Please see the note below regarding expectations for the use of Incremental Sampling Methodology (ISM) when assessing former agricultural lands.

Guidance for Evaluating Residual Pesticides

On Lands Formerly Used for Agricultural Production

January 2006

June 2019 - NOTE: Due to developments in Incremental Sampling Methodology (ISM), the sampling methodologies described in Section 8 of this guidance are no longer preferred and may not be accepted by DEQ. DEQ recommends that ISM be used to evaluate former agricultural lands and will unlikely accept discrete or (standard) composite sampling approaches without prior DEQ approval. Until this guidance is updated, please refer to the Interstate Technology & Regulatory Council (ITRC) document regarding ISM (https://www.itrcweb.org/ism-1/). The DEQ recommends entering the Voluntary Cleanup Program and consultation with the assigned manager prior to developing a sampling plan.

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

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State of Oregon
Department of Environmental Quality

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1/5/06
Date

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GUIDANCE FOR EVALUATING RESIDUAL PESTICIDES ON LANDS FORMERLY USED FOR AGRICULTURAL PRODUCTION

1. BACKGROUND AND PURPOSE

Studies conducted in Oregon and other western states[1] indicate that former agricultural lands may have pesticides and associated metals in soil, drainage-ditch sediments, or groundwater at concentrations above acceptable risk levels defined in Oregon Revised Statute (ORS) 465.315. This document provides direction to Oregon Department of Environmental Quality (DEQ) staff conducting assessments on former agricultural lands under the Hazardous Substance Remedial Action Rules (Oregon Administrative Rules (OAR) 340-122-0010 through 0115).

The selection of appropriate remedial actions at former agricultural sites depends partly on the types of reuse anticipated. For example, the State of California issued guidance in 2002 incorporating a sampling scheme for agricultural sites proposed to be redeveloped into schools. While DEQ has determined that this sampling approach is valid in Oregon for residential or school conversions, it may not be appropriate for industrial/commercial conversions. Therefore, this guidance has two sampling schemes, one for residential/school reuse and a second for industrial/commercial reuse. The latter has a less intensive sampling approach. Of course, at sites where persistent pesticides were never applied, sampling may not be needed at all.

2. SCOPE

This document is designed to guide DEQ staff in evaluating the potential human health and environmental effects of pesticides and associated metals on agricultural lands that are likely to be (or already have been) converted to residential, school, commercial, or industrial uses. DEQ evaluates sites by reviewing site history and operations. If sampling is warranted, sample results are compared to widely accepted, risk-based screening values, such as U.S. EPA Region 9's Preliminary Remediation Goals (PRGs). Such screening values are developed by applying risk-assessment methodology, which considers exposure point concentrations, exposure factors, and toxicities of the hazardous substances found. (See OAR 340-122-084.)

This document covers the definition and properties of pesticides, describes general pesticide types and typical uses in Oregon, and presents guidelines for site evaluation, sampling, and laboratory analyses for residual pesticides.

Note: Some areas of former agricultural lands may be contaminated with hazardous substances other than pesticides. Such areas should be evaluated the same way as at any other type of site in Oregon. Examples are petroleum contamination from underground or above-ground fuel tanks, and contamination from petroleum, solvents, metals, or other hazardous substances in areas used for equipment storage, repair, or maintenance.

3. APPLICABILITY

Under the Hazardous Substance Remedial Action Rules in ORS Chapter 465 (referred to in this document as the "cleanup rules"), and in order to protect public health, safety or welfare, or the

[1] Specific studies are listed in the Reference section.

environment, DEQ has the authority to require or undertake necessary investigation and cleanup of sites where "deposition, accumulation, or migration [of hazardous substances] resulting from otherwise permitted or authorized releases . . ." has occurred (See OAR 340-122-0030(2)). More specifically, while a pesticide product "applied for its intended purpose in accordance with label directions" is exempted as a hazardous-substance release under OAR 340-122-0073(d)[2], this exemption does not apply to agricultural sites where deposition, accumulation, or migration of pesticides has occurred.

Studies conducted in Oregon and other western states indicate that pesticides may accumulate on agricultural lands at concentrations above *acceptable risk levels*[3], especially for subsequent, more intensive land uses. Therefore, DEQ has determined that application of the cleanup rules might be necessary to protect public health, safety, welfare, and the environment from the deposition, accumulation, or migration of pesticides on agricultural land that has been, or is proposed to be, converted to residential, school, commercial, or industrial uses. This guidance is not intended for other types of conversions (e.g., transportation, drainage, or wetland-mitigation projects); actions or potential exposure associated with such alternative uses may be subject to other statutes, rules, or guidance.

This guidance document applies to former agricultural land that was ever under cultivation with row, fiber, or food crops, orchards, nurseries, or pasture. It also applies to fallow, former agricultural land that has not been disturbed beyond normal disking and plowing practices. This document is directed at DEQ staff conducting or overseeing site assessments on former agricultural lands planned for non-agricultural development. Examples of such assessments are:

- Oregon's Industrial Lands Initiative: a State process to certify sites for industrial development;
- Phase I Environmental Site Assessments (ESAs): limited evaluations usually conducted by environmental professionals to identify past and current site conditions that may require further investigation (see ASTM Standard E-1527);
- Phase II ESAs: evaluations usually conducted by environmental professionals that include sampling of areas of concern identified in Phase I ESAs;
- Site Evaluations (screenings): DEQ's initial site reviews, which are brief summaries of readily available information and usually do not include site visits;
- Preliminary Assessments (PAs): DEQ's more detailed site reviews that evaluate site histories, waste-management practices, past sampling data, potential exposure pathways, and usually do include site visits; or
- Site Investigations: comprehensive site evaluations of hazardous-substance releases, usually conducted by environmental professionals.

As part of the remedial investigation process, DEQ generally requires a determination of the full magnitude and extent of hazardous-substance contamination prior to making cleanup decisions such as no further action (NFA). This process normally includes an investigation on the property where contamination originated, and may also include adjacent properties – when contamination has or may have migrated across property lines. These are often referred to as "on-site" and "off-site" investigations, respectively.

In agricultural areas, pesticides used on one property may have been applied on adjacent or nearby properties, which can lead to "area-wide" contamination. In those areas, determining the

[2] The rule describes this exempted release as: *a pesticide product registered under the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136) and applied for its intended purpose in accordance with label directions, but not including deposition, accumulation, or migration of substances resulting from an otherwise-authorized release*.

[3] See ORS 465.315.

extent of off-site pesticide contamination can be impractical. Furthermore, off-site evaluations are not necessary to ensure safe, non-agricultural redevelopments on the sites themselves.

Therefore, with respect to former agricultural properties, off-site investigation of pesticides is generally not needed if **both** of the following conditions apply:

1. The property being evaluated for non-agricultural use is in an area where other nearby properties have had the same crop types or likely used the same types of pesticides; and

2. Pesticide contamination on the property being evaluated is attributable to deposition or accumulation of any pesticide applied for its intended purpose, as indicated by relatively uniform pesticide concentrations over the property.

