DOE/RL-2012-64
Draft A

Remedial Investigation/ Feasibility Study Work Plan to Evaluate the 100-OL-1 Operable Unit Pre-Hanford Orchard Lands

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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Richland, Washington 99352

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Summary

Prior to the acquisition of land by the U.S. Department of War in February 1943 for the creation of the Hanford Site, the land along the Columbia River was home to over 1000 people and was used for various farming and orchard operations by both homesteaders and commercial entities. Tree-fruit production increased around 1905, coinciding with the increased availability of irrigated water through canals and pumping plants provided by the Hanford Irrigation and Development Company. Control of codling moths was needed as the orchards expanded in the region. Beginning in the 1890s, lead arsenate was the pesticide of choice for codling moth control for most tree-fruits, which included apples, cherries, apricots, peaches, pears, plums, and prunes. Orchard activities and the associated application of lead arsenate ceased in 1943 when residents were moved from the Hanford Site. In some areas of the Hanford Site, there is still evidence of the old trees—stumps and branches mostly. Today, the residues from lead arsenate pesticide applications persist in soils in some areas on the Hanford Site.

In May 2012, the U.S. Department of Energy, U.S. Environmental Protection Agency, and the Washington State Department of Ecology established the 100-OL-1 Operable Unit (OU) through the Hanford Federal Facility Agreement and Consent Order. The pre-Hanford orchard lands identified as part of the 100-OL-1 OU are located from the 100-Area of the Hanford Site (south-side of the Columbia River) down to the Hanford townsite. The discontinuous orchard lands include approximately 20 km^2 (5000 ac). While most of the former orchard lands were not disturbed by activities during the Manhattan Project or during subsequent Hanford Site activities, some former orchard lands are located across the River Corridor Area and within some vadose zone operable units (specifically, 100-KR-1, 100-HR-1, 100-HR-2, 100-FR-2, 100-IU-2 and 100-IU-6). This work plan documents the decisions and evaluations made through a scoping process and identifies future tasks that will be undertaken to complete the remedial investigation (RI) and feasibility study (FS) for the 100-OL-1 OU.

This work plan presents the historical background (Section 2.0) of former orchard operations, including application of lead arsenate pesticides and irrigation. A conceptual site model is developed to incorporate the limited lead and arsenic concentration data available along with the former history of activities and anticipated future land uses. Section 3.0 discusses the rationale for the work plan, identifies data quality objectives for investigation of the site, and defines the areas of the 100-OL-1 OU into decision units for evaluation through field characterization activities. Section 4.0 identifies the tasks required to conduct the RI and FS. A cost estimate and assumptions for conducting the remedial investigation are presented in Section 5.0. Section 6.0 presents the anticipated schedule for conducting the remedial investigation. Section 7.0 describes the project management approach and resources required to conduct the remedial investigation. Appendix A includes the sampling and analysis plan for the RI/FS, as well as the quality assurance project plan, field sampling plan, and health and safety plan.

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Acronyms and Abbreviations

ac	acre(s)
ALARA	as low as reasonably achievable
As	arsenic
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cm	centimeter
DAHP	Department of Archaeology and Historic Preservation (Washington State)
dL	deciliter
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DOH	Washington Department of Health
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
ft	foot(feet)
µg	microgram(s)
g	gram(s)
gal	gallon(s)
GIS	geographical information system
HEIS	Hanford Environmental Information System
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectroscopy
IEUBK	Integrated Exposure Uptake Biokinetic
kg	kilogram(s)
km^2	square kilometer(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter
mg	milligram(s)
MTCA	*Model Toxics Control Act*
NA	not applicable
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
Pb	lead

$PbHAsO_4$	lead arsenate, acidic form
QA	quality assurance
QC	quality control
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
SAP	Sampling and Analysis Plan
SCBA	self-contained breathing apparatus
SD	standard deviation
TPA	Tri-Party Agreement
VSP	Visual Sample Plan (software tool)
WAC	*Washington Administration Code*
WCH	Washington Closure Hanford, Incorporated
WIDS	Waste Information Data System

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1.0 Introduction

This work plan was prepared to guide a remedial investigation (RI) and feasibility study (FS) of approximately 20 km^2 (5000 ac) of non-contiguous, former orchard lands on the Hanford Site. The former orchard lands were planted with fruit trees where settlers developed and cultivated upland areas along the Columbia River from the late 1800s until 1943, when the land was acquired by the Federal government for the development of the Hanford Site in support of the Manhattan Project. Inorganic pesticides containing arsenic and lead were applied in the orchards during that period. Concern about the residual lead and arsenic in soils of former orchards, on acreage from the 100 Area of the Hanford Site (south-side of the Columbia River) down to the Hanford townsite, led to the definition of the 100-OL-1 Operable Unit (100-OL-1 OU), which includes numerous former orchard lands found on the Hanford Site. This work plan is intended to define the scope of and describe the proposed RI to be conducted under the regulatory context of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) within the Hanford Tri-Party Agreement (TPA) (Ecology et al. 1989).

The 100-OL-1 OU was established through a TPA Change Control action, and a milestone was identified to develop a RI/FS work plan to evaluate the operable unit (TPA 2012a, b). Figure 1.1 is the map included in TPA Change Control Form C-12-01.

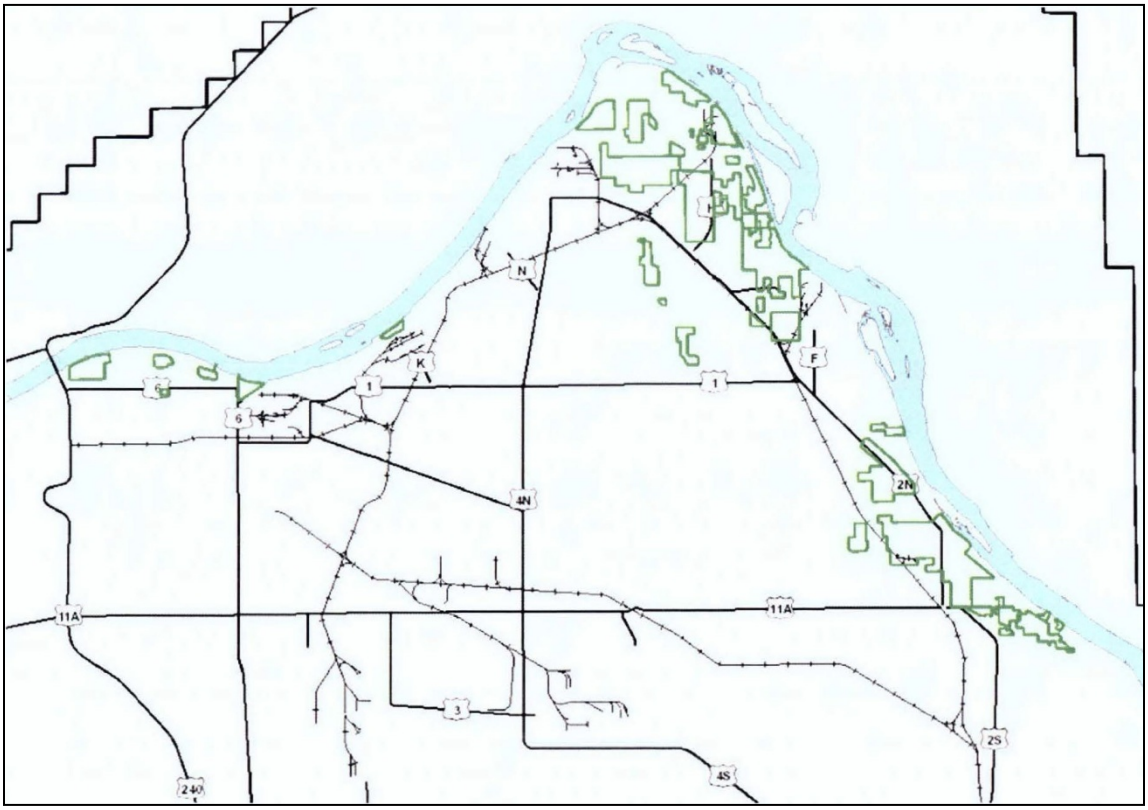


Figure 1.1. Section of the Hanford Site Showing Former Orchard Lands within the Green Boundaries (TPA 2012a)

The 100-OL-1 OU was organized using past information from a number of sources on former orchard lands and farm sites, where lead arsenate pesticide was likely used and where residuals of the pesticide are likely found in the soil today. This operable unit is similar to other operable units on the Hanford Site, in that the areas identified are associated with a common waste source; however, the areas within the 100-OL-1 OU are discontinuous and spread over a wide geographical area within the Hanford Site. Most of the areas within the 100-OL-1 OU are located outside of designated reactor vadose zone operable units. However, 4.5 percent of the 100-OL-1 OU is within vadose zone operable units located in 100-KR-1, 100-HR-1, 100-HR-2, 100-FR-2, 100-IU-2 and 100-IU-6. Orchards are visible on aerial photos taken in 1943, and this information, along with other historical reports, continue to be useful for understanding the areas to investigate for residual lead arsenate in soil on the Hanford Site.

This work plan presents the historical background (Section 2.0) of former orchard operations, including application of lead arsenate pesticides and irrigation. A conceptual site model is developed to incorporate the limited lead and arsenic concentration data available, along with the former history of activities and anticipated future land uses. Section 3.0 discusses the rationale for the work plan and identifies data quality objectives (DQO) for investigation of the site. This includes the discussion of dividing the operable unit into decision units (Section 3.1.4.5), or units of area within the 100-OL-1 OU for field characterization and application of the decision rule (Section 3.1.5) for evaluating the magnitude and extent of residual lead arsenate in the soil. Section 4.0 identifies the tasks required to conduct the RI and FS. A cost estimate and assumptions for conducting the remedial investigation are presented in Section 5.0. Section 6.0 presents the anticipated schedule for conducting the remedial investigation. Section 7.0 describes the project management approach and resources required to conduct the remedial investigation. Appendix A includes the sampling and analysis plan for the RI/FS, as well as the quality assurance project plan, field sampling plan, and health and safety plan.

2.0 Site Background

The Hanford Site was selected and created in 1943 as the location for production of weapons-grade plutonium during World War II. The residents of the area received only an official notification, known as a "declaration of taking," that informed them that the U.S. Army Corps of Engineers was taking their land for a top-secret project. As noted by Sharpe (1999), the Hanford Site is unique in that no other location in eastern Washington contains an equivalent array of preserved agricultural information dating from 1900 and 1943. Today, the U.S. Department of Energy (DOE) manages the 1517 km^2 (586 mi^2) Hanford Site in the Pasco Basin of south-central Washington State, including the areas where orchards once were treated with lead arsenate pesticide.

This section provides background information for understanding the approach to characterizing the magnitude and extent of the past use of lead arsenate pesticide on land encompassed by the Hanford Site. The extent of former orchard activities on the Hanford Site is still evident. A conceptual site model is discussed to integrate the information about former orchard activities and Hanford Site activities with the knowledge of the lead and arsenic fate and transport to support the approach for characterizing the residual lead arsenate contamination today. This section also includes background soil concentrations and an overview of human and environmental health benchmarks for lead and arsenic.

2.1 History of Pre-Hanford Orchards within the Orchard Lands Operable Unit

Prior to the acquisition of land by the U.S. Department of War in February 1943 for the creation of the Hanford Site, the land along the Columbia River was home to more than 1000 people, who used it for various farming and orchard operations by both homesteaders and commercial entities. Tree-fruit production increased around 1905, coinciding with the increased availability of irrigated water through canals and pumping plants provided by the Hanford Irrigation and Development Company. Control of codling moths (*Cydia pomonella*) was needed as the orchards expanded in the region. Beginning in the 1890s, lead arsenate was the pesticide of choice for codling moth control for most tree-fruits, which included apples, cherries, apricots, peaches, pears, plums, and prunes. Orchard activities stopped in 1943 when residents were moved from the Hanford Site, and the application of lead arsenate ceased (Sharpe 1999; DOE 1997; DOE-RL 2011a). In some areas of the Hanford Site, there is still evidence of the old trees—stumps and branches mostly—and a few investigations have been conducted to evaluate lead arsenate residues in the soil (Yokel and Delistraty 2003; Delistraty and Yokel 2011).

Sharpe (1999, 2000) prepared summaries of pre-Hanford (i.e., prior to 1943) agricultural history. The most common crops included alfalfa, strawberries, asparagus, peppermint, potatoes, apricots, cherries, pears, plums, prunes, peaches, and apples. Low precipitation, blowing dust, and jackrabbits limited dry-land crop development. Because irrigating land was labor-intensive, the typical orchard was 0.08 km^2 (20 acres) or less in size. These small orchards required the attention of many people for pruning, spraying, and harvesting. When commodity prices fell below labor costs in the 1920s many of the early orchards were abandoned. Irrigation of the orchards across most of the inland areas was dependent on water from the Hanford Irrigation Canal. Because of drought conditions and low water supply in the canal system, many of the apple orchards failed in the 1930s; the trees were cut down and used as firewood by 1943.

According to Sharpe (1999), orchards required protection from frost and pests. Heating systems and smudge pots, typically fueled by coal briquettes, were used to control frost in the spring. Rabbits were serious pests in orchards and other croplands. The rabbits chewed the bark around the bases of the trees, causing them to die. Rabbit drives were well-organized events across the region, with homesteaders rounding up and exterminating rabbits on a regular basis.

Insect management was used in the orchards to control codling moths, scale, and red spiders (Sharpe 1999). While a variety of insecticides were used on orchards around the United States, at the time of orchard development in the region of the Hanford Site, lead arsenate was the most common insecticide used in Washington State (Peryea 1998). The acidic form of lead arsenate, $PbHAsO_4$, was the most common type applied in Washington State (Peryea 1998). Lead arsenate could be spray-applied as a powder or mixed in a solution and applied as a mist (Figure 2.1 and Figure 2.2, respectively). Other insecticides included “lime sulphur” to control scale, and “lime sulfur, atomic sulphur, or flours of sulphur” to control red spiders (Sharpe 1999).

Figure 2.1. Application of Lead Arsenate as a Powder on Orchards in the Region of the Hanford Site

Specific directions on the formulation of the lead arsenate, as well as the time of year and the number of applications for lead arsenate, were available to the orchardist in the *White Bluffs Spokesman* and other news sources. Typically, applications of lead arsenate contained 2.7 kg (6 lb) of paste or 1.4 kg (3 lb) of powder to 757 L (200 gal) of water. The schedule for spraying and the number of applications depended on the type of fruit and changed over time as codling moths became resistant to lead arsenate (Sharpe 1999).

Figure 2.2. Application of Lead Arsenate as a Mist on Orchards in the Region of the Hanford Site

Today, residues from lead arsenate pesticide applications persist in soils at the Hanford Site as they do in other former orchard areas across Washington State and the nation. From 1910 to 1920, almost 14 million kg (30 million lb) of lead arsenate were used annually in the United States (ODEQ 2006). The levels of arsenic and lead in the soil from former orchard activities varies based on a number of factors: the number of applications in a season of production; the form of application (powder or solution); soil characteristics (soil texture, pH, organic matter, clay minerals, hydrous metal oxides, calcite); and precipitation rates (Frank et al. 1976; Maclean and Langille 1981; Veneman et al. 1983; Peryea and Creger 1994; Elfving et al. 1994; Peryea and Kammereck 1997; Peryea 1998; Sharpe 1999, 2000; Kabata-Pendias, 2001; Yokel and Delistraty 2003; Newton et al. 2006; Renshaw et al. 2006; Staed et al. 2009; Cadwalader et al. 2011; Sloan 2011; Delistraty and Yokel 2011).

2.2 Conceptual Site Model

The proposed conceptual site model for lead arsenate pesticide residues on the Hanford Site addresses the factors listed above as well as contamination pathways through 1943 and thereafter when pesticide application had ceased (Figure 2.3). The former orchard properties on the Hanford Site have residual lead arsenate contamination in the soil as a result of pesticide use in the first half of the 20th century

(Figure 2.3A). This condition is consistent with orchard properties across Washington State and the United States where lead arsenate pesticides were applied to a variety of fruit trees (AWSCFT 2003a; Hood 2006; Schooley et al. 2008). The concentrations of lead and arsenic are expected to be highly variable across the Hanford Site orchards because of the differences in spraying practices, the number of years an orchard was in production, irrigation during orchard operation, the physical form of the pesticide when applied, the physical properties of the soil at each orchard, and the amount of contaminant loss from individual orchards. In addition, activities on the Hanford Site have and continue to occur in areas that once were occupied by orchards. Soil with lead arsenate residues have been moved, excavated, and buried by these activities (Figure 2.3B). This section considers pathways for lead arsenate residues in the environment, background concentrations for lead and arsenic in soils, the waste sources and potential volume estimates for contaminated soil, and the history of disturbances.

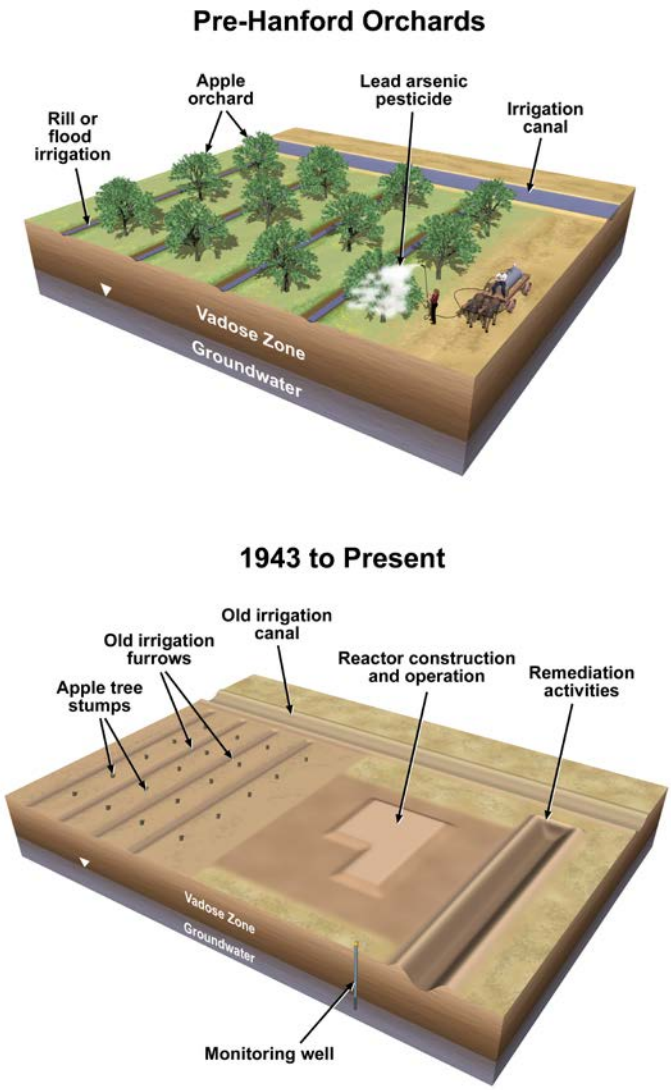


Figure 2.3. Conceptual Site Model for Lead Arsenate Pesticide Residues in Orchard Lands on the Hanford Site Prior to 1943 (A) and from 1943 to Present (B)

2.2.1 Historic Pathways for Lead Arsenate Residues in Pre-Hanford Orchards

During historic applications of lead arsenate pesticide, there were several pathways for contaminant migration: soil, water, air, and biota (Figure 2.3 A). The orchardists intended to apply the lead arsenate pesticide onto individual fruit trees to deter codling moths from laying eggs on the fruit or leaves. However, as a result of these applications, pesticide dripped from the trees onto the soil, lead arsenate powder or solution spilled onto the soil, and dead leaves and fruit contaminated with lead arsenate accumulated on the soil. Accumulation of lead arsenate residues in the soil would have been the most significant pathway for lead and arsenic.

Other less significant pathways would have included wind and water dispersion and the movement of people and animals through the orchards. Applications during windy conditions also could have led to dispersion of the lead arsenate beyond the orchards. Irrigation water, groundwater, or surface water (in the orchards close to the Columbia River) could have carried lead and arsenic away from the orchards in regions where applications were substantial. Overland flow from precipitation or irrigated water could have contributed to lead and arsenic in surface water sediments. In addition, human and animal activity could have tracked lead and arsenic away from the orchards. Certainly, the people who sprayed the lead arsenate and the ecological receptors using the orchards during applications of the pesticide were exposed to the lead and arsenic

2.2.2 Soil Pathway for Lead Arsenate Residues in Pre-Hanford Orchards

The highest concentration of lead arsenate residues are likely to be in the soil and within the boundaries of the 100-OL-1 OU. Evaluations of the dispersal of lead arsenate on the Hanford Site have been limited to a few special studies (e.g., Yokel and Delistraty 2003 and Delistraty and Yokel 2011); waste site evaluations have assessed for the presence and determined potential risk of lead and arsenic in soils and sediments from former orchard activities (e.g., DOE-RL 2010, 2011a and b, 2012a and b). Direct soil contact pathway is the primary pathway of concern today for lead arsenate found on the former orchard properties.

Dispersal in the soil beyond the boundaries of the 100-OL-1 OU would be minimal on the Hanford Site. Numerous studies have shown that there is limited potential for lead arsenate residues to move overland when water (irrigation or precipitation) is limited (Frank et al. 1976; Maclean and Langille 1981; Veneman et al. 1983; Peryea and Creger 1994; Elfving et al. 1994; Peryea and Kammereck 1997; Peryea 1998; Kabata-Pendias, 2001; Newton et al. 2006; Renshaw et al. 2006; Staed et al. 2009; Cadwalader et al. 2011).

Previous studies of the vertical transport of lead and arsenic through soil have indicated various depths of contamination below the surface. One consistent observation is that the arsenic is generally more mobile, moving to somewhat deeper depths than lead. This finding would indicate that the lead and arsenic are no longer chemically associated and could be treated as two distinct contaminants, which is consistent with previous work (Renshaw et al. 2006). Figure 2.4 illustrates the vertical profile of lead and arsenic as reported by Peryea and Creger (1994) in six orchard soils from Washington State. The vertical migration of contaminants is a function of soil type, soil chemistry, and precipitation/irrigation (Veneman et al. 1983; Newton et al. 2006; Maclean and Langille 1981; Renshaw et al. 2006; Staed et al. 2009; Delistraty and Yokel 2011). The studies of vertical migration most relevant to the former orchard

properties indicate that lead could be expected to have migrated down to 0.4 m (16 in.), and arsenic to 1 m (39 in.) (Peryea and Creger 1994; Yokel and Delistraty 2003).

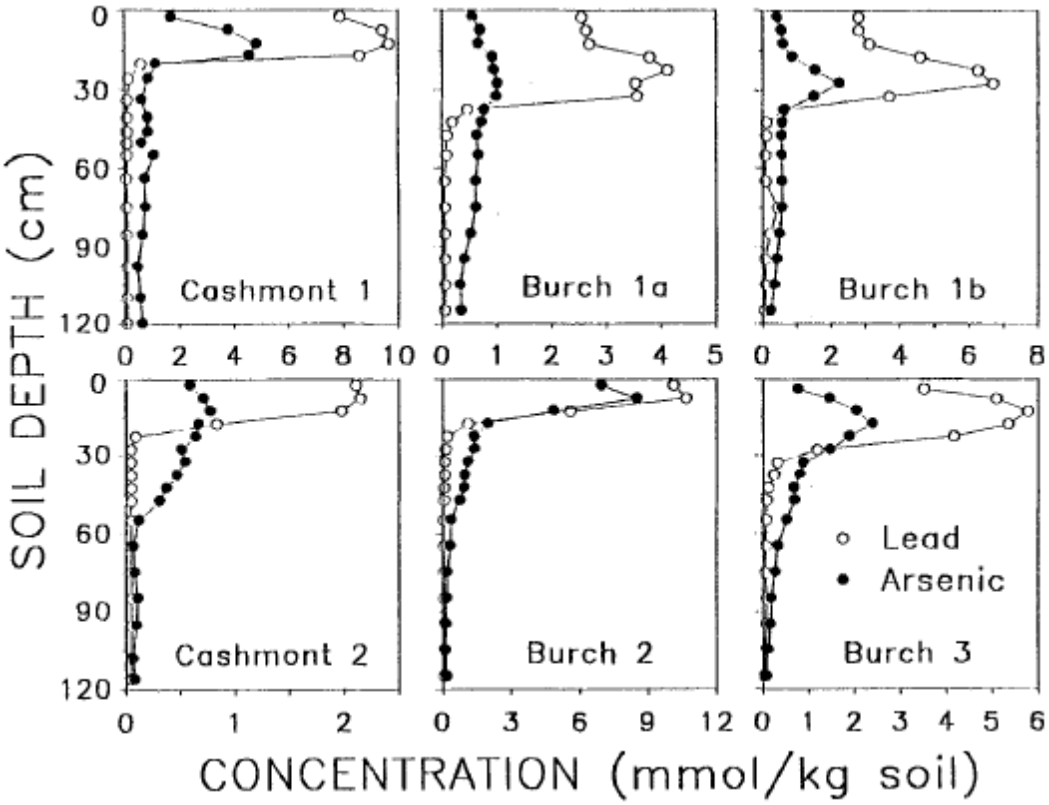


Figure 2.4. Vertical Profile of Lead and Arsenic in Six Lead Arsenate-Contaminated Orchard Soils (Peryea and Creger 1994; reproduced with publisher's permission)

Some limited data exist on the concentrations of lead and arsenic present in the surface soil of the former Hanford orchard properties. These data provide evidence for what the expected concentrations of arsenic and lead in the upper 1 m (39 in.) might be on the former orchard sites (Table 2.1). Delistraty and Yokel 2011 found that more than 99 percent of the total arsenic in the soil was present as arsenic (V) in the former Hanford orchards. A separate study also identified the 100-F and 100-H Areas as having statistically significant higher concentrations of arsenic and lead than the 100-D Area or the Hanford townsite (Yokel and Delistraty 2003). In Table 2.1, data from the Hanford Environmental Information System (HEIS) primarily were collected during remediation of other waste sites, and should be viewed with caution. While the soil samples were all taken from within the boundaries of the former orchards, the sampling sites were not evenly distributed in space so the samples might not be representative of the orchard soil, and they might not have been derived from the surface soils. The nature of the sampling results in some of the HEIS data could have biased the average concentration of the samples compared to the true average concentration expected on undisturbed orchard soils. However, the concentrations of arsenic and lead in soil measured in these samples are consistent with soil sampling studies across the United States on orchards treated with lead arsenate.

Table 2.1. Surface Soil Concentrations of Arsenic and Lead Measured on Former Orchards on the Hanford Site, and Other Orchard Locations

	Arsenic (in mg/kg)					Lead (in mg/kg)				
Source	*n*	Mean	Median	SD	Max	*n*	Mean	Median	SD	Max
Yokel and Delistraty (2003)	31	30	5.7	61	270	31	220	27	460	1,900
Delistraty and Yokel (2011)	11	39.5	NR	40.6	128	11	208	NR	142	390
HEIS Data[(a)]	881	8.7	4.0	14	111	825	35	9.8	91	1,240
HEIS Data[(b)]	113	8.0	5.2	7.9	54	78	55	23	98	665
HEIS Data[(c)]	108	26	15	27	111	109	113	44	173	1,240

(a) All HEIS soil samples occurred within the boundaries of the orchards as shown in Figure 1.1. Data were removed if sampling records confirmed a result was not representative of orchard surface soils. For example, sludge collected from the bottom of a sump, or soil in an excavation collected more than 1.5 m (4.9 ft) below grade did not qualify as surface soil samples.
(b) HEIS data from one orchard were used to determine distribution of soil concentrations (Decision Unit OL-IU2-4, 116-F-1 Lewis Canal waste site). Soil Sampling was conducted as part of the Limited Field Investigation Report for the 100-FR-1 Operable Unit (DOE-RL 1995).
(c) HEIS data from one orchard were used to determine distribution of soil concentrations (Decision Unit OL-10).
HEIS = Hanford Environmental Information System.
Max = Maximum number of samples.
n = Number of samples.
NR = Data not reported.
SD = Standard deviation.

