CONFEDERATED TRIBES
of the
Umatilla Indian Reservation
DEPARTMENT OF SCIENCE AND ENGINEERING

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August 19, 2009

Mr. Rich Duval
Department of Environmental Quality
Eastern Region Hermiston Office
256 East Hurlburt, Suite 105
Hermiston, OR 97838

Re: Final Sampling and Analysis Plan for UMCDF deposited contaminants within the UMCD fence line.

Dear Mr. Duval:

Enclosed is a final version of the Sampling and Analysis plan that the CTUIR would like to see incorporated into the closure plan for the Umatilla Chemical Agent Disposal Facility (UMCDF). This document is focused on the area outside the UMCDF fence line, but within the UMCD, that has the highest potential for the deposition of UMCDF wind-transported contaminants. The purpose of the sampling effort is to generate the information necessary to complete a human health closure risk assessment to determine if the site is safe to reuse, or if the UMCDF has generated contamination that will require remediation to safe levels.

I look forward to discussing the incorporation of this plan into the UMCDF closure strategy. If you have any questions concerning this matter please feel free to contact me at (541) 966-2413.

Sincerely,

Rodney S. Skeen, Ph.D, P.E.
Manager, CTUIR-EMP/DOSE

Cc:
Stuart Harris, Director, CTUIR DOSE
David Layman, PhD, Environmental Specialist
File

Enclosure

Sampling and Analysis Plan for Closure of the Umatilla Chemical Agent Disposal Facility

Final Draft

August 2009

Prepared by:
Confederated Tribes of the Umatilla Indian Reservation
P.O. Box 638
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Table of Contents

1 Executive Summary

This report contains a comprehensive plan for environmental sampling of soils within the fence line of the Umatilla Chemical Depot (UMCD) following deactivation and closure of the Umatilla Chemical Agent Disposal Facility (UMCDF) under the Resource Conservation and Recovery Act (RCRA). The objective of this sampling and analysis plan (SAP) is provide the environmental media data necessary to complete a post-closure human health risk assessment (HHRA) for future users of the UMCD land. This SAP is designed to determine the concentrations of selected compounds of potential concern (COPCs) in soils downwind from the UMCDF and to distinguish between naturally present compounds and those potentially originating from the UMCDF and UMCD activities. Selected COPCs are those which have a demonstrated high toxicity or cancer risk, have a high potential to be generated from the UMCDF or past UMCD activities, and which are persistent in the environment. The resulting 88 COPCs include:

- metals
- polychlorinated dibenzodioxins, dibenzofurans, and biphenyls
- semi- and non-volatile organic compounds including polycyclic aromatic hydrocarbons
- explosives and their degradation products
- organochlorine pesticides

The SAP design is based on the seven-step data quality objectives (DQOs) process recommended by the Environmental Protection Agency (EPA 2006). The DQOs clearly state the objectives of the SAP, the required inputs to design the SAP, and the desired outputs of the SAP. For the purpose of decision making, the DQOs state that the single most important output of this SAP is the ability to confidently compare mean COPC concentrations in soils at the survey site and at a well-chosen background site. The ability to confidently compare means requires adequate sample sizes at both sites. Quantities stated in the DQOs, including sampling uncertainties and limits on decision errors, are the inputs needed to determine the minimum required number of samples using appropriate statistical tools.

The primary statistical tool used in this SAP was the *Visual Sampling Plan* (VSP) software package (PNNL, 2007). Using inputs provided by the DQOs and a statistical model that make no assumptions about the spatial distribution of contamination, VSP calculated that 32 samples *each* in the two chosen survey sites and the background site are necessary to meet the DQOs. Thus a total of 96 field soil samples will be required to meet the DQOs.

Two survey areas within the UMCD fence line were selected. The first area, roughly centered on the UMCDF common-stack, is positioned to contain 99+% of the predicted emissions deposited on the ground as indicated by the results of the deposition modeling software *AERMOD*. The second area is positioned to provide a sampling area adjacent to the UMCD fence line and downwind from the UMCDF common stack. Sampling in this area will allow determination of the maximum spatial extent of contamination within the UMCD.

Finally, Section 6 contains the Quality Assurance Project Plan (QAPP) and discusses sampling and laboratory methodologies, and Section 7 describes the process by which the data obtained in this SAP will be used in the HHRA process.

2 Background

The Umatilla Chemical Depot (UMCD) is located in northeast Oregon on the border between Morrow and Umatilla Counties (Figure 2-1). The northern boundary of the UMCD is 5 km south of the Columbia River, which forms the border between Washington State and Oregon State. The UMCD is comprised of 19,729 acres of which approximately 17,000 acres is government owned and the remainder is private lands which have restricted easements (U.S. Army 1996). During its now 60-year history, The UMCD has supported multiple war efforts, including the Korean Conflict, Vietnam, Grenada, Panama, Operation Desert Shield, and Operation Desert Storm. Besides its conventional ammunition and general supply missions, the depot received a new mission in 1962 – receiving and storing chemical ammunition. Between 1962 and 1969, the depot received various types of ammunition with the chemical nerve agents VX and GB, and the mustard blister agent HD (called mustard gas).

In the mid-1980s, Congress directed the Army to dispose of the nation's aging chemical weapons stockpile. In 1988 the UMCD was placed on the Department of Defense Base Realignment and Closure list to review the future of the facility. It was decided that the base would be realigned and remain open until the chemical stockpile at the facility was destroyed. On April 25, 1997, the United States Senate ratified the Chemical Weapons Convention, an international treaty mandating stockpile destruction. In June 1997, construction started on the Umatilla Chemical Agent Disposal Facility (UMCDF) – the facility that would destroy the chemical ammunition stored at the UMCD. Construction was substantially complete in August 2001 and weapons destruction began 2004. The mission to destroy the UMCD stockpile of chemical weapons is scheduled to be complete by late 2010. Subsequent decontamination, decommissioning, and closure will last till approximately 2013. The Department of Defense Base Realignment and Closure law of 2005 has the UMCD scheduled to be closed after the incineration facility has completed its mission. The UMCD also has hazardous waste sites being remediated and closed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Environmental sampling at these sites will be addressed in a later document.

The CTUIR have an ancient relationship with the lands and resources throughout the Columbia Plateau, including within the UMCD, as documented by the extensive archaeological record, traditional stories, and oral histories. Usual and accustomed fishing sites, villages and camps, religious, funerary and other spiritual sites, plant gathering areas, grazing, and other sites are known to exist on, or near in this area. For this reason, the resources on the UMCD must be protected and preserved in a manner that meets the United States (US) Trust responsibility to the CTUIR which was established in the Treaty of 1855. The US government must protect the interests of the CTUIR by ensuring that lands, water, soil, air, biological, and cultural resources are clean and safe to use. The US government must also ensure to the CTUIR that, after clean-up, human health is not adversely affected from chemical and physical impacts that are related to operations or management of the UMCD site. It is for the above mentioned reasons that the CTUIR has undertaken the effort to complete this sampling and analysis plan for the UMCD and UMCD natural resources. It is the intent of this plan to provide a comprehensive sampling and analysis approach for the portion of the UMCD potentially impacted by air-transported emissions from the UMCDF.

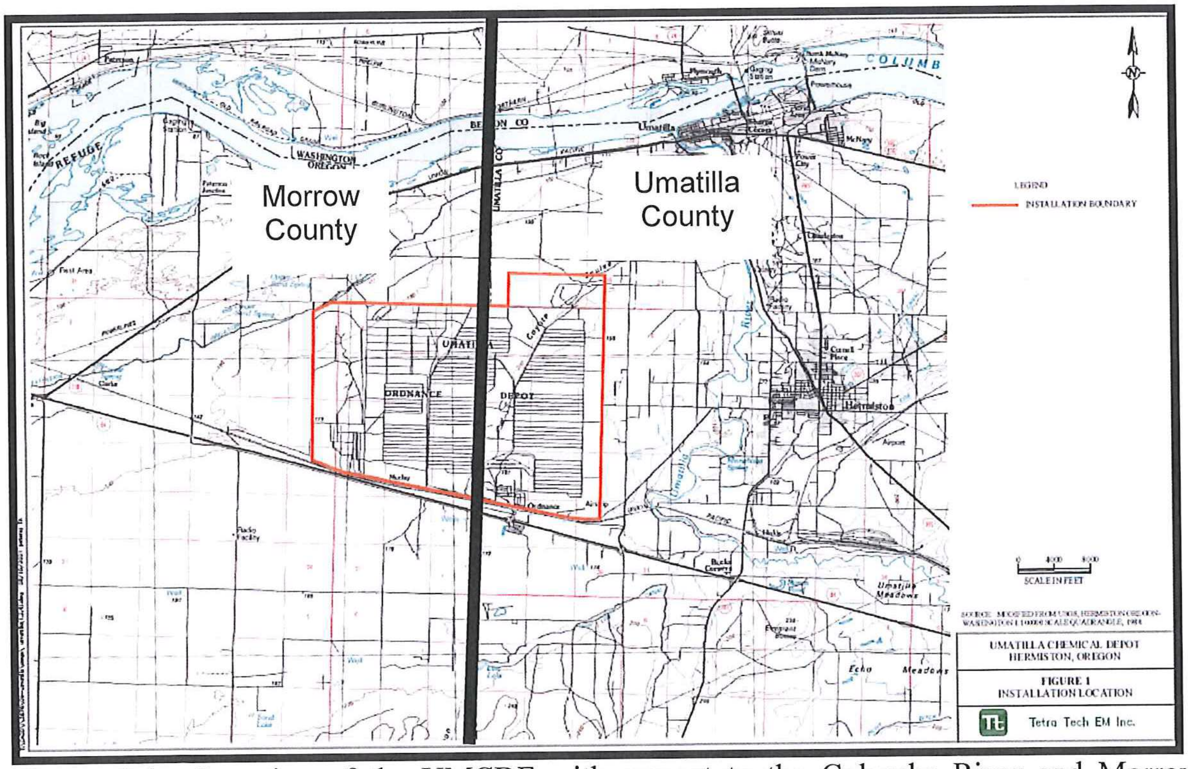

Figure 2-1: Location of the UMCDF with respect to the Columba River and Morrow and Umatilla Counties.

3 Site Description

NOTE: *The information presented in this section has been extracted from the 2004 RWAP (DEQ, 2004). This information has been reproduced here to provide a stand-alone document.*

3.1 *Topography*

The UMCD lies within a level to gently rolling plain that slopes generally to the northwest toward the Columbia River (Dames & Moore 1993). The landscape is dominated by two distinct features: parallel, lacustrine-deposited dune lines and Coyote Coulee. The dune lines are oriented along a north 69° east axis with a crest-to-crest interval ranging from approximately 60 meters to 300 meters (200 feet to 1,000 feet). Interdunal relief varies from 1.5 meters to 9 meters (5 feet to 30 feet), depending on the configuration of the plain on which the dunes were deposited. Winds have been instrumental in reshaping the surface in recent times, streamlining and rounding the dunes.

The second prominent surface feature, Coyote Coulee, is a valley that cuts across the facility along a north 30° east axis (Dames & Moore 1993). The western edge of Coyote Coulee has a 5% to 10% slope. The eastern edge is an escarpment that rises approximately 18 meters (60 feet) at a 30% to 45% slope. The coulee appears to be a large relict sand wave. Its exceptional size is likely due to extraordinary river discharge during historical catastrophic floods.

3.2 *Climate*

The UMCD has a moderate, semi-arid climate within the rain shadow of the Cascade Mountains (Dames & Moore 1993). From 1961 through 1990, at Hermiston, 6 kilometers (4 miles) east of the UMCD, the mean annual temperature was 11.4 °C (52.5 °F). The mean monthly temperatures varied from 0.6 °C (33.1 °F) in January to 22.7 °C (72.9 °F) in July. Precipitation at Hermiston is relatively low, with an annual mean of 22.9 centimeters (9 inches). Approximately 10% of the annual precipitation falls during summer. From November through March, some of the precipitation falls as snow. The area receives an average of 21.6 centimeters (8.5 inches) of snow annually (Oregon Climate Center 2003).

The Columbia River Valley is the major ingress point for the Pacific cyclonic weather systems through the Coastal and Cascade mountain ranges west of the facility (Dames & Moore 1993). Its location ensures that the site experiences nearly continuous winds. Prevailing winds are from the southwest (Figure 3-1). However, morning winds from the Blue Mountains to the southeast are common. The mean annual wind velocity, calculated from the on-post wind monitoring station between 1995 and 2000 is 14.0 kilometers per hour (kph). Wind velocity and direction are subject to rapid change.