For properties at which DEQ finds off-site pesticide delineation to be unnecessary, any DEQ remedial-action decisions will apply only to tax lots being evaluated for non-agricultural use.

Both on- **and** off-site pesticide evaluations may be needed if data indicate any of the following:

- Contamination is likely attributable to a spill or release (e.g., improper pesticide storage, application, or disposal); or
- Unusually high concentrations of pesticides are present; or
- Other site-specific factors indicate a need to determine the full extent of contamination, including possible off-site impacts, in order to assure protection of human health and the environment.

4. PESTICIDE DEFINITION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) defines a *pesticide* as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." FIFRA's definition of pesticides includes plant growth regulators, defoliators, and desiccants. The more detailed definition includes the following pesticide categories: 1) insecticides for killing insects; 2) fungicides for killing molds and fungi; 3) herbicides for killing plants; 4) rodenticides for killing rodents; 5) miticides for killing mites; 6) molluscicides for killing snails and slugs; 7) nematicides for killing nematodes; and 8) antimicrobials for killing bacteria and viruses. For the purpose of this document, the term "pesticide" has the same meaning as the FIFRA definition above.

Pesticides contain both active and other ingredients. Active ingredients are chemicals listed on the pesticide label. Examples of active ingredients used historically are lead arsenate, DDT, chlordane, toxaphene, aldrin, and dieldrin. Other ingredients, such as solvents, surfactants, propellants, and carriers, are not typically listed on the label. Because these other ingredients are non-toxic or non-persistent, they are not of concern to DEQ within the scope of this guidance.

5. PHYSICAL PROPERTIES OF PESTICIDES[4]

Factors that influence pesticide fate in soil include initial distribution, persistence, and mobility. Initial distribution describes the proportion of pesticide that is on or in the air, soil, water, plants, and animals after application. This is determined by the formulation, method, and rate of application. It is also affected by site-specific factors such as slope, soil types, erosion, vegetation, and weather, as well as human activities like landfilling, earth moving, irrigation

[4] This section is based on Oregon State University Extension Service's pamphlet entitled Understanding Pesticide Persistence and Mobility for Groundwater and Surface Water Protection (EM 8561), January 1994.

practices, and application of soil amendments. In some cases, an applied pesticide may be redistributed within the application site or may move off-site.

Persistence. Pesticide persistence is often expressed in terms of *half-life*. This is the length of time required for one-half of the original quantity to break down. Pesticides can be divided into three categories based on half-lives. *Nonpersistent* pesticides have typical soil half-lives of less than 30 days. *Moderately persistent* pesticides have typical soil half-lives of 30 to 100 days. *Persistent* pesticides have typical soil half-lives of more than 100 days. In general, pesticide residues in soil tend to be more persistent than residues on canopy foliage or ground cover.

Processes that affect persistence include microbial degradation, chemical degradation, and photodegradation. Microbial degradation is the breakdown of chemicals by microorganisms. It occurs when fungi, bacteria, and other soil microorganisms use pesticides as an energy source, or consume pesticides along with other substances. Chemical degradation occurs when a pesticide reacts with water, oxygen, or chemicals in the environment. Extremely acidic or alkaline soil may favor rapid chemical degradation. Photodegradation is the breakdown of pesticides by sunlight. Pesticides applied to foliage or to the soil surface are more susceptible to photodegradation than pesticides incorporated into the soil. Site characteristics and farming practices can also affect pesticide persistence.

Mobility. Pesticide mobility may result in redistribution within the application site or movement of some amount of pesticide off-site. After application, a pesticide may:

- sorb to soil particles, vegetation, or other surfaces and remain near the site of deposition;
- sorb to soil particles and move with eroded soil in runoff or wind;
- dissolve in water and be taken up by plants, move in runoff, or leach into the soil; or
- volatilize or erode from foliage or soil with wind, and become airborne.

Mobility is affected by the pesticide's sorption, water solubility, and vapor pressure, as well as by environmental and site characteristics such as weather, topography, canopy, ground cover, soil types, rainfall, flooding, and irrigation and tillage practices. It is also influenced by soil texture, structure, and organic matter content.

Sorption. This describes the binding of a chemical to soil particles. Sorption is determined by the chemical characteristics of the pesticide and is influenced by soil moisture, organic matter content, and texture. Pesticides are more readily sorbed onto dry soil because water competes with pesticides for binding sites in moist soil. Organic matter and clay particles have plenty of surface area to sorb pesticides. Sand particles provide less surface area for sorption, resulting in a greater tendency for pesticides to move away from the point of application. Soils that have an organic layer, such as crop residues or thatch in turf grass, may strongly sorb pesticides and reduce their mobility.

The sorption coefficient (K_{oc}) is used to compare the relative sorption of pesticides. The higher the K_{oc} value for a pesticide, the more strongly it is sorbed and the less mobile it is.

Water Solubility. This describes the amount of a pesticide that will dissolve in a known amount of water. Solubility is affected by temperature and the presence of other chemicals. Highly soluble pesticides are more likely to move within the site or off-site by runoff or leaching.

Volatilization. Pesticides may also volatilize (evaporate) from plant or soil surfaces. The degree of volatilization from foliage is determined by the pesticide's vapor pressure. Volatilization from moist soil is determined by the soil's moisture content and by the pesticide's vapor pressure, sorption, and water solubility. Volatilization from dry soil is determined by the pesticide's sorption and vapor pressure. In general, the higher the pesticide's vapor pressure, the more likely it is to volatilize. Site-specific factors affecting volatilization are temperature, humidity, wind, exposure, soil types, vegetation, and human activities.

In summary, any pesticide will remain in the environment for some amount of time and move to some degree following application. Pesticides that are highly water soluble, relatively persistent, and not sorbed to soil particles have the greatest potential for movement. Pesticides that have low water solubilities, long half-lives, and are sorbed to soil particles are persistent and can last for decades in soil. Examples of persistent pesticides are arsenicals, and synthetics such as aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene.

K_{oc}, half-life, and water-solubility values for specific pesticides, which are useful to estimate persistence, can be found in pesticide databases on the following web sites:

- Oregon State University (OSU) Extension Service database at http://npic.orst.edu/ppdmove.htm,
- Natural Resource Conservation Service (NRCS) database at http://go.usa.gov/Kok, and
- U.S. Department of Agriculture (USDA) database at https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/adaptive-cropping-systems-laboratory/docs/ppd/pesticide-properties-database/.

6. PESTICIDE TYPES AND RESIDUES FOUND IN OREGON

Pesticides have been used for centuries and were based on naturally occurring chemicals such as tobacco extracts, soap, turpentine/kerosene emulsions, fish oil, arsenicals, hydrogen sulfur, copper sulfate, pyrethrum powder, etc. The naturally occurring chemicals that have persisted are pesticides that contained metals. For example, lead arsenate was a commonly used pesticide in orchards from the 1800s until the 1940s, when DDT became available.