In an effort to make a more meaningful evaluation of existing Hanford Site data, data derived from a subset of soil samples collected from one former orchard property were evaluated. The samples were collected for evaluation of the 116-F-1 Lewis Canal, located north of the 100-F Area (DOE-RL 1995, 2012b). The data were selected for analysis because it was derived from samples collected from relatively evenly distributed sampling sites across the orchard, and represented enough samples to be statistically relevant (Figure 2.5). Histograms of the arsenic and lead concentrations indicate a log-normal distribution (Figure 2.6).

Key questions that typically are considered when evaluating soil exposure pathways are described below.

Are the contaminants moving? Most of the measurements of concentrations of arsenic and lead in Hanford Site soil on the former orchard properties occurred between 1995 and 2011. Given that the concentrations are still within the range of concentrations reported for other orchard sites (Kabata-Pendias 2001) and the vertical concentration data derived from Hanford soils show limited vertical movement through the soil column (Yokel and Delistraty 2003), the movement of arsenic and lead can be assumed to be very slow—on the order of 1 to 2 cm/yr (0.4 to 0.8 in./yr). This low transport rate is expected considering the low solubility of arsenic and lead (Liu et al. 2009), the low annual precipitation on the Hanford Site (17.7 cm [7 in.], Poston et al. 2004), and the fact that 99 percent of the total arsenic is present as arsenic (V) rather than the more soluble arsenic (III) (Newton et al. 2006; Delistraty and Yokel 2011). Phosphate fertilizers have been demonstrated to enhance the mobility of arsenic in soil (Peryea and Kammereck 1995; Staed et al. 2009). However, phosphate fertilizers were not historically used on the former orchard sites (Peryea and Kammereck 1995). Arsenic and lead from historic lead arsenate application have been shown to be associated primarily with the fine silt and clay size fraction of the soil

(Renshaw et al. 2006). This indicates that the mass loss rate of arsenic and lead from the former orchard sites could increase if the sites are disturbed; the small size fraction of soil is more mobile during erosion processes (Cadwalader et al. 2011).

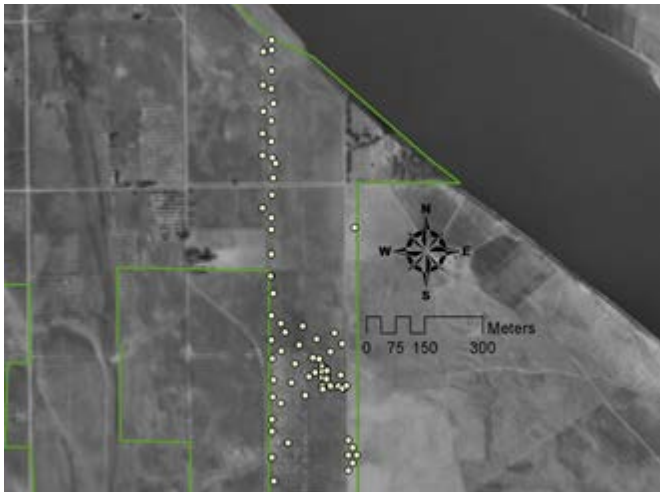
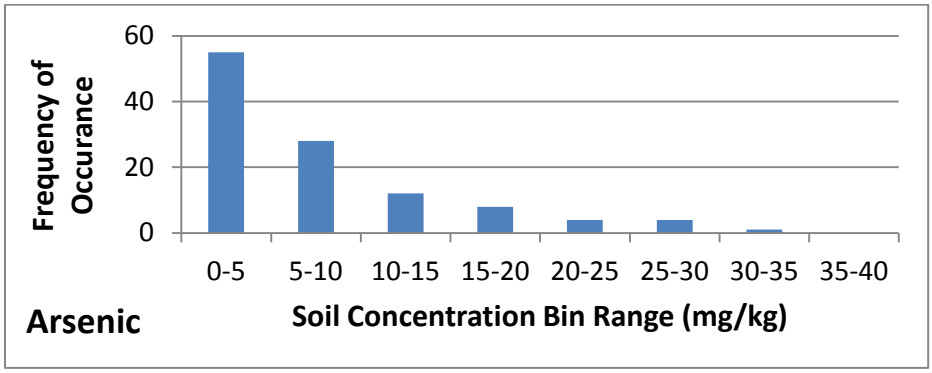


Figure 2.5. Soil Samples Collected on the Hanford Site, North of 100-F Area (116-F-1 Lewis Canal), with the 1943 Historical Aerial Imagery as a Background (results of soil sampling part of DOE-RL 1995)



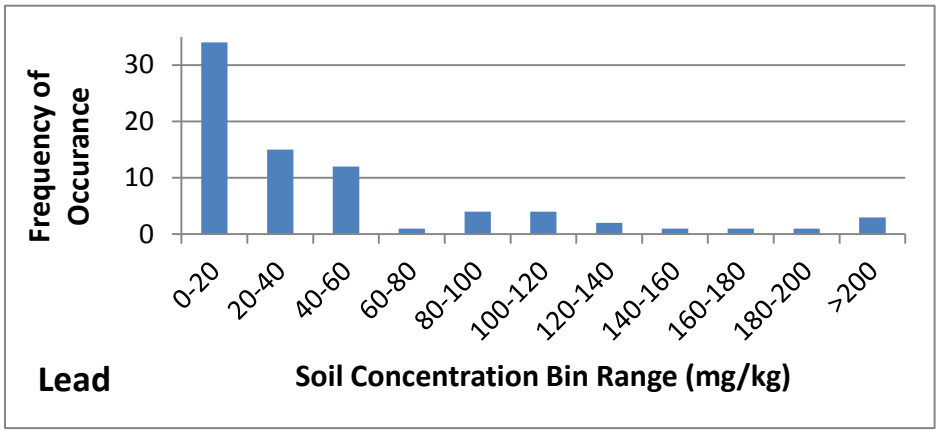


Figure 2.6. Histograms of Arsenic and Lead Soil Concentrations from 116-F-1 Lewis Canal Waste Site (results of soil sampling part of DOE-RL 1995)

How fast are contaminants dispersing along the flow path? Because arsenic and lead found in Hanford soil essentially are not moving, there is minimal dispersal along the flow path. The measured concentrations for vertical profile samples collected at the former orchards show that lead is dispersing even slower than arsenic (Yokel and Delistraty 2003). The concentrations decrease from 1100 mg/kg at a 10-cm (4-in.) depth to 30 mg/kg at a 50-cm (20-in.) depth, or by a factor of 36 over 40 cm (16 in.). Arsenic dispersal appears to be faster, with concentrations of 110 mg/kg at a 10-cm (4-in.) depth decreasing to 50 mg/kg at a 50-cm (20-in.) depth (Yokel and Delistraty 2003).

To what extent might natural attenuation be occurring? Natural attenuation of lead arsenate residues does not appear to be occurring in the soils in Washington State or across the nation. No mechanisms that could result in attenuation have been identified. As trace metals, arsenic and lead cannot be destroyed, and it appears that they are already in a relatively immobile state (Yokel and Delistraty 2003).

2.2.3 Other Pathways for Lead Arsenate Residues in Pre-Hanford Orchards

The groundwater pathway for lead arsenate residues is not significant at Hanford. Studies have shown that neither lead nor arsenic are mobile enough to have migrated downward to the top of the water table (Peryea and Creger 1994). Lead and arsenic are not detected in Hanford Site groundwater on a routine basis and, therefore, are not mapped or tracked by the groundwater monitoring program (DOE-RL 2011c). To evaluate the arsenic and lead concentrations in Hanford Site groundwater, data from 26 Hanford Site monitoring wells (located within the former orchard properties and close to the Columbia River) were evaluated. Analytical results for arsenic or lead (HEIS data) were reported for only eight of these wells. Of the 268 individual results, only 18 measurements did not have data qualifiers (e.g., measured concentrations above the required detection limit, high blank concentrations, etc.). Most of these 18 samples were taken from one location (199-F1-2), which had detectable concentrations of arsenic at concentrations between 9 and 12 µg/L. The 199-F1-2 sampling location is north of the 100-F Reactor, close to the former town of White Bluffs. Two up-gradient groundwater wells (199-F7-2 and 199-F7-3) appear to have arsenic concentrations at somewhat lower concentrations (6 to 8 µg/L). To put this in context, the drinking water standard for arsenic is 10 µg/L (Hartman et al. 2011). A recent evaluation of arsenic and lead in the 100-FR-3 OU concluded that the elevated levels detected in the groundwater were consistent with concentrations in background wells, and the contaminants were not retained for further evaluation in the Feasibility Study (DOE-RL 2012b). Lead arsenate residue does not appear to be transporting to groundwater at this time.

Lead arsenate residue in surface water today is unlikely. With no operating orchards on the Hanford Site, there is no lead arsenate application or irrigation to provide any potential for surface runoff from flood irrigating. The surface water sediment pathway is of limited concern, because of the potential for lead arsenate residue to have eventually migrated to Columbia River sediment. However, it has been documented that Columbia River sediments have slightly elevated levels of both lead and arsenic, which have been attributed to upriver mining operations (Patton and Crecelius 2001; DOE-RL 2012a). The concentrations of arsenic measured in Columbia River sediments (6 mg/kg) are less than the 95th percentile of the background arsenic concentrations (DOE-RL 1993; Patton and Crecelius 2001; DOE-RL 2012a). While the concentrations of lead measured in Columbia River sediment (35 mg/kg) are higher than the background surface soil concentrations of lead, the concentrations are slightly lower than, and not statistically different from, the concentrations measured in sediments upstream of Priest Rapids

Dam (DOE-RL 1993; Patton and Crecelius 2001; DOE-RL 2012a). This is a result of upstream mining activities and indicates that there is no significant accumulation of lead arsenate residue in Columbia River sediment.

The air pathway may continue to contribute to the spread of lead arsenate residues; windblown dust from areas with disturbed surface vegetation is a well-documented occurrence on the Hanford Site (Poston et al. 2003; DOE-RL 2012b). However, it also is documented that once vegetation (either native or non-native) returns to disturbed areas, windblown dust decreases dramatically (Poston et al. 2004). The literature concerning lead and arsenic migration through the soil column indicates that the very top of the surface soil should not have the maximum concentrations (Peryea and Creger 1994). The maximum concentrations occur at depths of 5 to 30 cm (2 to 12 in.). The air pathway should be a concern only if activities on the former orchard properties result in the removal/destruction of surface vegetation and bring below-grade soil to the surface.

The biotic pathway also is a complete pathway. Exposure to lead and arsenic primarily are through ingestion of contaminated soil. Biointrusion into contaminated areas can move contamination up to the surface by plant uptake through their roots and burrowing activity by animals or insects (DOE-RL 2012b). While plant and animal uptake rates of lead and arsenic are relatively low, the potential exists for human and biotic exposure along the food chain pathway, although this pathway is not significant (DOE-RL 2010, 2011a, 2012a, b).

2.3 Background Concentrations in Soil for Lead and Arsenic

This section provides background concentrations and potential screening levels for lead and arsenic to be considered for use on the Hanford Site. Several key reports (highlighted below) provide a range of expected background soil concentrations of lead and arsenic on and around the Hanford Site; the relevant background concentrations for arsenic and lead are provided in Table 2.2. These data will be used to determine the required analytical sensitivity and identify statistically significant differences between potentially contaminated orchard properties and background concentrations.

Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes. This report (DOE-RL 1993) documents the results of sampling and analysis activities designed to characterize the composition of soil background concentrations for nonradioactive analytes in the vadose (unsaturated) zone of the Hanford Site. For this study, samples were selected to provide a random, unbiased distribution of concentrations within the vadose zone of the Hanford Site. One hundred and four samples were used for both arsenic and lead. While the samples consisted of soil taken from throughout the vadose zone, the soil model assumed that there would be very little depth variability in the concentrations of metals in the Hanford vadose zone. This is due to the nature of the Hanford Site vadose zone formation; namely, the reworking and deposition of the soil by the Missoula floods. The results were analyzed using both log-normal and Weibull distribution techniques. Here, we include only the log-normal distribution statistics because they are more directly comparable to other data sources (Table 2.2); however, for lead and arsenic there was very little difference between the log-normal and Weibull distributions statistics.

Table 2.2. Relevant Background Concentrations (in mg/kg dry weight) for Arsenic and Lead

Analyte/Location	Mean	Standard Deviation	Range	90th Percentile
Arsenic (mg/kg dry weight)				
Hanford Site[(a)]	4.2 (3.55)[(b)]	1.68	3–11.4	6.47
Hanford Site[(c)]	3.11	2.04	1.1–22	NA
Eastern Washington[(d)]	2.53[(b)]	2.52[(e)]	0.5–7.19	5.76
United States, podzols and silty soils[(f)]	5.1	NA	<0.1–30	NA
United States, loamy and clay soils[(f)]	7.7	NA	1.7–27	NA
Lead (mg/kg dry weight)				
Hanford Site[(a)]	6.3 (5.45)[(b)]	3.46	1.1–26	10.2
Hanford Site[(c)]	10.3	7.67	3.21–60.3	NA
Eastern Washington[(d)]	6.4[(b)]	2.69[(e)]	4.2–11.7	9.85
United States, podzols and silty soils[(f)]	17	NA	<10–70	NA
United States, loess and silty soils[(f)]	19	NA	10–30	NA
United States, loamy and clay soil[(f)]	22	NA	10–70	NA

(a) DOE-RL (1993).
(b) Median value, not mean.
(c) Fritz (2009).
(d) San Juan (1994), specifically for Group "E", Benton, Spokane, Lincoln, Adams, Okanogan, and Whitman counties.
(e) Calculated from reported data as 90th percentile minus median, divided by 1.28.
(f) Kabata-Pendias (2001).
NA = Not applicable.

A Review of Metal Concentrations Measured in Surface Soil Samples Collected on and around the Hanford Site. Fritz (2009) collected surface soil samples (top 2.5 cm [1 in.]) on and around the Hanford Site, primarily at undisturbed locations away from Hanford Site operations. The concentrations of lead and arsenic measured were similar to the background concentrations determined by DOE and Washington State (Table 2.2). The highest lead and arsenic concentrations were measured in samples of shoreline soil and sediment. Columbia River sediment along the Hanford Reach is known to have higher metals concentrations than local soil as a result of upstream mining operations (Patton and Crecelius 2001).

Natural Background Soil Metals Concentrations in Washington State. This report (San Juan 1994) characterizes the natural background metals concentrations in surface soils in Washington State. The State defines background concentrations as the "… concentration of a hazardous substance consistently present in the environment which has not been influenced by localized human activities." The State of Washington was divided into 12 regions based on soil type, and samples were collected in each region. The Hanford Site lies within the Central Columbia Basin Region, which is defined as having unconsolidated windblown and alluvial materials on the surface. This study used a compositing scheme to remove extremely localized effects; however, only three composite samples were collected from the Central Columbia Basin Region. Apparently for this reason, the average concentrations within the Columbia Basin Region were not calculated, but were combined with several other areas in eastern Washington State. The background concentrations reported for this region ("E") are similar to the background concentrations identified for the Hanford Site (Table 2.2).

Trace Elements in Soils and Plants. Kabata-Pendias (2001) provides a comprehensive review of published concentrations of metals in soils across the planet. For lead and arsenic, concentration ranges are provided for various soil types in multiple countries. Podzol and sandy soils in the United States were chosen as the type most representative of the Hanford Site (Table 2.2). The range of background concentrations reported for arsenic and lead across the United States in podzol and sandy soil are somewhat higher than the background concentrations reported closer to the Hanford Site.

2.4 Soil Surface History

Characterization of the 100-OL-1 OU requires an understanding of the changes in the landscape of the orchard areas over time. The history of the soil surface on the former orchard properties is largely unknown. When the land was acquired for the Hanford Site, farms and orchards were abandoned in place. In the years that followed, construction activity at Hanford occurred at a frenetic pace. This activity resulted in reshaping of the land surface in the vicinity of the Hanford operating areas, including properties that had previously been orchards. The 100-KR-1, 100-HR-1, 100-HR-2, and 100-FR-2 vadose zone operable units as well as Camp Hanford, were all built on/over agriculturally developed lands, including orchards. Documentation of these construction activities is very limited. Recent remediation activities around the operating areas have resulted in excavations and other activities that disturb the soil surface, and documentation on those activities is available.

As an example, consider the 100-K Area, where a former orchard area was located (Figure 2.7). From historic aerial photographs, as well as the geographical information system (GIS) coverage, it is clear that the area between the water intake structures was a former orchard. Two soil samples were collected from this area in 1992. The sample results indicated lead concentrations in surface soil of about 14 mg/kg, or slightly higher than background concentrations (HEIS data).

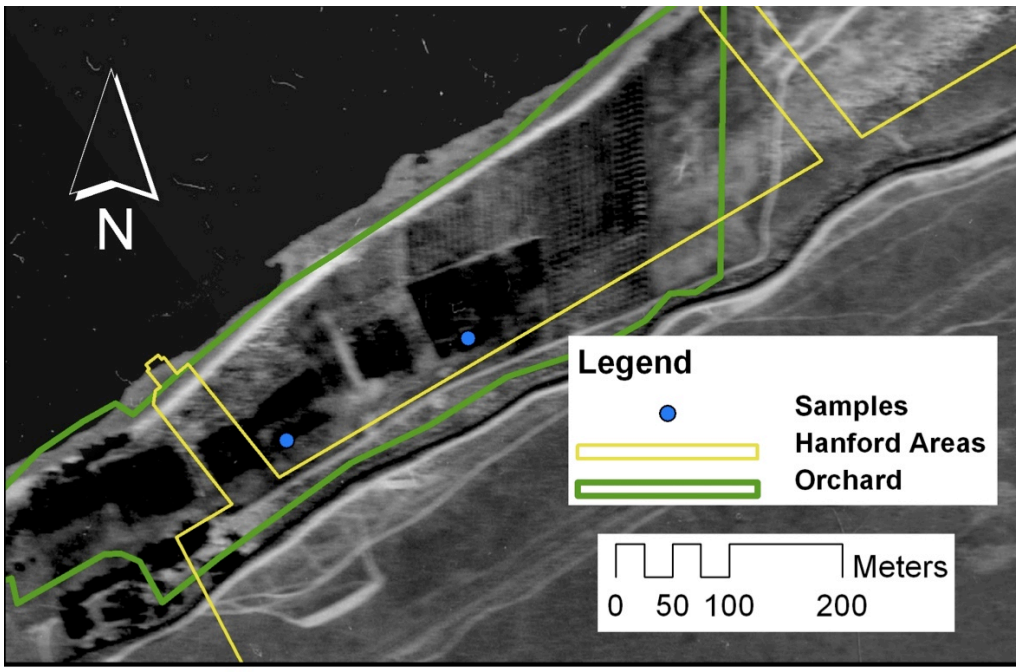


Figure 2.7. Map Showing the 100-K Area Boundary, Adjacent Orchard (1943), and the Location of Surface Soil Samples Collected Inside the Former Orchard Area in 1992

An image from 1954 taken during construction of the 100-K reactors provides evidence that this area was covered with backfill. The changed topography of this area is still visible in more recent photographs (Figure 2.8) (DOE-RL 2011a). Although the area was clearly covered with soil, the measured lead concentrations were still above the background level. Backfill soil from the Hanford operations era was probably not evaluated for presence of contaminants (e.g., lead or arsenic, unlike backfill soils used in current remediation efforts). This example of disturbed soils near the 100-K Area is typical of a number of the former orchards on or near operating areas, and around Camp Hanford (the Hanford townsite). This example highlights some of the difficulties in fully assessing the soil pathway, and raises questions to be considered in determining the appropriate sampling strategy; that is, how to account for anthropogenic changes to the soil surface over the last 65 years.

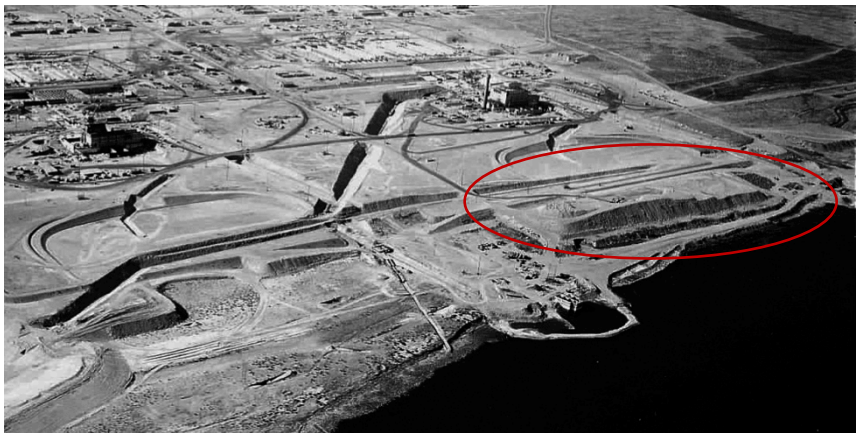


Figure 2.8. Former Orchard Area (red circle) Near the 100-K Area Seen in 1954 During Construction and in 2004 (DOE-RL 2011a)

2.5 Relevant Federal and Washington State Benchmarks for Protection of Human Health and the Environment

Lead arsenate residues in soil are the persistent pathway of concern based on the conceptual site model for current and future exposures to people and ecological receptors in the 100-OL-1 OU. The complexity of arsenic and lead chemistry, varying toxicity effects based on exposure pathways, and

natural background levels have resulted in numerous benchmarks considered for the protection of human health and the environment. Arsenic is a known carcinogen, and lead is known to cause neurological damage, particularly for prenatal and young children (Hood 2006; ATSDR 2007a, b). While acute effects are known for humans exposed to high concentrations of arsenic and lead, there are no reported cases for acute effects from exposure to lead arsenate residues in soils from the former orchard sites on the Hanford site (Hood 2006). Effects from exposure to arsenic and lead have been documented for plants, animals, and other ecological receptors (Eisler 1988a, b; Elving et al. 1994; Schooley et al. 2008; Delistraty and Yokel 2011). To date, scientific studies have not found conclusive evidence that exposure to low to moderate levels of arsenic and lead contamination in soil has caused or is causing deleterious health effects (AWSCTF 2003a).

2.5.1 Arsenic and Lead Contamination in Washington State

Several actions in Washington State concerning lead and arsenic are appropriate to consider for characterization of former orchards at the Hanford Site. Following are summaries of several actions in the State of Washington addressing arsenic and lead soil contamination. These reports have established approaches for evaluating contaminated areas and action levels for remediation.

Asarco Tacoma Smelter Superfund Site, Ruston and Tacoma Washington. Arsenic and lead are the primary contaminants of concern at the Asarco Tacoma Smelter Superfund site, located along the Commencement Bay shoreline within the municipal boundaries of the town of Ruston at the southern end of the main basin of Puget Sound. The site is an operational unit of the larger Commencement Bay Nearshore/Tideflats Superfund site. The Commencement Bay Nearshore/Tideflats Superfund site was listed on the interim priority list by EPA in 1981, and included in the first published National Priorities List in September 1983. Operation of the Asarco smelter for over 95 years resulted in contamination, primarily by arsenic and lead, of the smelter site, offshore sediments, and the surrounding residential area. The former copper and lead smelter specialized in processing ores with high arsenic concentrations, and recovered arsenic trioxide and metallic arsenic as byproducts. In 1995, EPA issued the first Record of Decision for the remediation of the Asarco Tacoma Smelter Facility and adjacent slag peninsula (EPA 1995). The 2009 Third Five-Year Review Report of the site summarized the remedy selection and remedial actions. Remedial action levels identified for soil removal of residential soil were 230 mg/kg for arsenic and 500 mg/kg for lead (EPA 2009).

Area-Wide Soil Contamination Project, Washington State Department of Ecology. The State of Washington created a task force in the early 2000s to develop a strategy for dealing with “area-wide” soil contamination. Area-wide soil contamination refers to low-to-moderate-level arsenic and lead soil contamination dispersed over a large area in the State of Washington, and the efforts of the task force are being used in addressing contamination from the Asarco Tacoma Smelter plume, the Everett Smelter, and at schools built on former orchard lands across the state. In 2003, the findings and recommendations of the Area-Wide Soil Contamination Task force were published (AWSCTF 2003a). The task force identified six categories of protection: 1) education programs, 2) public health programs, 3) individual protection measures, 4) land-use controls, 5) physical barriers, and 6) contamination reduction. The task force used Ecology’s current views of “low-to-moderate” levels of arsenic and lead in soil. In general, for schools, childcare centers, and residential land uses, the low-to-moderate range is up to 100 mg/kg for

total arsenic and 500 to 700 mg/kg for lead. For properties where exposure of children is less likely or less frequent, the low-to-moderate range is up to 200 total mg/kg for total arsenic and 700 to 1000 mg/kg for lead (AWSCTF 2003a, b).

Asarco Tacoma Smelter Site Final Interim Action Plan for the Tacoma Smelter Plume. While EPA's Asarco Tacoma Smelter Superfund Site is remediating the facilities and immediate area, Ecology is addressing air pollution contamination from the smelter in an area of over 2600 km^2 (1000 mi^2). The 2012 interim action plan describes how Ecology will remediate some of the Tacoma Smelter Plume and manage risk (Ecology 2012). Ecology plans to take four actions regarding the Tacoma Smelter Plume: 1) clean up home yards in the worst areas of the plume; 2) clean up play areas at schools, childcare centers, parks, camps, multi-family public housing, etc.; 3) educate people about the risk and how to protect themselves; and 4) encourage soil testing and cleanup during property development. The interim actions consist of a mix of physical cleanup methods (e.g., excavating, mixing, capping, etc.) and institutional controls (e.g., property use restrictions, environmental covenants or deed restrictions, zoning overlays, outreach, etc.). The action plan is divided into two phases. The first phase focuses on areas where children play and people live; and the second phase focuses on those areas not covered in the first phase. Action levels for each phase are divided into moderate zones and high zones. The moderate zone has an average concentration of 20 to 100 mg/kg arsenic (maximum concentration of 40 to 200 mg/kg arsenic) and average concentration of 250 to 500 mg/kg lead (maximum concentration of 500 to 1000 mg/kg lead). The high zone has an average concentration of >100 mg/kg arsenic (maximum concentration >200 mg/kg arsenic) and average concentration of >500 mg/kg lead (maximum concentration >1000 mg/kg lead).

Health Consultation Evaluation of Soil Contamination Washington Schools Eastern and Central Washington. The Washington Department of Health (DOH) in cooperation with Agency for Toxic Substances and Disease Registry (ATSDR) put together a health consultation to evaluate whether soil arsenic and lead levels found by Ecology between 2003 and 2006 on playgrounds at 113 eastern and central Washington elementary schools pose a health concern to children and residents in the nearby communities (DOH 2008). Of these 113 schools, 51 had maximum and/or mean arsenic and lead soil concentrations that exceeded the Model Toxics Control Act (MTCA) Method A cleanup levels (WAC 173-340-740). From a total of 51 elementary schools, 22 schools had 95th percentile upper confidence limit and/or mean values for either arsenic and/or lead that exceeded MTCA Method A cleanup levels, and four schools exceeded both MTCA and Ecology's Interim Action Levels (100 mg/kg arsenic and 500 mg/kg lead) (AWSCTF 2003a). DOH recommended that actions should be taken to reduce or eliminate exposure to arsenic and/or lead at the schools where these contaminants exceed MTCA cleanup levels and/or Ecology's Interim Action Levels.

2.5.2 Relevant Federal and Washington State Benchmarks

Federal and state benchmarks have been established for lead and arsenic. Table 2.3 includes selected benchmarks for the protection of human health relevant to soil exposures at the Hanford Site. Table 2.4 includes ecological benchmarks from scientific studies and Hanford Site-specific ecological risk assessments.