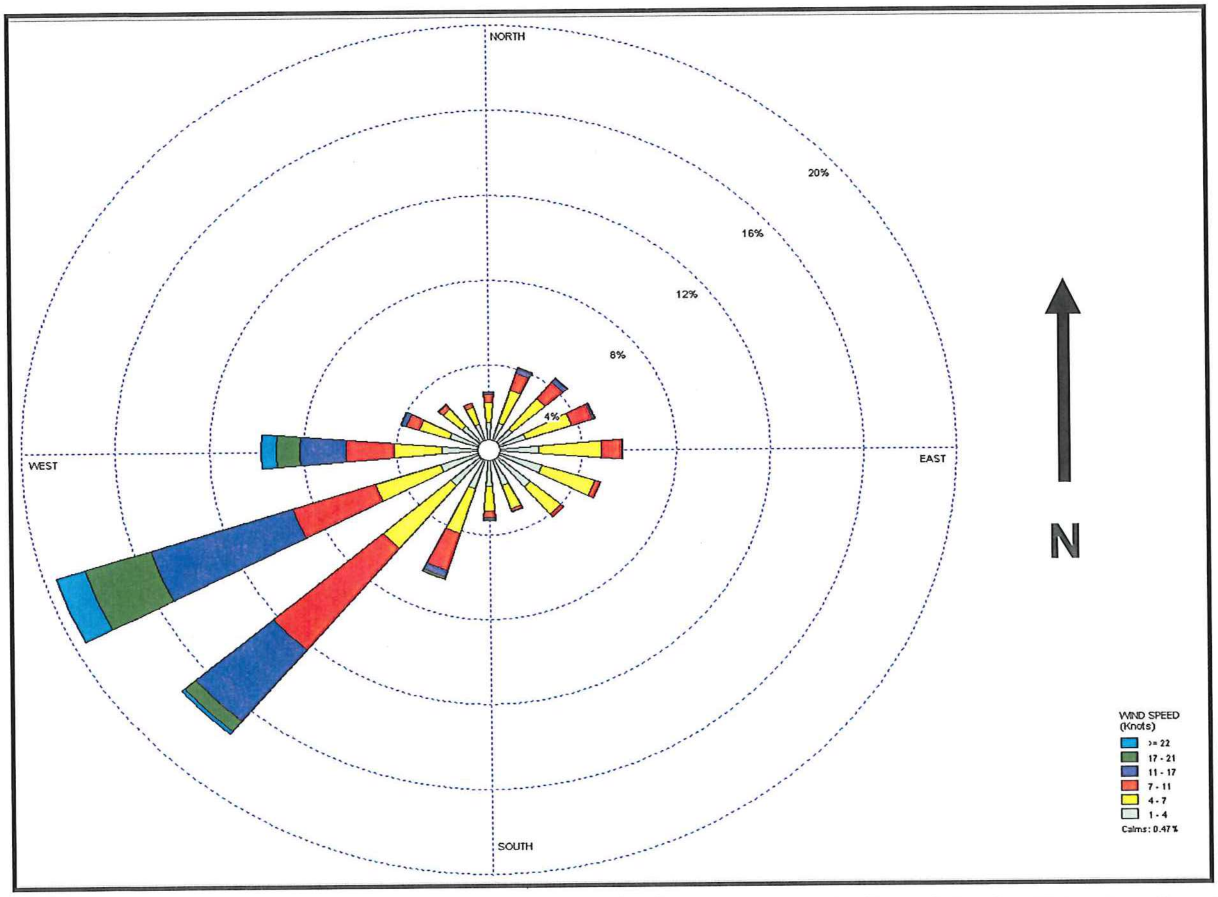

Figure 3-1: Average wind direction and velocity. Wind is indicated in the "blowing-from" direction.

3.3 *Geology and Soils*

The Columbia River basin is a basaltic plain overlain by sand, gravel, and silt deposited during the Pleistocene Missoula floods (Dames & Moore 1993).

The three soil series identified at the UMCD are Burbank loamy fine sand, Quincy fine sand, and Quincy loamy fine sand (Dames & Moore 1993). All series are of eolian origin (deposited by the wind), are unconsolidated, and therefore are susceptible to severe wind erosion when vegetative cover is removed. Burbank loamy fine sand is very deep, excessively drained soil formed in gravelly deposits and wind-worked material. Organic matter in the upper layer is low. Below this, a dense, very cobbley and gravelly layer restricts root penetration. Permeability is rapid throughout the column, and the water-holding capacity is low. Soil pH in the upper layer is near neutral (6.4 to 7.8), but beginning in the gravel layer, the pH increases to 8.4.

Quincy fine sand is very deep, excessively drained soil formed in mixed sand. Permeability is rapid, and water-holding capacity is low (Dames & Moore 1993). Effective rooting depth is greater than 1.5 meters (5 feet). However, 80% of roots are found in the upper 30.5 centimeters (12 inches). Soil pH gradually increases with depth from near neutral to 8.5 at 1.5 meters (5 feet). Organic matter content is low.

Quincy loamy fine sand is very similar to the Quincy fine sand but occurs on slightly flatter slopes and has slightly more silt and clay in the upper layer, resulting in a higher water-holding capacity (Dames & Moore 1993).

3.4 *Hydrology*

The UMCD area lies entirely within the Columbia River basin, the principal watershed near the UMCD. The mid-Columbia River flows west 5.3 kilometers (3.3 miles) from the northern UMCD boundary. McNary Dam, northeast of the UMCD, regulates the flow of the Columbia River near the UMCD. Additional dams are located upstream and downstream of McNary Dam. Snowmelt in the mountainous watershed results in high flows in late spring and early summer, while autumn and winter months are characterized by low flow. The average discharge of the Columbia River at McNary Dam is 3,500 cubic meters per second (m^3/s) (126,400 cubic feet per second [ft^3/s]). There are numerous pumping stations located along the Columbia River for irrigation (U.S. Army, 1996).

The surface area of the Columbia River that falls within a 50-kilometer radius of the UMCDF is 150 square kilometers (km^2), and the average water column depth is 10 meters (Ecology and Environment, 1997). The surface area of the Columbia River watershed that lies within the assessment area is 4,400 km^2, and 5% is assumed to be impervious to rainfall (Ecology and Environment, 1997). The surface area of the Umatilla River that lies within the assessment area is 9.8 km^2, and the average water column depth is 0.5 meter (Ecology and Environment, 1997). The surface area of the Umatilla River watershed is 2,700 km^2, and 5% is assumed to be impervious to rainfall (Ecology and Environment, 1997).

Within the Columbia River basin, the UMCD area is within the drainage area of the Umatilla River, Middle Columbia–Lake Wallula, and Willow Creek sub-basins (or watersheds). The

Umatilla River is located approximately 10 kilometers (6.25 miles) east of the UMCD. This river discharges to the Columbia River (U.S. Army, 1996). The Umatilla River is regulated by dams and reservoirs and is used for irrigation of agricultural land within the river basin. The average annual flow of the Umatilla River near Umatilla, Oregon, from 1990 through 2000 was approximately 16 m^3/s (568 ft^3/s) (United States Geological Survey [USGS] 2003a). The minimum mean monthly flow, which typically occurs in August or September, was 0.9 m^3/s (33 ft^3/s) from 1990 through 2000 (USGS 2003b). Butter Creek is an intermittent tributary of the Umatilla River that converges with the river approximately 2 miles southeast of the UMCD (U.S. Army, 1996). The Middle Columbia–Lake Wallula watershed encompasses acreage in Klickitat, Walla Walla, Yakima, and Benton Counties in Washington, and Gilliam, Morrow, and Umatilla Counties in Oregon. The Willow Creek watershed includes portions of Gilliam and Morrow Counties in Oregon. Willow Creek, with its headwaters upstream of Heppner, Oregon, flows north until its confluence with the mid-Columbia River in Boardman, Oregon.

Within the boundary of the UMCD, surface water runoff generally flows north to northwest toward the Columbia River (U.S. Army, 1996). Except for Coyote Coulee, which crosses the UMCD from the northeast to the southwest, no well-defined drainage system exists at the UMCD. Much of the precipitation percolates into the groundwater, where it eventually flows to a structural dip (bench) of basalt and then to the northwest to the Columbia River.

The north-central portion of the UMCD is situated on a subdued topographic high (U.S. Army, 1996). The terrain slopes gently away from this high to the southeast in the eastern portion of the UMCD, to the south in the central portion, and to the northwest in the western portion. Runoff from the western portion of the site tends to flow toward the West Extension Irrigation Canal, while runoff along the eastern portion is collected by a shallow, elongated depression that parallels the Union Pacific Railroad and Interstate 84. Irrigation canals enclose the eastern, western, and northern sides of the UMCD in a horseshoe-shaped pattern. Water is diverted from the Umatilla River into the canals for irrigation of crops.

Beneficial uses of surface waters within a 50-kilometer radius of the UMCD include irrigation, public water supply, industrial water supply, livestock watering, salmon and steelhead fish passage, salmonid fish spawning and rearing, resident fish and aquatic life habitat, wildlife habitat, hunting, fishing, boating, and hydropower. Irrigation is the main use for stream water withdrawal. The City of Hermiston draws water from the Columbia River above McNary Dam for drinking water use. The City of Boardman obtains drinking water from a subsurface water collection system located near the banks of the Columbia River. River and rain water enter the collection system via the subsurface soils.

3.5 *Land Use*

The UMCD has not been zoned by either Morrow or Umatilla Counties since it is federally owned and not part of the public domain. Current ownership is retained by the United States Army. As seen in Figure 3-2, the surrounding land-use of both counties, however, is overwhelmingly agricultural. Within Umatilla County, land to the north, northeast, and south of the depot is predominately zoned Exclusive Farm Use (EFU) with a minimum parcel size of 160 acres. There is also a 14 acre parcel on the southeast corner of the depot between I-82, I-84, and Westlund Road that falls within the Industrial Plan Designation (light industrial).

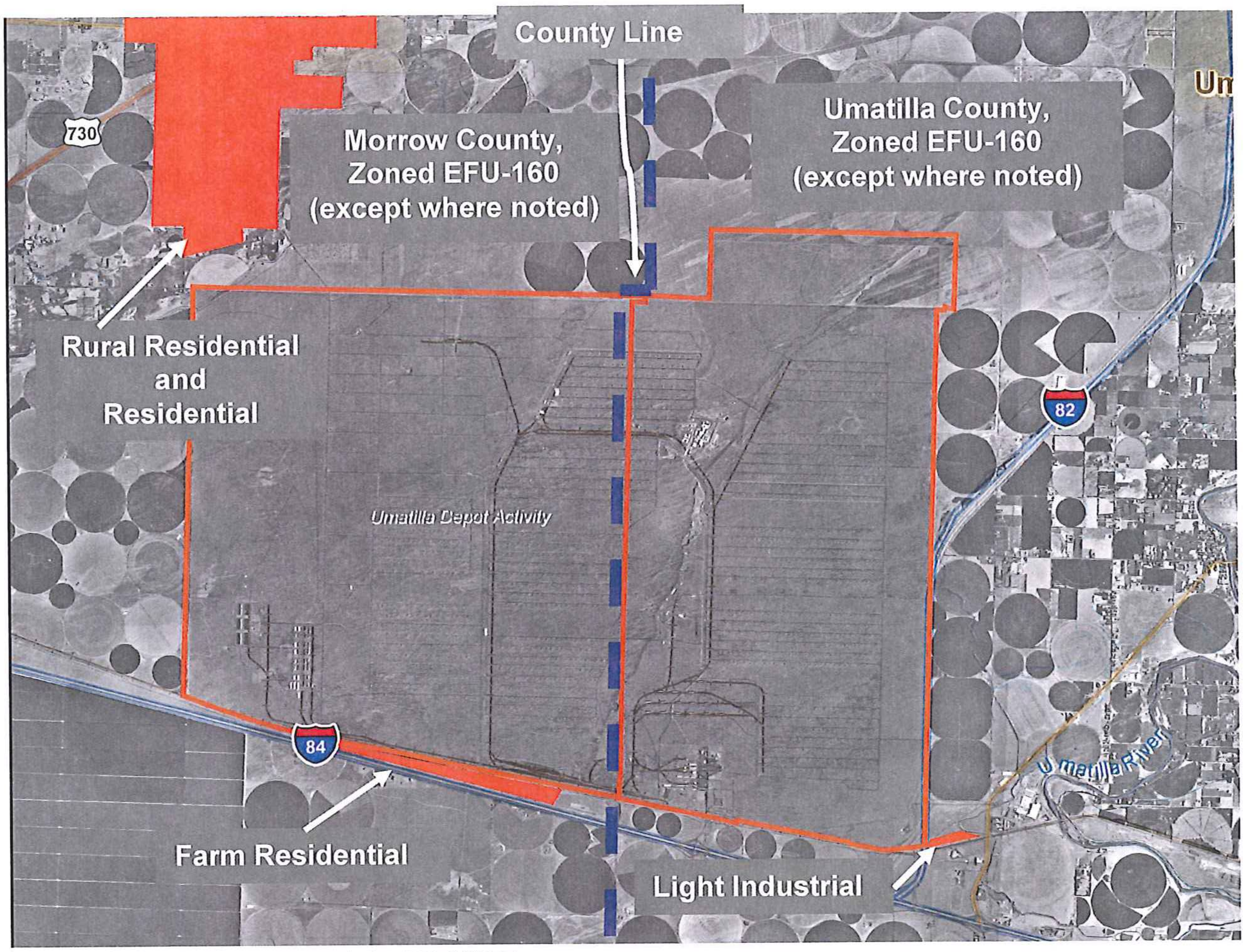

Figure 3-2: Zoning around the UMCDF.