During World Wars I and II, a "second generation" of pesticides was introduced from chemicals and technologies developed for warfare and applied to farms. This generation of pesticides largely included synthetic organic compounds. (Synthetic refers to pesticides made by humans and not occurring naturally. Organic refers to pesticides containing carbon.) The main classes of synthetic pesticides are organochlorines, organophosphates, carbamates, and pyrethroids.

As mentioned in the previous section, pesticides react in the environment to form new chemicals. Pesticides can react with oxygen (oxidation) or water (hydrolysis). Pesticides can break down in the presence of sunlight. In soil and sediments, microorganisms such as bacteria and fungi break down pesticides. Some pesticides enter plant roots or foliage and break down through plant metabolism. Sometimes the metabolite is more persistent than the parent pesticide. Examples of persistent metabolites and their associated parent pesticides are: dieldrin from aldrin; DDD and DDE from DDT; heptachlor epoxide from heptachlor; and aminomethylphosphonic acid (AMPA) from glyphosate. (See http://www.chemservice.com for lists of metabolites.)

The first important synthetic organic pesticide was DDT, discovered in 1939. In the 1960s, DDT was found to be very persistent. DDT and other pesticides with decades-long half-lives have been referred to as *legacy pesticides*. In May 2001, the following legacy pesticides were recognized internationally[5] as persistent organic pollutants (POPs): aldrin, chlordane, DDT,

[5] On May 23, 2001, the United States signed the Convention on Persistent Organic Pollutants (POPs) at a diplomatic conference in Stockholm, Sweden.

dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene. By contrast, today's pesticides are designed to persist for shorter periods in the environment.

Below is a summary of general groups of pesticides that have been used in Oregon[6]:

- Inorganic pesticides have been used in Oregon since the late 1800s; those first used included copper, sulfur, and arsenicals. Two major arsenic-bearing compounds were **Paris green** and **London purple**. Both were used extensively on fruit trees in Oregon from the late 1800s until the advent of **lead arsenate** after the turn of the 20th century. Between 1910 and 1920, 30 million pounds of lead arsenate were used annually in the United States. Many other arsenical products were tried (calcium, magnesium, iron, copper, etc.), with varying success.

- Organochlorines contain carbon, hydrogen, and chlorine. They were developed in the mid-1940s through the 1950s, and tend to persist in the environment for decades. Key organochlorines are **DDT, chlordanes, toxaphene, aldrin, dieldrin, and endrin**, all of which were banned for sale in the U.S. by the late 1980s. **Lindane (gamma-BHC)**[7] is an organochlorine insecticide and fumigant that has been used on a wide range of soil-dwelling and plant-eating insects. It is commonly used on a wide variety of crops, in warehouses, and (with fungicides) as a seed treatment. Other organochlorines and associated metabolites are: alpha-, beta-, & delta-BHC, DDD, DDE, endosulfan I, endosulfan II, endosulfan sulfate, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, and methoxychlor.

- Organophosphate is a generic term referring to insecticides containing phosphorus. Organophosphates were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some of these compounds are quite toxic (they were used in World War II as nerve agents). However, they usually are not persistent in the environment. Organophosphates were brought into agricultural use in the 1940s as substitutes for persistent organochlorine insecticides. Common insecticides in this class are **malathion, parathion, methyl parathion, diazinon, and dichlorvos**. Organophosphates account for about half of all insecticides used in the U.S. (by amount sold). In addition to major crops such as cotton, corn, and wheat, they are used on many important minor crops. Organophosphates also are used for mosquito control, to protect public health against diseases such as malaria, dengue fever, and encephalitis.

  The widely used herbicide **glyphosate** also contains phosphorous, but does not have the same mechanism of toxicity as true organophosphates and presents a relatively low acute toxicity to humans and wildlife, based on oral ingestion and dermal-contact pathways.

- In the 1940s, the phenoxy herbicides 2,4,5-trichlorophenoxyacetic acid (**2,4-5-T**) and 2,4-dichlorophenoxyacetic acid (**2,4-D**) were developed to control woody plants and broadleaf herbaceous weeds. While neither is considered persistent, each has an association with highly toxic and persistent **dioxins**. Dioxins, including the most toxic form of **TCDD** (2,3,7,8-tetrachlorodibenzo-p-dioxin), were found in early batches of 2,4,5-T due to inadequate temperature controls during 2,4,5-T formulation. 2,4-D was also found to be contaminated with low levels of other dioxins (i.e., not TCDD) during synthesis. Due to the dioxins issue, 2,4,5-T was phased out in the 1970s and withdrawn from use in the U.S. in 1983. In 1990, EPA required 2,4-D to be synthesized so as to reduce dioxin impurities to less than 1 part per million.

- In 1959, the triazine herbicide **atrazine** was developed; it remains one of the two most widely used agricultural pesticides in the U.S. Due to its leachability, atrazine is frequently detected in rivers, streams, and wells.

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6 Additional pesticides used in Oregon are listed in Appendix A of this document.

7 Lindane (also known as hexachlorocyclohexane, or HCH) has often been referred to - inappropriately - as "benzene hexachloride" or "BHC." Lindane should not be confused with hexachlorobenzene, or HCB. According to the MERCK Index, 13th Edition, lindane can also be called gamma-benzene hexachloride, gamma-BHC, or gamma-HCH.

- Carbamate insecticides came into use after the organochlorines and organophosphates (approximately in the 1950s). Some examples of carbamates are **carbaryl, propoxur, and aldicarb.** These materials are toxic, and vary in persistence from weeks to months. Carbamates act through a similar mechanism as organophosphates, by blocking an enzyme essential to the transmission of nerve impulses.
- Dithiocarbamate fungicides are used on fruit-tree crops like apples. Some examples of dithiocarbamates are **mancozeb, maneb, zineb, and ziram**. Dithocarbamates break down into thioureas, which are thyroid hormone inhibitors.
- The quaternary nitrogen herbicide **paraquat** was registered in the U.S. in 1964. Paraquat was a widely used, non-selective herbicide that kills all green plant tissue it contacts. It was used to control broadleaf weeds and grasses. It becomes unstable in alkaline conditions, and has a relatively long persistence in soil (half-life of 1,000 days).
- Synthetic pyrethroids, developed in the 1970s, are more stable in the presence of light and have a higher insecticide activity than organophosphates or carbamates. Pyrethroids (an example is permethrin) have been used on fruits, vegetables, and corn. These compounds are less toxic to mammals than organophosphate insecticides, but are highly toxic to fish.

OSU conducted pesticide-use surveys in the 1980s and 1990s, listing the pesticides used on various crops in Oregon. Unfortunately, OSU is no longer conducting these surveys. Other good resources for pesticide application are the PNW Insect Management Handbook (https://pnwhandbooks.org/insect), the PNW Weed Management Handbook (https://pnwhandbooks.org/weed), and the PNW Plant Disease Management Handbook (https://pnwhandbooks.org/plantdisease). These handbooks have been published annually since the 1970s.