Table 2.3. Arsenic and Lead Benchmarks for Protection of Human Health

Exposure Scenario and Pathway	Arsenic (mg/kg dry wt)	Lead (mg/kg dry wt)	Reference
1E-6 cancer risk for humans, unrestricted land use (soil ingestion, dermal contact)	0.62	NA	Ecology 2001; Yokel and Delistraty 2003
1% risk of exceeding a blood Pb level of 15 µg/dL in children with IEUBK model, unrestricted land use (ingestion)	NA	250	Ecology 2001; Yokel and Delistraty 2003
5% risk if exceeding a blood Pb level of 10 µg/dL in children, residential land use (ingestion)	NA	400	EPA 1994a; Yokel and Delistraty 2003
Unrestricted land use soil cleanup standards, Washington State, MTCA Method A	20	250	WAC 173-340-740
Schools, childcare centers, and residential land uses, low-to-moderate range for Area Wide Soil Contamination, Washington State	100	500-700	AWSCTF 2003a, b
Properties where exposure to children is less likely or less frequent, low-to-moderate range for Area Wide Soil Contamination, Washington State	100-200	700-1000	AWSCTF 2003a, b
Tacoma Smelter Plume, moderate zone, average concentration (maximum concentration)	20-100 (40-200)	250-500 (500-1000)	Ecology 2012
Tacoma Smelter Plume, high zone	>100 (>200)	>500 (>1000)	Ecology 2012
Residential land use soil action levels, EPA	230	500	EPA 2009
Remedial action goals, direct exposure cleanup level	20	353	DOE-RL 2008; WAC 173-340-740(3)(a)(iii)(A) and (B); EPA 1994b

IEUBK = Integrated Exposure Uptake Biokinetic model.
NA = Not applicable.

Table 2.4. Arsenic and Lead Benchmarks for Protection of the Environment

Benchmark Basis	Arsenic (mg/kg dry wt.)	Lead (mg/kg dry wt.)	Reference
Soil microbes	100	900	Delistraty and Yokel 2011
Plant, soil screening level	18	120	EPA 2005a, b; Delistraty and Yokel 2011
Plants, 10th percentile of ranked LOEC values for crop growth, soil screening level	10	50	Efroymson et al. 1997a, b; Yokel and Delistraty 2003
Plant	NR	50	WAC 173-340
Invertebrate, soil screening level	NR	1700	EPA 2005a, b
Soil biota	NR	500	WAC 173-340
Invertebrate, LOEC for earthworm reproduction, soil screening level	60	500	Efroymson et al. 1997a, b; Yokel and Delistraty 2003
NOEC for lettuce and earthworm bioassay	128	390	Delistraty and Yokel 2011
Avian, soil screening level	43	11	EPA 2005a, b; Delistraty and Yokel 2011
Mammalian, soil screening level	46	56	EPA 2005a, b; Delistraty and Yokel 2011; CHPRC 2011
All avian wildlife, risk-based soil concentration for Generic - EcoSSL	43	11	CHPRC 2011
As (III): All wildlife, risk-based soil concentration for Generic - MTCA	7	NA	WAC 173-340; Yokel and Delistraty 2003; CHPRC 2011
As (V): All wildlife, risk-based soil concentration for Generic - MTCA	132	NA	WAC 173-340; Yokel and Delistraty 2003; CHPRC 2011
Pb: All wildlife, risk-based soil concentration for Generic - MTCA	NA	118	WAC 173-340; Yokel and Delistraty 2003; CHPRC 2011
California quail, Tier 2	4776	559	CHPRC 2011
Western meadowlark, Tier 2	7403	664	CHPRC 2011
Killdeer, Tier 2	2284	156	CHPRC 2011
Red-tailed hawk, Tier 2	40,102	2300	CHPRC 2011
Great Basin pocket mouse, Tier 2	201	2672	CHPRC 2011
Deer mouse, Tier 2	127	1578	CHPRC 2011
Grasshopper mouse, Tier 2	302	3807	CHPRC 2011
Badger, Tier 2	847	3966	CHPRC 2011

Eco SSL = Ecological soil screening level.
LOEC = Lowest observed effect concentration.
NA = Not applicable.
NOEC = No observed effect concentration.
NR = Not reported.

2.6 100-OL-1 OU Boundaries

The TPA Change Control Form that established the 100-OL-1 orchard lands operable unit, C-12-02 (TPA 2012a), included a low-resolution map defining the boundaries of the operable unit (Figure 1.1).

As part of the development of the conceptual site model for the Work Plan, it was necessary to obtain the map as a GIS layer. This proved to be difficult, because the map had grown and changed in an undocumented manner over the years in response to numerous and diverse project and program objectives. Following is a description of the process used while developing the Work Plan to produce and verify a traceable history for the GIS coverage of the 100-OL-1 OU boundaries.

The first known version of the GIS coverage was a "Hanford Farm" layer. Washington Closure Hanford (WCH) inherited this GIS coverage from Bechtel Hanford, Inc. when WCH took over the contract. The origin of the initial coverage could not be verified. WCH staff modified the Hanford Farm layer based on manual inspection of and comparison with historical (1941 and 1943) and more recent (1999, 2002, and 2008) aerial photography. The modifications were thought to be limited to the shifting of boundaries to better match dividing points (e.g., roads) identified in the aerial photography.

WHC used the Hanford Farm layer to identify orchards by manually noting the presence or absence of orchard trees within a particular farm in the historical imagery (1943 aerial photography). In addition, field observations performed during orphan site evaluations and the 1943 platted lands map were used to provide evidence of orchard trees. If a farm was observed (by any method) to have some evidence of orchard trees being grown, it was classified as an orchard. If no orchard trees were observed, it was considered a farm, and not included in the "Orchards" GIS layer.

The WCH Orchards GIS layer then was used by CH2M Hill Plateau Remediation Company to prepare documentation for DOE's Richland Operations Office (DOE-RL) for the TPA Change Control Form establishing the 100-OL-1 OU. Through this process, some areas (or polygons) were added or removed. In addition, one orchard that is visible in the 1943 aerial photography was found to have been included in the Hanford Farm coverage, but not in any other versions of orchard layers. For completeness of this investigation, all of the different versions of the Orchards GIS coverage were merged to include all potential orchard properties. The result was the 44 individual areas identified in the map included in TPA Change Control Form C-12-01 (TPA 2012a), and shown in Figure 1.1 in the Work Plan.

Two additional areas of orchards on the Hanford Site within the vicinity of other areas identified in TPA Change Control Form C-12-02 (TPA 2012a) were identified during preparation of this Work Plan. One area is next to the river upstream of the 100-F Area, and the other is located southwest of the 100-F Area. These areas are now included in the 100-OL-1 OU.

3.0 Investigative Approach

This section describes the approach for investigating the 100-OL-1 OU, including the data quality objectives (DQOs) for the RI/FS. The sampling design and characterization approach incorporating the DQOs is discussed. Values associated with the *National Environmental Policy Act of 1969* as amended (NEPA) also are discussed.

3.1 Data Quality Objectives

The DQO process involves a series of systematic steps to plan for resource-effective acquisition of data to characterize the pre-Hanford orchard lands for the RI/FS of the 100-OL-1 OU. The purpose of this process is to prepare project-specific DQOs to provide clear direction for collection of data in the characterization of the orchard areas and to provide a framework for assessing the overall quality of the sampling strategy and analyses for use in the RI/FS for the 100-OL-1 OU (EPA 2000).

3.1.1 State the Problem

Characterization of the magnitude and extent of lead and arsenic contamination (residue from lead arsenate pesticide) in the 100-OL-1 OU is incomplete. Characterization is needed to evaluate potential risk to human health and the environment and support remedial action decisions.

3.1.2 Identify the Decision

Characterization of the 100-OL-1 OU will determine the average concentration representative of the soil contained within defined areas or “decision units” within the operational unit. It will provide information for the FS and support refinement of the conceptual site model and options for any remedial actions that will be identified during the FS. The decisions for characterizing the magnitude and extent of lead and arsenic contamination in the 100-OL-1 OU are associated with the following:

- Areas of the Hanford Site identified as former orchard areas and the need to define decision units for areas where lead arsenate pesticide residues persist
- Physical/chemical characteristics of lead and arsenic in the soil in the former orchard areas
- Benchmarks for characterizing lead and arsenic residue concentrations in soils that are protective of human health and the environment.

The former orchard lands or suspected former orchard properties are shown in Figure 1.1. Information that can be used to establish the validity of the identified areas is not well documented (as discussed in Section 2.6). As part of the RI, a task will be implemented to certify the areas for characterization (discussed further in Section 3.1.4). Historical aerial imagery shows regions with rows of trees in areas of known commercial orchards. However, most areas making up the 100-OL-1 OU have historical aerial imagery that documents patchworks of trees along with other agricultural crops and outbuildings. Because lead arsenate pesticide was only applied to orchard trees, the soil in these areas will likely have varying concentrations of lead and arsenic.

Characterization of the lead arsenate residuals in soils will provide greater understanding of the mobility of the lead and arsenic since application of the pesticide ceased. Past studies at Hanford, in Washington State, and elsewhere indicated that the peak concentration of the lead and arsenate remains in the upper 30 cm to 1 m (12 to 39 in.) of the soil column (discussed further in Section 2.2.2).

Federal, Washington State, and Hanford Site-specific thresholds or benchmarks identified for lead and arsenic range from below to well above the Hanford Site-specific background concentrations (see Table 2.3 and Table 2.4). The 90th percentile level for the Hanford Site-specific background concentrations are 6.47 mg/kg arsenic and 10.2 mg/kg lead (Table 2.2). The difference between the benchmark and background concentration levels is the least in general for arsenic; therefore, the criterion for evaluating arsenic is the critical criterion for decisions purposes. One of these decisions is the number of soil samples needed to achieve a statistically relevant understanding of lead arsenate residue contamination in an area within the 100-OL-1 OU.

For the purposes of characterization of the 100-OL-1 OU, the benchmark for total arsenic in soil will be 20 mg/kg and the benchmark for lead in soil will be 250 mg/kg. These benchmarks are the MTCA Method A soil cleanup level for unrestricted land use (WAC 173-340-740, Table 740-1).

3.1.3 Identify Inputs to the Decision

To resolve the decision statement, a number of information inputs are required. These inputs address the distribution of contamination, the expected range and variability of concentrations in soil, and the acceptable concentrations in soil to prevent harm to human health and the environment. Table 3.1 lists information requirements and antecedent information sources required for the characterization study to enable informed decision-making that will answer the site assessment question.

3.1.4 Definition of Boundaries for the Study

This section provides a description of the boundaries for characterization sampling of the 100-OL-1 OU. This includes spatial boundaries (in all three dimensions) as well as limitations in media sampled, compounds analyzed, analytical techniques, and temporal boundaries.

3.1.4.1 Media, Analytes, and Methods

Site characterization sampling will be limited to soil sampling because soil is the primary medium of concern identified in the conceptual model. It is the medium of interest that most likely will contain arsenic and lead concentrations at levels of concern for human or ecological health.

Collection of soil samples should be done using a small-diameter stainless steel coring tool. This collection approach will provide adequate sample volume, will not bias the results vertically (as can happen with a shovel), and will result in minimal disturbance to the soil surface and surrounding environment. If attempts in areas with significant cobble are encountered and collection of soil with the coring tool is not possible, then a shovel may be used to collect a vertical soil sample down to a depth of 30 cm (12 in.).

Table 3.1. Information Inputs Necessary to Support the Decision

Information Input	Source of Information
Contaminant Distribution	
Contaminants of concern	Arsenic, lead
Spread of contamination within orchards	Conceptual site model
Spread of contamination beyond the orchards	Conceptual site model
Vertical distribution of contaminants of concern	Conceptual site model, previous studies
Range and Variability of Concentrations	
Range of concentrations on Hanford Site orchards	Previous studies, HEIS data
Range of concentrations on non-Hanford Site orchards	Literature review
Acceptable Soil Concentrations	
Soil screening levels	Federal and State regulations and criteria; Hanford Site-specific levels (see Table 2.3 and Table 2.4)
Comparison of Measured Results to Acceptable Concentrations	
Statistical comparison approach	Collaborative sampling strategy considers multiple analytical techniques for characterization of decision units
Parameters necessary for chosen statistical approach	Field/laboratory detection limits, spatial and depth variability (based on existing data), soil background concentrations for contaminants of concern, confidence limit, cost
Collection/Analysis Methodology	
Analogous site sampling density/number of samples	Conceptual site model with statistical protocol
Total depth of sample collection	Conceptual site model
Depth intervals sampled	Conceptual site model with statistical protocol

The soil samples will be analyzed only for lead and total inorganic arsenic content. Lead arsenate pesticide residue was the contaminant of concern identified in TPA Change Control Form C-12-02 (TPA 2012a), and nothing identified in the background research or conceptual site model for the 100-OL-1 OU has provided any indication that any additional contaminants from former orchard activities should be considered. Previous work by Delistraty and Yokel (2011) demonstrated that the >99 percent of the total inorganic arsenic existed as arsenic (V) in the surficial soils of the former orchards sites evaluated. This information supports the decision to characterize only for total inorganic arsenic.

For laboratory analyses of the soil samples, inductively coupled plasma mass spectroscopy (ICP-MS), inductively coupled plasma–atomic emission spectrometry (ICP-AES), and inductively coupled plasma optical emission spectra (ICP-OES) analytical techniques would meet desired detection limits for lead and arsenic. However, ICP-MS would be the recommended analytical technique for consistency with other characterization and waste-site verification efforts at Hanford (DOE-RL 2007).

3.1.4.2 Areas to Sample

The total area sampled will include all of the land identified on the map included in TPA Change Control Form C-12-02 (Figure 1.1). The conceptual model did not provide any indication that property

identified as potential orchard lands should be excluded from sampling, except for addressing disturbed areas from remediation activities. While remediation activities in areas such as around 100-HR-1 did not remove all surface soils with elevated levels of arsenic and soil, many of these areas had soil excavated to depths greater than 30 cm (12 in.). For all planning efforts, these excavated areas will be removed from the decision units so no sample collection will occur within the existing waste sites. These sites represent a very small percentage of the total orchard acreage. Sample collection locations will be determined using a software tool (e.g., Visual Sample Plan [VSP]) (Matzke et al. 2010). Existing waste sites will be treated as exclusion zones within each decision unit to prevent the placement of the sampling grid within existing waste sites.

During the RI, a task will be defined to verify that the areas identified in Figure 1.1 are former orchard sites rather than farm areas. In addition, the areas will be geo-referenced in a fashion that enables the field characterization teams to use the GIS information for their characterization efforts, and to verify that existing waste sites are excluded from sampling. The orchard property identified in TPA Change Control Form C-12-02 (TPA 2012a) will be sub-divided into separate decision units. The methodology for dividing the orchard lands into the specific decision units is described below. Sampling will be limited to the area defined by the decision unit boundary; characterization sampling will not extend beyond these boundaries. The conceptual model highlighted the fairly limited mobility of residual lead and arsenic derived from use of lead arsenate pesticide. The highest concentrations of lead and arsenic will likely be found within the defined boundaries of the former orchard sites.

The process to define the decision units in the 100-OL-1 OU identified two additional areas of historic orchards that were not included in TPA Change Control Form C-12-02 (TPA 2012a). One area is next to the river upstream of the 100-F Area; the other area is located southwest of the 100-F Area. Addition of these areas was consistent with the criteria used to develop the map in C-12-02 (TPA 2012a) as well as with the criteria used to define the decision units (see Section 3.1.4.5).

3.1.4.3 Depths to Sample

As discussed in the conceptual model for 100-OL-1 OU, the maximum concentration in the vertical direction for both lead and arsenic has been shown to occur at depths less than 30 cm (12 in.). Consequently, surface soil samples from 0 to 30 cm (0 to 12 in.) deep will be collected in all decision units. These samples will be collected on a random start, systematic grid pattern.

3.1.4.4 Time of Year to Sample

Soil sampling will be generally feasible any time of the year when the ground is not frozen. The biological resources in some decision units may require adjustment to the sampling schedule (e.g., roosting bald eagles during the winter in decision units along the shoreline).

3.1.4.5 Decision Units

The orchard lands as presented in TPA Change Control Form C-12-02 (Figure 1.1) will be divided into decision units for characterization and evaluation of alternative actions for the 100-OL-1 OU. The need for the division of the orchards into decision units stems from the variability expected in residual lead arsenate concentrations identified in the conceptual model. Varying application rates, irrigation

techniques, orchard ownership, or years of production could all impact the concentration of residual lead arsenate currently present in soil. Therefore, the characterization of decision units will facilitate evaluations for the FS of the 100-OL-1 OU.

The process for dividing the orchards into decision units considered the location of the orchard on the Hanford Site as well as any soil disturbance, historical imagery of the pre-Hanford orchard lands, and the size of the decision unit. The decision units include the area inscribed in TPA Change Control Form C-12-02 and the two additional areas not included, but meet the criteria (Section 2.6); any existing waste sites are excluded (see Section 3.1.4.2).

The first criterion for division of the 100-OL-1 OU into decision units considered the presence or absence of trees in the historical aerial imagery from 1941 and 1943. It is recognized that the creation of the polygons identified as orchards in the TPA Change Control Form C-12-02 (TPA 2012a) were more often than not farms, of which a portion of the property was planted with fruit trees. Distinct differences are expected between the concentration of lead and arsenic present in soil for areas in which fruit trees were grown relative to areas where no fruit trees were planted. Therefore, the presence or absence of trees in the historical aerial photography was used as a basis for the decision units within 100-OL-1 OU. While it is possible that areas with no trees present in the historical imagery were at some point orchards, division of 100-OL-1 OU into decision units based on the historical aerial imagery was the only practical means of defining the decision units within 100-OL-1 OU based on past fruit production.

The second criterion used in the creation of decision units for the 100-OL-1 OU was size. It is desirable to minimize large decision units for use in evaluation of a probabilistic decision rule. Unfortunately, the large difference in size between small family orchards and large commercial tracts made it impossible to eliminate size variations between the decision units. After division of the 100-OL-1 OU into decision units based on the first two criteria, larger decision units were further sub-divided so that the largest decision units is 1.18 km^2 (292 ac).

Individual decision units are categorized according to the criteria outlined in Table 3.2. Another distinction used in categorizing the decision units was evidence of surface soil disturbance since 1943. For the Hanford townsite, where evidence indicates that heavy surface disturbance likely resulted in movement and mixing of surface soil, several areas identified in TPA Change Control Form C-12-02 (TPA 2012a) were combined into a larger decision unit (1.18 km^2 [292 acres]). Within a decision unit, areas that have been or will be remediated will not be sampled. GIS information on the Hanford Site Waste Information Data System (WIDS) will be used to exclude these areas for sampling locations. Table 3.3 lists the decision units and describes the area of the decision unit, criteria for defining the decision unit, and the category of the decision unit.

3.1.5 Develop a Decision Rule

The decision rule should consider the sampling strategy, characterization benchmarks, and knowledge of the lead arsenate residues in Hanford Site soil to propose a statistically based sampling design to evaluate the magnitude and extent of lead and arsenate in the 100-OL-1 OU.

Table 3.2. Categories for the 100-OL-1 OU Decision Units

Decision Unit Category	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Number of Decision Units by Category
A	Yes	No	31
AX	Yes	Yes	13
B	No	No	21
BX	No	Yes	4

Table 3.3. Preliminary Decision Units for 100-OL-1 Operable Unit

Orchard Area Decision Unit ID	Area of Decision Unit			WIDS site Within Decision Unit Boundaries?	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Decision Unit Category
	km^2	m^2	Acres				
OL-1	0.37	371,968	91.9	No	Yes	No	A
OL-2	0.25	248,827	61.5	No	No	No	B
OL-3	0.16	164,306	40.6	No	Yes	No	A
OL-4	0.04	39,280	9.7	No	Yes	No	A
OL-5	0.04	40,704	10.1	No	No	No	B
OL-6	0.13	134,923	33.3	No	Yes	No	A
OL-7	0.19	193,851	47.9	Yes	Yes	No	A
OL-8	0.02	18,863	4.7	No	Yes	No	A
OL-9	0.62	618,124	152.7	No	Yes	No	A
OL-10	0.43	426,167	105.3	Yes	Yes	No	A
OL-11	0.25	248,746	61.4	Yes	No	No	B
OL-12	0.10	97,956	24.2	No	Yes	No	A
OL-13	0.17	166,170	41.0	No	No	No	B
OL-14	0.19	187,909	46.4	Yes	Yes	No	A
OL-15	0.02	21,267	5.3	Yes	Yes	No	A
OL-16	0.17	165,626	40.9	Yes	Yes	Yes	AX
OL-17	0.16	161,361	39.9	No	No	No	B
OL-18	0.57	571,198	141.1	Yes	Yes	No	A
OL-19	0.17	174,674	43.1	Yes	No	No	B
OL-20	0.11	109,250	27.0	No	No	No	B
OL-21	0.43	428,636	105.9	Yes	Yes	No	A
OL-22	0.05	54,558	13.5	No	No	No	B
OL-23	0.17	172,314	42.6	Yes	Yes	No	A
OL-24	0.12	123,686	30.6	No	Yes	No	A
OL-25	0.09	87,225	21.5	No	Yes	No	A
OL-26	0.12	124,215	30.7	No	Yes	No	A
OL-27	0.35	350,563	86.6	No	No	No	B
OL-28	0.37	370,134	91.4	No	Yes	No	A
OL-29	0.39	393,837	97.3	Yes	No	No	B
OL-30	0.09	85,648	21.2	No	Yes	No	A

Table 3.3. (contd)

Orchard Area Decision Unit ID	Area of Decision Unit			WIDS site Within Decision Unit Boundaries?	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Decision Unit Category
	km^2	m^2	Acres				
OL-31	0.10	103,247	25.5	No	No	No	B
OL-32	0.66	658,530	162.7	Yes	Yes	Yes	AX
OL-33	0.36	359,670	88.8	Yes	No	Yes	BX
OL-34	0.26	262,519	64.8	No	Yes	No	A
OL-35	0.19	191,796	47.4	No	No	No	B
OL-36	0.24	237,582	58.7	Yes	Yes	No	A
OL-37	0.03	33,420	8.3	No	No	No	B
OL-38	0.16	161,730	39.9	Yes	Yes	No	A
OL-39	0.19	186,697	46.1	No	No	No	B
OL-40	0.43	427,759	105.7	Yes	Yes	No	A
OL-41	0.12	121,401	30.0	No	No	No	B
OL-42	0.07	66,509	16.4	No	Yes	No	A
OL-43	0.05	45,179	11.2	Yes	Yes	No	A
OL-FR2-1	0.19	194,197	48.0	Yes	No	Yes	BX
OL-HR1-1	0.53	528,127	130.5	Yes	Yes	Yes	AX
OL-HR2-1	0.07	71,609	17.7	Yes	Yes	Yes	AX
OL-HR2-2	0.00	3740	0.9	Yes	No	Yes	BX
OL-HR2-3	0.02	18,931	4.7	No	Yes	No	A
OL-HR2-4	0.05	51,376	12.7	Yes	No	Yes	BX
OL-IU2-1	0.41	410,726	101.5	Yes	No	No	B
OL-IU2-2	0.31	306,758	75.8	No	Yes	Yes	AX
OL-IU2-3	0.43	430,232	106.3	Yes	Yes	No	A
OL-IU2-4	0.57	573,048	141.6	Yes	No	No	B
OL-IU2-5	0.98	981,074	242.3	Yes	Yes	Yes	AX
OL-IU2-6	0.08	83,396	20.6	No	No	No	B
OL-IU2-7	0.08	84,050	20.8	No	Yes	No	A
OL-IU6-1	0.12	124,851	30.8	No	Yes	No	A
OL-IU6-2	0.08	79,895	19.7	No	No	No	B
OL-IU6-3	0.43	431,090	106.5	No	No	No	B
OL-IU6-4	1.01	1,014,419	250.6	Yes	Yes	No	A
OL-IU6-5	0.13	132,875	32.8	No	No	No	B
OL-IU6-6	0.22	215,125	53.1	No	Yes	No	A
OL-IU6-7	0.99	992,034	245.0	Yes	Yes	Yes	AX
OL-IU6-8	0.89	893,534	220.7	Yes	Yes	Yes	AX
OL-IU6-9	0.75	752,807	186.0	Yes	Yes	Yes	AX
OL-IU6-10	1.03	1,025,275	253.3	Yes	Yes	Yes	AX
OL-IU6-11	0.06	64,481	15.9	Yes	Yes	Yes	AX
OL-IU6-12	1.18	1,181,310	291.8	Yes	Yes	Yes	AX
OL-KR1-1	0.03	27,944	6.9	Yes	Yes	Yes	AX

Each decision unit will be randomly sampled. Soil samples will be collected at depth and analyzed as discussed in Section 3.1.4.2. While some decision units may have evidence of former orchards (e.g., tree stumps or branches), other decision units have no evidence of former orchards. A random sampling approach provides the best opportunity to characterize the magnitude and extent of lead and arsenic in the soil across the decision units. Factoring in health and safety considerations and access limitations resulting from cultural resources protection concerns may modify the sampling locations, but these factors are not anticipated to change many sampling locations.

The number of samples collected in every decision unit is based on the characterization benchmark and background concentration, tolerance for an incorrect decision risk (type II error or false positive), statistical distribution assumptions, and the variability in contamination in the soil. As discussed in Section 3.1.2, the difference between the characterization benchmark and the background concentration of arsenic is less than that for lead. Thus, the number of samples per decision unit is driven by the values for arsenic (20 mg/kg and 6.47 mg/kg arsenic, benchmark and background respectively). A 95th percentile upper confidence interval is typically used on the Hanford Site and for application with MTCA Method A (WAC 173-340-740). The tolerance for an incorrect decision (i.e., a type II error) is 20 percent. A review of sampling activities in former orchards showed that the relative standard deviation varied from 12 to 209 percent. For determining the number of samples per decision unit, the relative standard deviation was assumed to be 100 percent. Based on this information, the number of samples per decision unit would be 26 samples if the presence of lead and arsenic in a decision unit was normally distributed.

The decision rule for characterization of a decision unit relates the magnitude and extent of lead and arsenic contamination to the protection of human health and the environment. The decision rule for each decision unit is stated below:

> Based on characterization results, the benchmark of 250 mg/kg lead and 20 mg/kg arsenic will be the basis for further evaluation within the Feasibility Study.

This decision rule will be used to evaluate the decision units within the 100-OL-1 OU for the magnitude and extent of lead and arsenic contamination.

3.1.6 Specify Tolerable Limits on Decision Errors

As mentioned above, the design of the characterization efforts for the 100-OL-1 OU are driven by the ability to discern the arsenic benchmark from background in soil and the variability of lead and arsenic concentrations within a decision unit. The range of concentrations for arsenic and lead will likely vary from background concentrations (Table 2.2) to the highest values measured to date in pre-Hanford orchards (Table 2.1). The difference between the background concentration and the benchmarks (the "gray region") for arsenic is less than that for lead. The consequence of a small gray region is that the sample design is optimized to detect the difference for arsenic. Optimization of the sample design based on arsenic will increase the ability to statistically differentiate areas with lead contamination in the soil that is above the benchmark.

The sampling design considers the potential for false negative and false positive results. That is, the values for the 95th percentile upper confidence limit for a decision unit does not exceed the benchmarks for arsenic and lead when, in truth, the 95th percentile upper confidence limit for arsenic and lead exceed

the benchmarks (type I error or false negative). The false positive error would be that the values for the 95th percentile upper confidence limit for a decision unit does exceed the benchmarks for arsenic and lead when, in truth, the 95th percentile upper confidence limit for arsenic and lead does not exceed the benchmarks (type II error or false positive). The consequence of this decision error is that the decision unit is considered for further action to address contamination, and unnecessary costs will be incurred.

3.1.7 Other Sampling Considerations

The statistical evaluation of the field characterization results and evaluation of the 95th percentile upper confidence limit for arsenic and lead compared to the benchmark will be in accordance with WAC 173-340-740. Should the Tri Parties determine that further characterization is needed to support the FS, than a Work Plan amendment will be required.

