lead Information Center
- http://www.epa.gov/lead/nlic.htm
- By Phone: 1(800) 424-LEAD [5323].

Department of Housing and Urban Development
Seattle Regional Office
909 1st Avenue, Suite 200
Seattle, WA 98104-1000
- By Phone: (206) 220-5101
- http://www.hud.gov/local/index.cfm?state=wa

Spokane Field Office
US Courthouse Building
920 W. Riverside, Suite 588
Spokane, WA 99201-1010
- By Phone: (509) 353-0674
- http://www.hud.gov/local/index.cfm?state=wa

Bureau of Reclamation
Pacific Northwest Region
U.S. Bureau of Reclamation
1150 N. Curtis Rd., Suite 100
Boise, Idaho 83706-1234
- By Phone: (208) 378-5020
- http://www.pn.usbr.gov/contact/index.shtml

Columbia Basin Civilian Conservation Center
Building 2402, 6739 24th St.
Moses Lake, WA 98837
- (509) 762-2301

Ephrata Field Office
Box 815
Ephrata, WA 98823
- (509) 754-0214

Fort Simcoe Civilian Conservation Center, White Swan, WA
Route 1
White Swan, WA 98952
- (509) 974-2244

Upper Columbia River Area Office
1917 Marsh Road, Yakima WA
98901-2058
- (509) 575-5848 ext. 202

Local Agencies

County Planning Departments and Health Districts

County	Agency Name & Website	Phone
Adams	**Adams County Building and Planning Department** http://www.co.adams.wa.us/departments/default.asp?DeptID=3	(509) 488-9441
	Adams County Health District http://www.co.adams.wa.us/departments/default.asp?DeptID=10	(509) 659-3321
Asotin	**Asotin County Planning Department** http://www.co.asotin.wa.us/ASOTIN/building.html	(509) 243-2020
	Asotin County Health District http://www.co.asotin.wa.us/ASOTIN/health.html	(509) 758 3344
Benton	**Benton County Building/Planning Department** http://www.co.benton.wa.us/planning.htm	(509) 786-5612
	Benton-Franklin Health District http://www.bfhd.wa.gov/	(509) 943-2614
Chelan	**Chelan County Building, Fire Safety, and Planning** http://www.co.chelan.wa.us/bl/bl1.htm	(509) 667-6225
	Chelan-Douglas Health District http://www.cdhd.wa.gov/index.asp	(509) 886-6400
Clallam	**Clallam County Department of Community Development** http://www.clallam.net/Departments/html/dept_dcd.htm	(360) 417-2420
	Clallam County Environmental Health Services http://www.clallam.net/EnvHealth/	(360) 417-2258
Clark	**Clark County Department of Community Development** http://www.co.clark.wa.us/ComDev/Default.asp	(360)397-2375
	Southwest Washington Health District http://www.swwhd.wa.gov/	(360) 397-8215
Columbia	**Columbia County Planning Department** http://www.columbiaco.com/	(509) 382-4541
	Columbia County Health District	(509) 382-2181
Cowlitz	**Cowlitz County Department of Building and Planning** http://www.co.cowlitz.wa.us/buildplan/default.htm	(360) 577-3052
	Cowlitz County Health Department http://www.co.cowlitz.wa.us/health/	(360) 414-5599
Douglas	**Douglas County Department of Transportation and Land Services** http://www.douglascountywa.net/departments/tls/	(509) 884-7173
	Chelan-Douglas Health District http://www.cdhd.wa.gov/index.asp	(509) 886-6400
Ferry	**Ferry County Planning Department** http://www.ferry-county.com/countygov.htm	(509) 775-5209
	Northeast Tri-County Health District http://homepage.plix.com/tricohealth/	(509) 684-1301

County	Agency Name & Website	Phone
Franklin	**Franklin County Planning and Building Department** http://www.co.franklin.wa.us/planning/	(509) 545-3521
	Benton-Franklin Health District http://www.bfhd.wa.gov/	(509) 943-2614
Garfield	**Garfield County Commissioners**	(509) 843-1391
	Garfield County Health District	(509) 843-3412
Grant	**Grant County Planning Department** http://www.grantcounty-wa.com/Planning/index.htm	(509) 754-2011
	Grant County Health District http://www.granthealth.org/index.htm	(509) 766-7960
Grays Harbor	**Grays Harbor County Planning & Building Division** http://www.co.grays-harbor.wa.us/info/pub_svcs/PlanningBuilding.htm	(360) 249-3203
	Grays Harbor County Environmental Health Division http://www.co.grays-harbor.wa.us/info/pub_svcs/envhealth.html	(360) 249-4413
Island	**Island County Planning and Community Development** http://www.islandcounty.net/planning/	(360) 678.5111
	Island County Health Department http://www.islandcounty.net/health/	(360) 679-7350
Jefferson	**Jefferson County Community Development Department** http://www.co.jefferson.wa.us/commdevelopment/default.htm	(360) 379.4450
	Jefferson County Health & Human Services http://www.co.jefferson.wa.us/health/default.htm	(360) 385.9400
King	**King County Department of Development & Environmental Services** http://www.metrokc.gov/ddes/	(206) 296-6600
	Public Health – Seattle & King County http://www.metrokc.gov/health/ http://www.metrokc.gov/health/tsp/arsenic.htm	(206) 296-4600
Kitsap	**Kitsap County Department of Community Development** http://www.kitsapgov.com/dcd/default.htm	(360) 337-7150
	Bremerton-Kitsap County Health District http://www.wa.gov/kitsaphealth/	(360) 337-5235
Kittitas	**Kittitas County Planning Office** http://www.co.kittitas.wa.us/planning/default.asp	(509) 962-7506
	Kittitas County Public Health Office http://www.co.kittitas.wa.us/health/default.asp	(509) 962-7515
Klickitat	**Klickitat County Planning Department** http://www.klickitatcounty.org/Planning/	(509) 773-5703
	Klickitat County Health Department http://www.klickitatcounty.org/Health/	(509) 773-5991
Lewis	**Lewis County Community Development Division** http://www.co.lewis.wa.us/CommunityDevelopment/commdev.htm	(360) 740-1146
	Lewis County Health Department http://www.co.lewis.wa.us/HealthSocialServices/Health.htm	(360) 740-1223