Agricultural laboratories in Oregon have found that the pesticide residues most often detected in soil are lead, arsenic, cadmium, and mercury among inorganics, and DDT, dieldrin, and toxaphene among organics. Inorganic residues most often found in water samples are lead, arsenic, cadmium, and mercury, while the most common organic residues in water samples are DDT, dieldrin, toxaphene, and atrazine[8].

Other states, including New Jersey, Wisconsin, and Washington, have identified arsenic and lead in former orchards as potential human health concerns[9]. Aldrin, dieldrin, and DDT have also been identified as pesticides of concern in some states[10].

The U.S. Geological Survey (USGS) has conducted several studies on pesticides in groundwater and surface water. A 1996 survey of small streams in the Willamette Basin detected 36 pesticides (29 herbicides and 7 insecticides). The five most frequently detected compounds were the herbicides atrazine (99% of the samples), desethylatrazine (93%), simazine (85%), metolachlor (85%), and diuron (73%).[11] A more recent 2000-2001 USGS study of the Clackamas River basin showed seven insecticides exceeding aquatic life criteria in streams within the basin. More generally, USGS has stated: “Studies by USGS in agricultural and urban watersheds throughout

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8 DEQ communications with Pacific Agricultural Laboratory and Antech Laboratory.

9 Findings and Recommendations for the Remediation of Historical Pesticide Contamination, New Jersey Dept. of Environmental Protection, March 1999; Identifying and Cleaning up Sites Contaminated with Lead and Arsenic from Historical Pesticide Use, Wisconsin Dept. of Agricultural, Trade, and Consumer Protection, June 26, 2001; Area-Wide Soil Contamination Task Force Report for Washington Department of Ecology, June 2003.

10 See http://ehp.niehs.nih.gov/members/2001/suppl-1/pdf/jorgenson.pdf [NOTE: link no longer available.]

11 Distribution of Dissolved Pesticides and Other Water Quality Constituents in Small Streams, and their Relation to Land Use, in the Willamette River Basin, Oregon, Chauncey Anderson, Tamara Wood, Jennifer Morace, 1997.

the United States since the early 1990s found that more than half of streams sampled contained pesticides at concentrations that exceeded aquatic life criteria."[12]

With respect to groundwater, in a survey conducted from 1991-1995 in the Willamette Basin, the USGS detected one or more of 13 different pesticides in 23 wells sampled. Most frequently detected (mostly herbicides) were atrazine, simazine, metolachlor, diuron, and deethylatrazine.[13]

See USGS' website for more information about these and other pesticide surveys that USGS has conducted in Oregon: http://www.usgs.gov.

7. EVALUATING HISTORICAL PESTICIDE USAGE AT AGRICULTURAL SITES

When assessing former agricultural lands, it's important to obtain and evaluate information from the following sources/methods, as available or appropriate:

- Interview people familiar with the site's farm operation and types of pesticides used. Ask the farmer for crop history and pesticide application history and records. This information may indicate the types of pesticides used, or the general likelihood of pesticide usage, based on crop type and history of cropping or use of the acreage in question. Certain pesticide materials and application methods were commonly employed for specific crops; knowing when various crops were in production can be very useful in helping to narrow down to the materials that may have been used historically. See Appendix A for details on pesticides historically associated with different crop types in Oregon.
- Identify areas where pesticides were stored, mixed, or disposed of, and where pesticide application equipment was cleaned. Such areas may have high concentrations of residual pesticides and may also be at risk for well or groundwater contamination.
- Check for evidence of spills or releases (e.g., stained soil or stressed vegetation).
- Identify low-lying areas, drainage ditches, swales, or other surface-water features where pesticides might have accumulated.
- Contact local agricultural extension agents, who may know about crops grown and pesticides used at the site or in the area (http://extension.oregonstate.edu/find-us). These agents may be a good source of information when the operators of the former agricultural land cannot be located or interviewed, and little is known about the type of crops grown or pesticides used.

8. SAMPLING STRATEGIES AT AGRICULTURAL SITES [SEE NOTE ON COVER]

Generally, sampling of soil, sediment in drainage ditches, and/or groundwater should occur at former agricultural sites if any of the following applies:

- Persistent pesticides were or are likely to have been used.
- Pesticides were or are likely to have been stored, mixed, or disposed of on the property, or pesticide-application equipment was cleaned there.
- There are known or suspected spills or accumulations of pesticides.
- Pesticides are present in groundwater or there is reason to believe they may be present in groundwater.
- The site has ever had intensive management for orchard, nursery, or other high-value crops, including significant use of pesticides and irrigation.

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[12] The Quality of our Nation's Waters – Nutrients and Pesticides: U.S. Geological Survey Circular 1225, U.S. Geological Survey, 1999.

[13] Water Quality in the Willamette Basin, Oregon, 1991 – 1995, Dennis Wentz, Bernadine Bonn, Kurt Carpenter, Stephen Hinkle, Mary Janet, Frank Rinella, Mark Uhrich, Ian Waite, Antonium Laenen, Kenneth Bencala, 1998.

If it is unlikely that persistent pesticides were ever used, stored, mixed, or disposed of at the site, AND there are no indications of pesticide spills, releases, or accumulations, sampling is typically not needed to complete a site assessment. It is important to document this determination. Otherwise, sampling may be needed to complete a site assessment.

For sampling plan design, DEQ assumes that each area of a site with the same crop or crop type was watered, fertilized, and treated with pesticides homogenously. Conversely, DEQ assumes highly variable pesticide levels in mixing/loading areas, disposal/cleaning areas, fence lines, ditches, canals, and berms. Therefore, additional sampling may be needed to characterize these latter areas.

To understand how a site was farmed, consider crop size, crop rotation, and shifts in crops planted due to changes in economic value. County extension offices may have information about crops grown historically in the area. The Oregon Department of Agriculture (ODA) has annual crop reports at the county level that contain some of this information for the last 5 years. Historical aerial photos may help identify crop and boundary changes over time.

A Note about Surface Water Sampling. Because this document addresses historical pesticide application, and surface water contamination usually is associated with current applications, it is rarely productive to collect samples from surface water during a site evaluation. However, accumulations of persistent pesticides can contaminate surface water when there is runoff, soil erosion, pesticide desorption from contaminated sediment, or groundwater movement into surface water bodies. To evaluate the potential for surface water impacts, DEQ recommends sampling: 1) soil near a surface water body where erosion has occurred; 2) sediment where soil runoff has accumulated; or 3) groundwater wells or probe points near surface water.

8.1 Soil Sampling **[SEE NOTE ON COVER. ISM SHOULD BE USED]**

Sampling Density and Methodology. Sampling plans should be designed to characterize sites under investigation. The number of sampling locations will depend on the size, condition, history, and future use of the site. Sites to be redeveloped for residences or schools have a more conservative sampling scheme, because these uses present more opportunities for human exposure to hazardous substances. Sites to be redeveloped for commercial or industrial use have a less conservative sampling scheme, because these types of facilities generally present fewer opportunities for human exposure to hazardous substances. For both schemes, DEQ has attempted to balance sample coverage, potential future exposures, and the costs to obtain and analyze samples. As mentioned previously, sampling may not be necessary at sites where DEQ can determine that persistent pesticides were not used.