3.2 Characterization Approach for the Remedial Investigation

The magnitude and extent of lead and arsenic soil contamination in the 100-OL-1 OU will be determined by characterization activities conducted as part of the RI. The sampling design for the characterization activities is based on the DQO for 100-OL-1 OU and the conceptual model for lead arsenate residues in Hanford Site soils.

The probability-based sampling design provides the best approach for evaluating the magnitude and extent of the lead and arsenic soil concentrations within the decision units of the 100-OL-1 OU. A probabilistic sampling design meets the approach for evaluating the average concentration of lead and arsenic in a decision unit and compares the 95th percentile upper confidence limit to the benchmarks defined by the DQO decision rule. An alternative sampling design, such as a judgmental sampling design, would be difficult because evidence of the orchards today is not significant. The orchards have not been in production for 70 years, activities on the Hanford Site have removed many of the orchards and disturbed the soil, and wildfires have eliminated the presence of stumps and other signs of fruit trees.

A random-start, systematic-grid-sampling design is used as the overall approach for sampling the decision units within the 100-OL-1 OU (Figure 3.1 to Figure 3.6). Based on the limited characterization efforts (Yokel and Delistraty 2003; Delistraty and Yokel 2011; DOE-RL 2011a), there is a high variability of lead and arsenic in soils. The approach for determining whether a decision unit is above or below respective benchmarks hinges on the sampling design to address the variability of lead and arsenic in the soil.

Sampling will be limited to the area defined by the decision unit boundary; characterization sampling will not extend beyond these boundaries. A random-start, systematic-grid-sampling design will be used to select the layout of the sampling locations within a decision unit. As discussed in Section 3.1.4.5, GIS information on WIDS will be considered when determining sample locations. Sample locations within decision units where the soil has been excavated to 1 m (3.28 ft) or more will be relocated. Field samplers may have to use discretion if additional soil disturbances or cultural resources are found at pre-determined sampling locations.

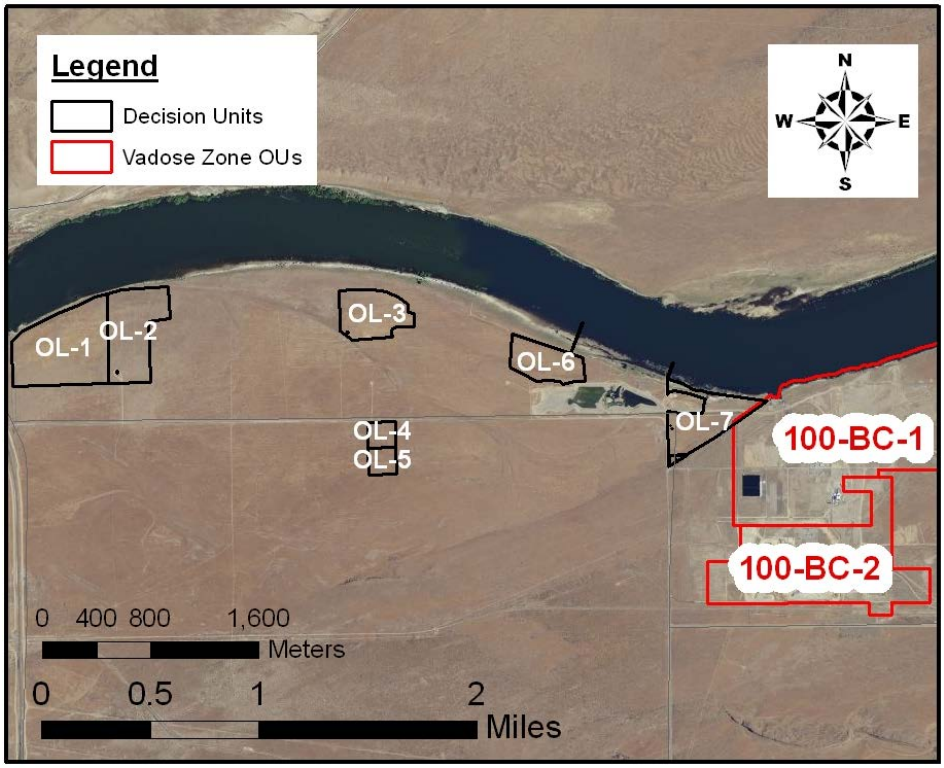


Figure 3.1. Decision Units in the 100-OL-1 OU Located Around the 100-BC Area

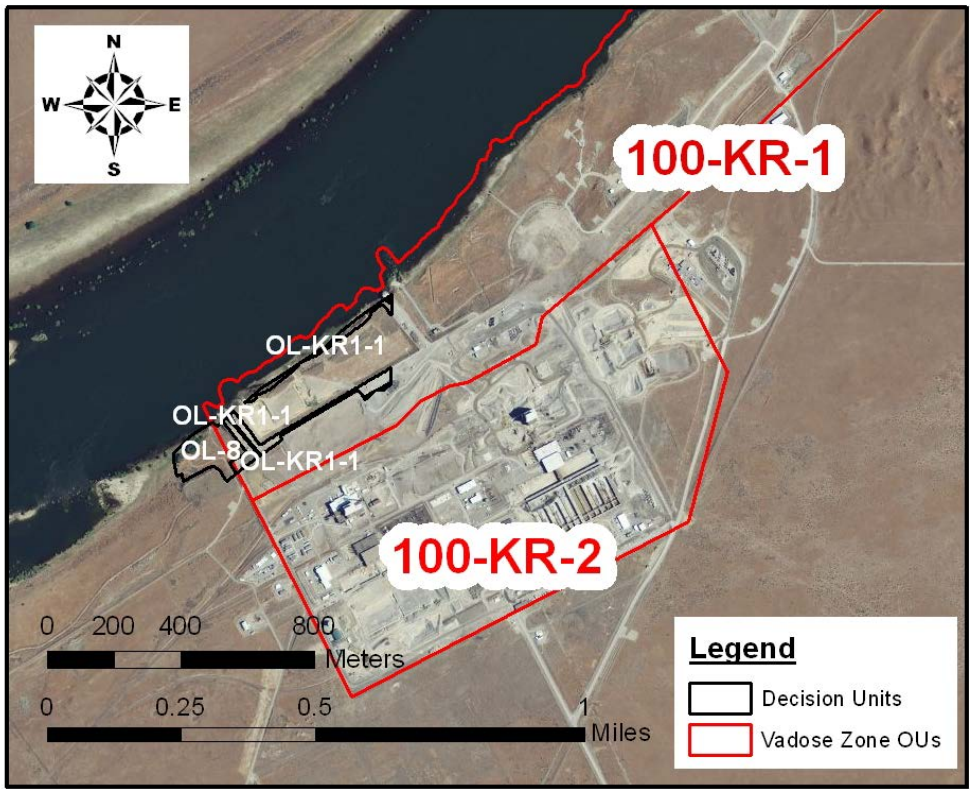


Figure 3.2. Decision Units in the 100-OL-1 OU Located Around the 100-K Area

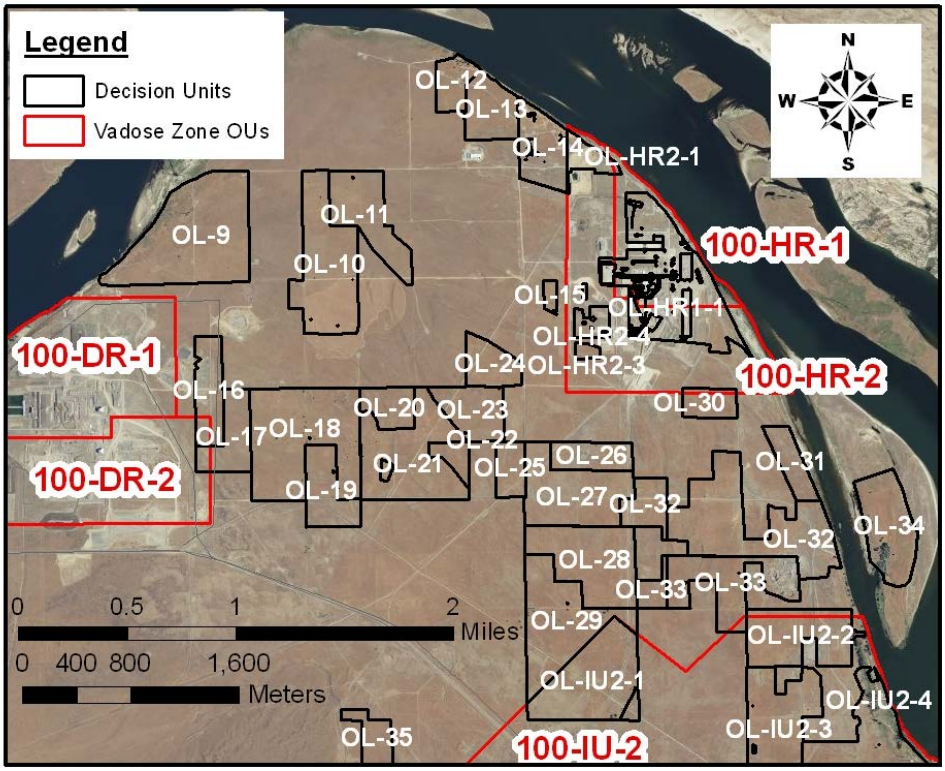


Figure 3.3. Decision Units in the 100-OL-1 OU Located Around the 100-D/H and 100-IU-2/IU-6 Areas

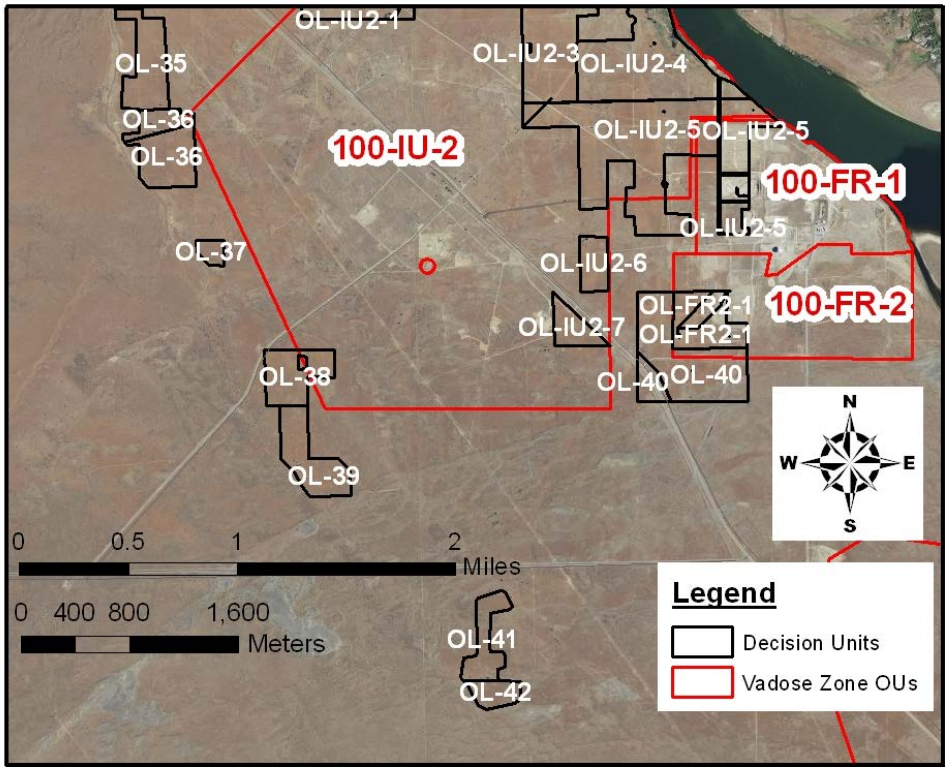


Figure 3.4. Decision Units in the 100-OL-1 OU Located Around the 100-F Area and 100-IU-2/IU-6 Areas

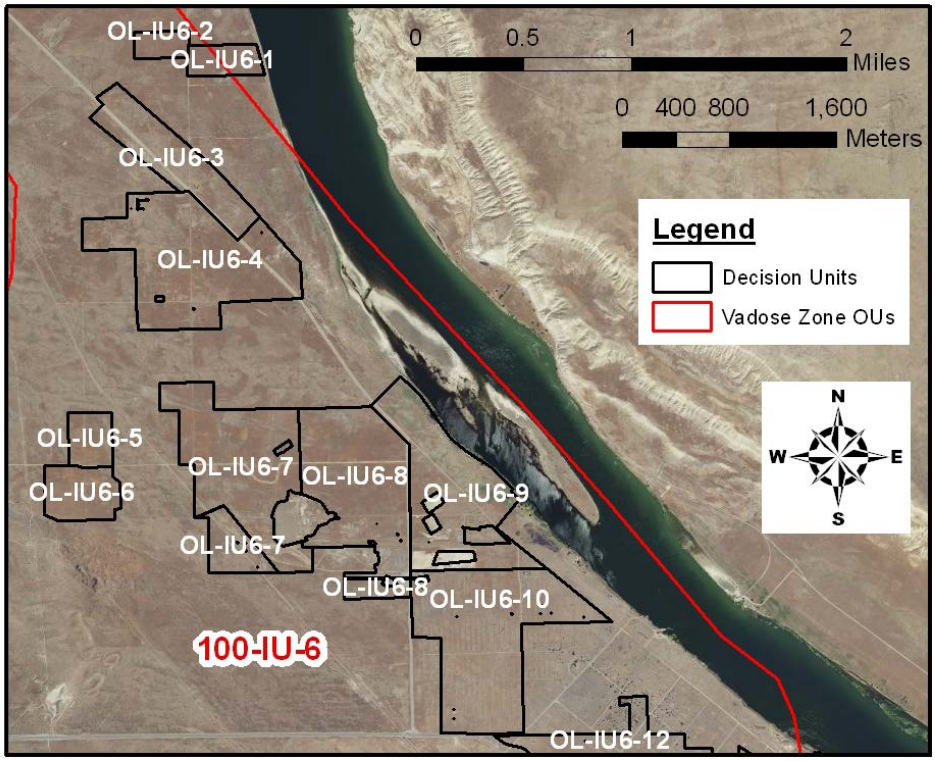


Figure 3.5. Decision Units in the 100-OL-1 OU Located Around the 100-IU-2/IU-6 Area and the North End of the Hanford Townsite

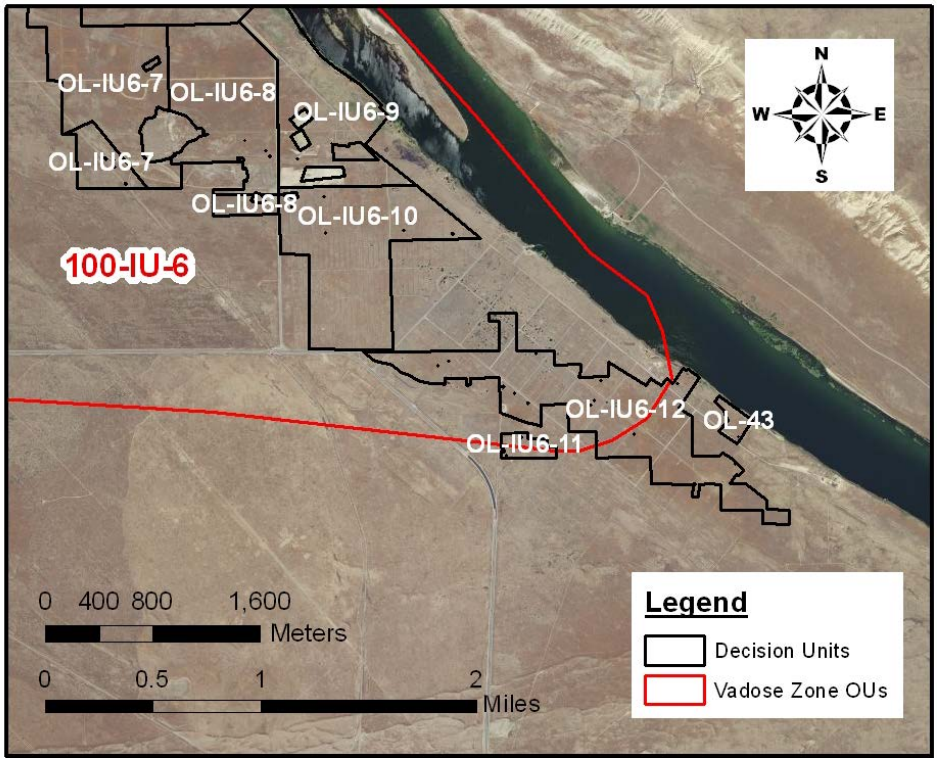


Figure 3.6. Decision Units in the 100-OL-1 OU Located Around the 100-IU-2/IU-6 Area and the South End of the Hanford Townsite

3.3 NEPA Values

In accordance with DOE Order 451.1 and NEPA, DOE CERCLA documents are to incorporate NEPA values to the extent practicable. NEPA values include, but are not limited to, the following:

- Analysis of cumulative offsite ecological and socioeconomic impacts
- Description of the affected environment (including meteorology, hydrology, geology, cultural and ecological resources, and land use)
- Short-term and long-term impacts on human health and the environment
- Emissions to air and water.

Costs are also typically included in a CERCLA FS.

As with the 100-Area operable units, the NEPA value analysis for the 100-OL-1 OU will be documented in conjunction with the CERCLA criteria in the FS study and in the resulting Record of Decision. Several NEPA values common to all of the 100-Area operable units, including laws and guidelines, are addressed in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994). NEPA values specific to the characterization of the 100-OL-1 OU are as follows:

- Cultural and biological resources reviews will be performed prior to any disturbance of the 100-OL-1 OU areas and in accordance with Hanford Site mitigation plans (DOE-RL 2001, 2003a, 2003b).
- Releases to the atmosphere are not expected from the characterization activities. Hand coring will be used to collect samples. Characterization activities are expected to occur over short durations. Use of vehicles to access the areas is likely to be limited because of cultural and environmental concerns. Heavy vehicles would be necessary for some remedial alternatives considered in the FS.
- Removal, storage, and disposal of waste from characterization activities would be minimal (mostly associated with laboratory analyses of soil samples) and would be conducted in accordance with applicable federal and state regulations and guidelines and would not impact employees or the environment.
- All activities are expected to be above groundwater, and the activities will be conducted in a manner that will not impact water resources.
- Several decision units are within 0.4 km (0.25 mi) of the Columbia River shoreline. The U.S. Fish and Wildlife Service will be notified prior to any action in decision units within the Hanford Reach National Monument.
- The 100-OL-1 OU RI/FS represents a small fraction of the total Hanford Site budget, and the affected area is restricted to the public. Therefore, the project is not expected to impact socioeconomics in the vicinity of the Hanford Site or other parts of Benton and Franklin Counties, and the potential for environmental justice concerns is small.
- The project staff and materials associated with the 100-OL-1 OU RI/FS will not significantly impact transportation in the area.

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4.0 Remedial Investigation/Feasibility Study Tasks

Table 4.1 includes the tasks identified for the 100-OL-1 OU RI/FS. At this time, no treatability studies have been identified for the RI because the likely remedial alternatives for lead arsenate residuals in soil would include alternatives that have been implemented in Washington State and other locations across the United States. These RI and FS tasks are discussed further below.

Table 4.1. RI/FS Tasks

Task	Description of Task for Remedial Investigation and Feasibility Study
RI-1	Project Planning • Project Support • GIS finalization of decision units • Section 106 Documentation • Ecological Review
RI-2	Community Relations
RI-3	Field Characterization Activities
RI-4	Sample Analysis and Validation
RI-5	Data Evaluation
RI-6	Risk Assessment
RI-7	Remedial Investigation Report • Report Preparation • Review Cycle
FS-1	Remedial Alternatives Development and Screening
FS-2	Detailed Analysis of Remedial Alternatives
FS-3	Feasibility Study Report • Report Preparation • Review Cycle

Task RI-1: Project Planning. Several activities are included in project planning for successful implementation of the RI.

Subtask RI-1a − Project Support. Plan, organize, and provide top-level guidance and direction for overall project performance. Also provide project-level cost and schedule control, quality control, tracking, and reporting. As needed, review and update DQOs to meet the current project scope. Update plans for field characterization, including the Health and Safety Plan, Sampling and Analysis Plan (SAP), and Quality Assurance Project Plan. Coordinate with other work scope in the Hanford Site's River Corridor to facilitate characterization activities that are in the vicinity of other remediation actions (e.g., in the reactor vadose zone operable units). Coordination activities may include meetings with onsite contractors and peer reviews.

Subtask 1b – Finalization of Decision Units. Decision units identified in this work plan will be reviewed, updated, and finalized (Table 3.3). GIS documentation for the 100-OL-1 OU will be finalized, including metadata, additional geo-referencing activities, new information about former orchards, and anything necessary for the data to meet the Hanford GIS clearinghouse standards. Activities of the DOE

Richland Operations Office (DOE-RL), DOE Office of River Protection (DOE-ORP), and site contractors will be coordinated. Particular efforts will be coordinated with any decision units within source operable units (e.g., 100-K Area) or where other activities are ongoing.

Subtask 1c – Section 106 Documentation. As the RI begins, a Cultural Resources Review Request will be submitted to the DOE-RL Cultural Resources Program, in accordance with the Hanford Cultural Resources Management Plan. This will be followed by National Historic Preservation Act of 1966, as amended, Section 106 documentation and consultation with Washington State Department of Archaeology and Historic Preservation (DAHP). The process will share the plans for the RI with agencies, Tribes, and other interested parties, and will allow them to comment on the plans. The involvement of a cultural historic specialist will be necessary to prepare this documentation and coordination with DAHP and interested parties will involve a work order to Mission Support Alliance, LLC. The consultation will be consistent with the Hanford Cultural Resources Management Plan. The Section 106 process will derive concurrence from DAHP and clearance from DOE-RL Cultural Resources Program for RI activities to commence with any recommendations.

Subtask 1d – Ecological Compliance Review of Decision Units. An ecological compliance review will be conducted when the areas for field characterization are finalized. This review will ensure that the field characterization activities do not conflict with laws—for example, the Endangered Species Act of 1973, Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Washington State regulations protecting threatened, endangered, and listed species. A Mission Support Alliance, LLC biological resource specialist will conduct the ecological compliance review.

Task RI-2: Community Relations. Coordinate, organize, and provide top-level guidance and direction for any community relations plans necessary for the RI and FS. These activities will supplement any community relation activities associated with the Section 106 documentation for the project.

Task RI-3: Field Characterization Activities. Field characterization activities will begin after receipt of confirmation from the DOE-RL Cultural Resources Program that the Section 106 process is complete or mitigating actions are in place and field activities can begin. Field activities for the characterization efforts will be completed in accordance with the Sampling and Analysis Plan (Appendices A and B). Subcontracts for field activities may be required.

Task RI-4: Sample Analysis and Validation. Laboratory analyses of soil samples (with ICP-MS) will be performed by a contract laboratory that has qualifications in accordance with *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 2007). Data validation will be performed by a third party, performing an independent review of laboratory and field data to assure that the procedures, protocols, and requirements in the SAP were correctly followed. Data assessment will address any anomalies in the data and determine if any corrective actions are needed. Validation and assessment of the data will be performed in accordance with *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 2007).

Task RI-5: Data Evaluation. Data from field characterization will be evaluated to determine magnitude and extent of lead and arsenic in the 100-OL-1 OU. Data evaluation will be consistent with DQOs and include comparison of field characterization results to benchmarks for arsenic and lead

concentrations in soil from each decision unit. The characterization data will be evaluated to determine if the data is of the right type, quality, and quantity to support the RI and provides adequate information to proceed to the FS.

Task RI-6: Risk Assessment. Field characterization information from each decision unit will be evaluated in comparison to selected risk-informed benchmarks for human and ecological health (e.g., benchmarks in Table 2.3 and Table 2.4). These benchmarks include risk-informed decisions and action levels identified at Hanford and for other actions within the State of Washington (CHPRC 2011; Delistraty and Yokel 2011; DOE-RL 2008; Ecology 2012; EPA 2009; WAC 173-340; Yokel and Delistraty 2003).

Task RI-7: Remedial Investigation Report. This work element will consist of managing, compiling, and evaluating all of the data generated during the RI activities. The final report will cover activities ranging from field characterization of the orchards to evaluation of decision rules for determining further action in the decision units within the 100-OL-1 OU. Findings presented in this report will form the basis of the FS for future actions in the 100-OL-1 OU.

Task FS-1: Remedial Alternatives Development and Screening. This task will include efforts to select alternatives that will undergo further evaluation. Typical alternatives for addressing lead arsenate residues in soil at former orchard sites will include institutional controls, excavation, replacement with clean fill, and deep soil mixing, or some combination of these (e.g., as described in Ecology 2012). A complete set of applicable alternatives will be assembled, action-specific applicable or relevant and appropriate requirements will be identified, and evaluation criteria for alternatives will be identified (including effectiveness, ability to be implemented, and cost). Initial refinement of remedial alternatives will be completed as part of the report for this task.

Task FS-2: Detailed Analysis of Remedial Alternatives. This task will involve the detailed analysis and comparison of alternatives. Alternatives to be considered will be described in detail, and a comparative analysis of the detailed alternatives against agreed to criteria will be performed.

Task FS-3: Feasibility Study Report. The final FS report will be produced to describe the remedial alternative development and screening process as well as the detailed analysis of the remedial alternatives.

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5.0 Costs and Key Assumptions

Costs for RI activities are associated with the tasks discussed in Section 4.0. The total cost for the RI is estimated at this time to be $1.4M based on the sampling design discussed herein.

Critical assumptions associated with the cost estimate include the number of decision units and samples needed to characterize each decision unit, and the actions needed to acquire a cultural resources review of the characterization activities. This Work Plan has identified 69 decision units. Each decision unit will be characterized by 29 samples. The number of samples is based on statistical assumptions and quality control. Prior to any field activities, the RI contractor will need permission from the DOE-RL Cultural Resources Program to proceed. The activities needed for Section 106 documentation are uncertain and may involve cultural resources monitoring during field activities, The best available information on these cultural resources activities have been included in the cost estimate.

Costs for the FS cannot be estimated at this time. A cost analysis for the FS will be developed at the end of the RI activities.

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6.0 Schedule

The time for initiation of the RI for the 100-OL-1 OU has not been determined by DOE-RL. The DOE-RL Cultural Resources Program must concur that the Washington State DAHP has approved Section 106 documentation for the 100-OL-1 OU before any field work for RI characterization can commence. Several activities to prepare for the field work can be conducted concurrent with the cultural resources review, including acquiring field equipment, finalizing decision units and sampling locations, and placing analytical laboratory contracts and other associated subcontracts.

The schedule for the FS will depend on the outcomes of the RI. A schedule for the FS will be developed at the end of the RI activities. Table 6.1 is a generic schedule based on the sample design and activities discussed in Section 4.

Table 6.1. Generic Schedule for Remedial Investigation Activities

Task	Description of Task for Remedial Investigation	Duration (in months)	Year 1												Year 2												Year 3						
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
RI-1	**Project Planning**																																
	Project Support	32																															
	GIS Finalization of Decision Units	3																															
	Section 106 Documentation	12																															
	Ecological Review	3																															
RI-2	**Community Relations**	32																															
RI-3	**Field Characterization Activities**	5																															
RI-4	**Sample Analysis and Validation**	6																															
RI-5	**Data Evaluation**	3																															
RI-6	**Risk Assessment**	2																															
RI-7	**Remedial Investigation Report**																																
	Report Preparation	5																															
	Review Cycle	5																															

7.0 Project Management

This section addresses the basic aspects of project management, which will ensure that the project has defined goals, the project team understands the goals and the approaches used, and the planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities for the RI covered under this Work Plan. The approved contractor for the 100-OL-1 OU RI is responsible for planning, coordinating, collecting, and analyzing field samples and preparing, packaging, and shipping samples to the analytical laboratory, as defined in its contract. The following sections describe the project organization, relative to sampling and characterization, which is also shown graphically in Figure 7.1. The project lead maintains a list of individuals or organizations as points of contact for each functional element shown in the figure. For each functional primary contractor role, a corresponding oversight role exists within DOE-RL.