Land adjacent to the depot in Morrow County is almost exclusively zoned as EFU with a minimum parcel size of 160 acres. One exception is a small area zoned Rural Residential that allows single family dwellings with a one acre minimum. The only other exception lies along the south of boundary of the UMCD and north of I-84. This area is zoned Farm Residential and is similar to Rural Residential, but with a minimum acreage designation of 2 acres.

It is important to note that while the UMCD is surrounded by irrigated farms, the potential for developing new groundwater sources is limited. Almost all of the lands in the vicinity of the Depot lie within the boundaries of critical groundwater areas (Benkendorf Associates Corp., 1993). When an area is so designated, new wells cannot be developed and existing wells cannot be expanded. Hence, development of depot lands will depend on existing water rights and wells on the facility.

Zoning and development of the UMCD will occur through the actions of the Local Reuse Authority (LRA). The LRA is the legally recognized entity that is responsible for transitioning the land from federal ownership to the private sector. This organization comprises 12 voting members and two non-voting member. The voting members are two each from Umatilla County, the Port of Umatilla, Morrow County, and the Port of Morrow, and four representatives from CTUIR while the State of Oregon and the Oregon National Guard hold the non-voting seats.

In 1993 the LRA developed an initial future use vision for the UMCD lands (Benkendorf Associates Corp., 1993). Figure 3-3 presents the land use vision contained in this document. The LRA is currently in the process of updating its land use vision and a new plan will be available by March 2010. It is anticipated that while the new plan will result in a different configuration from that presented in 1993, similar land uses will be represented. Hence, both farming and traditional tribal uses will occur on UMCD lands and the application of subsistence Tribal use generated risk standards to establish clean-up requirements is applicable for the site.

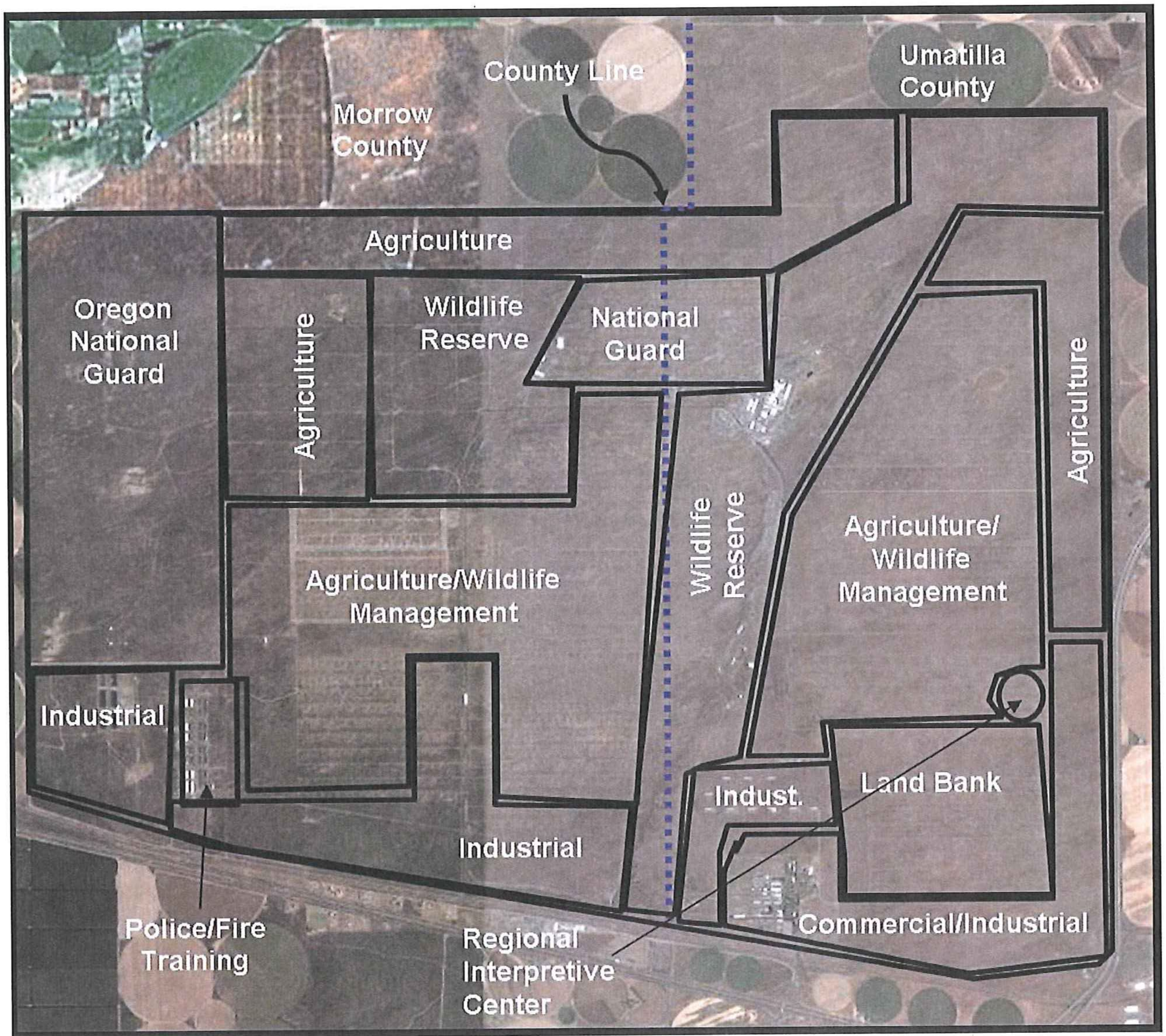

Figure 3-3: Proposed reuse of the UMCD from the 1993 LRA plan.

3.6 *Natural and Cultural Resources*

NOTE: *The information presented in this section has been extracted from the 2006 INRMP (Integrated Natural Resources Management Plan). This information has been reproduced here to provide a stand-alone document.*

3.6.1 Surface Water

A National Wetlands Inventory was conducted on the Depot in June, 2000, and no permanent, naturally occurring surface water features were found on the installation (Swords and Tiner 2001). The final report documents 11.6 acres of palustrine wetland habitat on the Depot, however the accompanying map indicates that those acres are located on adjacent properties immediately east of the installation. A couple of sprinkler systems create wetland microhabitats on the Depot although that designation is determined more by the presence of wetland vegetation than surface waters.

The lack of wetlands is due to the region's arid climate; annual rainfall is approximately 10 inches and infiltration is rapid (U.S. Army 1995). The Depot's highest point is in the north-central portion of the installation with an elevation of 677 feet msl. From this high region, the land slopes gently southeast in the eastern portion of the Depot; south in the central and southern portions; and northwest in the western portion. Runoff on the western portion of the Depot flows toward the West Extension Irrigation Canal. An approximately 1,750-foot section of the canal is located in the extreme northwest corner of the Depot, entering on the north boundary and leaving on the west boundary. The irrigation canal runs west as a ditch for about 18 miles before ending just northwest of the Boardman Naval Training Facility

3.6.2 Groundwater

The Depot's groundwater exists in unconfined alluvial aquifers within surface sediments, as well as in a confined basalt aquifer system (U.S. Army 1996). Localized hydraulic interconnection exists between the unconfined aquifer and the uppermost portion of the basalt aquifer system in the Saddle Mountain Basalt. Groundwater in the alluvial aquifer and the interflow zones between basalt flows or layers primarily flows in a horizontal direction. Groundwater flow in areas where vertical joining of the basalt is prevalent has higher vertical flow rates. All interflow zones in the Columbia River Basalt Group are hydrologically interconnected, creating a large aquifer system.

The overall flow direction of unconfined and confined aquifers near the Depot is northwest toward the Columbia River, from recharge areas in the Blue Mountains. This overall flow is diverted northward on the southeastern corner of the Depot. It is probably attributed to year-round pumping of groundwater at the Lamb-Weston well located near the Depot. Unconfined alluvial aquifers, and possibly the Saddle Mountain Basalt portion of the confined basalt aquifers, discharge into local streams and rivers via seeps and springs with an ultimate discharge point at the Columbia River. The deeper portions of the confined basalt aquifers in the Wanapum Basalt and particularly in the Grande Ronde Basalt, provide minimal input to these baseflows.

The Depot's groundwater is slightly alkaline and of the calcium, sodium calcium, or sodium bicarbonate type. Dissolved solid concentrations in the basalt aquifer system range from 200 to 400 milligrams/liter (mg/L) with an average of 230 mg/L. Higher concentrations of dissolved solids exist in the alluvial aquifer at the surface. While groundwater is suitable for most purposes, its hardness in the alluvial aquifer is greater than what is desired for domestic use. Groundwater in the deeper portions of the basalt aquifer system has decreased hardness and concentrations of sulfate and bicarbonate, with greater concentrations of sodium and fluoride.

3.6.3 Flora

The Depot is situated in what is classified as an *Artemisia-Agropyron* steppe biome located in the upper part of the Columbia Basin floristic province of northeastern Oregon (Gene Stout and Associates 1997). Kagan et al. (2000) indicates that the Umatilla Chemical Depot and the Boeing Lease Lands contain the largest remaining bitterbrush shrub-steppe habitats in the Columbia Basin. As such, the Depot provides valuable habitat for native plant and animal species. Due to the limited distribution of the shrub-steppe habitat, many of the associated wildlife species are listed by the state as sensitive. The passive nature of the Depot's mission as a munitions storage facility, established in the early 1940s, has resulted in preservation of this significant habitat.

Tetra Tech EM Inc. (Tetra Tech) conducted Planning Level Vegetation Surveys on the Depot in 1999-2000, identifying seven shrubland and seven grassland vegetative communities on the site (Figures 3-4 through 3-7). Most of the communities appear to be variations of *Artemisia tridentata/Stipa comata*, *Purshia tridentata/Stipa comata*, and *Stipa comata-Poa secunda* associations (Tetra Tech 2002b). Overall, the vegetative communities support a relatively high degree of native species diversity.

The classification and distribution of vegetative communities as described by Tetra Tech (2002b) do not match those of the 1993 Ecological Assessment Report (USACE 1993), as presented in Gene Stout and Associates (1997). This may be due to differences in interpretation; changes in plant associations and distributions from 1992 to 1999 due to weather conditions and other environmental and human-induced influences; and/or an apparent lack of sufficient time spent in the field during the 1992 inventories (Gene Stout and Associates 1997).

In general, the Depot supports large communities of shrublands, dominated by sagebrush and bitterbrush with an understory of annual grasses and forbs; and grasslands, dominated by a mixture of native and exotic species such as Sandberg's bluegrass, cheatgrass (downy bromegrass), and crested wheatgrass. The shrublands are found primarily in the eastern and southwestern portions of the Depot on soils with a higher silt content, and consequently a higher moisture capacity. Note that Kagan et al. (2000) indicates that the Depot contains the largest remnants of bitterbrush habitat in the Columbia Basin, as well as high quality needle-and-thread sandy grasslands. The central region of the Depot is dominated by the grasslands, which are intermixed with the shrublands in the eastern portions as well. Tetra Tech (2000b) also identifies what they call "mixed communities", defined as areas wherein several vegetative communities are present and intermingled. The mixed communities are primarily in the northwestern and northeastern portions of the Depot. Cheatgrass is a prevalent understory in many of the shrubland communities.