Analysis of discrete samples is preferred, but may not be practical at large sites. Since this guidance assumes a relatively even distribution of pesticides across a site, compositing of discrete samples is acceptable. Each composite may contain up to 4 discrete subsamples for residential or school sites, and up to 8 for industrial sites. The number of subsamples was chosen to avoid dilution that might mask the presence of pesticides above appropriate risk levels in one or more subsamples. Therefore, among typical pesticides analyzed for, DEQ calculated ratios between *risk-based screening values for common exposure scenarios (from EPA Region 9 Preliminary Remediation Goals – PRGs)* and *typical reporting limits* for these pesticides. Based on the lowest of these ratios, DEQ derived the maximum number of subsamples per composite. For example, dividing the 1.6 mg/kg screening value for occupational exposure to toxaphene by the 0.2 mg/kg reporting limit for this compound yields a quotient of 8.

Composite Sampling Design. Prior to compositing, each discrete subsample should be homogenized thoroughly and divided. Half of the subsample should then be added to the composite, and the other half archived. If the pesticide concentration in a composite exceeds the reporting limit, subsamples comprising that composite should be analyzed individually to determine the location and extent of contamination. All subsamples to be added to the same composite should be of equal volume, mass, and shape. All composites collected from within a single crop area should have the same number of discrete subsamples. For more information about sampling design, see the *Guidance for Choosing a Sampling Design for Environmental Data Collection* (EPA QA/G-5S).

Note: Each location sampled according to the tables below should include one surface sample (0 - 6 inches) and one subsurface sample (2 - 3 foot range). As applicable, use the same compositing scheme for subsurface as for surface samples. In all cases, keep surface and subsurface samples separate. If there are thick mats of vegetable material or roots at the surface, sample soil below this material. Subsurface samples should be frozen and archived, pending the outcome of surface sampling results. The total number of samples should be doubled if both surface and subsurface samples are to be collected during a single field event.

Tables 1 and 2 present DEQ's recommended (default) sampling strategies for sites or portions of sites (areas) with a single crop or crop type. These tables assume uniform pesticide distribution in single crop areas. Known areas of pesticide storage, mixing, or spillage should be characterized separately. In all cases, collect subsamples from the center of each plot, or as close as possible to the center. Use Table 1 for residential/school redevelopment scenarios, and Table 2 for commercial/industrial scenarios. A custom sampling plan can be developed for sites of any size, but is needed for sites over 100 acres.

Table 1: Default Sampling Scheme for Residential/School Redevelopment Sites

Size of Single-Crop Area (acres)[1]	Equal Plot Size for Each Discrete Sample Location (acre)	No. of Discrete Samples[2]	No. of Composite Samples[3]
1	¼	4	No compositing
2	¼	8	2
3 - 4	½	8	2
5 - 20	½	10 - 40	3 - 10
21 - 60	½ - 1 (minimum 40 plots)	40 - 60	10 - 15
61 - 100	1	61 - 100	15 - 25

[1] If the size of a single-crop area is between the values shown in this column, use standard rounding rules to determine which row to use, e.g., use the first row for a 1.3-acre crop area and the second row for a 1.7-acre area.

[2] Collect one discrete sample from as close as possible to the center of each plot. Discrete samples that are composited must be from adjacent sampling locations. Where two or more crops were grown on the site, only discrete samples from within the same crop area may be composited. Collect equal aliquots and thoroughly homogenize the discrete samples comprising each composite before filling sample containers. Arrange to freeze and archive unused portions of discrete samples, should composite results indicate a need for discrete analyses.

[3] To determine the number of composite samples to submit for laboratory analysis, first divide the crop area by the plot size to get the number of discrete samples. Then divide the number of discrete samples by 4 to get the number of composites. Round up whenever the number of discrete samples is not a multiple of 4 For example, the number of composites for a 5-acre site would be 5 acres/0.5-acre plot = 10 discrete samples; then 10 (discrete samples)/4 (no. of discrete samples per composite) = 2.5 composites; round up to 3 composites.

Table 2: Default Sampling Scheme for Commercial/Industrial Redevelopment Sites			
Size of Single-Crop Area (acres)[1]	**Equal Plot Size for Each Discrete Sample Location (acres)**	**No. of Discrete Samples[2]**	**No. of Composite Samples**
1 - 7	1	1 - 7	1
8 - 15	1 – 2	8	1
16 - 23	1 – 1.5	16	2
24 - 31	1 – 1.33	24	3
32 – 39	1 – 1.25	32	4
40 – 47	1 – 1.2	40	5
48 – 55	1 – 1.17	48	6
56 – 63	1 – 1.14	56	7
64 – 71	1 – 1.13	64	8
72 – 79	1 – 1.11	72	9
80 – 100	1 – 1.25	80	10

[1] If the size of a single-crop area is between the values shown in this column, use standard rounding rules to determine which row to use, e.g., use the first row for a 7.3-acre crop area and the second row for a 7.7-acre area.

[2] Collect one discrete sample from as close as possible to the center of each plot. Discrete samples that are composited must be from adjacent sampling locations. Where two or more crops were grown on the site, only discrete samples from within the same crop area may be composited. Collect equal aliquots and thoroughly homogenize the discrete samples collected for each composite before filling sample containers. Arrange to freeze and archive unused portions of discrete samples, should composite results indicate a need for discrete analyses.

If different crops were produced consistently on different areas of the site, or in areas where pesticides may have accumulated (e.g., ditches or low-lying areas), address each area separately, and make sure the sampling density is sufficient to characterize each area.

For service/maintenance areas where pesticides were stored, mixed, or disposed of, or where application equipment was cleaned or spills occurred, select at least one sample location from each area where these different activities occurred. Additional sampling may be needed to fully characterize the extent of pesticide impacts in such areas.

Sampling both the furrows and beds of existing rows is likely to produce the greatest variability in concentrations of residual pesticides. That is because some methods of pesticide application lead to residuals in the beds, while other methods lead to greater accumulations in furrows. To address this expected variability in fields where rows remain, gather roughly half of the samples from the furrows and half from the beds, in an alternating pattern.

For orchards, where a similar variability may be present, alternate sample locations between the following areas:

- at the current drip line of fruit trees;
- the historical drip line when fruit trees were immature or when different fruit trees were grown (e.g., a peach vs. a pear orchard);
- under the canopy;
- between tree rows, and
- between trees within the row.

If an orchard has been removed, it may be hard to identify the past drip lines. Historical photos may help in locating past drip lines; otherwise, use your best judgment.

For sites with slopes, swales, or other uneven topography, modify the "center of plot" strategy described above to include samples from any areas where surface water would be expected to flow or accumulate.

Background Samples. Samples may be collected off-site or in undisturbed areas on-site to determine background or ambient levels of inorganic pesticide components (metals)[14]. The soil type of background samples should be similar to that of other samples from the site.