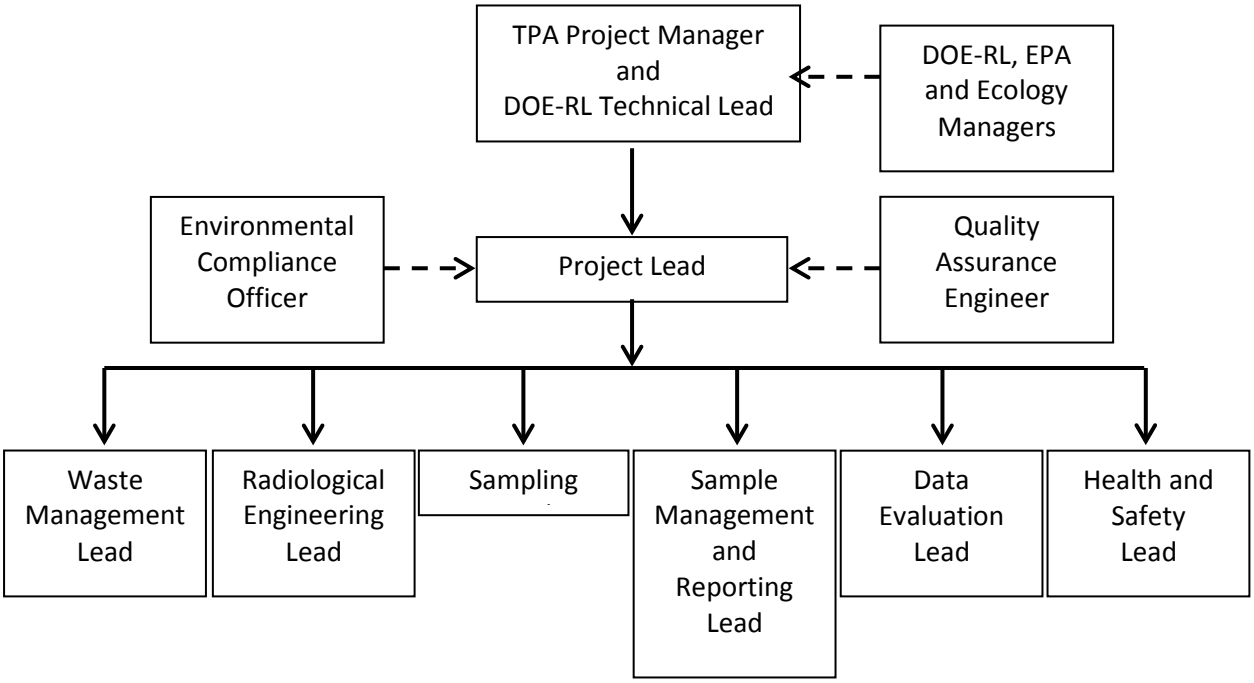

Figure 7.1. Project Organization

DOE-RL, EPA, and Ecology Project Managers. EPA and Ecology will be the lead organizations for the 100-OL-1 OU (TPA 2012b), working with DOE-RL. Each organization has assigned project managers responsible for overseeing the activities identified in the plan to accomplish the scope of this plans. EPA and Ecology will work with DOE-RL to resolve concerns about the work as described in this SAP in accordance with the TPA (Ecology et al. 1989). The managers will be responsible for the risk management evaluation of the RI characterization results and will determine if there is a need for any additional characterization efforts before proceeding with the FS.

Tri-Party Agreement Project Manager and DOE-RL Technical Lead. The TPA project manager is responsible for:

- Authorizing RI/FS activities for the 100-OL-1 OU
- Obtaining regulatory approval of the work plan and SAP that authorize the RI/FS activities under the TPA (Ecology et al. 1989).

The DOE-RL technical lead is responsible for:

- Overseeing the contractor in performing the work scope
- Working with the contractor and the regulatory agencies to identify and work through issues
- Providing technical input to the TPA project manager.

Project Lead. The project lead is responsible for:

- Planning and implementing work scope
- Managing sampling documents and requirements, field activities, and subcontracted tasks, and ensuring that personnel are working in accordance with the most current job requirements
- Requesting and obtaining permission from the DOE-RL Cultural Resources Program before initiating any field activities, and ensuring that the mitigation actions are incorporated and implemented into the field activities
- Maintaining version control for the SAP.

The project lead will work closely with the quality assurance (QA) engineer, the health and safety lead, and the sampling lead to integrate these and the other lead disciplines in planning and implementing the work scope. The project lead will maintain a list of individuals or organizations that fill each of the functional elements of the project organization (Figure 7.1). The project lead will work with the data evaluation lead and the sampling lead after field characterization begins to propose any changes to the SAP to optimize the sampling design. The project lead also will coordinate with DOE-RL and the primary contractor management on sampling activities. The project lead will support DOE-RL in coordinating sampling activities with the regulators, including any revisions to the Work Plan.

Environmental Compliance Officer. The environmental compliance officer will be responsible to the project lead and will be responsible for:

- Providing technical oversight, direction, and acceptance of project and subcontracted environmental work
- Developing appropriate mitigation measures with a goal of minimizing adverse environmental impacts
- Reviewing plans, procedures, and technical documents to ensure that environmental requirements have been addressed
- Identifying environmental issues affecting operations and develops cost-effective solutions
- Responding to environmental/regulatory issues or concerns raised by DOE-RL and/or regulatory agencies.

The environmental compliance officer also may oversee project implementation to ensure compliance with applicable internal and external environmental requirements.

Quality Assurance Engineer. The QA engineer will be responsible to the project lead and will be responsible for QA issues on the project. Responsibilities will include:

- Overseeing implementation of the project QA requirements
- Reviewing project documents, including data needs summary reports, the field sampling plan, and the quality assurance project plan
- Participating in QA assessments on sample collection and analysis activities, as appropriate.

The QA engineer must be independent of the unit generating the data.

Waste Management Lead. The waste management lead will be responsible for:

- Communicating policies and procedures
- Ensuring project compliance with requirements for providing storage, transportation, disposal, and waste tracking in a safe and cost-effective manner
- Identifying waste management sampling and characterization requirements to ensure regulatory compliance
- Interpreting the characterization data to generate waste designations and profiles
- Maintaining other documents that confirm compliance with waste acceptance criteria.

Radiological Engineering Lead. While characterization of the 100-OL-1 OU decision units will not involve analysis of radiological contaminants of concern, areas of the operable unit are in radiological control areas. The radiological engineering lead will be responsible for:

- Providing radiological/health physics support within the project
- Working with the project lead to coordinate with other site contractors and DOE-RL for characterization activities within other operable units
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for work planning
- Identifying radiological hazards and implementing appropriate controls to maintain worker exposures at ALARA levels (e.g., requiring personal protective equipment).

The radiological engineering lead will interface with the project health and safety contact, and will plan and direct radiological control technician support for activities.

Sampling Lead. The sampling lead will have overall responsibility for planning, coordinating, and executing sampling activities. Specific responsibilities will include:

- Converting the sampling design requirements into field task instructions that provide specific direction for field activities
- Implementing any cultural resources mitigation activities

- Directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified
- Communicating with the project lead to identify field constraints or emergent conditions that will affect sampling design and/or execution
- Managing field collection efforts
- Procuring and installing material and equipment needed to support field work
- Preparing data packages based on instructions from the project lead and information contained in this SAP.

The shipping lead will report to the sampling lead for shipment authorization.

Sample Management and Reporting Lead. The sample management and reporting lead will be responsible for:

- Managing and reporting of soil analyses
- Coordinating with laboratory analytical work
- Ensuring that the laboratories conform with Hanford Site internal laboratory QA requirements, or their equivalent, as approved by DOE-RL, EPA, and Ecology
- Entering data into the HEIS
- Arranging for and overseeing data validation of all analyses
- Informing the project lead of any issues reported by the analytical laboratory.

The sample management and reporting organization also will be responsible for conducting the data needs process, or equivalent. Additional related responsibilities will include developing the SAP, including documenting the data needs and the sampling design; preparing associated presentations; resolving technical issues; and preparing revisions to the SAP. Samples collected in the field for shipping and analysis, as well as the resulting data, will be managed in accordance with applicable procedures, and work plans.

Data Evaluation Lead. The data evaluation lead will be responsible for evaluating the results of the field characterization, perform the statistical analyses, and evaluate the data to meet DQOs. The data evaluation lead will work with the project lead and sampling lead on the recommendations and any proposed revisions to the SAP.

Health and Safety Lead. The health and safety lead will be responsible for coordinating industrial safety and health support for the project through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or by internal primary contractor work requirements. The health and safety lead will work with the project lead. In addition, the health and safety lead will assist project personnel in complying with applicable health and safety standards and requirements, particularly for decision units located in other operable units. The health and safety lead will coordinate with the radiological engineering lead to determine personal protective clothing requirements.

Laboratories. The laboratories will analyze samples in accordance with established procedures, provide necessary sample reports, and explain results in support of data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

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Appendix A

Sampling and Analysis Plan for the Remedial Investigation/Feasibility Study Work Plan to Evaluate the 100-OL-1 Operable Unit Pre-Hanford Orchard Lands

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Acronyms and Abbreviations

°C	degree(s) Centigrade
°F	degree(s) Fahrenheit
ALARA	as low as reasonable achievable
ASTM	American Society for Testing and Materials
CFR	*Code of Federal Regulations*
cm	centimeter(s)
CPR	cardiopulmonary resuscitation
CRZ	contamination reduction zone
DAHP	Department of Archaeology and Historic Preservation (Washington State)
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DQA	data quality assessment
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	Expedited Response Action
FS	Feasibility Study
g	gram(s)
GIS	geographical information system
GPS	global positioning system
GW	groundwater
HASP	Health and Safety Plan
HASQARD	*Hanford Analytical Services Quality Assurance Requirement Documents*
HEIS	Hanford Environmental Information System
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectroscopy
kg	kilogram(s)
km^2	square kilometer
LCS	laboratory control sample
m	meter(s)
m^2	square meter
mg	milligram(s)
mOhms	milliohms
MB	method blank
MDL	minimum detection limit
MS	matrix spike

MSD	matrix spike duplicate
NA	not applicable
OJT	on-the-job training
OU	Operable Unit
$PbHAsO_4$	lead arsenate, acidic form
PD	percent difference
PPE	personal protective equipment
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
RI	Remedial Investigation
RL	reporting limit
RPD	relative percent difference
RPT	radiation protection technician
RSD	relative standard deviation
SAP	Sampling and Analysis Plan
SCBA	self-contained breathing apparatus
SRM	standard reference material
TBD	to be developed
TPA	Tri-Party Agreement
UFP-QAPP	EPA's Uniform Federal Policy for Quality Assurance Project Plans
UST	Underground Storage Tank
VSP	Visual Sampling Plan (software tool)
WAC	*Washington Administrative Code*
WBGT	wet bulb globe temperature
WIDS	Waste Information Data System

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Appendix A

Sampling and Analysis Plan for the Remedial Investigation/Feasibility Study Work Plan to Evaluate the 100-OL-1 Operable Unit Pre-Hanford Orchard Lands

A.1 Introduction

This Sampling and Analysis Plan (SAP) presents the details of the proposed sampling identified in the Remedial Investigation/Feasibility Study Work Plan for Orchard Land (this document, hereafter called the RI/FS Work Plan). This SAP is based on the data quality objective (DQO) process, which is summarized in the RI/FS Work Plan. This SAP addresses the characterization efforts necessary to evaluate the magnitude and extent of lead and arsenic soil contamination in the 100-OL-1 Operable Unit (OU).

The former orchard areas are found in current vadose zone operable units (100-KR-1, 100-HR-1 and HR-2, and 100-FR-2), remaining operable units (100-IU-2 and 100-IU-6), and in other areas of the River Corridor that have not been disturbed since the land was designated as the Hanford Site (Figure A.1).

The Quality Assurance Project Plan (QAPjP), Field Sampling Plan (FSP), and Health and Safety Plan (HASP) are discussed in Sections A.2, A.3, and A.4, respectively. The SAP is intended as a standalone part of the RI/FS Work Plan for the 100-OL-1 OU, as recommended in U.S. Environmental Protection Agency (EPA) guidance (EPA 1988), and contains redundant sections with the RI/FS Work Plan. Prior to characterization activities, the SAP will be reviewed and updated to include any changes in locations and decision units as well as reflect any updates to the conceptual approach for evaluating lead and arsenic in soils at former orchard properties on the Hanford Site.

A.1.1 Orchard Lands History

Prior to the acquisition of land by the U.S. Department of War in February 1943 for the creation of the Hanford Site, the land along the Columbia River was home to over 1000 people and was used for various farming and orchard operations by both homesteaders and commercial entities. Tree-fruit production increased around 1905, coinciding with the increased availability of irrigated water through canals and pumping plants provided by the Hanford Irrigation and Development Company. Control of codling moths was needed as the orchards expanded in the region. Beginning in the 1890s, lead arsenate was the pesticide of choice for codling moth control for most tree-fruits, which included apples, cherries, apricots, peaches, pears, plums, and prunes. Orchard activities and the associated application of lead arsenate ceased in 1943 when residents were moved from the Hanford Site. In some areas of the Hanford Site, there is still evidence of the old trees—stumps and branches mostly.

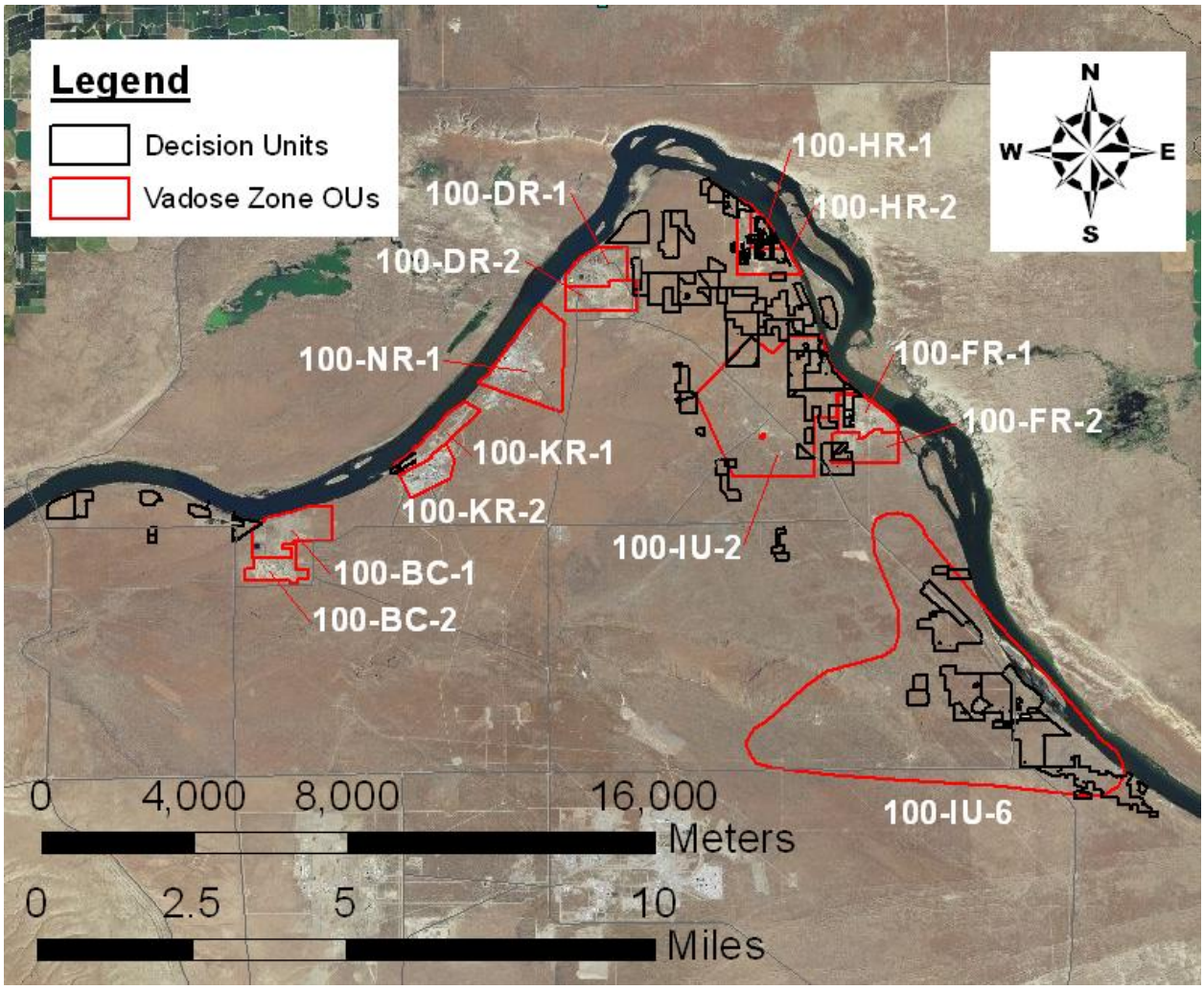

Figure A.1. The Areas Designated as the 100-OL-1 OU Across the Hanford Site Identified as Decision Units in the RI/FS Work Plan

Today, residues from lead arsenate pesticide applications persist in soils at the Hanford Site as they do in other former orchard areas across Washington State and the nation. From 1910 to 1920, almost 14 million kg (30 million lb) of lead arsenate were used annually in the United States (ODEQ 2006). The levels of arsenic and lead in the soil from former orchard activities varies based on a number of factors: the number of applications in a season of production; the form of application (powder or solution); soil characteristics (soil texture, pH, organic matter, clay minerals, hydrous metal oxides, calcite); and precipitation rates. The acidic form of lead arsenate, $PbHAsO_4$, was the most common type applied in Washington State (Frank et al. 1976; Maclean and Langille 1981; Veneman et al. 1983; Peryea and Creger 1994; Elfving et al. 1994; Peryea and Kammereck 1997; Peryea 1998; Sharpe 1999, 2000; Kabata-Pendias 2001; Yokel and Delistraty 2003; Newton et al. 2006; Renshaw et al. 2006; Staed et al. 2009; Cadwalader et al. 2011; Sloan 2011; Delistraty and Yokel 2011).

A.1.2 Characterization of the Orchard Land Soil

This SAP describes the activities planned to characterize the pre-Hanford orchards at the 100-OL-1 OU. Soil samples will be collected and analyzed to evaluate the magnitude and extent of contamination across the 100-OL-1 OU. During the development of the Work Plan, geographical information system (GIS) data on the former orchards was evaluated and decision units were identified for sample planning and decision purposes.

A.1.2.1 Decision Units for 100-OL-1 OU

The extensive areas of tree-fruit production in the 100-OL-1 OU were divided into decision units when developing the RI/FS Work Plan. The intent was to define decision units that capture the areas where lead arsenate pesticide residues are likely to be found in the soil today from past application on orchard trees or other activities that might have contributed to lead and arsenic contamination of soil (e.g., storage, preparation of mixtures, or cleaning of equipment). Decision units encompass the source areas for the lead and arsenic contamination and the areas of human and ecological exposure today. The size of the decision unit is related to the sampling area, and the decisions associated with the sampling and characterization of the orchard area (ITRC 2012).

The process for dividing the orchards into decision units considered the location of the orchard on the Hanford Site as well as any soil disturbance, historical imagery of the pre-Hanford orchard lands, and the size of the decision unit. The decision units include the area inscribed in TPA Change Control Form C-12-02 (TPA 2012a). The first criterion for division of the 100-OL-1 OU into decision units considered the presence or absence of trees in the historical aerial imagery from 1941 and 1943. The second criterion used in the creation of decision units for the 100-OL-1 OU was size. Another distinction used in categorizing the decision units was evidence of surface soil disturbance since 1943. Within a decision unit, areas that have been or will be remediated will not be sampled. GIS information on the Hanford Site Waste Information Data System (WIDS) will be used to exclude these areas for sampling locations.

Table A.1 describes the number of decision units by category. Table A.2 lists each decision unit and the criteria used to identify the decision unit. Figure A.2 through Figure A.7 show the decision units for the 100-OL-1 OU, with areas of existing waste sites excluded.

From the 44 areas in the map of the 100-OL-1 OU included in Tri-Party Agreement (TPA) Change Control Form C-12-02 (TPA 2012a), 69 decision units were identified when developing the RI/FS Work Plan. Notable changes during the DQO preparation process included further division of decision units into areas with and without the presence of trees in the 1943 imagery and coalescing decision units around the Hanford townsite because of the highly disturbed soils in that region. Three decision units, OL-34, OL-41, and OL-42 (Figure A.4 and Figure A.5), were added because review of the aerial imagery confirmed orchards were present in those areas in 1943. The addition of these decision units was consistent with the criteria used to develop the map in TPA Change Control Form C-12-02 (TPA 2012a) and to define the other decision units. Field characterization of the decision units will be used to compare the 95th percentile upper confidence limit for the lead and arsenic in the soil to the decision rule of 250 mg/kg lead and 20 mg/kg total inorganic arsenic.

Table A.1. 100-OL-1 OU Decision Unit Categories

Decision Unit Category	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Number of Decision Units by Category
A	Yes	No	31
AX	Yes	Yes	13
B	No	No	21
BX	No	Yes	4

Table A.2. Preliminary Decision Units for 100-OL-1 Operable Unit

Orchard Area Decision Unit ID	Area of Decision Unit			WIDS site Within Decision Unit Boundaries?	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Decision Unit Category
	km^2	m^2	Acres				
OL-1	0.37	371,968	91.9	No	Yes	No	A
OL-2	0.25	248,827	61.5	No	No	No	B
OL-3	0.16	164,306	40.6	No	Yes	No	A
OL-4	0.04	39,280	9.7	No	Yes	No	A
OL-5	0.04	40,704	10.1	No	No	No	B
OL-6	0.13	134,923	33.3	No	Yes	No	A
OL-7	0.19	193,851	47.9	Yes	Yes	No	A
OL-8	0.02	18,863	4.7	No	Yes	No	A
OL-9	0.62	618,124	152.7	No	Yes	No	A
OL-10	0.43	426,167	105.3	Yes	Yes	No	A
OL-11	0.25	248,746	61.4	Yes	No	No	B
OL-12	0.10	97,956	24.2	No	Yes	No	A
OL-13	0.17	166,170	41.0	No	No	No	B
OL-14	0.19	187,909	46.4	Yes	Yes	No	A
OL-15	0.02	21,267	5.3	Yes	Yes	No	A
OL-16	0.17	165,626	40.9	Yes	Yes	Yes	AX
OL-17	0.16	161,361	39.9	No	No	No	B
OL-18	0.57	571,198	141.1	Yes	Yes	No	A
OL-19	0.17	174,674	43.1	Yes	No	No	B
OL-20	0.11	109,250	27.0	No	No	No	B
OL-21	0.43	428,636	105.9	Yes	Yes	No	A
OL-22	0.05	54,558	13.5	No	No	No	B
OL-23	0.17	172,314	42.6	Yes	Yes	No	A
OL-24	0.12	123,686	30.6	No	Yes	No	A
OL-25	0.09	87,225	21.5	No	Yes	No	A
OL-26	0.12	124,215	30.7	No	Yes	No	A
OL-27	0.35	350,563	86.6	No	No	No	B
OL-28	0.37	370,134	91.4	No	Yes	No	A
OL-29	0.39	393,837	97.3	Yes	No	No	B
OL-30	0.09	85,648	21.2	No	Yes	No	A

Table A.2. (contd)

Orchard Area Decision Unit ID	Area of Decision Unit			WIDS site Within Decision Unit Boundaries?	Presence of Trees in 1943 Aerial Photos?	Evidence of Soil Disturbance Since 1943?	Decision Unit Category
	km^2	m^2	Acres				
OL-31	0.10	103,247	25.5	No	No	No	B
OL-32	0.66	658,530	162.7	Yes	Yes	Yes	AX
OL-33	0.36	359,670	88.8	Yes	No	Yes	BX
OL-34	0.26	262,519	64.8	No	Yes	No	A
OL-35	0.19	191,796	47.4	No	No	No	B
OL-36	0.24	237,582	58.7	Yes	Yes	No	A
OL-37	0.03	33,420	8.3	No	No	No	B
OL-38	0.16	161,730	39.9	Yes	Yes	No	A
OL-39	0.19	186,697	46.1	No	No	No	B
OL-40	0.43	427,759	105.7	Yes	Yes	No	A
OL-41	0.12	121,401	30.0	No	No	No	B
OL-42	0.07	66,509	16.4	No	Yes	No	A
OL-43	0.05	45,179	11.2	Yes	Yes	No	A
OL-FR2-1	0.19	194,197	48.0	Yes	No	Yes	BX
OL-HR1-1	0.53	528,127	130.5	Yes	Yes	Yes	AX
OL-HR2-1	0.07	71,609	17.7	Yes	Yes	Yes	AX
OL-HR2-2	0.00	3740	0.9	Yes	No	Yes	BX
OL-HR2-3	0.02	18,931	4.7	No	Yes	No	A
OL-HR2-4	0.05	51,376	12.7	Yes	No	Yes	BX
OL-IU2-1	0.41	410,726	101.5	Yes	No	No	B
OL-IU2-2	0.31	306,758	75.8	No	Yes	Yes	AX
OL-IU2-3	0.43	430,232	106.3	Yes	Yes	No	A
OL-IU2-4	0.57	573,048	141.6	Yes	No	No	B
OL-IU2-5	0.98	981,074	242.3	Yes	Yes	Yes	AX
OL-IU2-6	0.08	83,396	20.6	No	No	No	B
OL-IU2-7	0.08	84,050	20.8	No	Yes	No	A
OL-IU6-1	0.12	124,851	30.8	No	Yes	No	A
OL-IU6-2	0.08	79,895	19.7	No	No	No	B
OL-IU6-3	0.43	431,090	106.5	No	No	No	B
OL-IU6-4	1.01	1,014,419	250.6	Yes	Yes	No	A
OL-IU6-5	0.13	132,875	32.8	No	No	No	B
OL-IU6-6	0.22	215,125	53.1	No	Yes	No	A
OL-IU6-7	0.99	992,034	245.0	Yes	Yes	Yes	AX
OL-IU6-8	0.89	893,534	220.7	Yes	Yes	Yes	AX
OL-IU6-9	0.75	752,807	186.0	Yes	Yes	Yes	AX
OL-IU6-10	1.03	1,025,275	253.3	Yes	Yes	Yes	AX
OL-IU6-11	0.06	64,481	15.9	Yes	Yes	Yes	AX
OL-IU6-12	1.18	1,181,310	291.8	Yes	Yes	Yes	AX
OL-KR1-1	0.03	27,944	6.9	Yes	Yes	Yes	AX