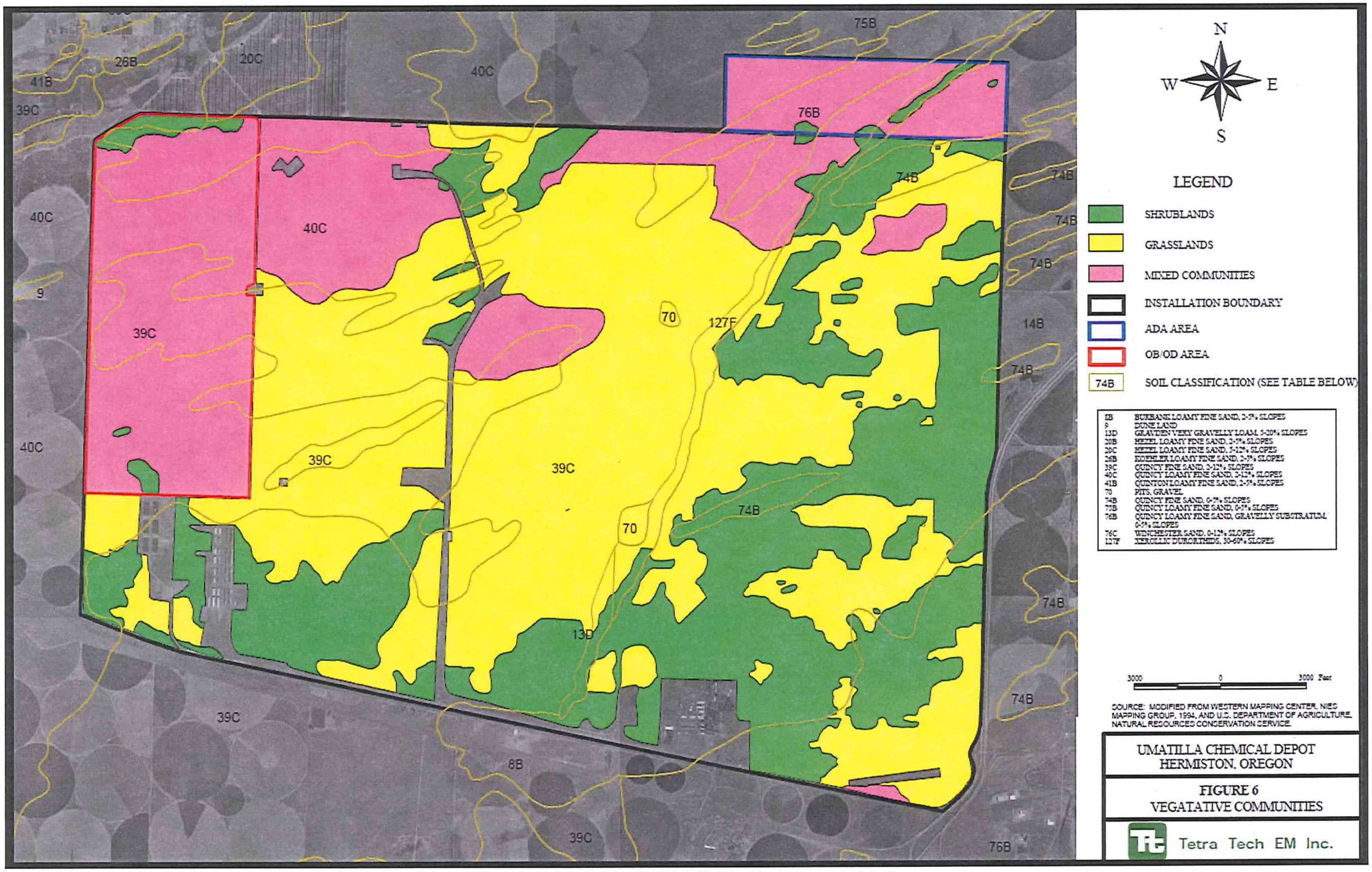

Figure 3-4: Vegetative community map identified in the 2006 INRMP (US Army, 2006).

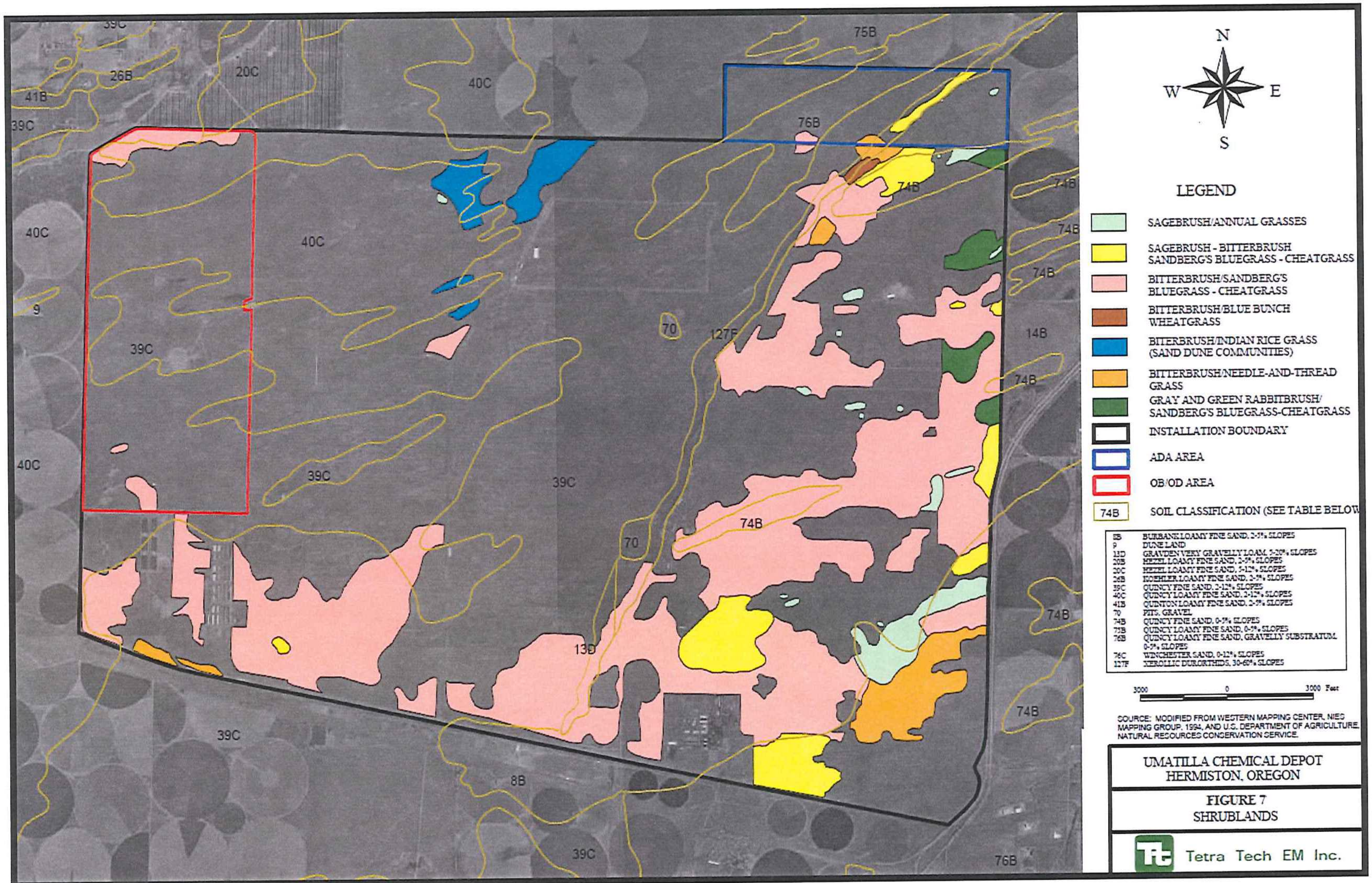

Figure 3-5: Shrubland communities map identified in the 2006 INRMP (US Army, 2006).

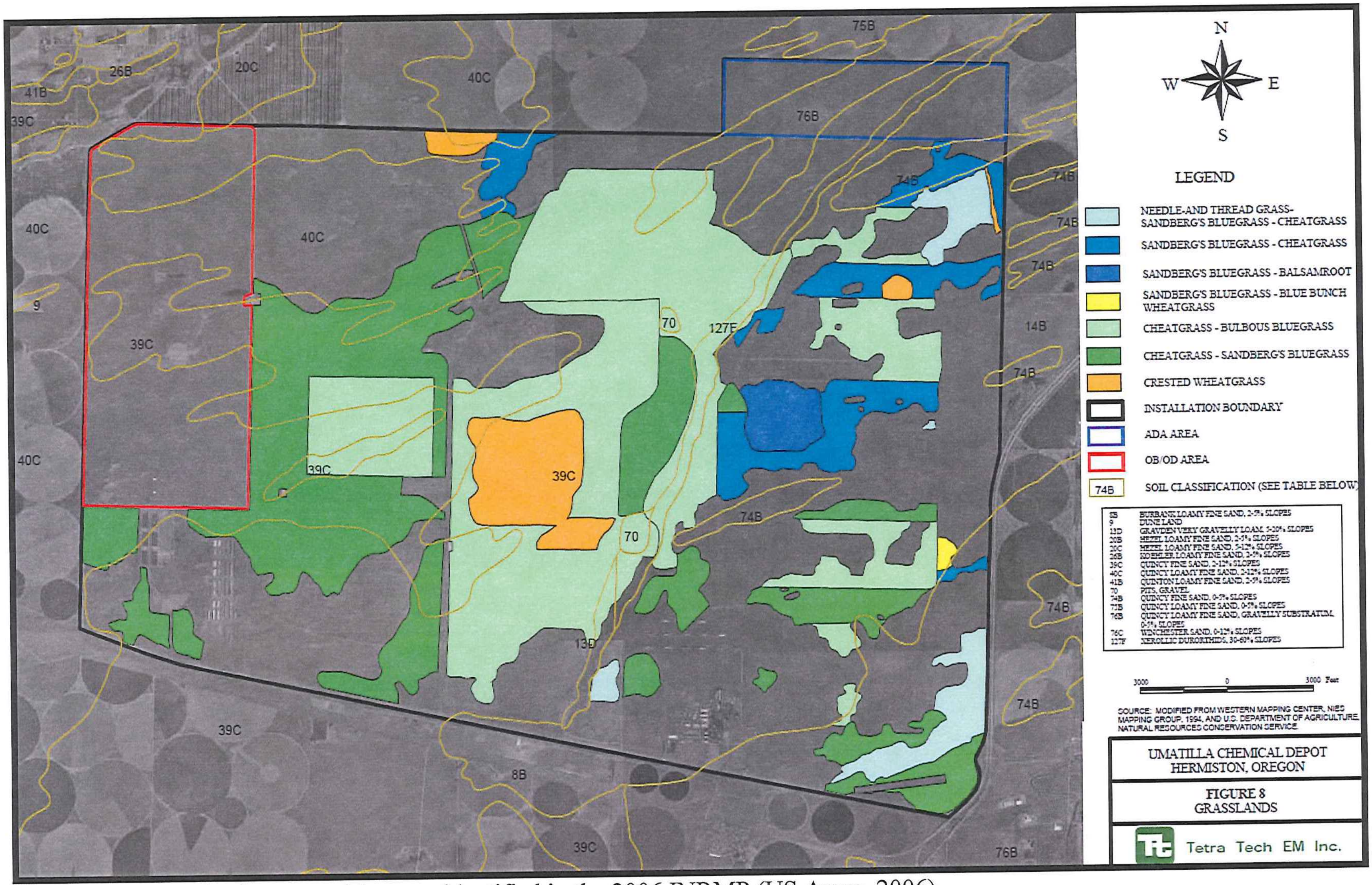

Figure 3-6: Grassland communities map identified in the 2006 INRMP (US Army, 2006).