Background samples are not typically collected for anthropogenic pesticides. However, samples collected off-site may indicate the presence of ambient levels of anthropogenic pesticides in surrounding areas.

8.2 Sediment/Soil Sampling from Surface Water Bodies

Collect at least one discrete sample from any ditch, stream, swale, or other surface water body on-site where the weight of evidence suggests that pesticides may have accumulated. Depending upon the season, collect surface *sediment* samples from these areas when water is present, or surface *soil* samples when water is not present.

8.3 Groundwater Sampling

If a well is present on-site, collect a water sample from the well if any of the following applies:

- pesticides were likely stored, mixed, or disposed of near the well;
- persistent pesticides were likely used near the well; or
- there are indications of spills, releases, or accumulations of pesticides near the well.

Prior to sampling, purge the well a minimum of three pore volumes, or until field parameters (pH, temperature, and conductivity) are stable within $\pm$ 10%.

9. REQUIREMENTS FOR LABORATORY ANALYSES; SPECIAL SITUATIONS

Persistent pesticides are the chemicals of greatest concern at former agricultural sites. For most new pesticides, half-life is limited to days or weeks. However, organochlorines can remain in soil at levels of concern for many years following application. Unless there is convincing evidence that organochlorines were never used on-site, consider them contaminants of potential concern (COPCs), and request their analyses in samples collected. The holding time associated with organochlorine-pesticide analysis is 14 days.

Metals are also COPCs, since they have been used as ingredients in pesticides. Specific metals that may be present in agricultural fields include antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, mercury, molybdenum, selenium, silver, thallium, vanadium, and zinc. Request analyses for all 17 of these metals, unless site-specific data already gathered or in-depth knowledge of farm chemical use at a site allows the list of metal COPCs to be narrowed. The holding time associated with metals analysis is six months.

[14] Background samples are compared to on-site sample results to determine if the level of metals on-site is naturally occurring and therefore does not require remediation. It is best to collect site-specific background samples wherever possible; if that is impossible or impractical, contact a toxicologist in DEQ's Cleanup Program to discuss appropriate background metal levels.

As indicated previously, subsurface samples should be frozen and archived, pending the outcome of surface sampling results.

Other COPCs. Analysis for pesticides other than organochlorines and metals may be necessary, if the history of agricultural activities at the site is known and it suggests the use or application of specific pesticides covered in Section 6 of this document, or any other pesticides that are considered persistent (as defined in Section 5 of this document).

If 2,4,5-T was used at the site, composite samples should be analyzed for dioxins, for the reason explained in Section 6. Initially, the composite sample with the highest concentration of 2,4,5-T should be analyzed for dioxins. If dioxins are detected in the composite, additional dioxin sampling may be needed, in consultation with DEQ.

If 2-4-D was used at the site, sampling for dioxins may also be needed in some cases; it is best to consult with DEQ in such circumstances.

9.1 Analytical Methods

Depending on the COPCs at a site, use the appropriate analytical methods below:

- Organochlorine pesticides: EPA Method 8081A or equivalent;
- Metals: EPA 6000/7000 series;
- Chlorinated herbicides including 2,4,5-T: EPA Method 8151;
- Organophosphate pesticides: EPA Method 8141A; and
- Dioxins: EPA Method 1613B.

If organic pesticide use is unknown at a site, some laboratories can run a *multi-residue screening method* on samples (called a screen) to identify pesticides present. A screen can detect active ingredients, metabolites, and breakdown products for over 200 pesticides. Once this screening method identifies pesticide groups that are present, request the applicable method(s) listed above for analyses of additional samples collected.

9.2 Detection Limits

In general, data quality objectives for a site should call for detection limits that are low enough to allow use of applicable risk-screening values (DEQ typically uses EPA Region 9's Preliminary Remediation Goals, or PRGs.) Detection limits actually obtained in the laboratory will vary with analytes and the physical conditions of the samples submitted. For organochlorine pesticides in soil, the analytes typically causing detection-limit concerns are aldrin, dieldrin, and toxaphene. For these compounds, detection limits to meet *residential* screening PRGs should be 0.005, 0.005, and 0.2 mg/kg, respectively. Detection limits to meet *industrial* screening PRGs should be 0.05, 0.05, and 1 mg/kg, respectively.

In samples with elevated DDT, detected concentrations may be above the range of calibration. This can result in the analytical laboratory diluting the sample for re-analysis, and then reporting only the final result. This may in turn cause the reported detection limits for aldrin, dieldrin, and toxaphene to exceed data quality objectives. To address this potential problem, ask the lab to report if aldrin, dieldrin, or toxaphene were detected in the first analysis (i.e., prior to dilution).

9.3 Quality Control

Follow all quality-control (QC) procedures specified in SW-846. Perform a matrix spike/matrix spike duplicate on one soil sample per batch of samples to demonstrate that the targeted pesticide(s) can be recovered from the soil investigated. Highly organic topsoil may interfere with proper extraction of pesticides. The laboratory data package must include a summary of QC results appropriate for the method used, including the matrix spike/matrix spike duplicate, blanks, surrogate recoveries, laboratory control samples, etc. Furthermore, the lab should provide a signed narrative addressing QC issues and listing any QC discrepancies.

10. RISK SCREENING

Background - Risk Screening in DEQ's Cleanup Program. Risk-based decision making for all types of contaminated sites involves evaluating current and reasonably likely future risks that site contamination poses to human health and the environment, and using that information to develop the best combination of cleanup and site-management actions that will reduce risks to acceptable levels. Contaminants found above background levels are compared to PRGs and DEQ's risk-based concentrations (RBCs) to evaluate whether these contaminants pose unacceptable risks to current or future site users, construction and/or excavation workers, or surrounding properties.[15] Human health exposure pathways of particular concern may include:

- soil ingestion;
- dermal contact and inhalation;
- soil volatilization to outdoor and indoor air;
- soil leaching to groundwater;
- groundwater ingestion and inhalation from tap water;
- groundwater volatilization to outdoor and indoor air; and
- groundwater in excavations.

Risk Screening at Former Agricultural Sites. At most former agricultural sites, while potential human health risks are likely to be of greatest interest, pesticides may also affect ecological receptors. Since this document is intended to guide the evaluation of pesticides on agricultural lands that are likely to be, or have already been, converted to residential, school, commercial, or industrial uses, evaluation of ecological risk generally will not be required unless a site's redevelopment includes wetlands, ponds, or other significant natural habitat. In that case, a *Level 1 Scoping Assessment* should be prepared. This is a conservative, qualitative determination as to whether ecological receptors and/or exposure pathways are present at or near the site. If ecological receptors are present, and there are relevant and complete exposure pathways between contaminants and receptors, additional ecological assessment may be needed. See http://www.oregon.gov/deq/FilterDocs/GuidanceEcologicalRisk.pdf for detailed guidance on Level 1 Scoping Assessments – or contact a DEQ toxicologist for assistance.