County	Agency Name & Website	Phone
Lincoln	**Lincoln County Planning Department**	(509) 725-7041
	Lincoln County Public Health Department http://www.co.lincoln.wa.us/	(509) 725-2500
Mason	**Mason County Department of Community Development** http://www.co.mason.wa.us/community_dev/default.shtml	(360) 427-9670 Ext. 352
	Mason County Environmental Health Department http://www.co.mason.wa.us/envhealth/default.shtml	(360) 427-9670 Ext. 352
Okanogan	**Okanogan County Office of Planning & Development** http://www.okanogancounty.org/planning/index.html	(509) 422-7160
	Okanogan County Health District http://www.okanogancounty.org/ochd/index.htm	(509) 422-7140
Pacific	**Pacific County Department of Community Development** http://www.co.pacific.wa.us/dcd/index.htm	(360) 875-9356
	Pacific County Environmental Health Division http://www.co.pacific.wa.us/dcd/ENVHEALTH.htm	(360) 642-9382
Pend Oreille	**Pend Oreille Planning Department**	(509) 447-4821
	Northeast Tri-County Health District http://homepage.plix.com/tricohealth/	(509) 684-1301
Pierce	**Pierce County Planning and Land Services** http://www.co.pierce.wa.us/pc/services/home/property/pals/palsmain.htm	(253) 798-7210
	Tacoma-Pierce County Health Department http://www.tpchd.org/ http://www.healthdept.co.pierce.wa.us/eh/arsenic.htm	(253) 798-6500
San Juan	**San Juan County Planning Department** http://www.co.san-juan.wa.us/planning/index.html	(360) 378-2393
	San Juan County Department of Health and Community Services http://www.co.san-juan.wa.us/apages/health.html	(360) 378-4474
Skagit	**Skagit County Planning and Permit Center** http://www.skagitcounty.net/Common/asp/default.asp?d=PlanningAndPermit&c=General&p=main.htm	(360) 336 -9410
	Skagit County Health Department http://www.skagitcounty.net/Common/asp/default.asp?d=Health&c=General&p=main.htm	(360) 336-9380
Skamania	**Skamania County Planning and Community Development Department** http://www.skamaniacounty.org/Planning%20and%20Development%20Department.htm	(509) 427-9458
	Southwest Washington Health District http://www.swwhd.wa.gov/	(360) 397-8215
Snohomish	**Snohomish County Department of Planning & Development Services** http://www.co.snohomish.wa.us/pds/index.asp	(425) 388-3311
	Snohomish Health District http://www.snohd.org/	(425) 339.5210

County	Agency Name & Website	Phone
Spokane	**Spokane County Planning Department** http://www.spokanecounty.org/planning/	(509) 477-7200
	Spokane Regional Health District http://www.spokanecounty.org/health/index.asp	(509) 324-1500
Stevens	**Stevens County Planning Department** http://www.co.stevens.wa.us/planning/Index.htm	(509) 684-2401
	Northeast Tri-County Health District http://homepage.plix.com/tricohealth/	(509) 684-1301
Thurston	**Thurston Regional Planning Council** http://www.trpc.org/	(360) 786-5480
	Thurston County Public Health & Social Services Department http://www.co.thurston.wa.us/health/welcome.html	(360) 786-5581
Wahkiakum	**Cowlitz-Wahkiakum Council of Governments, Wahkiakum County Planning Department** http://www.cwcog.org/building.html	(360) 577-3041
	Wahkiakum County Health & Human Services http://www.cwcog.org/humanservices.html	(360) 795-6207
Walla Walla	**Walla Walla County Regional Planning** http://www.co.walla-walla.wa.us/Departments/planning/regional-plan/regional_planning.htm	(509) 527-3285
	Walla Walla County Health Department http://www.co.walla-walla.wa.us/Departments/health/health.htm	(509) 527-3290
Whatcom	**Whatcom County Planning & Development Services** http://www.co.whatcom.wa.us/PDS/home.htm	(360) 676-6907
	Whatcom County Health Department http://www.co.whatcom.wa.us/Health/home.htm	(360) 676-6720
Whitman	**Whitman County Department of Public Works** http://www.whitmancounty.org/PubWorks/	(509) 397-6206
	Whitman County Department of Public Health http://www.whitmancounty.org/PubHealth/	(509) 397-6280
Yakima	**Yakima County Planning Department** http://www.pan.co.yakima.wa.us/Planning/Default.htm	(509) 574-2230
	Yakima County Department of Public Health http://www.co.yakima.wa.us/health/default.html	(509) 575-4040