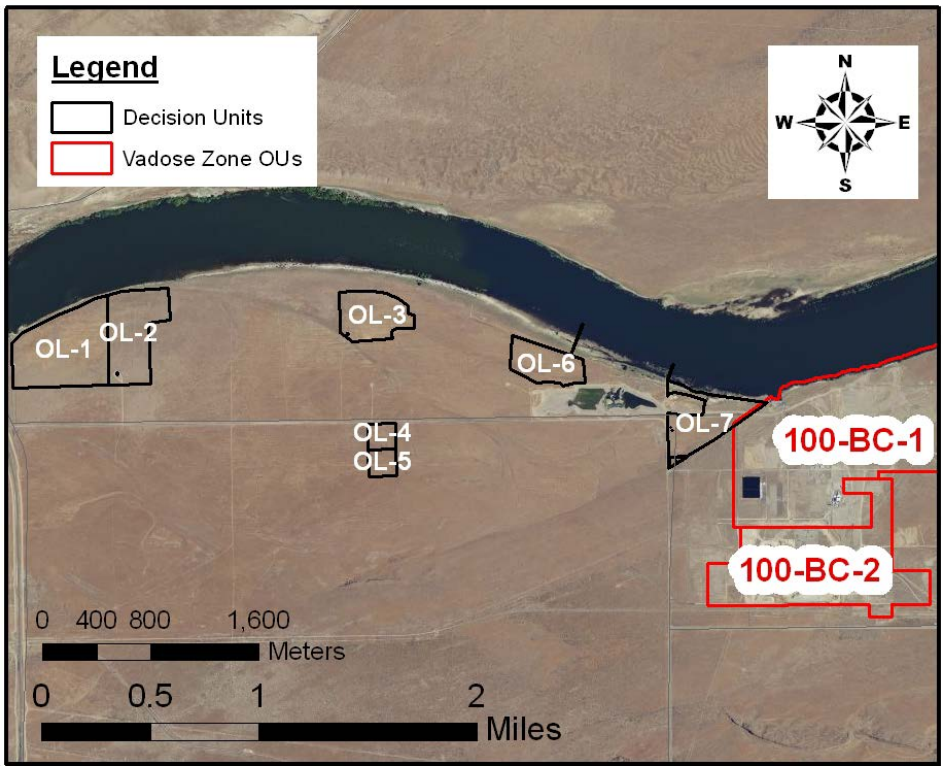

Figure A.2. Decision Units in the 100-OL-1 OU Located Around the 100-BC Area

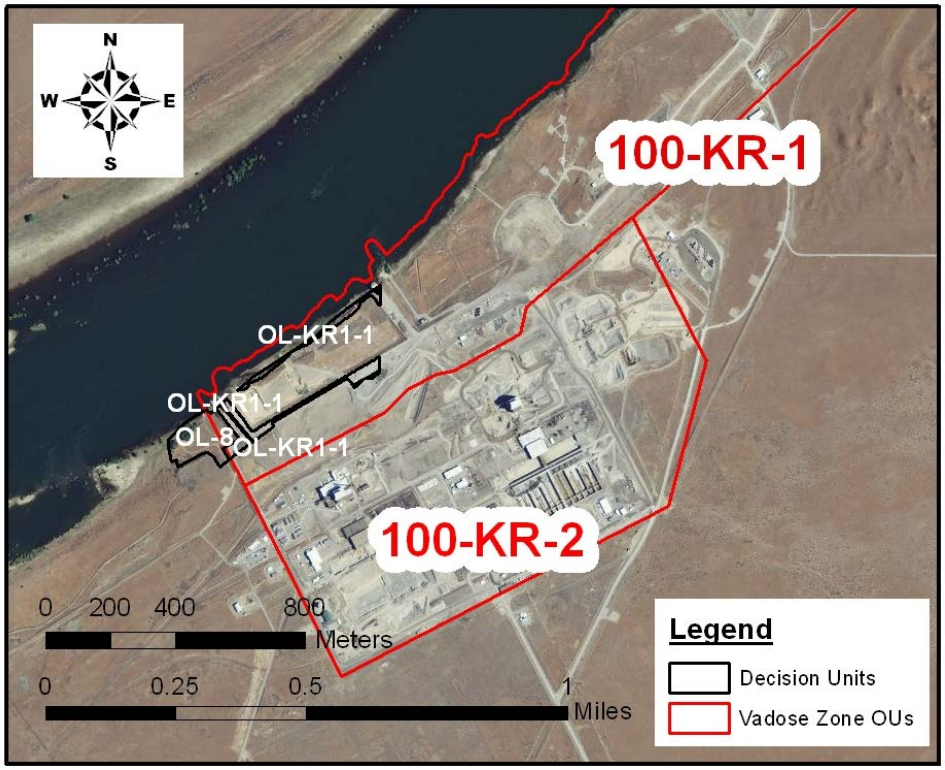

Figure A.3. Decision Units in the 100-OL-1 OU Located Around the 100-K Area

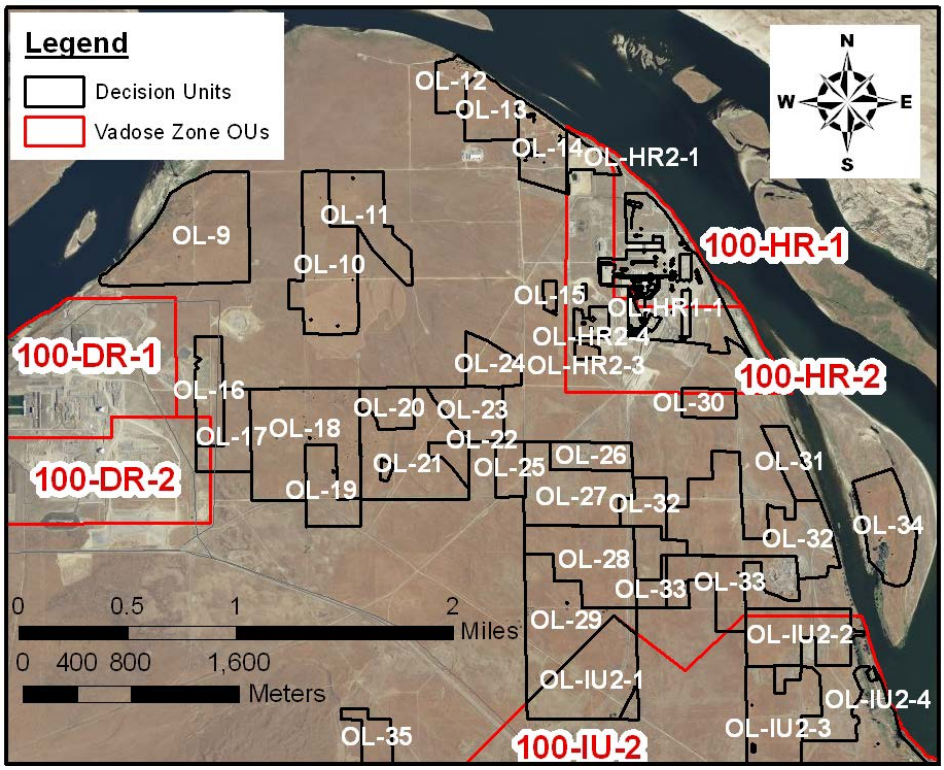

Figure A.4. Decision Units in the 100-OL-1 OU Located Around the 100-D/H and 100-IU-2/IU-6 Areas

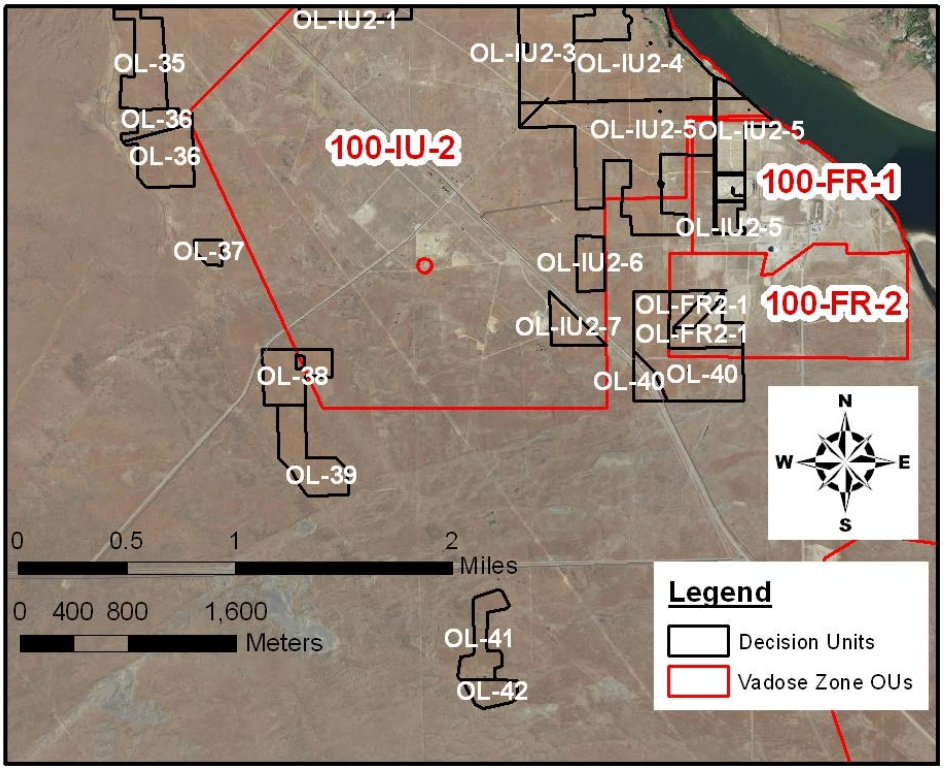

Figure A.5. Decision Units in the 100-OL-1 OU Located Around the 100-F Area and 100-IU-2/IU-6 Areas

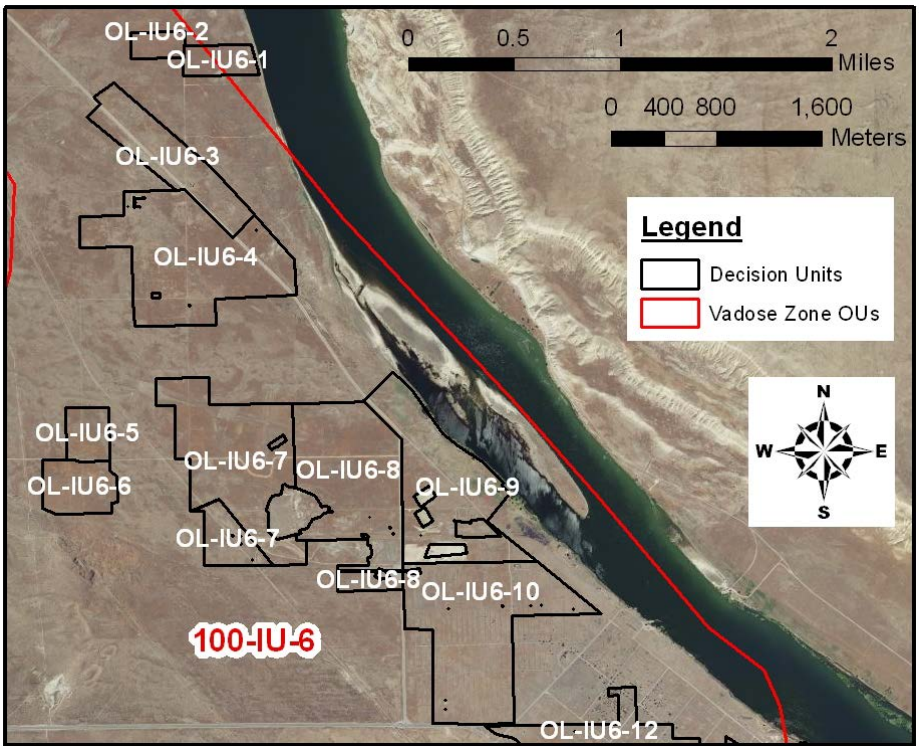

Figure A.6. Decision Units in the 100-OL-1 OU Located Around the 100-IU-2/IU-6 Area and the North End of the Hanford Townsite

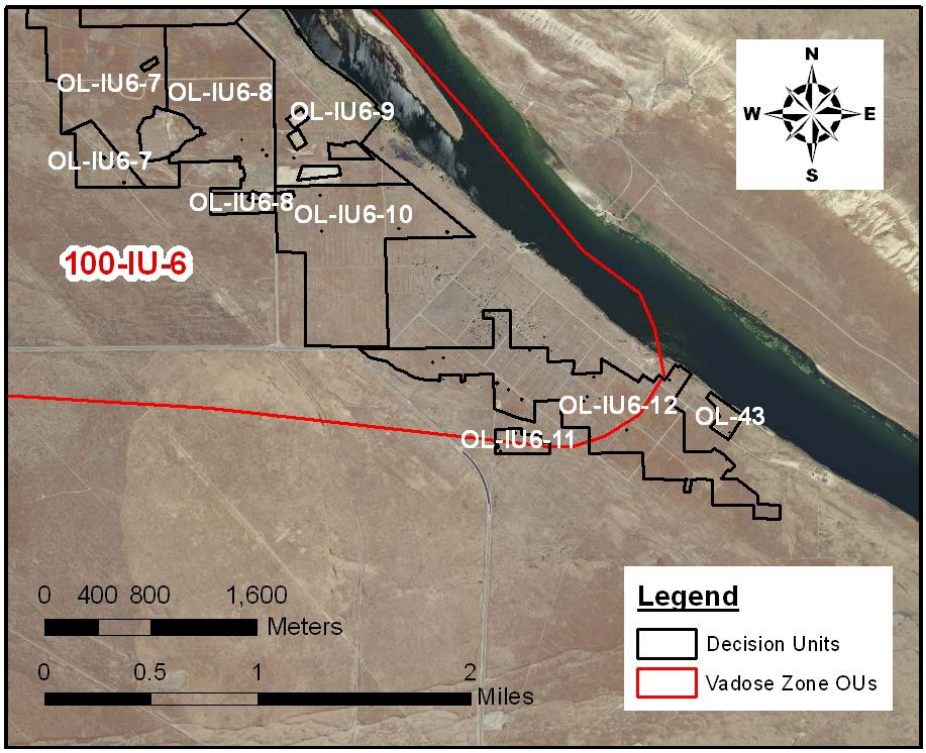

Figure A.7. Decision Units in the 100-OL-1 OU Located Around the 100-IU-2/IU-6 Area and the South End of the Hanford Townsite

A.1.3 Contaminants of Concern

The DQOs included in the RI/FS Work Plan for the 100-OL-1 OU identified lead and total inorganic arsenic in soil as the only contaminants of concern for the characterization efforts. DQOs were identified during meetings with program managers and technical leads from U.S. Department of Energy Richland Operations Office (DOE-RL), the Washington State Department of Ecology (Ecology), and EPA. The decision was to limit the contaminants of concern to lead and total inorganic arsenic based on the conceptual site model for evaluating lead arsenate residues, research on historical orchard practices in the region, and the limits of the TPA description of the 100-OL-1 OU (TPA 2012a, b). Delistraty and Yokel (2011) demonstrated that >99 percent of the total inorganic arsenic existed as arsenic (V) in the surficial soils of the orchards sites evaluated. This supports the decision to characterize only for total inorganic arsenic. The description and justification for the 100-OL-1 OU (TPA 2012a) identified contamination from lead arsenate in the non-contiguous, historic, orchard lands on the south side of the Columbia River.

A.1.4 Data Needs

The RI/FS Work Plan for the 100-OL-1 OU identified several data needs that are time dependent. The cultural resources review of the 100-OL-1 OU decision units and approval to proceed from the DOE-RL Cultural Resources Program are needed before any field sampling activities can be conducted. This process will identify any areas or activities that need mitigating actions prior to and during field-sampling activities. Similarly, a biological review of the area needs to be performed prior to field characterization activities and will identify areas of concern for the field samplers to avoid during field characterization. Another task is updating the boundaries of the decision units to reflect current GIS data. In particular, the latest areal locations for waste sites and remediation activities within the decision units are needed prior to field characterization activities.

A.1.5 Sampling Design

The probability-based sampling design provides the best approach for evaluating the magnitude and extent of the lead and arsenic soil concentrations within the decision units of the 100-OL-1 OU. A probabilistic sampling design meets the approach for evaluating the average concentration of lead and arsenic in a decision unit and compares the 95th percentile upper confidence limit to the benchmarks defined by the DQO decision rule. An alternative sampling design, such as a judgmental sampling design, would be difficult because evidence of the orchards today is not significant. The orchards have not been in production for 70 years, activities on the Hanford Site have removed many of the orchards and disturbed the soil, and wildfires have eliminated the presence of stumps and other signs of fruit trees.

Sampling will be limited to the area defined by the decision unit boundary; characterization sampling will not extend beyond these boundaries. The layout of the sampling locations within a decision unit will be selected using a random-start, systematic-grid-sampling design. Sample locations can be identified using software tools that support sample planning and statistical analyses of sample results, such as the Visual Sampling Plan (VSP) tool (Matzke et al. 2010). As agreed during the DQO meetings, GIS information on WIDS will be used to determine sample locations. Sample locations within decision units where the soil has been excavated to 1 m (39 in.) or more will be relocated. Some discretion will be needed to perform routine sampling around layback areas from remediation activities that may not be included in the GIS information for WIDS. Note that Figure A.8 illustrates sample location placement in

decision unit OL-HR1-1 using VSP with a random-start, systematic-grid-sampling design, and exclusion of locations identified by WIDS. Field samplers may have to use discretion if additional soil disturbances are found at pre-determined sampling locations.

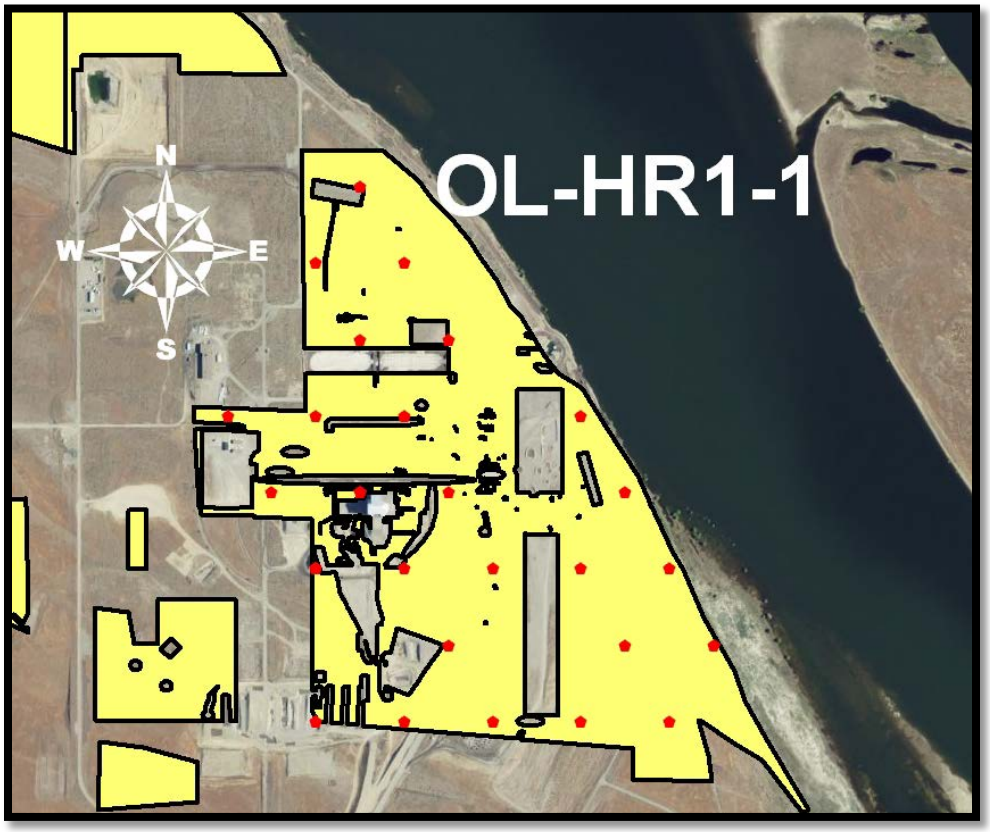

Figure A.8. Proposed Sample Locations (red dots) within Decision Unit OL-HR1-1 using VSP to Select the Locations but Avoid Waste Sites and Remediation Sites

All samples collected will be analyzed using inductively coupled plasma mass spectroscopy (ICP-MS). ICP-MS has been used routinely to characterize soil samples for lead and arsenic at Hanford, including activities within former orchard lands during other remediation and monitoring activities, and well established quality control and quality assurance procedures for the technique have been implemented (DOE-RL 2007).

A.1.6 Project Schedule

The schedule for implementing the RI for the 100-OL-1 OU has not been determined by DOE-RL. Table 6.1 in the RI/FS Work Plan provides a generic schedule based on the sample design and activities to produce the RI final report. The DOE-RL Cultural Resources Program must concur that the Washington State DAHP has approved Section 106 documentation for the 100-OL-1 OU before any field work for RI characterization activities can commence. Several activities to prepare for the field work can be conducted concurrent with the cultural resources review, including acquiring field equipment, finalizing decision units and sampling locations, and placing analytical laboratory contracts and other associated subcontracts.

The schedule for the FS will depend on the outcomes of the RI. A schedule for the FS will be developed at the end of the RI activities.

A.2 Quality Assurance Project Plan

The QAPjP establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis. The work performed under this QAPjP is conducted in accordance with the following:

- *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD) (DOE-RL 2007)
- DOE O 414.1C, "Quality Assurance"
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5 (EPA 2001).

Sections 6.5 and 7.8 of the Hanford Federal Facility Agreement and Consent Order Action Plan (Ecology et al. 1989) require that quality assurance (QA)/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal units, as well as past practice processes. Therefore, this QAPjP follows the QA elements of QA/R-5 (EPA 2001), and demonstrates conformance to Part B requirements of American National Standards Institute/American Society for Quality (ANSI/ASQ) Standard E4-2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use* (ANSI/ASQ 2004).

In addition to the requirements cited above, the EPA's *Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Manual* (EPA 2005) also was used as a resource for identification of QAPjP elements. Although the UFP-QAPP Manual (EPA 2005) is not imposed by the TPA, it is a valuable resource and provides a comprehensive treatment of quality elements that should be addressed in any SAP. The UFP-QAPP Manual also was designed to be compatible with QA/R-5 (EPA 2001), which forms the basis for this QAPjP.

The QAPjP is divided into the following four sections that describe the quality requirements and controls applicable to this investigation:

- **Section A.2.1, Project Management**. This section addresses project management, including the project history and objectives, and the roles and responsibilities of the participants. These elements ensure that the project has defined goals, participants understand the goals and the approaches to be used, and planning outputs are documented.
- **Section A.2.2, Data Generation and Acquisition**. This section addresses aspects of project design and implementation. Implementing these elements ensures that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are used and properly documented.
- **Section A.2.3, Assessment and Oversight**. This section addresses the activities for assessing the effectiveness of the implementation of the project and associated QA/QC activities. The purpose of the assessment is to ensure that the QAPjP is implemented as prescribed.

- **Section A.2.4, Data Validation and Usability**. This section addresses the QA activities occurring after data collection is completed. Implementing these elements ensures that data conform to the specified criteria, thereby achieving the project objectives.

A.2.1 Project Management

The following sections address the basic aspects of project management, ensuring the project has defined goals, the project team understands the goals and the approaches used, and the planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities covered under this SAP.

A.2.1.1 Project and Task Organization

The approved contractor for the 100-OL-1 OU RI is responsible for planning, coordinating, collecting, analyzing field samples and preparing, packaging, and shipping samples to the laboratory, as defined in its contract. The following sections describe the project organization, relative to sampling and characterization, which is also shown graphically in Figure A.9. The project lead maintains a list of individuals or organizations as points of contact for each functional element shown in the figure. For each functional primary contractor role, a corresponding oversight role exists within the DOE.

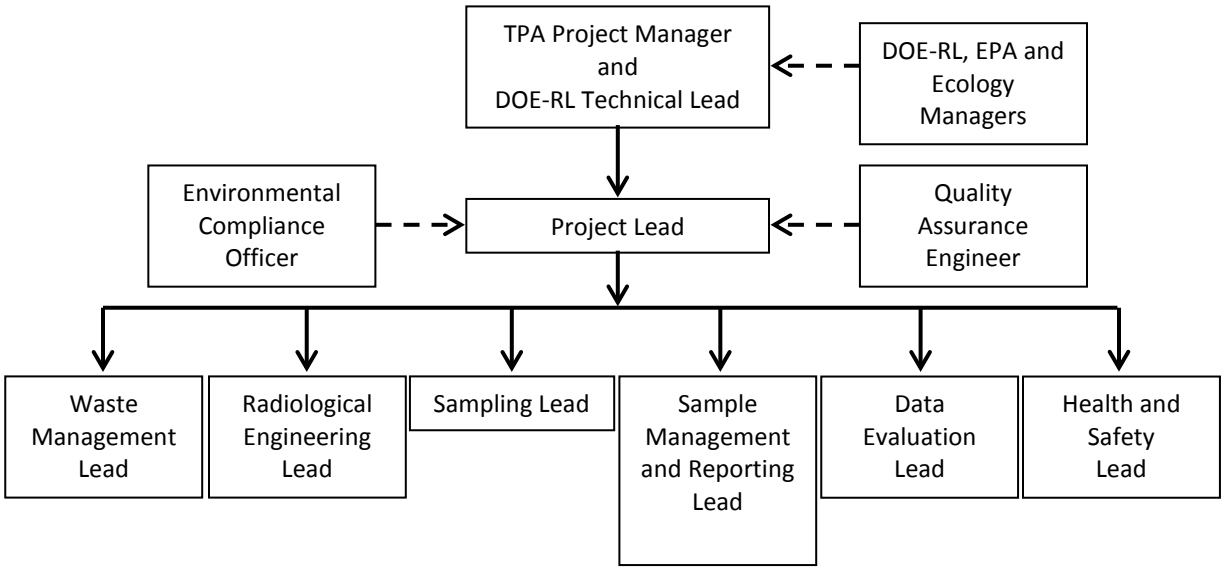

Figure A.9. Project Organization

DOE-RL, EPA and Ecology Project Managers. EPA and Ecology will be the lead organizations for the 100-OL-1 OU (TPA 2012b), working with DOE-RL. Each organization has assigned project managers responsible for overseeing the activities identified in the plan to accomplish the scope of this plans. EPA and Ecology will work with DOE-RL to resolve concerns about the work as described in this SAP in accordance with the TPA (Ecology et al. 1989). The managers will be responsible for the risk management evaluation of the RI characterization results and will determine if there is a need for any additional characterization efforts before proceeding with the FS.

Tri-Party Agreement Project Manager and DOE-RL Technical Lead. The TPA project manager is responsible for:

- Authorizing RI/FS activities for the 100-OL-1 OU
- Obtaining regulatory approval of the work plan and SAP that authorize the RI/FS activities under the TPA (Ecology et al. 1989).

The DOE-RL technical lead is responsible for:

- Overseeing the contractor in performing the work scope
- Working with the contractor and the regulatory agencies to identify and work through issues
- Providing technical input to the TPA project manager.

Project Lead. The project lead is responsible for:

- Planning and implementing work scope
- Managing sampling documents and requirements, field activities, and subcontracted tasks, and ensuring that personnel are working in accordance with the most current job requirements
- Requesting and obtaining permission from the DOE-RL Cultural Resources Program before initiating any field activities, and ensuring that the mitigation actions are incorporated and implemented into the field activities
- Maintaining version control for the SAP.

The project lead will work closely with the quality assurance (QA) engineer, the health and safety lead, and the sampling lead to integrate these and the other lead disciplines in planning and implementing the work scope. The project lead will maintain a list of individuals or organizations that fill each of the functional elements of the project organization (Figure A.9). The project lead will work with the data evaluation lead and the sampling lead after field characterization begins to propose any changes to the SAP to optimize the sampling design. The project lead also will coordinate with DOE-RL and the primary contractor management on sampling activities. The project lead will support DOE-RL in coordinating sampling activities with the regulators, including any revisions to the Work Plan.

Environmental Compliance Officer. The environmental compliance officer will be responsible to the project lead and will be responsible for:

- Providing technical oversight, direction, and acceptance of project and subcontracted environmental work
- Developing appropriate mitigation measures with a goal of minimizing adverse environmental impacts
- Reviewing plans, procedures, and technical documents to ensure that environmental requirements have been addressed
- Identifying environmental issues affecting operations and develops cost-effective solutions
- Responding to environmental/regulatory issues or concerns raised by DOE-RL and/or regulatory agencies.

The environmental compliance officer also may oversee project implementation to ensure compliance with applicable internal and external environmental requirements.

Quality Assurance Engineer. The QA engineer will be responsible to the project lead and will be responsible for QA issues on the project. Responsibilities will include:

- Overseeing implementation of the project QA requirements
- Reviewing project documents, including data needs summary reports, the field sampling plan, and the quality assurance project plan
- Participating in QA assessments on sample collection and analysis activities, as appropriate.

The QA engineer must be independent of the unit generating the data.