[15] For additional information about the risk-screening process in Oregon, see DEQ's web page on Human Health Risk Assessments: http://www.oregon.gov/deq/FilterDocs/HumanHealthRiskAssessmentGuidance.pdf.

11. ADDITIONAL SOURCES OF INFORMATION

11.1 Agency/Organization Contacts

http://www.oregon.gov/oda/programs/Pesticides/Pages/AboutPesticides.aspx (Oregon Department of Agriculture, Pesticide Division)

http://agr.wa.gov/ (Washington Dept. of Agriculture)

http://www.epa.gov (U.S. Environmental Protection Agency)

http://www.usgs.gov (U.S. Geological Survey)

http://npic.orst.edu (National Pesticide Information Center)

http://www.pesticideinfo.org/Index.html (Pesticide Action Network North America)

http://www.pesticide.org/ (Northwest Coalition for Alternatives to Pesticides)

11.2 Pesticide Physical Properties and Half-Lives

http://ace.orst.edu/info/extoxnet/pips/ghindex.html

http://npic.orst.edu/envir/efate.html

http://npic.orst.edu/factsheets/half-life.html

http://extoxnet.orst.edu/ghindex.html

11.3 Active Pesticide Ingredients by Brand Name

http://npic.orst.edu/ingred/active.html

11.4 OSU Extension Offices in Oregon

http://extension.oregonstate.edu/find-us

11.5 Risk-Screening Guidance

https://www.epa.gov/risk/regional-screening-levels-rsls (EPA Regional Screening Levels)

https://www.oregon.gov/deq/FilterDocs/RBDMGuidance.pdf (DEQ Risk-Based Decision Making for the Remediation of Contaminated Sites)

https://www.oregon.gov/deq/FilterDocs/GuidanceEcologicalRisk.pdf (DEQ Ecological Guidance)

https://www.oregon.gov/deq/FilterDocs/HumanHealthRiskAssessmentGuidance.pdf (DEQ Human Health Risk Guidance)

https://www.energy.ca.gov/sitingcases//palmdale/documents/2011-02-02_Exhibits_FSA_TN-59585.pdf (California DTSC Interim Guidance for Sampling Agricultural Properties, Third Revision, August 7, 2008)

11.6 Laboratories and Laboratory Methods

A list of analytical laboratories serving Oregon:
https://catalog.extension.oregonstate.edu/em8677

A list of laboratory methods and analytes listed in the guidance:

- Metals per EPA 6000/7000 series.
- Chlorinated Herbicides per EPA Method 8151: 2,4-D, 2,4-DB, 2,4,5-T, 2,4,5-TP (Silvex), Dalapon, Dicamba, Dichlorprop, Dinoseb, MCPA, and MCPP.
- Organochlorine Pesticides per EPA Method 8081: aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (lindane), gamma-Chlordane, alpha-Chlordane, Chlordane (tech), 4,4-DDD, 4,4-DDE, 4,4-DDT, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, Heptachlor, Heptachlor epoxide, Methoxychlor, and Toxaphene.
- Organophosphate Pesticides per EPA Method 8141A: Azinphos methyl, Bolstar, Chlorpyrifos, Coumaphos, Demeton, Diazinon, Dichlorvos, Dimethoate, Disulfoton, Ethoprop, Fensulfothion, EPN, Fenthion, Malathion, Mevinphos, Naled, Parathion-methyl, Parathion-ethyl, Phorate, Ronnel, Stirophos, Tokuthion, and Trichloronate.
- Multi-residue screens test for over 200 pesticide active ingredients, metabolites, and breakdown products, to achieve a broad-spectrum analysis. Check with individual labs for their multi-residue screening capabilities.

12. REFERENCES

Interim Guidance for Sampling Agricultural Fields for School Sites (Second Revision) by California Department of Toxic Substances Control, California Environmental Protection Agency, August 26, 2002.

Guidance for Choosing a Sampling Design for Environmental Data Collection (Peer Review Draft) by Office of Environmental Information, United States Environmental Protection Agency, document number QA/G-5S, August 2000.

Oregon Pesticide Use Estimates for Tree Fruit, 1991 by John Rinehold and Jeff Jenkins, September 1993.

Oregon Pesticide Use Estimates for Small Grains, Forage, and Livestock, 1994 by John Rinehold and Jeff Jenkins, June 1997.

Oregon Pesticide Use Estimates for Vegetable Crops, 1993 by John Rinehold and Jeff Jenkins, August 1996.

Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992 by John Rinehold and Jeff Jenkins, September 1994.

Introduction to Insecticides, by George Ware, University of Arizona.

Area-wide Soil Contamination Task Force Report, by Ross & Associates Environmental Consulting, Ltd, Landau Associates, Inc., Hubbard Gray Consulting, Inc., June 30, 2003.

What is a Pesticide?, by Northwest Coalition for Alternatives to Pesticides, Journal of Pesticide Reform, Summer 1999.

Distribution of Dissolved Pesticides and Other Water Quality Constituents in Small Streams, and their Relation to Land Use in the Willamette River Basin, Oregon, 1996, by Chauncey W. Anderson, Tamara M. Wood, and Jennifer L. Morace, 1997.

Water Quality in the Willamette Basin, Oregon, 1991-95, by Dennis A. Wentz, Bernadine A. Bonn, Kurt D. Carpenter, Stephen R. Hinkle, Mary L. Janet, Frank A. Rinella, Mark A. Uhrich, Ian R. Waite, Antonius Laenen, and Kenneth E. Bencala, 1998.

The Quality of Our Nation's Waters – Nutrients and Pesticides: U.S. Geological Survey Circular 1225, U.S. Geological Survey, 1999.

Pesticides in the Lower Clackamas Basin, 2000-2001: U.S. Geological Survey Water Resources Investigations Report 03-4145, U.S. Geological Survey, 2004.

Area-Wide Contamination Task Force Report, Washington State Department of Ecology, June 30, 2003, (web site: http://www.ecy.wa.gov/programs/tcp/area_wide/Final-Report/PDF/TF-Report-final.pdf).

National Agricultural Library website: http://www.nal.usda.gov.

Findings and Recommendation for the Remediation of Historical Pesticide Contamination, New Jersey Dept. of Environmental Protection, March 1999 (http://www.state.nj.us/dep/special/hpctf/pestfact.pdf).

Identifying and Cleaning up Sites Contaminated with Lead and Arsenic from Historical Pesticide Use, Wisconsin Dept. of Agriculture, Trade, and Consumer Protection, June 26, 2001.

Oregon DEQ. Personal communication between Mary Camarata of DEQ, and Rick Jordan of Pacific Agricultural Laboratory, March 2004.

Oregon DEQ. Personal communication between Mary Camarata of DEQ and Diane Tracy of Antech Laboratory, March 2004.