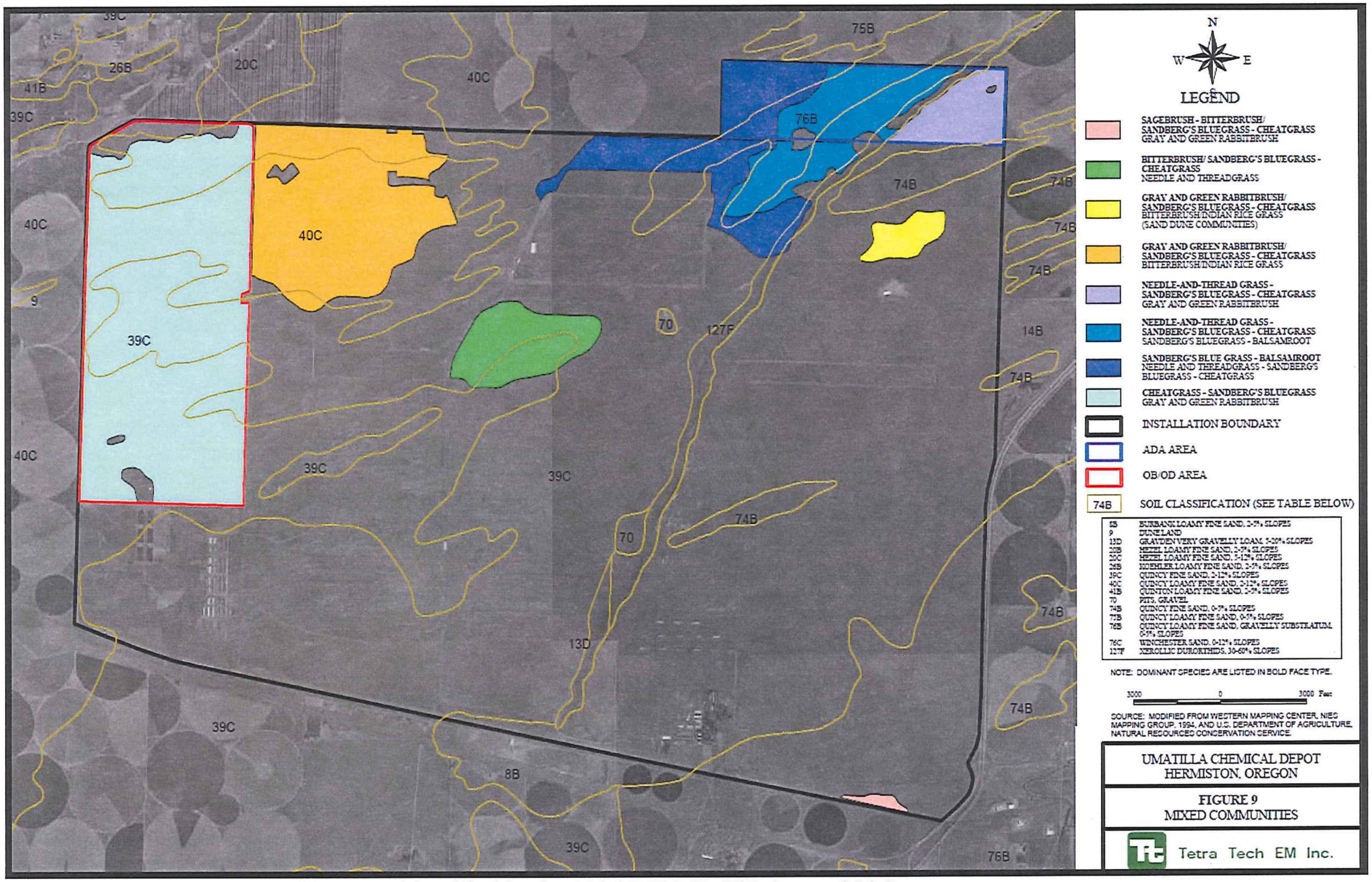

Figure 3-7: Mixed communities map identified in the 2006 INRMP (US Army, 2006).

3.6.4 Fauna

In general, faunal species on the Depot are consistent with what one would expect in Columbia Basin native shrub-steppe and grassland habitats: pronghorn, coyote, American badger, jack- and cottontail rabbits, Swainson's and redtail hawks, burrowing owl, long-billed curlew, and many other species common to this habitat. Note that the pronghorn herd is not free-ranging, as the Depot's perimeter fence keeps it captive. The lack of permanent surface water on the Depot precludes the occurrence of native fish species; however, mosquito fish are stocked in a storm water retention pond to eat mosquito larvae.

Tetra Tech conducted Planning Level Surveys for threatened and endangered wildlife species on the Depot in 1999 and 2000. They focused their survey efforts primarily on three species: the bald eagle, the peregrine falcon, and the Washington ground squirrel (Tetra Tech 2000a). However, other sensitive species were the subject of investigation as well. Table 3-1 presents the results of Tetra Tech's survey efforts for threatened and endangered species on the Depot, and unless otherwise indicated, the data presented is from Tetra Tech (2000a). A complete list of the confirmed and possible mammal, bird, and reptile and amphibian species can be found in Appendix B2 of (USACE 1993).

Table 3-1: Federal and State Faunal and Floral Species of Special Concern Potentially Found on Umatilla Chemical Depot				
Common Name	**Scientific Name**	**Federal Status**	**State Status**	**Occurrence**
Reptiles and Amphibians				
Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*	SoC	SV	Present
Birds				
Long-billed Curlew	*Numenius americanus*	None	SV	Present
Bald Eagle	*Haliaeetus leucocephalus*	LT	LT	Transient
Swainson's Hawk	*Buteo swainsoni*	None	SV	Present
Ferruginous Hawk	*Buteo regalis*	SoC	SC	Present
Peregrine Falcon	*Falco peregrinus*	None	LE	Transient
Sage Grouse	*Centrocercus urophasianus*	None	SV	Potential
Western Burrowing Owl	*Athene cunicularia hypugea*	SoC	SC	Present
Lewis' Woodpecker	*Melanerpes lewis*	None	SC	Present
Bank Swallow	*Riparia riparia*	None	SU	Present
Loggerhead Shrike	*Lanius ludovincianus*	None	SV	Present
Grasshopper Sparrow	*Ammodramus savannarum*	None	SV	Present
Black throated Sparrow	*Amphispiza bilineata*	None	SP	Present
Sage Sparrow	*Amphispiza belli*	None	SC	Present
Bobolink	*Dolichonyx oryzivorus*	None	SV	Present
Tricolored Blackbird	*Agelaius tricolor*	SoC	SP	Potential
Mammals				
Western Small-footed Myotis	*Myotis ciliolabrum*	SoC	SU	Potential
Long-eared Myotis	*Myotis evotis*	SoC	SC	Potential
Long-legged myotis	*Myotis volans*	SoC	SU	Potential
Townsend's Big-eared Bat	*Corynorhinus townsendii*	SoC	SC	Potential
Pallid Bat	*Antrozous pallidus*	None	SV	Potential
White-tailed Jackrabbit	*Lepus townsendii*	None	SU	Potential
Washington ground squirrel	*Spermophilus washingtoni*	SoC	SE	Potential

Federal:

LT: Listed Threatened. This category includes taxa listed as threatened by the USFWS under the Endangered Species Act.

C: Candidate species. This category includes taxa for which the USFWS has sufficient biological information to support a proposal to list as endangered or threatened.

SoC: Species of Concern. This category includes taxa for which existing information may warrant listing, but for which substantial biological information is lacking.

State Protected: (State Protected List also includes the categories listed as State Sensitive.)

LE Listed as an Endangered Species.

LT Listed as a Threatened Species.

PE Proposed as an Endangered Species.

PT Proposed as a Threatened Species.

SC Sensitive - Critical. Those species for which state listing as threatened or endangered is pending, or for which state listing as threatened or endangered may be appropriate if immediate conservation efforts are not taken.

SV Sensitive - Vulnerable. Those species for which state listing is not believed to be imminent and could be avoided through continued or expanded conservation measures or monitoring.

SP Sensitive - Peripheral or Naturally Rare. Those species that occur in the state at the edge of their distribution.

SU Sensitive - Undetermined Status. Those species whose status is unclear.

3.7 *Environmental Status of Site*

The current activities at the UMCD are governed by two sets of environmental laws. The active missions of the site, storage and disposal of the chemical weapons, are Resource Conservation and Recovery Act (RCRA) actions. Remediation of soils and groundwater that were contaminated by past base activities are Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities. The RCRA activities are governed by State of Oregon permits and both missions are scheduled to be completed by 2013. The RCRA permits for both storage and disposal require clean closure of the facilities. For the land and other natural resources the CTUIR defines clean closure as being free of facility generated contamination above levels that would preclude safe Tribal use of the property. The term "safe Tribal use" is defined in the 2004 Post-Trial Burn Risk Assessment Work Plan as having estimated risks below the levels indicated in Table 3-2 when the tribal use exposure scenario is applied to the depot media (CTUIR 2008, ODEQ 2004).

Table 3-2: Risk Action Levels Described 2004 RAWP

Risk Assessment	**Risk Measurement**	**Individual COPC Risks**	**Cumulative Risk**
Human Health	Chronic Cancer Risk	> 1.0E-06	> 1.0E-05
Human Health	Chronic Non-cancer Risk	> 0.25	> 1.0[†]
Human Health	Infant exposure to Dioxin and Furan in Breast Milk	--	> 0.25 pg-TEQ/kg-day

[†] The 2004 RAWP used an HI action level of 0.25 to account for other possible exposures. Since this analysis is based on lifetime exposure at the measured soil concentrations there is no other exposure and so an HI action level of 1.0 is proposed.

Remediation planning and assessment for CERCLA were initiated in the late 1970s through 1988. Response actions begin after the completion of the Remedial Investigation and Feasibility Study (RI/FS) reports. Eight operable units (OU) were identified for remedial action. These OUs are:

- Explosive Washout Lagoons Soils OU
- Deactivation Furnace OU
- Active Landfill OU
- Inactive Landfills OU
- Explosives Washout Lagoons Groundwater OU
- Explosives Washout Plant OU
- Ammunition Demolition Activity (ADA) OU
- Miscellaneous Sites OU

In the 2004 Five Year Review Report for the UMCD it is noted that four OUs have been successfully remediated (US Army 2004). These four OUs are Explosive Washout Lagoons Soils, Explosive Washout Plant, Deactivation Furnace Soils, and Inactive Landfills. The completeness of remediation in light of base closure and the potential reuse of the facility for tribal activities will be evaluated in this closure sampling and analysis effort. The remaining four

OUs (Active Landfill, Explosives Washout Lagoons Groundwater, ADA, and Miscellaneous Site 39) required further monitoring and/or remedial actions. The physical location of these four OUs is indicated in Figure 3-8 while Table 3-3 summarizes the status of clean up actions for these OUs.

Table 3-3: Status of Open CERCLA Operable Units

Operable Unit	**Action Required or Being Taken**	**Expected End Date**
Active Landfill	Monitoring of (now) closed landfill, potential for future remediation of selenium.	Ongoing monitoring till 2025, restricted GW use. Selenium in GW is currently an issue and a ROD is being developed.
Explosives Washout Lagoons Groundwater	On-going pump-and-treat activities.	Models show current clean-up levels will be achieved by 2022. The clean-up levels will be re-evaluated against the Tribal use scenario in this closure sampling and analysis plan.
Ammunition Demolition Activity	Explosives removal and soil remediation needed once a future land use criteria had been established.	FY 2009 BRAC report indicates cleanup will be to agricultural reuse standard (4 ft). Remedial design to be completed in 2013.
Miscellaneous Site 39	Subsurface clearing to a depth of 2 feet for 176 acres.	Field work completed, December 2008. Final Report expected, September 2009.