Waste Management Lead. The waste management lead will be responsible for:

- Communicating policies and procedures
- Ensuring project compliance with requirements for providing storage, transportation, disposal, and waste tracking in a safe and cost-effective manner
- Identifying waste management sampling and characterization requirements to ensure regulatory compliance
- Interpreting the characterization data to generate waste designations and profiles
- Maintaining other documents that confirm compliance with waste acceptance criteria.

Radiological Engineering Lead. While characterization of the 100-OL-1 OU decision units will not involve analysis of radiological contaminants of concern, areas of the operable unit are in radiological control areas. The radiological engineering lead will be responsible for:

- Providing radiological/health physics support within the project
- Working with the project lead to coordinate with other site contractors and DOE-RL for characterization activities within other operable units
- Conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for work planning
- Identifying radiological hazards and implementing appropriate controls to maintain worker exposures at ALARA levels (e.g., requiring personal protective equipment).

The radiological engineering lead will interface with the project health and safety contact, and will plan and direct radiological control technician support for activities.

Sampling Lead. The sampling lead will have overall responsibility for planning, coordinating, and executing sampling activities. Specific responsibilities will include:

- Converting the sampling design requirements into field task instructions that provide specific direction for field activities
- Implementing any cultural resources mitigation activities

- Directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified
- Communicating with the project lead to identify field constraints or emergent conditions that will affect sampling design and/or execution
- Managing field collection efforts
- Procuring and installing material and equipment needed to support field work
- Preparing data packages based on instructions from the project lead and information contained in this SAP.

The shipping lead will report to the sampling lead for shipment authorization.

Sample Management and Reporting Lead. The sample management and reporting lead will be responsible for:

- Managing and reporting of soil analyses
- Coordinating with laboratory analytical work
- Ensuring that the laboratories conform with Hanford Site internal laboratory QA requirements, or their equivalent, as approved by DOE-RL, EPA, and Ecology
- Entering data into the HEIS
- Arranging for and overseeing data validation of all analyses
- Informing the project lead of any issues reported by the analytical laboratory.

The sample management and reporting organization also will be responsible for conducting the data needs process, or equivalent. Additional related responsibilities will include developing the SAP, including documenting the data needs and the sampling design; preparing associated presentations; resolving technical issues; and preparing revisions to the SAP. Samples collected in the field for shipping and analysis, as well as the resulting data, will be managed in accordance with applicable procedures, and work plans.

Data Evaluation Lead. The data evaluation lead will be responsible for evaluating the results of the field characterization, perform the statistical analyses, and evaluate the data to meet DQOs. The data evaluation lead will work with the project lead and sampling lead on the recommendations and any proposed revisions to the SAP.

Health and Safety Lead. The health and safety lead will be responsible for coordinating industrial safety and health support for the project through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or by internal primary contractor work requirements. The health and safety lead will work with the project lead. In addition, the health and safety lead will assist project personnel in complying with applicable health and safety standards and requirements, particularly for decision units located in other operable units. The health and safety lead will coordinate with the radiological engineering lead to determine personal protective clothing requirements.

Laboratories. The laboratories will analyze samples in accordance with established procedures, provide necessary sample reports, and explain results in support of data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

A.2.1.2 Problem Definition/Background

This SAP describes the sampling and analysis for the characterization of soil in the 100-OL-1 OU. The RI/FS Work Plan provides the specific problems to be solved, background information, and general information. Figure A.1 through Figure A.7 show the areas for sampling within the scope of this SAP. The regulatory drivers and references to agreement documents for the activity are provided in the RI/FS Work Plan.

A.2.1.3 Quality Objectives and Criteria

The QA objective of this plan is to develop implementation guidance for providing data of known and appropriate quality. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. The principal data quality indicators are precision, bias or accuracy, representativeness, comparability, completeness, and sensitivity. These data quality indicators are defined for the purposes of this document in Table A.3. The data quality indicators will be evaluated during the data quality assessment (DQA) process (Section A.2.4.3).

Table A.3. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information	Corrective-Action Examples
Precision	The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated either as the range or as the standard deviation. May also be expressed as a percentage of the mean of the measurements, such as relative range, relative percent difference, or relative standard deviation (coefficient of variation).	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory or have two or more laboratories analyze identical samples with the same method. Split a sample in the field and submit both for sample handling, preservation and storage, and analytical measurements.	Field precision: 2 duplicate samples will be taken at randomly selected locations within each decision unit. Laboratory precision: analysis of laboratory duplicate or matrix spike duplicate samples.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement. • Qualify the data before use.

Table A.3. (contd)

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information	Corrective-Action Examples
		Collect, process, and analyze co-located samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.		
Accuracy	A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of sampling and analytical operations.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample); usually expressed either as percent recovery or as a percent bias.	Laboratory accuracy determination based on matrix spike and matrix spike duplicate results.	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or re-measurement.
Representativeness	A qualitative term expressing "the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition." (ANSI/ASQ 1995)	Evaluate whether measurements are made and physical samples are collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	Samples will be collected as described in the sampling design. Judgment sampling ensures areas most likely to be contaminated, based on current information, will be evaluated.	If results are not representative of the system sampled: • Identify the reason the result is not representative. • Reject the data, or, qualify the data for limited use, and define the portion of the system the data represent. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze.
Comparability	A qualitative term expressing the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.	Compare sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.	Sampling personnel will use the same sampling protocols. Samples will be submitted to the same laboratories when possible (based on laboratory contracts) for analysis using the same methods; thus data results will be comparable.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate.

Table A.3. (contd)

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information	Corrective-Action Examples
				• Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's data needs.	The percent complete will be determined during data validation.	If the data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze, if needed. • Revise sampling/analysis protocols to ensure future comparability.
Sensitivity	The capability of a method or instrument to discriminate among measurement responses representing different levels of the variable of interest.	Determine the minimum concentration or attribute to be measured by a method (method detection limit), by an instrument (instrument detection limit), or by a laboratory (quantitation limit). The practical quantitation limit is the lowest level that can be routinely quantified and reported by a laboratory.	Ensure that sensitivity, as measured by detection limits, is appropriate for the action levels.	If sensitivity does not meet objective: • Request reanalysis or re-measurement. • Qualify/reject the data before use.

Table A.4 presents the laboratory analytical performance requirements for an ICP-MS analysis of soil samples based on site-specific lists for arsenic and lead. Laboratory operations and analytical services will be performed in compliance with Volume 4 of the HASQARD (DOE-RL 2007) and specific criteria

identified in Table A.4. The criteria listed in Table A.4 take precedence over similar criteria in the HASQARD. In consultation with the laboratory, the project lead, and/or sample management and reporting lead can approve changes to analytical methods as long as the method is based upon a nationally recognized (e.g., EPA, American Society for Testing and Materials [ASTM]) method, the new method achieves project DQOs as well as or better than the replaced method, and the new method is required due to the nature of the sample (e.g., high radioactivity).

Table A.4. Laboratory Analytical Performance Requirements for Soil Analyses

CAS	Analyte	Quantitation Limit	Benchmarks for the 100-OL-1 OU[(a)]	Analytical Method (SW-846)[(b)]	Precision Requirements	Accuracy Requirements
7440-38-2	Arsenic	1 mg/kg	Soil Background: 6.47 mg/kg Unrestricted Land Use Soil Cleanup Standard: 20 mg/kg	Method 6010 or 6020	≤30%	70–130%
7439-92-1	Lead	0.5 mg/kg	Soil Background: 10.2 mg/kg Unrestricted Land Use Soil Cleanup Standard: 250 mg/kg	Method 6010 or 6020	≤30%	70–130%

(a) Soil background is the 90th percentile for the Hanford Site (DOE-RL 1993), and the unrestricted land-use soil cleanup standard is the Model Toxics Control Act Method A (WAC 173-340-740).
(b) Analytical methods based on EPA's SW-846, 846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Third Edition; Final Update IV-B.

A.2.1.4 Special Training and Certification

A graded approach is used to ensure workers receive a level of training commensurate with responsibilities, and it complies with applicable DOE Orders and government regulations. The sampling lead, in coordination with line management, will ensure that field personnel meet special training requirements.

Because the 100-OL-1 OU includes decision units that are found in other vadose zone operable units, training requirements for personnel will reflect what is needed to enter and perform sampling activities at these locations. Typical training requirements or qualifications include those imposed by the contract, regulations, DOE Orders, DOE contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers, and Washington Administrative Code (WAC). For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste-site experience

- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Hanford general employee training
- Radiological worker training.

Project-specific safety training, geared specifically to the project and the day's activity, will be provided. Project-specific training requirements include the following:

- Training requirements or qualifications needed by sampling personnel will be in accordance with QA requirements.
- Samplers are required to have training and/or experience with soil sampling being performed in the field.
- The Radiation Protection Program establishes qualification requirements for radiological control technicians. The radiological control technicians assigned to these activities will be qualified through the prescribed training program and will undergo ongoing training and qualification activities.

In addition, pre-job briefings will be performed to evaluate an activity and its hazards by considering many factors, including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety procedures applicable to the job
- Training requirements for individuals assigned to perform the work
- Level of management control
- Proximity of emergency contacts.

Training records are maintained for each individual in an electronic training record database. The contractor training organization maintains the training records system. Line management will confirm an individual employee's training is appropriate and up-to-date before performing any field work.

A.2.1.5 Documents and Records

The project lead is responsible for ensuring the current version of the SAP is being used and for providing updates to field personnel. Version control is maintained through the administrative document control process. Before implementation of field activities, the project lead will obtain permission to

proceed from the DOE-RL Cultural Resources Program, any recommendations from the biological review of the area will be considered, and the project lead will update any part of the SAP necessary to incorporate mitigation actions. DOE-RL and the regulatory agencies will review and approve changes to the sampling plan that affect the data needs. Information pertinent to sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols in the HASQARD (DOE-RL 2007).

The sampling lead is responsible for ensuring the field instructions are maintained up-to-date and aligned with revisions or other approved changes to the SAP. The sampling lead will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook, on nonconformance report forms) in accordance with internal corrective action procedures.

The project lead, sampling lead, or designee, will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities. Table A.5 presents the change control for this project.

Table A.5. Change Control for the 100-OL-1 OU Remedial Investigation

Type of Change	Action	Documentation
By sampling lead: • Relocation of a pre-determined soil sampling location due to cultural resources or presence of soil disturbances (e.g., waste site lay down material) • Location of focused sampling effort around orchard tree stumps	No SAP revision necessary	Field logbooks or operational records
By project lead: • Changes to field sampling plan	Revise SAP; obtain regulatory approval; distribute plan	Revised plan or approved TPA Change Notice

Logbooks are required for field activities. Each logbook must be identified with a unique project name and number. Only authorized persons may make entries in logbooks. Logbooks will be signed by the sampling lead, cognizant scientist/engineer, or other responsible individual. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason.

Logbook entries will be made in indelible ink. Corrections will be made by striking through the erroneous data with a single line of ink, entering the correct data, and initialing and dating the changes.

The project lead is responsible for ensuring the project file is properly maintained. The project file will contain the records or references to their storage locations. The project file will include the following, as appropriate:

- Field logbooks or operational records
- Data forms

- Global positioning system (GPS) data
- Chain-of-custody forms
- Sample receipt records
- Inspection or assessment reports and corrective action reports
- Interim progress reports
- Final reports
- Laboratory data packages
- RI report
- Verification and validation reports.

The laboratory is responsible for maintaining and having available upon request, the following:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information.

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure accuracy and availability of stored records. Records required by the TPA will be managed in accordance with the requirements of the Agreement.

A.2.2 Data Generation and Acquisition

The following sections address data generation and acquisition to ensure the project methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented.

A.2.2.1 Sampling Process Design (Experimental Design)

As discussed previously, the sampling approach uses a probability-based design. Probability-based sampling designs apply sampling theory and involve random selection of the location of the sampling. An important feature of a probability-based sample is that each member of the population from which the sample was selected has a known probability of being selected. Thus, when a probability-based design is used, statistical inferences are made about the sampled population from the data obtained; e.g., comparing the 95th percentile upper confidence limit for lead or arsenic in a decision unit to a benchmark. A random-start, systematic-grid-sampling design will be used to determine the locations within a decision unit. The sampling lead, or designee, may modify the exact location for soil collection to avoid cultural resources or other features not readily observable prior to field activities. Section A.3.5 provides the types, number, and location of samples.

A.2.2.2 Sample Handling and Custody

A sampling and data tracking database is used to track the samples from the point of collection through laboratory analysis process. Laboratory analytical results are entered and maintained in the HEIS. The HEIS sample numbers are issued to the sampling organization for the project. Each sample is identified and labeled with a unique HEIS sample number.

Section A.3.7 provides the following specific sample handling information:

- Sample packaging
- Container labeling
- Sample custody requirements
- Sample transportation.

Sample custody during laboratory analysis is addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Storage of samples at the laboratory will be consistent with laboratory instructions prepared by sample management and reporting lead.

A.2.2.3 Analytical Methods

Table A.4 provides information about analytical methods. These methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor participates in overseeing the offsite analytical laboratories to qualify them for performing Hanford Site analytical work.

If the laboratory uses a nonstandard or unapproved method, then the laboratory must provide method validation data to confirm the method is adequate for the intended use of the data. This includes information such as determination of detection limits, quantitation limits, typical recoveries, and analytical precision and bias. In consultation with the laboratory, the project lead, and/or sample management and reporting lead can approve changes to analytical methods as long as the method is based upon a nationally recognized (e.g., EPA, ASTM) method, the new method achieves project DQOs as well as or better than the replaced method, and the new method is required due to the nature of the sample (e.g., high radioactivity).

Laboratories providing analytical services in support of this SAP will have in place a corrective action program addressing analytical system failures and documenting the effectiveness of corrective actions. Issues affecting analytical results are to be resolved by the sample management and reporting lead in coordination with the project lead.

A.2.2.4 Quality Control

QC procedures must be followed in the field and laboratory to ensure reliable data are obtained (DOE-RL 2007, Volume 2). Field personnel will collect QC samples to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of two field duplicates per decision unit and one equipment rinsate blank per

decision unit. A field duplicate is defined as a sample that is collected and homogenized before being divided into two samples in the field (DOE-RL 2007, Volume 2). Equipment blanks are samples of reagent water passed through decontaminated sampling equipment prior to use of the equipment in the field (DOE-RL 2007, Volume 2). Field trip blanks and transfer blanks will not be needed because all containers and transfer equipment will be pre-cleaned. The QC samples and frequency are listed in Table A.6.

Table A.6. Definitions, Requirements, and Frequency for Field and Laboratory Quality Control Samples

QC Sample	Definition/Purpose	Frequency
Equipment Rinsate Blank	Verify adequacy of sampling equipment decontamination	1 sample per decision unit
Field Duplicates	Estimate precision, including sampling and analytical variability	2 samples per decision unit
Method or Procedural Blank (MB)	A combination of solvents, surrogates, and all reagents used during sample processing, processed concurrently with the field samples. Monitors purity of reagents and laboratory contamination.	1 per 20 batch[(a)] All analytes
Standard Reference Material (SRM)	An external reference sample that contains a certified level of target analytes; serves as a monitor of accuracy. Extracted and analyzed with samples of a like matrix.	1 per sample batch[(a)]
Matrix Spike (MS)	A field sample spiked with the analytes of interest is processed concurrently with the field samples; monitors effectiveness of method on sample matrix; performed in duplicate for sediments. An MS must be processed for each distinct matrix.	1 per sample batch[(a)]
Duplicate Sample	Second aliquot of a field sample processed and analyzed to monitor precision; each sample set should contain a duplicate.	1 per sample batch[(a)]

(a) A batch is defined as 20 field samples or fewer processed simultaneously and sharing the same QC samples.

Field assessment sampling as outlined in this plan is designed to assess sampling reproducibility. If sampling requirements cannot be met due to sampling or measurement system failure, field conditions, or other factors that cannot be controlled, corrective actions will be discussed with the sampling lead, project lead, QA engineer, and DOE-RL technical lead. A corrective action will be agreed upon based on the critical/non-critical nature of the parameter, documented in the field log, and the action will be communicated to the sampling team. In general, if critical measurements or samples cannot be collected, then sampling will be re-scheduled. If a non-critical measurement or sample cannot be collected, then the deviation will be documented. The QA engineer will review corrective actions to assess their effectiveness. Any deviations from the SAP will be documented.

The study design and QC samples are intended to help assess the major components of total study error, which facilitates the final evaluation of whether environmental data are of sufficient quality to support the related decisions. The QC sample requirements are designed to provide measurement error

information that can be used to initiate corrective actions with the goal of limiting the total measurement error. Measurement quality objectives for the analyses can be expressed in terms of accuracy, precision, completeness, and sensitivity goals. Accuracy and precision are monitored through the analysis of QC samples. Table A.7 defines the required accuracy and precision for QC samples, along with corrective actions that must be implemented when QC criteria are not met.

Table A.7. Measurement Quality Criteria

QC Parameter	Acceptance Criteria	Corrective Action
Accuracy: • *Method Blank (MB)*	MB undetected or MB<MDL If MB>MDL and <RL, then perform corrective action	Review data and analysis for possible sources of contamination. Reanalyze and/or document corrective action.
	If MB>MDL and >RL; sample values >10X MB, then perform corrective action	Review data and analysis for possible sources of contamination. Reanalyze and/or document corrective action. Data must be flagged.
	If MB>MDL and >RL; sample values ≤10X MB, then perform corrective action	Perform corrective action as above and re-process (extract, digest) sample batch. If batch cannot be re-processed, notify client and flag data.
• *Standard Reference Material (SRM)*	Metals: ≤20% PD (percent difference). Determined vs. certified range.	Review data to assess impact of matrix. Reanalyze sample and/or document corrective action. If other QC data are acceptable then flag associated data if sample is not reanalyzed.
• *Matrix Spike (MS)/ MS Duplicate (MSD)*	Metals: 70−130% recovery	Review data to assess impact of matrix. If other QC data are acceptable and no spiking error occurred, then flag associated data. If QC data are not affected by matrix failure or spiking errors occurred, then re-process MS. If not possible, then notify client and flag associated data.
• *Laboratory Control Sample (LCS)*	Metals: 70−130% recovery	Perform corrective action. Re-analyze and/or re-process sample batch. Batch data associated with failed LCS (LCS data outside control limits) cannot be reported. If batch cannot be re-processed, notify client, flag data, discuss impact in report narrative.
Precision: • *Laboratory Duplicates*	Metals: ≥30% RPD (relative percent difference)	Review data to assess impact of matrix. If other QC data are acceptable, then flag associated data. If QC data are not affected by matrix failure, then re-process duplicate. If not possible, then notify client and flag associated data.

Table A.8 provides formulas for the calculation of QC sample assessment statistics. All QC sample failures and associated corrective actions will be documented. If data must be reported with failing QC results, then data qualifiers will be assigned to the QC sample data. Table A.9 defines project data qualifiers.

Table A.8. Calculation of Quality Control Assessment Statistics

Percent Recovery

The percent recovery is a measurement of accuracy, where one value is compared with a known/certified value. The formula for calculating this value is:

$$Percent\ Recovery = \frac{amount\ detected}{amount\ expected} \times 100$$

Percent Difference

The percent difference (PD) is a measurement of precision as an indication of how a measured value is difference from a "real" value. It is used when one value is known or certified, and the other is measured. The formula for calculating PD is:

$$Percent\ Difference = \frac{X_2 - X_1}{X_1} \times 100$$

where X_1 is the known value (e.g., SRM certified value) and X_2 is the determined value (e.g., SRM concentration determined by analyst).

Relative Percent Difference

The relative percent difference (RPD) is a measurement of ***precision***; it is a comparison of two similar samples (matrix spike/matrix spike duplicate pair, field sample duplicates). The formula for calculating RPD is:

$$RPD = \left| \frac{2 \times (X_1 - X_2)}{(X_1 + X_2)} \right| \times 100$$

where X_1 is the concentration or percent recovery in sample 1 and X_2 is the concentration or percent recovery in sample 2.

Note: Report the absolute value of the result – the RPD is always positive.

Relative Standard Deviation

The relative standard deviation (RSD) is a measurement of ***precision***; it is a comparison of three or more similar samples (e.g., field sample triplicates, initial calibration, MDLs). The formula for calculating RSD is:

$$\%RSD = \frac{Standard\ Deviation\ of\ all\ Samples}{Average\ of\ all\ Samples} \times 100$$

Table A.9. Project Data Qualifiers

Method Qualifiers	
NR	Method qualifier − Analyte was not required
P	Method qualifier – ICP
Data Qualifiers	
B	Analyte found in both sample and associated blank. The "B" will be reported on the result associated with the field samples, not the blank
J	Estimated concentration between the MDL and RL
U	The concentration is less than the MDL, or the analyte was not detected; the MDL value with a U flag is reported
W	Post-digestion matrix or blank spike out of control limits
Quality Control Qualifiers	
N	Spiked sample recovery not within control limits
&	Accuracy result not within control limits (outside recovery of SRM)
*	Precision result not within control limits

A.2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

Equipment used for collection, measurement, and testing should meet the applicable standards (e.g., ASTM standards) or have been evaluated as acceptable and valid in accordance with the procedures, requirements, and specifications. The sampling lead or equivalent will ensure that the data generated with computer software systems are backed up and/or downloaded on a regular basis. Software configuration will be acceptance tested before use in the field.

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (such as documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with three- and four-digit EPA methods (EPA 1983, 1994, 2007), or consistent with auditable Hanford Site and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

A.2.2.6 Instrument and Equipment Calibration and Frequency

Section A.3.4 provides specific field equipment calibration information. Analytical laboratory instruments and equipment are calibrated in accordance with the laboratory's QA plan.

A.2.2.7 Inspection and Acceptance of Supplies and Consumables

Supplies and consumables used in support of sampling and analysis activities will be procured in accordance with internal work requirements and processes described in the contractor acquisition system.

Responsibilities and interfaces necessary to ensure items are procured and/or acquired for the contractor must be in place and meet specific technical and quality requirements. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables will be checked and accepted by users before use. Supplies and consumables procured by the analytical laboratories will be purchased, checked, and used in accordance with the laboratories' QA plans.

A.2.2.8 Non-Direct Measurements

Non-direct measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. Non-direct measurements will not be evaluated as part of the work within the scope of this SAP.

A.2.2.9 Data Management

The sample management and reporting lead, in coordination with the project lead, is responsible for ensuring analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management procedures. Electronic data access, when appropriate, will be via a database (e.g., HEIS, a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Hanford Federal Facility Agreement and Consent Order Action Plan (Ecology et al. 1989).

Laboratory errors will be reported to sample management and reporting routinely. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with contractor procedures. This process is used to document analytical errors and to establish resolution with the project lead. The sample issue resolution forms become a permanent part of the analytical data package for future reference and for records management.

Planning for sample collection and analysis will be in accordance with the programmatic requirements governing fixed-laboratory sample collection activities, as discussed in sampling procedures. In the event specific procedures do not exist for a particular work evolution, or it is determined additional guidance is needed to complete certain tasks, a work package will be developed to adequately control the activities, as appropriate. Examples of the sampling procedure requirements include activities associated with the following:

- Chain-of-custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks
- Checklists
- Sample packaging and shipping.

When this SAP is implemented, approved work control packages and procedures will be used to document field activities, including radiological and nonradiological measurements. Field activities will be recorded in the field logbook.

A.2.3 Assessment and Oversight

Assessment and oversight address the activities for assessing the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A.2.3.1 Assessments and Response Actions

Contractor management, quality, and/or health and safety organizations may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, procedures, and regulatory requirements. Section A.2.4 discusses the only planned assessment, a DQA, for the activities identified in this SAP. The results of the DQA will be provided to the project lead.

If circumstances arise in the field dictating the need for additional assessment activities, then additional assessment activities will be performed. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain will coordinate the corrective actions and/or deficiencies in accordance with the contractor QA program, the corrective action management program, and associated procedures that implement these programs.

Oversight activities in the analytical laboratories, including corrective action management, will be conducted in accordance with the laboratories' QA plans. The contractor will oversee offsite analytical laboratories and qualify the laboratories for performing Hanford Site analytical work.

A.2.3.2 Reports to Management

Data quality issues will be reported to the project lead. Issues reported by the laboratories will be communicated to the sample management and reporting lead, which will initiate a sample issue resolution in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the project lead.

At the end of the project, a DQA report will be prepared to determine whether the type, quality, and quantity of collected data met the quality objectives described in this SAP.

A.2.4 Data Validation and Usability

The elements under data validation and usability address the QA activities occurring after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thereby satisfying the project objectives.

A.2.4.1 Data Review, Verification, and Validation

The criteria for verification include, but are not limited to, review for completeness (samples were analyzed as requested), use of the correct analytical method or procedure, transcription errors, correct application of dilution factors, appropriate reporting of units (e.g., dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

Validation activities will be based on EPA functional guidelines and the HASQARD (DOE-RL 2007). Data validation may be performed by the sample management and reporting organization and/or by a party independent of both the data collector and the data user. Data validation qualifiers must be compatible with the HEIS database.

Data validation will be performed to ensure that the data quality goals established during the planning phase have been achieved. Data validation will be performed in accordance with internal procedures. The criteria for data validation are based on a graded approach. Five levels of validation have been defined, Level A through Level E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of data (e.g., calibration data; calculations of representative samples from the data set). Validation will be performed to Level C, which is a review of the QC data. Level C validation specifically requires verification of deliverables; requested versus reported analyses; and qualification of the results based on analytical holding times, method blank results, matrix spike/matrix spike duplicate results, surrogate spike recoveries, and duplicate sample results. Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. For this QAPjP, analyte group refers to categories such as lead or arsenic. The goal is to cover the various analyte groups and matrices during the validation.

When outliers or questionable results are identified, the data associated with these outlines and questionable data will be validated and additional data validation will be performed. This data validation will consist of selecting up to an additional 5 percent of the data for the analytical method for which statistical outliers and/or questionable data were found during the initial round of data validation. The additional validation will begin with Level C and may increase to Levels D and E, as needed, to ensure that data are usable. Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the data set. Data validation will be documented in data validation reports. An example of questionable data is the positive detections are greater than the practical quantitation limit or reporting limit in soil/aquifer sediment from a site that should not have exhibited contamination. Similarly, results below background would not be expected and could trigger a validation inquiry. Data validation will be documented in data validation reports, which will be included in the project file.

Relative to analytical data in sample media, physical data and/or field screening results are of less importance in making inferences of risk. Field QA/QC data will be reviewed to ensure that physical property data and/or field screening results are usable.

A.2.4.2 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine whether quantitative data are of the correct type and are of adequate quality and quantity

to meet the project data needs. The results of the DQA will be used in interpreting the data and determining whether the objectives of this activity have been met. The DQA will be in accordance with EPA's *Data Quality Assessment: A Reviewer's Guide*, and *Data Quality Assessment: Statistical Methods for Practitioners* (EPA 2006a, b).

A.2.4.3 Corrective Actions

The responses to data quality defects identified through the DQA process will vary and may be data- or measurement-specific. Some pre-identified corrective actions are identified in Table A.3 and Table A.7.

A.3 Field Sampling Plan

The following sections provide additional details regarding field-specific sample and data collection requirements.

A.3.1 Site Background and Objectives

Site background information is contained in the RI/FS Work Plan. The area of land potentially contaminated by lead arsenic pesticide use is 20 km^2 (5000 ac), and it is identified as the 100-OL-1 OU (TPA 2012a). Sections A.1.2 through A.1.5 of this SAP discuss the overall approach for field characterization of decision units identified in the 100-OL-1 OU. Section A.1.6 provides guidance for developing the schedule. FSP uses the sampling design identified during the systematic planning process and presents the design to identify sampling locations, the total number of samples to be collected, and analyses to be performed.