APPENDIX A: CROP-SPECIFIC PESTICIDE USE IN OREGON

Oregon grows a variety of crops. The crop categories include tree fruits, small fruits, small grains and forage, vegetables, seed and specialty crops, mushrooms, and nursery sites. Oregon State University (OSU) extension services conducted pesticide-use surveys for Oregon crops in 1981, 1987, and 1990 - 1994. The surveys requested information about pesticide use by pesticide class, and amounts of individual pesticides used. This information is useful in determining the specific types of pesticides historically applied to different crops during the period the survey was taken. Another useful resource is the Pacific Northwest Pest Management handbooks, published annually since the 1970s (see http://pnwpest.org).

Results from OSU's 1981 – 1994 surveys are summarized below.

Tree Fruits include apples, apricots, cherries, hazelnuts (filberts), pears, prunes, plums, peaches, walnuts, and chestnuts. According to the pesticide use surveys, pears received the most pesticides of all tree fruits, followed by apples, sweet cherries, and hazelnuts. The pesticide classes used most in 1991 were insecticides at 60% (1,720,000 lbs. used) and fungicides at 32% (920,000 lbs. used). The specific pesticides mentioned in the survey were oil, lime sulfur, copper, sulfur, azinphos methyl, dodine, chlorpyrifos, ziram, malathion, phosmet, diazinon, carbaryl, 2,4-D amine, and captan. [Oregon Pesticide Use Estimates for Tree Fruits, 1991].

Small Fruits include blackberries, raspberries, blueberries, cranberries, strawberries, gooseberries, currants, and grapes. According to the pesticide use surveys, the small fruits receiving the most pesticides are strawberries, blackberries, loganberries, boysenberries, and red and black raspberries. Categories of pesticides most used in 1990 were miticides at 40% (276,000 lbs. used) and fungicides at 26% (181,000 lbs. used). Specific pesticides mentioned in the survey as used most often included lime sulfur, oil, copper, dichloropropene, captan, napropamide, sulfur, methyl bromide, simazine, iprodione, diphenamid, ethylene dibromide, dinoseb, and diazinon. [Oregon Pesticide Use Estimates for Small Fruits, 1990].

Small Grains and Forage include wheat, oats, barley, rye, silage corn, grain corn, alfalfa hay, legume hay, and grass hay. According to the pesticide use surveys, wheat received the most pesticides of all small grains and forage, followed by barley, and silage and grain corn. The pesticide classes used most in 1994 were herbicides at 83% (1,047,000 lbs. used) and insecticides at 11% (140,000 lbs. used). Specific pesticides mentioned in the survey as used most often included diuron, MCPA, 2,4-D, metribuzin, bromoxynil, EPTC, diclofop-methyl, triallate, hexazinone, glyphosate, atrazine, carboxin, carbon tetrachloride, dicamba, benomyl, terbutryn, simazine, and propham. [Oregon Pesticide Use Estimates for Small Grains and Forage, 1994].

Vegetables include potatoes, dry onions, sweet corn, beans, peas, crucifers (broccoli, cauliflower, cabbage, radishes, turnips, and rutabagas), cucurbits (squash, pumpkins, watermelons, cantaloupes, and cucumbers), table beets, carrots, and asparagus. According to the pesticide use surveys, potatoes received the most pesticides of all vegetables, followed by onions, snap beans, and sweet corn. The pesticide classes most used in 1993 were fumigants at 76% (4,544,000 lbs. used), herbicides at 9% (553,000 lbs. used), insecticides at 7% (443,000 lbs. used), and fungicides at 6% (376,000 lbs. used). Specific pesticides mentioned in the survey as used most often included metam-sodium, 1,3-dichloropropene, EPTC, mancozeb, metolachlor, DCPA, disulfoton, ethoprop, methamidophos, chlorothalonil, zineb, dinoseb, atrazine, fonofos, maneb, aldicarb, phorate, and trifluralin. [Oregon Pesticide Use Estimates for Vegetable Crops, 1993].

Seed and Specialty Crops. Grass seed crops include perennial ryegrass, annual ryegrass, tall fescue, orchard grass, and blue grass. Legume seed crops include alfalfa seed, red and crimson clover, and sugar beet seed. Vegetable and flower seed crops include flowers, brassica, red and daikon radishes, cabbage, carrots, onions, and sweet corn. Specialty crops include hops, peppermint, sugar beets, and Christmas trees. According to the pesticide use surveys, grass seed received the most pesticides of all seed and specialty crops, followed by sugar beets and peppermint. The pesticide classes most used in 1992 were herbicides at 47% (1,390,000 lbs. used), fungicides at 28% (810,000 lbs. used), and insecticides at 20% (110,000 lbs. used). Specific pesticides mentioned in the survey as used most often included sulfur, diuron, terbufos, glyphosate, propargite, 2,4-D, terbacil, chlorpyrifos, cycloate, bentazon, chlorothalonil, mancozeb, nickel sulfate, atrazine, bordeaux, 1,3-dichloropropene, fonofos, dinoseb, asulam, simazine, dicamba, ethofumesate, and maneb. [Oregon Pesticide Use Estimates for Seed and Specialty Crops, 1992].

Nursery Crops include container nurseries, color and bedding plants, field trees and shrubs, cut flowers, and ornamental bulbs. Nurseries grow a diverse group of plants and are chemical-intensive; they use fungicides, herbicides, insecticides, plant-growth regulators, water-treatment compounds, and fumigants. Specific pesticides mentioned in the survey as used most often included copper, Bordeaux, dacthal, ferbam, pentachloronitrobenzene, napropamide, oryzalin, oxadiazon, oxyfluorfen, acephate, naled, oil, trichlorfon, 1,3-dichloropropene, metam-sodium, and methyl bromide.

Mushrooms. Roughly 300 mushroom species are edible, but only 30 have been domesticated and only 10 are grown commercially. Button, oyster, and shiitake mushrooms make up about 70% of the world's production. Some mushrooms commercially produced in Oregon include button, shiitake, oyster, truffles, cremini, and chanterelles. Pesticides are used to control flies and molds. Fungicides, insecticides, and water-treatment compounds are used in mushroom production. Some pesticides used in mushroom production include thiabendazole, calcium hypochlorite, diflubenzuron, permethrin, azadirachtin, piperonyl butoxide, and pyrethrins.

APPENDIX B: ACRONYMS USED IN THIS DOCUMENT

ASTM	American Society of Testing and Materials
COPC	Contaminant of Potential Concern
DDD	1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene
DDT	2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane
DEQ	[Oregon] Department of Environmental Quality
DTSC	[California] Department of Toxic Substances Control
EPA	[U. S.] Environmental Protection Agency
ESA	Environmental Site Assessment
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
NFA	No Further Action
NRCS	Natural Resource Conservation Service
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ORS	Oregon Revised Statutes
OSU	Oregon State University
PA	Preliminary Assessment
PNW	Pacific Northwest [Pest Management Program (OSU)]
POP	Persistent Organic Pollutant
PRGs	[U. S. EPA Region 9] Preliminary Remediation Goals
QC	Quality Control
RBCs	Risk-Based Concentrations
USC	United States Code
USDA	U. S. Department of Agriculture
USGS	U. S. Geological Survey