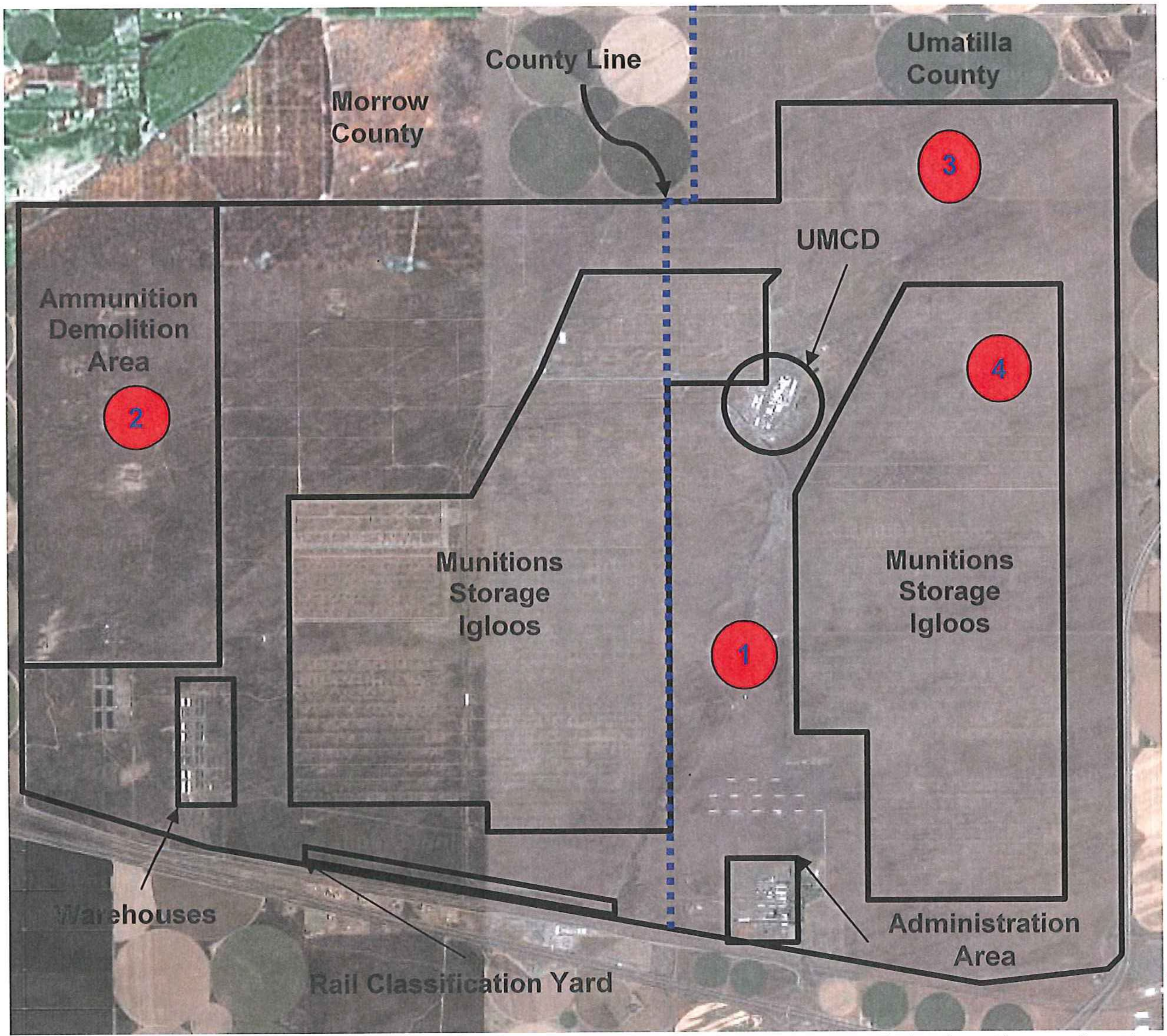

Figure 3-8: Aerial view of the UMCD showing major land use areas and the locations of active CERCLA OUs; Explosives Washout Lagoons Groundwater (1), Ammunition Demolition Activity (2), Miscellaneous Site 39 (3), Active Landfill (4).

4 Data Quality Objectives

Data quality objectives (DQOs) are a self-developed guide used to clearly state the objectives, the required inputs, and the desired outputs of an environmental sampling event. EPA guidance (EPA 2006) recommends the seven-step DQO process outlined in this section. This seven step process is designed to help environmental planners create sampling and analysis plans that allow decision making with a minimum of uncertainty and waste of funds.

4.1 *Step 1 – Problem Statement*

Statement of the problem - The stated problem is the measurement of RCRA and other select *compounds of potential concern* (COPCs) levels in appropriate natural resources within the emissions footprint of the Umatilla Chemical Disposal Facility (UMCDF) up to the Umatilla Chemical Depot (UMCD) boundary. The analytes to be measured (see Tables 4-1, 4-2, and 4-3) are those which have the potential to be emitted from the UMCDF, persist in the environment, and have known adverse health effects. In addition, several COPCs that could be present in this geographic sampling area from past UMCD activities have been included to provide a comprehensive data set that can be directly used for base closure. The end objective of this work is to generate a post-closure human health risk assessment (HHRA) for future users of the UMCD land. It should be noted that the *traditional tribal subsistence lifestyle* (Harper et al. 2007) will be used as the benchmark scenario for the HHRA process. These DQOs will ensure that the data provided by sampling and chemical analysis of UMCD natural resources are as useful to the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) HHRA process as practically possible. The UMCD-wide sampling and analysis plan to be submitted in late 2009 will include all locations and media; this document is applicable to UMCDF emissions only.

Table 4-1: Analytes Considered in this SAP

polychlorinated biphenyls		**polychlorinated dibenzodioxins/dibenzofurans**	
	CAS #		CAS #
3,3',4,4'-TeCB (PCB 77)	32598-13-3	2,3,7,8-TCDD	1746-01-6
3,3',4,4',5-PeCB (PCB 126)	57465-28-8	1,2,3,7,8-PeCDD	40321-76-4
3,3',4,4',5,5'-HxCB (PCB 169)	32774-16-6	1,2,3,6,7,8-HxCDD	57653-85-7
2,3,4,4',5-PeCB (PCB 114)	74472-37-0	1,2,3,4,7,8-HxCDD	39227-28-6
2,3,3',4,4',5-HxCB (PCB 156)	38380-08-4	1,2,3,7,8,9-HxCDD	19408-74-3
2,3,3',4,4',5'-HxCB (PCB 157)	69782-90-7	1,2,3,4,6,7,8-HpCDD	35822-46-9
2,3,3',4,4'-PeCB (PCB 105)	32598-14-4	OCDD	3268-87-9
2,3',4,4',5-PeCB (PCB 118)	31508-00-6	2,3,7,8-TCDF	51207-31-9
2',3,4,4',5-PeCB (PCB 123)	65510-44-3	1,2,3,7,8-PeCDF	57117-41-6
2,2',3,3',4,4',5-HpCB (PCB 170)	35065-30-6	2,3,4,7,8-PeCDF	57117-31-4
2,3,3',4,4',5,5'-HpCB (PCB 189)	39635-31-9	1,2,3,6,7,8-HxCDF	57117-44-9
		1,2,3,7,8,9-HxCDF	72918-21-9
		1,2,3,4,7,8-HxCDF	70648-26-9
		2,3,4,6,7,8-HxCDF	60851-34-5
		1,2,3,4,6,7,8-HpCDF	67562-39-4
		1,2,3,4,7,8,9-HpCDF	55673-89-7
		OCDF	39001-02-0

Table 4-2: Analytes Considered in this SAP

metals and metal compounds		**polycyclic aromatic hydrocarbons**	
	CAS #		CAS #
mercury[◊]	7439-97-6	benzo[a]pyrene	50-32-8
arsenic	7440-38-2	benzo[b]fluoranthene	205-99-2
cadmium	7440-43-9	benzo[k]fluoranthene	207-08-9
thallium	7440-28-0	benzo[j[fluoranthene	205-82-3
lead	7439-92-1	7,12-dimethylbenz[a]anthracene	57-97-6
beryllium	7440-41-7	chrysene	218-01-9
manganese	7439-96-5	benzo[a]anthracene	56-55-3
boron	7440-42-8	indeno[1,2,3-cd]pyrene	193-39-5
chromium[♦]	18540-29-9	dibenzo[a,h]anthracene	53-70-3
antimony	7440-36-0	dibenzo[a,e]pyrene	192-65-4
barium	7440-39-3	dibenzo[a,h]pyrene	189-64-0
silver	7440-22-4	dibenzo[a,l]pyrene	191-30-0
vanadium	7440-62-2	dibenzo[b.k]fluoranthene	205-97-0
zinc	7440-66-6	2-methylnaphthalene	91-57-6
selenium	7782-49-2	acenaphthene	83-32-9
cobalt	7440-48-4	anthracene	120-12-7
copper	7440-50-8	phenanthrene	85-01-8
nickel	7440-02-0	fluorene	86-73-7
tin	7440-31-5	pyrene	129-00-0
aluminum[‡]	7429-90-5	fluoranthene	206-44-0

[◊] *Total* mercury will be measured but will be assumed as elemental mercury in the CTUIR HHRA

[♦] *Total* chromium will be measured but will be assumed as hexavalent chromium in the CTUIR HHRA

[‡] Potential UMCD generated contaminants (Dames and Moore 1992)

Table 4-3: Analytes Considered in this SAP

explosives and their degradation products		**semi-volatile analytes with high cancer risk insecticides/herbicides**	
	CAS #		CAS #
TNT[‡]	118-96-7	4-aminobiphenyl	92-67-1
RDX[‡]	121-82-4	benzidine	92-87-5
HMX[‡]	2691-41-0	3,3'-dichlorobenzidine	91-94-1
Tetryl[‡]	479-45-8	3,3'-dimethylbenzidine	119-93-7
2,4-dinitrotoluene[‡]	121-14-2	2,4-D[‡]	94-75-7
2,6-dinitrotoluene[‡]	606-20-2	2,4,5-T[‡]	93-76-5
1,3,5-trinitrobenzene[‡]	99-35-4	Chlordane[‡]	57-74-9
1,3-dinitrobenzene[‡]	99-65-0	DDD[‡]	72-54-8
nitrobenzene[‡]	98-95-3	DDE[‡]	72-55-9
		DDT[‡]	50-29-3

[‡] Potential UMCD generated contaminants (Dames and Moore 1992)

Conceptual model of contamination by UMCDF and human health risk - The conceptual model describes contaminants that were initially wind-deposited onto soils after being emitted by UMCDF stacks or present from UMCD activities within the region where UMDCF contaminates were most likely deposited. Natural resources such as animals and vegetation uptake the contaminants through physical and biological processes, and human users contact the contaminants through consumption of the natural resources, dermal contact with soils, and inhalation of soil based dust.

The initial list of contaminants to be assessed were chosen based on the results of the UMCDF post trial burn HHRA completed by the CTUIR in 2008 (CTUIR 2008). Additional COPCs were chosen based on criteria discussed later in this section. These COPCs, listed in Tables 4-1 through 4-3, include:

- metals
- polychlorinated dibenzodioxins, dibenzofurans, and biphenyls
- semi- and non-volatile organic compounds including polycyclic aromatic hydrocarbons (PAHs)
- explosives and their degradation products
- organochlorine pesticides

Analytes were chosen based on insufficient evidence that they are not present in levels that create human health risks above action levels determined by the traditional tribal subsistence lifestyle exposure scenario. Volatile and most semi-volatile organic compounds were excluded since the results of the CTUIR HHRA indicate that they generate low human health risk due to lack of persistence in the environment or low toxicity/carcinogenicity. However, a few high carcinogenic semi-volatile compounds were chosen. Non-volatile organic compounds, primarily PAHs, were selected based on their high carcinogenicity and the human health risk shown for UMCDF non-volatile emissions in the recent CTUIR HHRA (CTUIR 2008).

It is recognized that areas of the UMCD may have been contaminated prior to the start of UMCDF operations and some are undergoing cleanup under CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act). CERCLA and RCRA closure of the full UMCD will not be addressed in this SAP. The focus of these DQOs is limited to the RCRA closure process of the UMCDF, and this SAP will be designed to quantify absolute levels of any COPCs that *could have* been emitted by UMCDF. Closure of the other CERCLA operable units and RCRA closure of the entire UMCD will be addressed in a separate SAP. However, some COPCs (i.e. explosives, pesticides, herbicides) that can be attributed only to UMCD actions (Dames and Moore 1992) have been included in this SAP. This allows data collected for UMCDF RCRA closure to be used for UMCD CERCLA/RCRA closure activities.

Available resources and relevant deadlines - David Laman (CTUIR physical scientist) will complete these DQOs and design the SAP. Rodney Skeen (CTUIR chemical engineer) will support the overall process, primarily through critical review of the SAP design and drafting of the background and other support sections of the document. A completed draft of the SAP will be submitted to the Army for review by June 2009 when HD trial burns are scheduled to begin. Actual sampling will not commence until after the incinerator operations are complete.

4.2 *Step 2 – Identify the Decision*

Identify the principle study question – COPCs may have been deposited in soil within the UMCD boundary as a direct result of UMCDF operations. The principle study question is: *What are the present spatial distributions of absolute concentrations of pertinent COPCs in soil within the UMCD boundary that are likely to have originated from the UMCDF or originated from the UMCD and are contained in the region of UMCDF deposition?*

It is important to stress that well-characterized uncertainties are an integral part of any absolute concentration measurement. The absolute concentrations of COPCs will be the inputs into the HHRA. Since absolute concentrations alone determine human health risk, pre-operational COPC background concentrations are not necessary for the HHRA process. However, this should not be regarded as an indicator that detailed knowledge of pre-operational background levels is not necessary, as well-defined pre-operational background levels are required to draw conclusions regarding the origins of contamination for decisions regarding remediation efforts.

It should also be noted that while soil has been specified as the only medium to be sampled, it will be necessary to include sampling of biota in the UMCD-wide CERCLA/RCRA closure activities. Sampling of biota will be important for incorporating methyl mercury and polychlorinated biphenyls/dibenzodioxins/dibenzofurans in a HHRA, since these compounds bioaccumulate in plants and animals. The mammalian, invertebrate, and vegetation data which has been generated through the UMCDF CMP (Comprehensive Monitoring Plan) *might* be sufficient for this purpose and a later review will be required to determine its adequacy.