A.3.2 Documentation of Field Activities

Logbooks or data forms are required for field activities (Section A.2.1.5 provides logbook requirements). Data forms may be used to collect field information. However, the data forms must be referenced in the logbooks and must follow the same requirements as those for logbooks presented below. The following is a summary of information to be recorded in logbooks:

- Purpose of the activity
- Day, date, time, weather conditions
- Names, titles, organizations of personnel present
- Deviations from the QAPjP or procedures
- All site activities or other relevant observations
- Details of samples collected (primary, splits, duplicates, blanks)
- Location (GPS coordinates) and types of samples
- Chain-of-custody details and variances relating to the chain of custody
- Field measurements

- Field surveys and equipment identification numbers, as applicable
- Equipment decontaminated, number of decontaminations, and variations to any decontamination procedures
- Equipment failures or breakdowns and descriptions of corrective actions
- Phone calls relating to field activities.

All field logbook and field sampling forms will be completed using indelible ink. Data recording and documentation errors will be corrected as follows: 1) draw a single line through the error, 2) make the correction, and 3) initial, date, and provide justification for the error correction.

A.3.3 Sampling Design

Characterization of the 100-OL-1 OU decision units uses a probability-based sampling design. Sections A.1.5 and A.2.2.1 of this SAP describes the sampling design.

A.3.4 Instrumentation/Equipment Testing, Inspection, and Maintenance

The sampling lead is responsible for ensuring that field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions and/or internal work requirements that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from instrument calibration activities are recorded in the field logbooks. Hard-copy or electronic versions are acceptable.

Calibrations must be performed as follows:

- Before initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or procedure, or as required by regulations
- Upon failure to meet specified QC criteria.

Daily calibration checks will be performed and documented for each instrument used to characterize areas under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.

The GPS manual or standard operating procedures must be available in the field. Any problems with the operation of GPS must be documented, along with corrective action and the results of performance verification.

The sampling lead is also responsible for ensuring that laboratory equipment to support field characterization is calibrated appropriately. All analytical instruments and equipment will be maintained according to standard operating procedures and the manufacturers' instructions. Equipment and instrument and maintenance and frequency are defined in standard operating procedures and are summarized in Table A.10. All routine maintenance and non-routine repairs are to be documented in a bound logbook. The information recorded should include analyst initials, date maintenance was

performed, a description of the maintenance activity, and (if the maintenance was performed in response to a specific instrument performance problem) the result of re-testing to demonstrate that the instrument performance had been returned to acceptable standards prior to re-use. The return to analytical control will be demonstrated by successful calibration. ICP-MS analyses are to be performed by a contractor, and that organization will be responsible for following all contractual requirements associated with testing, maintenance, and inspection.

Table A.10. Maintenance Procedures for General Laboratory and Equipment and Analytical Instruments

Equipment	Activity	Frequency
Deionized water system	Replace seals. Replace cartridges.	As needed for leaks and to maintain resistivity >18 mOhms
MilliQ® deionized water system	Replace seals. Replace cartridges.	Every 6 months or as needed for leaks and to maintain resistivity >18 mOhms
Electronic balances	Clean	As needed
Freezers/refrigerators	Clean Defrost	As needed As needed
Ovens	Clean	As needed
Glass thermometers	Store in protective case.	Always except when in use
Digital thermometer	Avoid bending thermocouples.	Always

A.3.5 Characterization of Representative Decision Units

Decision units representing several of the decision unit categories (Table A.2) will be characterized. There will be 26 samples collected in each decision unit. Two randomly selected samples will be designated as field duplicates, and the sample will be homogenized and split in the field prior to laboratory analysis.

Soil sampling will be conducted at all the locations identified by using a visual sample planning tool using the random-start, systematic-grid-sampling option. Areas designated as WIDS sites from the sample location will be excluded from the random-start, systematic-grid-sampling. Coordinates of all sampling locations will be used by the sampling lead to collect soil samples. However, the sampling lead, or designee, can relocate the position for sampling just beyond any area that is not representative of the soil profile in the decision unit (e.g., a disturbed area next to a waste site, or a laydown area) or if cultural or biological resources are found at the location. The sampling location may be moved anywhere within a 2-m (79-in.) radius of the target sampling location without documentation of a deviation. Change in the sampling location beyond 2-m (79-in.) requires documentation of the deviation.

A.3.6 Sampling Methods

Soil sampling will be performed in accordance with approved procedures for soil sampling using a coring device. The sample diameter should be between 1 and 2 cm, or of sufficient size to collect 40 g (0.09 lb) of soil over the 30-cm (12-in.) sampling interval. At the sampling location, any plant or non-soil material on the surface will be scraped away prior to sampling to ensure that only soil is collected. Site personnel will not overdrive the sampling device, and the use of a coring device with a preset foot pedal

above the core-tip is recommended. The entire soil column from the coring device will be transferred to a sample container. For field duplicates, soil will be transferred to a pre-cleaned, mixing bowl or other suitable pre-cleaned container, homogenized, then containerized in accordance with the sampling procedure.

Some sampling attempts may result in collection of an incomplete core. This could be caused by hitting an obstruction (e.g., rock), soil falling out of the coring tool during extraction, or by other reasons. If this occurs, the remaining sample will be discarded and a new sample collected within a 2-m radius of the target sampling location. If four unsuccessful sample attempts are made at a single location, the sampling team will move on to the next site and document the unsuccessful attempt. If attempts in areas with significant cobble are encountered and collection of soil with the coring tool is not possible, then a shovel may be used to collect a vertical soil sample down to a depth of 30 cm (12 in.). The use of a shovel will likely bias the results compared to samples collected with a coring device, thus, the use of a shovel should be minimized as much as possible. The sampling and project leads will determine what modifications are necessary to the sampling approach in order to return and successfully collect a sample from that location.

A.3.6.1 Corrective Actions and Deviations for Sampling Activities

Either the project lead, sampling lead, or designee must document deviations from procedures or other problems pertaining to sample collection, chain of custody, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of cultural resources, or physical obstructions. The exception to this is minor changes in sampling location. The GPS accuracy will be on the order of 1 to 2 m. Samples may be collected anywhere within a 2-m radius of the target location without documentation of a deviation. This may be done to avoid vegetation, animal dens, or other non-representative soil (e.g., laydown material).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action procedures. The project lead, sampling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

More significant changes in sample locations not affecting the data needs will require notification and approval of the project lead. Changes to sample locations resulting in impacts to meeting the data needs will require concurrence from DOE-RL and regulator project leads. Changes to the SAP will be documented as noted in Section A.2.1.5.

A.3.6.2 Decontamination of Sampling Equipment

Field personnel will wear Nitrile® gloves during sample collection activities, and they will change gloves between sample locations. Surface soil cross-contamination will be avoided by cleaning equipment thoroughly between sampling stations (or using pre-cleaned equipment), and collecting only sample material that is not in direct contact with sample collection equipment. The stainless steel coring device will be scrubbed with a stiff brush and thoroughly rinsed with deionized water at the beginning of each day. Decontamination of the coring device between samples will consist of scrubbing with a stiff brush and wiping the tool with clean disposable wipes. Utensils, such as stainless steel spoons or spatulas

used to collect soil from the samplers, will be pre-cleaned (soap/water washed, rinsed three times using deionized water, air dried, and methylene-chloride-rinsed), and packaged in Ziploc bags prior to use in the field each day. Equipment blanks will not be collected as part of this study, because soil used for chemical analysis will contact only pre-cleaned surfaces.

A.3.7 Sample Handling

Sample handling, including sample packaging, container labeling, sample custody, and sample transportation, is discussed in this section.

A.3.7.1 Sample Packaging

Level I EPA pre-cleaned sample containers will be used for soil samples collected for laboratory analyses. Each sample will be placed in a wide-mouth, pre-cleaned glass bottle. All samples will be cooled to 4°C ± 2°C (39°F ± 4°F) within 24 hours of sample collection. The holding time for lead and arsenic analyzed by EPA Method 6010/6020 (EPA 2007) is six months at 4°C ± 2°C (39°F ± 4°F).

Some of the decision units in the 100-OL-1 OU may be in radiological areas (e.g., in 100-FR-2, 100-HR-1, 100-HR-2 or 100-KR-1 vadose zone operable units). The radiological engineering lead will measure the contamination levels and dose rates associated with the sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received at offsite locations or by the analytical laboratory in accordance with those facilities' acceptance criteria. If the dose rate on the outside of a sample container exceeds levels deemed acceptable by an offsite laboratory, the sampling lead, in consultation with the sample management and reporting lead, can send smaller volumes to the laboratory.

A.3.7.2 Container Labeling

The sample location (decision unit and GPS coordinates), depth, and corresponding HEIS numbers will be documented in the sampler's field logbook. Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- HEIS number
- Sample collection date and time
- Analysis required
- Sampling authorization form number
- Field data (e.g., soil moisture, radiological readings).

A custody seal (e.g., evidence tape) will be affixed to the lid of each sample container. The custody seal will be inscribed with the sampler's initials and the date. Custody seals and any other required labels/documentation can be affixed to the exterior of a sample container holding vials in such a manner as to detect potential tampering.

A.3.7.3 Sample Custody

Sample custody will be maintained in accordance with existing Hanford Site protocols to maintain sample integrity throughout the analytical process. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Sample shipping containers will be prepared according to the necessary shipping requirements for transport of the samples. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to the sample management and reporting organization within 48 hours of shipping.

The following information is required on a completed chain-of-custody form:

- Project name
- Signature of sampler
- HEIS number
- Date and time of collection
- Matrix
- Preservation requirements
- Signatures of individual involved in sample transfer
- Requested analyses.

A.3.7.4 Sample Transportation

Sample transportation will be performed in compliance with the applicable regulations for packaging, marking, labeling, and shipping hazardous materials, hazardous substances, and hazardous waste mandated by the U.S. Department of Transportation (49 CFR 171-177) in association with the International Air Transportation Authority, DOE requirements, and applicable program-specific implementing procedures.

A.3.8 Management of Waste

All investigation-derived waste will be handled in accordance with contractor waste management procedures and applicable Hanford Site requirements. Expected waste streams may include the following:

- Miscellaneous solid waste such as wipes, gloves, and other personal protective equipment
- Decontamination solutions.

Miscellaneous solid waste that has contacted potentially contaminated soil will be segregated from other materials and will be transported offsite for disposal based on a waste designation in accordance

with contractor waste management procedures. Waste will be designated in accordance with WAC 173-303, "Dangerous Waste Regulations," using a combination of process knowledge, historical analytical data, and analyses of samples collected from the site.

All generated decontamination water will be handled in accordance with Hanford Site requirements.

Waste generated by samples shipped offsite for laboratory analysis will be managed in accordance with contract specifications. Pursuant to 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," approval from the CERCLA lead agency Remedial Project Manager is required before returning unused samples or waste from offsite laboratories.

A.4 Health and Safety Plan

The Site-Specific HASP in the following landscaped pages addresses: the project site and historical disposal practices; key personnel, job title, and training/site entry requirements; waste types, waste characteristics, and hazard concerns; the health and safety checklist; personal protective equipment; decontamination and emergency procedures. Attachment A is a map of the site and 100-OL-1 OU decision units. Attachment B is a list of emergency contacts for the area. An Approval Page is also provided such that staff can sign indicating they have read and understand the HASP.

SITE SPECIFIC HEALTH AND SAFETY PLAN

Project Name/Description:

Soil Sampling on Former Orchards (100-OL-1 Operable Unit), Hanford Site, Washington

This site-specific Health and Safety Plan (HASP) covers soil sampling conducted in support of for the Remedial Investigation of 100-OL-1 Operable Unit (OU). The OU is located on the Hanford Site in Benton Country, Washington. The primary objective of this work scope is to collect soil samples that are representative of the OU in order to compare them against benchmark concentrations.

This HASP addresses the hazards and countermeasures used to perform the sampling activities involved in this project.

Location: Hanford Site, Washington	Facility Name/Number: 100-OL-1 Operable Unit

Objective of Project:

[ ] ERA	[ ] Drum Sampling	[ ] Drilling
[X] RIFS Characterization	[X] Sampling	[ ] UST Removal
[ ] RCRA	[ ] Soil Removal	[ ] Treatability Test
[ ] Scoping Study	[ ] Soil-Gas Sampling	[ ] Well Injection
[ ] Reconnaissance	[ ] Remediation	[ ] Well Monitoring
[ ] Spill Response	[ ] GW Sample	

Site Description/History/Disposal Practices:

The 100-OL-1 OU boundaries are around former orchards where fruit was grown prior to 1943. Lead arsenate residue is the contaminant of concern for this work. Lead arsenate was sprayed as a pesticide on fruit trees for the control of codling moths. The use of lead arsenate began in the late 1890s and continued through 1943. Because the pesticide was sprayed in the air as a mist or fine powder, the contamination ended up on the surface of the soil. The limited mobility of lead arsenate resulted in most of the contamination being present in the top meter of the soil column. For this work, samples down to 30 cm (12 in.). Samples will be collected with a coring tool or, if necessary, a shovel.

SITE SPECIFIC HEALTH AND SAFETY PLAN

KEY PERSONNEL, JOB TITLE, AND TRAINING/SITE ENTRY REQUIREMENTS

Job Title and/or Name	Training Requirements	Misc. Information
Sampling lead	A, B. C, G, Q.	
Technical Field Support	A, B. C, G, Q.	
Visitors	G, Q - Visitors will be allowed provided they have previously made arrangements with the sampling lead to visit the site.	

NOTE: Sampling lead, or designee, will conduct Hanford Site orientation. 100-OL-1 OU decision units that reside within other vadose zone OUs (e.g., 100-KR-1, 100-HR-1, 100-HR-2, 100-FR-2) may require additional safety orientation and safety briefings.

List the letter(s) of training requirements (classes) required for individuals(s) named above.

A.	40 Hr Haz. Waste Operations	G.	Site Orientation	M.	Bioassay
B.	8/24 Haz. Waste Operations	H.	SCBA	N.	Whole Body Count
C.	Rad. Worker Training	I.	First Aid/CPR	O.	Chest Count
D.	1 Day OJT	J.	Noise Control	P.	Asbestos Worker
E.	8 Hr Supervisor	K.	Mask Fit	Q.	Read Safety Plan
F.	8 Hr Refresher	L.	Haz. Waste Worker Medical Exam	R.	Escorted

SITE SPECIFIC HEALTH AND SAFETY PLAN

WASTE TYPES, WASTE CHARACTERISTICS, AND HAZARD CONCERNS

Waste Types: ☐ Liquid ☒ Solid ☐ Gas ☐ Unknown ☐ Other Specify:

Waste Characteristics:

- ☐ Chemical
- ☐ Corrosive
- ☐ Toxic
- ☒ Inert
- ☐ Biological
- ☐ Flammable
- ☐ Volatile
- ☐ Reactive
- ☐ Radiological (Per RPT direction)
- ☐ Unknown
- ☐ Other:
- ☐

Hazards of Concern:

- ☒ Temperature Extremes
- ☐ Fire Hazards
- ☐ Unusual Conditions
- ☒ Remote Work Area
- ☐ Hazard Communications
- ☒ Pinch Points
- ☐ Overhead Hazards
- ☐ Noise
- ☐ Electrical
- ☐ Lifting
- ☐ Sanitation
- ☐ Fall Protection
- ☒ Biological (snakes, wasps, etc.)
- ☒ Walking/Working Surfaces
- ☐ Compressed Air
- ☐ Off-road Vehicle Use
- ☐ Radioactive Sources/RGDs
- ☒ Adverse Weather conditions
- ☐ Non-Ionizing radiation

OVERALL HAZARD CLASSIFICATION: ☐ **High** ☐ **Medium** ☒ **Low** ☐ **Negligible** ☐ **Unknown**

JUSTIFICATION: The hazards are typical of basic field work. While there is slight soil contamination, the only pathway of concern is ingestion. PPE and hand washing will mitigate this risk.

SITE SPECIFIC HEALTH AND SAFETY PLAN

CHECKLIST

WALKING/WORKING SURFACES	LIFTING	ADVERSE WEATHER CONDITIONS
Carry out daily housekeeping efforts. Wear boots or sturdy, closed-toed, above the ankle shoes. Keep walkways/work areas clear. Designate walkways/routes where appropriate. Flag or post problem areas where necessary. Keep tools in proper storage area.	In general, keep equipment under 6.8 kg (15 lb) Lift with legs. Use proper lifting techniques. Use buddy system for awkward/heavy loads. Use mechanical lifting devices as appropriate. Determine the weight of the object(s) • >20 kg (44 lb) consider >1 person for lift or use lifting device • <20 kg (44 lb), 1 person should be able to lift. Consider >1 person for lift or lifting device if: ▪ Awkward lift ▪ Repetitive lift ▪ Employee lifting has previous injury/illness that could be aggravated • When lifting: ▪ Keep objects close to your body. ▪ Do not twist while lifting. ▪ Lift with legs and not your back. ▪ Use caution when lifting over your head. ▪ Minimize repetitive lifts. Workers with previous injuries/illness, contact Worker Safety & Health Representative	Severe thunderstorms/lightning. Avoid doing field work when thunder showers are expected. If a storm is approaching, drive to nearest large enclosed building. If caught out in open when a thunder shower occurs, take shelter in vehicles with windows rolled up. http://www.lightningsafety.noaa.gov/outdoors.htm Avoid doing work when the temperature is below 0°C (32°F).
PINCH POINTS	**BIOLOGICAL**	**REMOTE WORK AREA**
Brief site personnel on the location of potential pinch points. Wear gloves. Plan ahead to avoid pinch points when handling/moving equipment and materials. Think about the consequences of your actions prior to moving heavy objects.	Control rodent intrusion and harborage. Be cognizant of poisonous reptiles and insect. Pay attention to the environment and observe these guidelines concerning biological hazards: • Be aware of your surroundings. • Avoid blind reaching. • Be able to recognize potential pests. • Wear leather boots. • Wear leather gloves (as necessary). • Use insect repellant (as necessary). • Be prepared to provide first aid. • Know the signs of anaphylaxis. • Watch for and report all contact with dangerous or poisonous animals.	Know your location. Ensure communication is available − phone/radio. Ensure first-aid kit and trained personnel are available. Know emergency numbers. Use buddy system when required by supervision

TEMPERATURE EXTREMES Monitor work periodically. Adjust work/rest regimen according to wet bulb globe temperature (WBGT). Minimize/maximize clothing where possible. Drink cool/warm liquids as appropriate. Discuss signs/symptoms of cold/heat stress. NOTE: Temperature extremes are related to seasonal climatic changes. Any introduced temperature extremes require Health and Safety Lead, Project Lead, or designee evaluation and approval. Hypothermia, or severe decrease in body temperature, must be guarded against if work at the site takes place during temperatures below 18°C (65°F). Wear appropriate clothing. Wear several layers of loose clothing. Layering provides better insulation. Tight clothing reduces blood circulation. Warm blood needs to be circulated to the extremities. When choosing clothing, be aware that some clothing may restrict movement resulting in a hazardous situation. Make sure to protect the ears, face, hands, and feet in extremely cold weather. Boots should be waterproof and insulated. Wear a hat; it will keep your whole body warmer. (Hats reduce the amount of body heat that escapes from your head.) Move into warm locations during work breaks; limit the amount of time outside on extremely cold days. Carry cold weather gear, such as extra socks, gloves, hats, jacket, blankets, a change of clothes and a thermos of hot liquid. Include a thermometer and chemical hot packs in your first-aid kit. Avoid touching cold metal surfaces with bare skin. Monitor your physical condition and that of your coworkers.	**TEMPERATURE EXTREMES** (contd) Hyperthermia or heats stroke is the result of significant overexposure to the factors of heat stress. Heat stroke is usually identified with a body temperature that increases to greater than 40°C (104°F). Symptoms are chills, irritability, hot and dry skin, convulsions leading to unconsciousness. Heat stroke is prevented by limiting or gradual increase (acclimation) of work load during extreme temperature conditions, take frequent breaks in shaded or cooled areas, and consume plenty of liquids prior to and during work activities. Heat stress is a potential hazard during heavy exertion in the summer, especially if the workers have not had enough liquids in their diet. Potable water should be carried into the field in appropriate containers when working in remote areas. Coffee, tea, and caffeine-containing soft drinks should be avoided. The Project Manager shall determine if heat stress poses a particular risk during the project and shall have the field staff members monitor their pulse rate periodically when heat stress potential is high. If the worker's pulse exceeds 110 beats per minute, a 15-minute break period in the shade and ingestion of water will be required. If the ambient temperature is above 27°C (80°F), or if strenuous work in heavy clothing is anticipated, the Sampling Lead shall take special precautions against heat stress. Workers shall force fluids prior to work (such as a good electrolyte replenishment drink) and monitor their vital signs such as pulse to lessen the likelihood of a heat related illness at the site.	

SITE SPECIFIC SAFETY HEALTH AND SAFETY PLAN

PERSONAL PROTECTIVE EQUIPMENT

Job Task	Work Zone/Location	PPE Level
1– Collecting soil samples	7	Level D

List the letter or number corresponding to the requirement in the appropriate space above or fill in pertinent information. Underline necessary PPE.

1. Sampling
2. Excavation
3. Decontamination
4. Observation
5. Monitoring
6. Drilling
7. Support Zone
8. CRZ
9. Exclusion Zone

Level "D"

- Field appropriate clothing - long pants.
- Leather/rubber gloves as necessary.
- Boots/shoes – closed-toed, above the ankle
- Safety glasses - as necessary

SITE SPECIFIC HEALTH AND SAFETY PLAN

DECONTAMINATION PROCEDURES

Personnel Decontamination:	**Sampling Equipment Decontamination:**	**Support Equipment:**
Wash hands prior to eating lunch and at end of shift.	Sampling equipment will be cleaned prior to being taken off of site.	1 and 3 are located in the vehicle. Other equipment needed include 2, 7, 8, 12, and 15.

EQUIPMENT REQUIREMENTS CHECKLIST (Underline required items or add others):

1. First Aid Kit
2. PPE
3. Fire Extinguisher
4. Wind Indicator
5. Eye Wash
6. Signs-PPE, Zones, Etc.
7. Decon Equipment
8. Radio/Phone
9. Breathing Air
10. Signal Device
11. Portable Toilet (or use facility restrooms if close)
12. Potable Water/Cups
13. Wash Water
14. Spill Kit (in lab)
15. Liquid Washing Solution and Waste Container

SITE SPECIFIC HEALTH AND SAFETY PLAN

EMERGENCY PROCEDURES

CONTINGENCY PLANS

FIRE: Call 911 on cellular phone, put out fire if able to do so safely. Notify Project Lead and call single point of contact phone number as soon as possible. The Project Lead will make additional notifications if necessary. The Sampling lead will be onsite commander until relieved by Fire Department Personnel or other emergency response personnel.

SAFETY RELATED WORK STOPPAGE:
Any person may shut down Operations based on health or safety concern.

PERSONAL INJURY: Call 911 from cellular phone if more than first aid is required. Administer first aid if trained. Make notifications per emergency contacts list.

EMERGENCY CONTACTS	NAME	PHONE
All Emergencies Fire/Patrol/Ambulance	ALL	911
Any Incident	(Call Single Point Contact)	TBD
Safety Representative:	TBD	TBD
Sampling lead	TBD	TBD
Kadlec Medical Center 4611	Emergency Room	509- 946-

SPILL CONTROL PLAN

Contacts: Report all spills related to activities under this HASP to Sampling lead.

Containment Kit Located: NA

Actions to Take: If a fuel leak or other chemical spill occurs, contain spill if it can be safely accomplished, keep personnel upwind until spill is abated.

MEDICAL FACILITIES / LOCATION

See Attachment B

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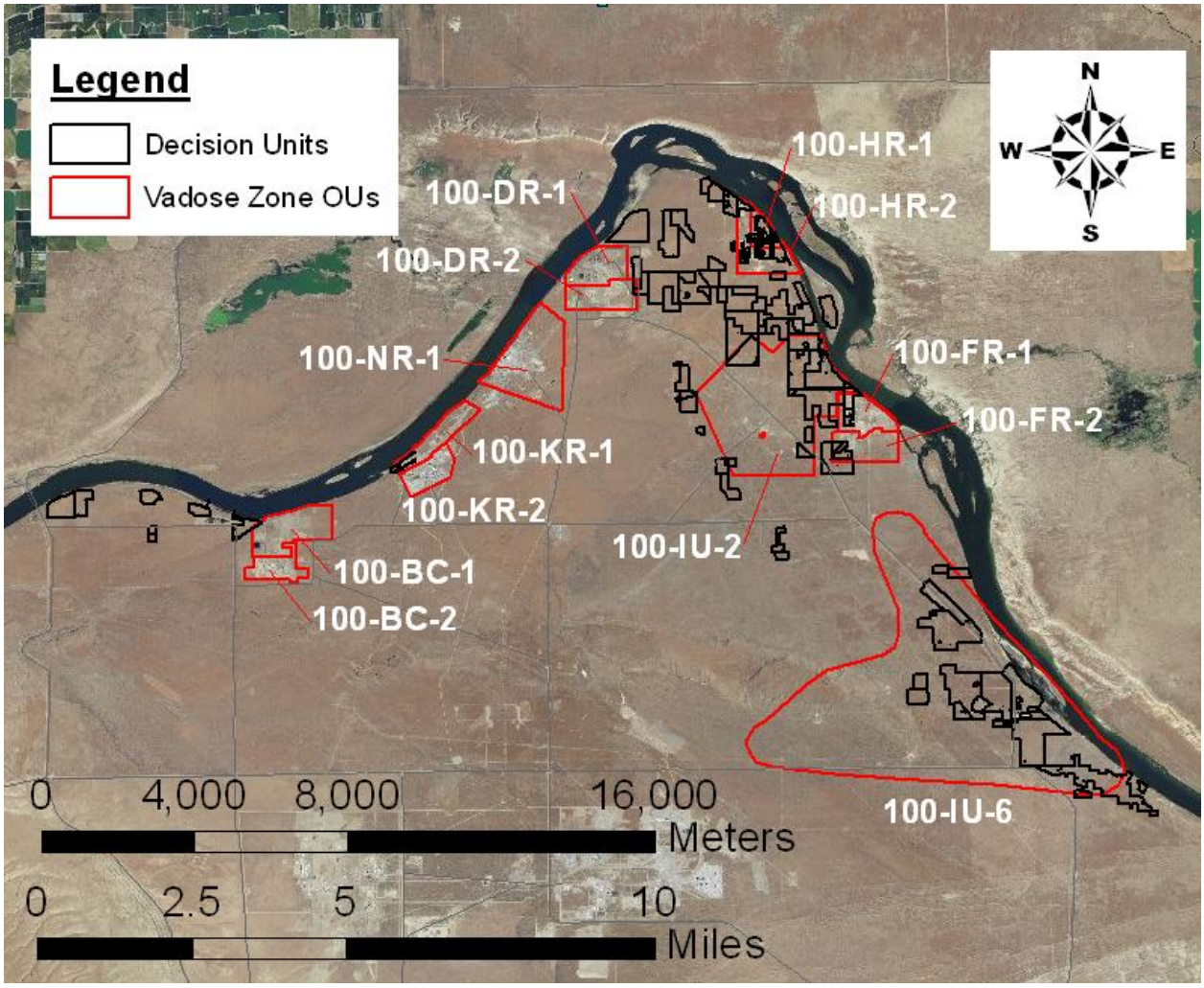
Attachment A: Site Plan

All 100-OL-1 OU decision units will be sampled.



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Attachment B: Emergency Phone Numbers

Emergency Contacts and Phone Numbers		
Organization Specific Single Point of Contact		
Organization	Contact	Phone Number
Local Medical Emergency Facility (HPMC Occupational Medical Services)	1979 Snyder Street Richland, WA 99354	376-3333
Sampling Lead	TBD	TBD
Site Safety Officer	TBD	TBD
Local Medical Emergency Facility(s)		
Name of Hospital: Kadlec Hospital	888 Swift Blvd, Richland, WA	946-4611

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Approval Page

Approver Signatures

Name (Printed)	Title	Signature
	Sampling lead	Signature on hard copy
	Worker Safety and Health	Signature on hard copy
	Project Lead	Signature on hard copy

By signing here, you acknowledge having read and understood the Health and Safety Plan.

Signature	Date	Signature	Date	Signature	Date

A.5 References

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