Identify the alternative actions – The alternative action that might result from resolution of the principle study question is remediation of contaminated areas under RCRA. This action would be necessary if the HHRA indicates the presence of risk above action levels for any of the human exposure scenarios considered by the HHRA *and* if pre-operational background data can attribute the contamination to UMCDF.

Combine the principal study question and alternative actions into a decision statement – *Determine whether the absolute concentrations of RCRA COPCs present in soil downwind of the UMCDF generate human health risks above action levels for the Native American human exposure scenarios described in the 2008 UMCDF HHRA* (CTUIR, 2008). *If human health risk is above action levels,* ***and*** *the contamination can be attributed to the UMCDF through appropriate background data, then remediation of contaminated areas will be necessary for any COPCs that could have originated from the UMCDF.*

4.3 *Step 3 – Identify the Inputs*

Identify the information required to resolve the decision statement – To determine whether COPCs exceed HHRA-based action limits in distinct areas within the UMCDF emissions footprint, the following questions were asked:

1. What were the recorded prevailing winds since agent processing began in September 2004?
2. Where can appropriate background data be obtained i. e. what areas can reasonably be expected to be free of UMCDF generated COPCs, and what are the concentrations of COPCs in those areas?
3. What COPCs have been detected in previous sampling efforts, and what are their spatial distributions
4. What COPCs have been detected in UMCDF stack emissions?

Determine the sources of each informational input –The following sources for the required information were used for this analysis:

1. *What were the recorded prevailing winds during each major operational period of UMCDF?* – On-site meteorological data is available from the UMCDF meteorology station. "Monthly hourly" on-site wind rose plots are available, or can be generated, from the on-site meteorological data. Wind data during major agent processing periods are of primary interest.

2. Where can appropriate background data be obtained i.e. what areas can reasonably be expected to be free of UMCDF generated COPCs, and what are the concentrations of COPCs in those areas? – Location of an area for background sampling within the UMCD boundary is problematic due to non-UMCDF related contamination from past UMCD activities and from surrounding farms and freeways. Appropriate locations for background data will preferably be:
    - outside the UMCD boundary and with minimum likelihood of having been impacted by UMCD operations
    - upwind from all potential airborne sources of contamination within UMCD
    - upwind from other local sources of airborne contamination
    - without a history of agricultural use

3. *What has been found in previous sampling activities?* – The UMCDF Comprehensive Monitoring Program (CMP) has been monitoring levels of selected COPCs on a quarterly basis since April 1999. Data collected prior to July 2004 is considered the pre-operational "baseline" data. Mean annual *greater-than-baseline* (GTB) values, expressed as a percentage above the maximum value for the baseline sampling period, reported for sampling sites within the UMCD boundary (Zone 1) are summarized in Tables 4-4 through 4-7 (UMCDF 2004-2007). The bolded entries suggest that evidence might exist for dioxin, furan, PCB, chromium, and cadmium concentrations that are higher than pre-operational background levels as defined in the UMCDF CMP background report. All these compounds have been included in the COPC list for this sampling effort.

Table 4-4: Summary of GTB Values in Zone 1 - **Soil**

report year	**dioxins/furans** mean % GTB	**PCBs** mean % GTB	**beryllium** mean % GTB	**chromium** mean % GTB	**manganese** mean % GTB	**arsenic** mean % GTB	**cadmium** mean % GTB
2004	-	-	12	-	-	-	-
2005	-	-	34	-	-	-	-
2006	**11**	-	-	-	-	-	-
2007	**18**	-	-	-	-	-	-
2008	**18**	-	-	-	-	-	-

Table 4-5: Summary of GTB Values in Zone 1 - **Small Mammals**

report year	**dioxins/furans** mean % GTB	**PCBs** mean % GTB	**beryllium** mean % GTB	**chromium** mean % GTB	**manganese** mean % GTB	**arsenic** mean % GTB	**cadmium** mean % GTB
2004	-	-	-	-	-	-	-
2005	**36**	-	-	-	-	-	**24**
2006	**29**	**200**	-	-	-	-	**74**
2007	**423**	**112**	2	-	-	-	-
2008	**22**	-	-	-	-	-	-

Table 4-6: Summary of GTB Values in Zone 1 – **Vegetation**

report year	**dioxins/furans** mean % GTB	**PCBs** mean % GTB	**beryllium** mean % GTB	**chromium** mean % GTB	**manganese** mean % GTB	**arsenic** mean % GTB	**cadmium** mean % GTB
2004	**69**	-	-	5	-	1	-
2005	-	-	-	-	-	-	-
2006	-	**40**	-	**46**	18	61	-
2007	**52**	-	-	-	-	-	-
2008	-	-	-	-	-	-	-

Table 4-7: Summary of GTB Values in Zone 1 - **Terrestrial Invertebrates**

report year	**dioxins/furans** mean % GTB	**PCBs** mean % GTB	**beryllium** mean % GTB	**chromium** mean % GTB	**manganese** mean % GTB	**arsenic** mean % GTB	**cadmium** mean % GTB
2004	**87**	-	-	-	-	-	-
2005	**141**	**49**	-	-	-	-	-
2006	**536**	-	-	**397**	-	-	**183**
2007	**300**	-	-	-	-	-	**27**
2008	**430**	-	-	-	-	-	**55**

4. *What is the spatial distribution of analytes in soil and biota found in previous sampling activities?* – Figure 4-1 and Table 4-8 summarize the spatial distribution of GTB findings reported in the 2004-2007 CMP annual reports. Soil and biota were sampled from all the sites in Figure 4-1 except for Site 4 (adjacent to UMCDF) where only soil was sampled (UMCDF 2004-2007).

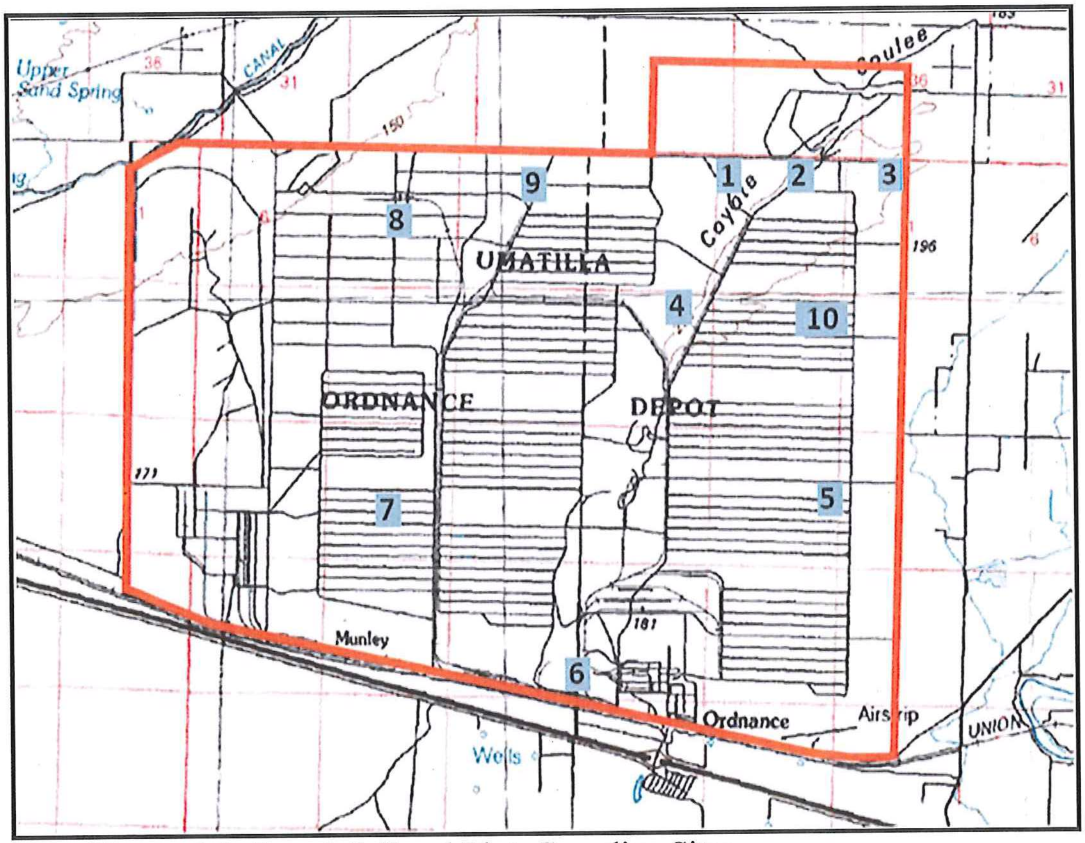

Figure 4-1: Zone 1 Soil and Biota Sampling Sites

Table 4-8: GTB Frequency Summary at Sampling Sites in Zone 1

Zone 1 Site Number	Total Number of GTB Findings Reported in 2004-7
1	2
2	2
3	8
4*	1
5	5
6	60
7	0
8	36
9	1
10	0

*adjacent to the incinerator

The GTB results at Sites 6 and 8 cannot currently be attributed to the UMCDF with confidence for the following reasons:

- Prevailing winds are predominantly to the east-northeast, making sites 1,2,3 and 10 the most likely recipients of UMCDF generated contaminants
- The presence of I-84 just south of Site 6
- The presence of CERCLA operable units west of Site 8 in the ADA area

The presence of GTB results in areas 1, 2, and 3, which are downwind of UMCDF, might indicate UMCDF related impacts requiring sampling in those areas.

Identify the information needed to determine if delineated areas exist with GTB COPC levels that can be attributed to UMCDF emissions – The following information will be gathered to assess whether the UMCDF is the source of any contamination detected in this sampling effort:

- Identification of a well-established background outside the UMCD boundary with minimum likelihood of having been impacted by UMCDF operations.
- Spatial patterns of contamination will be established. Areas of the UMCD that *are expected and are not expected* to be impacted by UMCDF wind-blown contamination should be identified. Sampling sites were chosen so that predictive air-deposition models will be able to differentiate between UMCDF and non-UMCDF deposited contamination with a minimum of uncertainty.
- As above, areas of the UMCD that are both expected and not expected to be impacted by other UMCD activities were identified.
- Correlation, if any, between quarterly CMP GTB findings and the volume of agent and secondary wastes processed during each quarter will need to be quantified if contamination that might be attributed to the UMCDF is detected.
- Correlation, if any, between quarterly CMP GTB findings and prevailing winds during each quarter will need to be quantified if contamination that might be attributed to the UMCDF is detected.

Confirm that appropriate measurement methods exist – The following EPA SW-846 analytical methods are available:

- Semi-volatile and non-volatile organic compounds will be assayed with Method 8270 (gas chromatography/mass spectrometry - GC/MS), which has compound-dependent detection limits. A version of method 8270 with lower detection limits is being implemented for the UMCDF HD trial burns in summer 2009. If this method proves useful for the HD trial burns, it should also be employed for post-closure sampling and analysis.
- Method 8310 (high pressure liquid chromatography/fluorescence detection – HPLC/FL) for polycyclic aromatic hydrocarbons
- Method 1668 (high resolution gas chromatography/mass spectrometry – HRGC/MS) for PCBs
- Method 8290 (HRGC/MS) for dioxins and furans
- Method 6010 (inductively coupled plasma/atomic emission spectroscopy – ICP/AES) for metals
- Method 6020 (inductively coupled plasma/mass spectrometry – ICP/MS) for metals
- Methods 7470/7471 (cold vapor atomic absorption) for *total* mercury

- Method 8330 (high pressure liquid chromatography/ultraviolet absorption detection – HPLC/UV) for explosives and degradation products of explosives
- Method 8081A (gas chromatography/electron capture detection - GC/ECD) for organochlorine pesticides
- Speciation of non-volatile organics in the GRAV fraction via scanning electron microscopy/X-ray fluorescence will be attempted for first time during the HD trial burns. This method could be utilized if it proves successful during the HD trial burns.

Each method listed above has associated approved sample preparation methods for a wide variety of sample matrices.

Since the objective of this SAP is to determine absolute analyte concentrations with well-characterized uncertainties, the most sensitive techniques necessary to accomplish this objective should be used. For example, if the less sensitive Method 6010 is adequate to provide a sufficiently accurate *and* precise measurement of antimony for the HHRA, then the more sensitive Method 6020 is not necessary. However, if Method 6010 is only able to report detection of antimony with a high degree of fractional uncertainty, then Method 6020 for subsequent samples needs to be considered.

Finally, action levels for human health risk are a consideration for choice of analytical technique. Methods which cannot detect analytes at concentrations at human health risk action levels, especially for cumulative exposures, will not be capable of providing useful information for the HHRA. The SAP design should consider human health risk action levels for analytes and choose appropriate analytical methods based on those action levels. Section 7 lists these action levels and analytical methods/detection limits are discussed in the Methodology and Quality Assurance Project Plan section (Section 6).

4.4 Step 4 – Define the Boundaries of the Study

What population will be sampled? – The sample population consists of sampling points, chosen by Visual Sampling Plan (VSP), within designated survey areas. Designated survey areas were selected based on the results of predictive air deposition models and the desire to determine the spatial extent of contamination in the direction of the prevailing winds up to the UMCD fence line. VSP uses a probabilistic algorithm to generate the sampling points within each survey area.

Sampling points generated by VSP falling on sites not suitable for sampling (for example impenetrable surfaces or within CERCLA operable units) will be adjusted according to the guidelines in the Methodology and Quality Assurance Project Plan document (Section 6).

What will be the Spatial Boundaries? – The area to be sampled is inside the boundaries of the UMCD; however, *this survey area excludes the region inside the UMCDF fence line,* as sources of contamination other than stack emissions exist within this area. The area within the UMCDF fence line will be addressed in the SAP for closure of the UMCD in its entirety.

The depth to which soil needs to be sampled is also a spatial boundary. The most relevant sampling depths are a function of the expected human health exposure routes. For coarse medium sand with sandy loam soil (as is found at UMCD), sampling to the average root depth of the existing vegetation covers the expected common exposure routes including direct ingestion, inhalation of blown dust, inhalation during gardening and children's games, ingestion of home grown vegetables, and dermal contact. This depth, which will be somewhere in the range 10-30 cm, will be specified in the Methodology and Quality Assurance Project Plan document (Section 6).

What will be the appropriate timeframe for sampling? – Sampling cannot commence until incinerator operations are complete, however, the results of the post-closure HHRA must be available so that the LRA can make reuse recommendations in a timely manner. Thus, sampling should commence *as soon as is practically possible* after incinerator operations are complete.

What is the scale of inference for decision making? – The "scale of inference" the smallest spatial unit which provides adequate site characterization. Due to the complexity of site contamination, there is no likely single area within the UMCD boundary that can be predicted to be characteristic of the entire site. For example, it makes no sense to remediate one part of the site that is devoid of lead just because another part of the site is heavily contaminated with lead. It is thus possible that individual scales of inference will be required for different areas. For this SAP, the scale of inference is the size of the area required to cover at least 99% of the contamination deposited on the ground by the UMCDF common stack. This area is about 3 km^2.

What are the practical constraints for collecting data? - Sampling cannot occur until incineration operations are complete, sampling during winter months is impractical because of periodic snow cover and frozen ground, budget constraints might limit the sampling population, and the presence of artificial structures (e. g. roads) limits the freedom of choosing sampling points.

4.5 *Step 5 – Develop a Decision Rule*

In this step quantitative health-based criteria are used to create an "if…then…" statement i.e. *the decision rule* regarding the actions that need to be taken once the level of contamination is reliably known.

What level of comparison with conditions at the background site will be used to establish the decision rule?

1. *Specify the statistical parameters used to characterize the population of interest.* – *Sample mean* concentrations and their associated uncertainties at the survey site *and* at an appropriate "pristine" background site are required for a proper comparison. It is especially important to stress that meaningful comparisons cannot be made unless the uncertainties for both the survey site and the background site are known.

2. *Specify the level of comparison for the decision* – "Cleanliness goals" will be determined by the *sample mean* concentrations and associated uncertainties of analytes at the background site, and by appropriate confidence intervals. Thus levels of comparison can only be established once background concentrations are known. It should be noted that the level of comparison is *not* the *sample mean* concentration; it is the *true mean* concentration i.e. the *population mean* concentration estimated from the *sample mean* and its uncertainty.

Develop the decision rule – The following are the two decision rules applied in this effort.

- **Decision rule 1**: If the *true mean* concentration at the survey site is greater than the *true mean* concentration at the background site with statistical significance, evaluate the results from a health risk perspective in order to determine what risk management and cleanup actions are necessary.
- **Decision rule 2**: If the *true mean* concentration at the survey site is *not* greater than the *true mean* concentration at the background site with statistical significance, then no further action is required independent of the results of the HHRA.

These decision rules and their associated actions are illustrated in Figure 4-2.

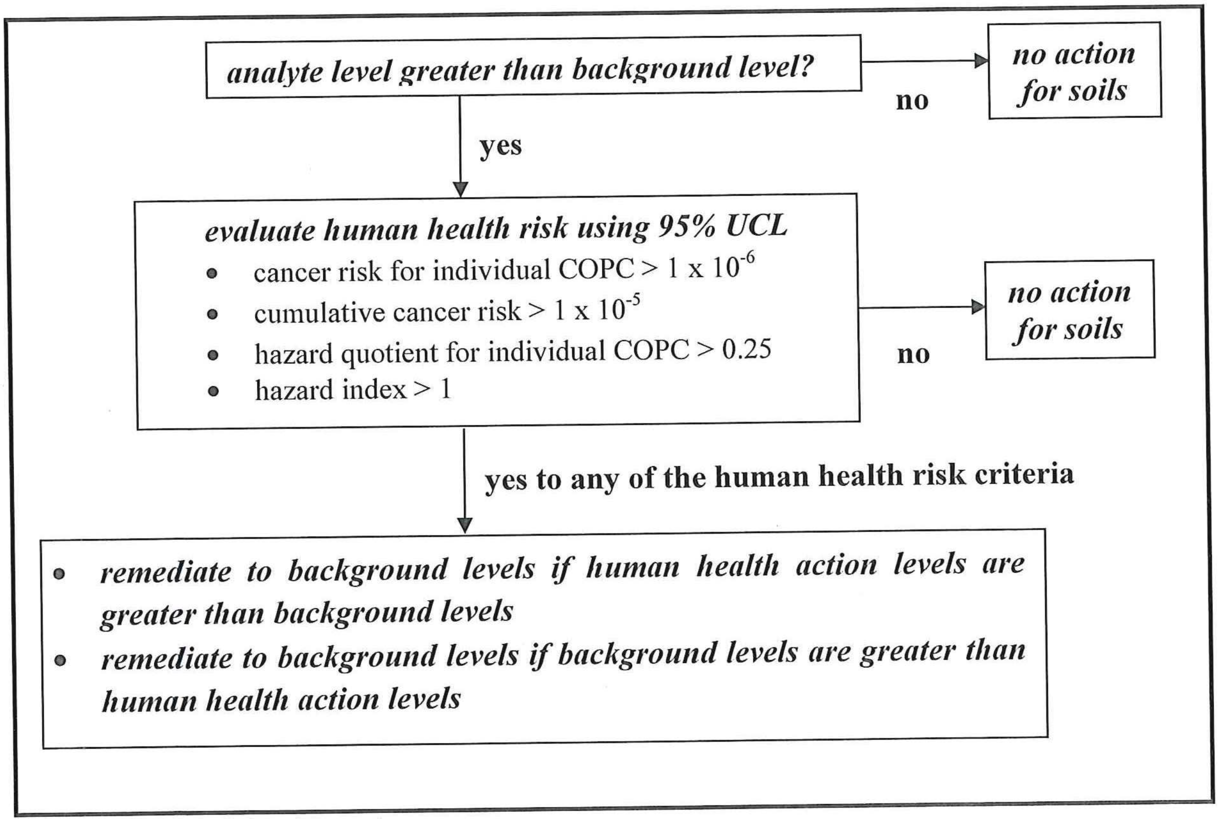

Figure 4-2: Decision Flowchart

Non-detects will be incorporated into the decision process according to the guidelines outlined in the Methodology and Quality Assurance Project Plan document (Section 6).

4.6 *Step 6 – Specify Tolerable Limits on Decision Errors*

In this step quantitative performance criteria are specified and maximum tolerable probabilities for decision errors are assigned.

Set the baseline condition – The baseline condition is defined based on background levels of analytes that are established by sampling in the type of "pristine" area specified in **Step 3**. Until this is accomplished, the baseline condition can be only generally stated. Determination of background levels would thus seem to be a time-sensitive step and should be pursued as soon as is practically possible. However, decision error limits can still be specified without a complete background survey.

Determine the impact of decision errors and set tolerable decision error limits – Two potential decision errors can be made as a result of random uncertainty in the sampling process:

- **Decision error 1**: Concluding that the *true mean* concentration of an analyte at the survey site is not higher than the level of comparison with statistical significance when it actually is.

- **Decision error 2**: Concluding that the *true mean* concentration of an analyte at the survey site is higher than the level of comparison with statistical significance when it actually is not.

The consequences of both decision errors are clear. Decision error 1 could result in unacceptable health risk going undetected and unaddressed for perpetuity, depending on whether or not human health action levels are exceeded. Decision error 2 will result in needless expenditures. This SAP team has determined that the consequences of decision error 1 are more severe, i.e. unaddressed health risks are significantly less acceptable than unnecessary expenditures.

Thus the *baseline condition* for this SAP is that the true mean concentration of an analyte at the survey site is greater than the level of comparison with statistical significance, while the alternative condition is that it is not. The equivalent statistical hypothesis is:

H_0: The *true mean* analyte concentration at the survey site is greater than the level of comparison (the "null hypothesis")
H_a: The *true mean* analyte concentration at the survey site is less than or equal to the level of comparison (the "alternative hypothesis")

Alternatively, if we denote the true mean concentration at the survey site as μ, and the true mean concentration at the background (reference) site as μ_{ref}, the null and alternative hypotheses can be stated as:

H_0: $\mu > \mu_{ref}$
H_a: $\mu \leq \mu_{ref}$

Thus if the data cannot provide *convincing evidence* that the true mean concentration at the survey site is *greater than* the true mean concentration at the background site, we will accept H_a

as true. It should be noted that H_0 and H_a are stated in the standard convention for hypotheses: H_a is reserved for the outcome that we hope or suspect to be true i.e. that the survey site is clean.

What is a tolerable probability that H_0 might be rejected incorrectly? – This question essentially asks: What is an acceptable fraction of the total number of null hypothesis rejections being false as a result of random uncertainty. The answer to this question will determine how large the sample size needs to be, since the fraction of false rejections will decrease as the sample size increases. EPA guidance recommends 1% as the starting point for assignment of the maximum probability of false rejection of the null hypothesis (EPA 2006). This SAP will attempt to follow this guidance. Stated in terms of confidence levels, choosing a 1% false rejection rate means that this SAP is designed such that the data is capable of allowing decision making at the 99% confidence level.

What does the confidence level mean in terms of the required sample size? The required sample size can be estimated if preliminary estimates of the population mean and standard deviation are known. Since these preliminary estimates are currently not available, we refer to EPA assessment of sampling data from Superfund sites: *"...fewer than 10 samples per exposure area provide poor estimates of the mean concentration..."* and *"...data sets with 10 to 20 samples per exposure provide somewhat better estimates of the mean, and data sets with 20 to 30 samples provide fairly consistent estimates of the mean..."* (EPA 1992). This says that the confidence interval is unacceptably large for only 10 samples, and that the size of the confidence interval shrinks as the sample size increases, as is expected. It should be noted that, while this EPA assessment actually refers to the size of the 95% confidence interval, it still provides a starting point for the minimum sample size required to manage the size of the 99% confidence interval.

Specify the "gray region" for the decision performance curve – The "gray region" addresses the question: *Is there a range of analyte concentrations for which there is a tolerable probability of making an incorrect decision, and if so what is that range?* This requires that we specify a range of mean analyte concentrations where the consequences of a decision error are insignificant.

Consider Figure 4-3. The left-hand boundary of the gray region is the analyte action level. The other boundary corresponds to mean values of the analyte concentration for which the consequences of a false rejection start to become significant. For example, if we set the upper limit at 15% above the action level, then when the sample mean is greater than 115% of the action level the data provides *absolutely sufficient* evidence that the true mean is above the action level. This essentially amounts to requiring that the fractional uncertainty near the action level be ≤ 15% of the mean. This situation is illustrated in Figure 4-3. Given the error bars shown, the uncertainty associated with measurement **A** is small enough to say with confidence that the true mean is above the action level, while the same cannot be said for the uncertainty associated with measurement **B**. The site associated with measurement **A** can be said to contain human health risk with a fairly high probability, while the site associated with measurement **B** cannot, even though the mean value of measurement **B** is greater than that of measurement **A**. It is very clear that the width of the gray zone dictates the maximum allowable experimental uncertainties.

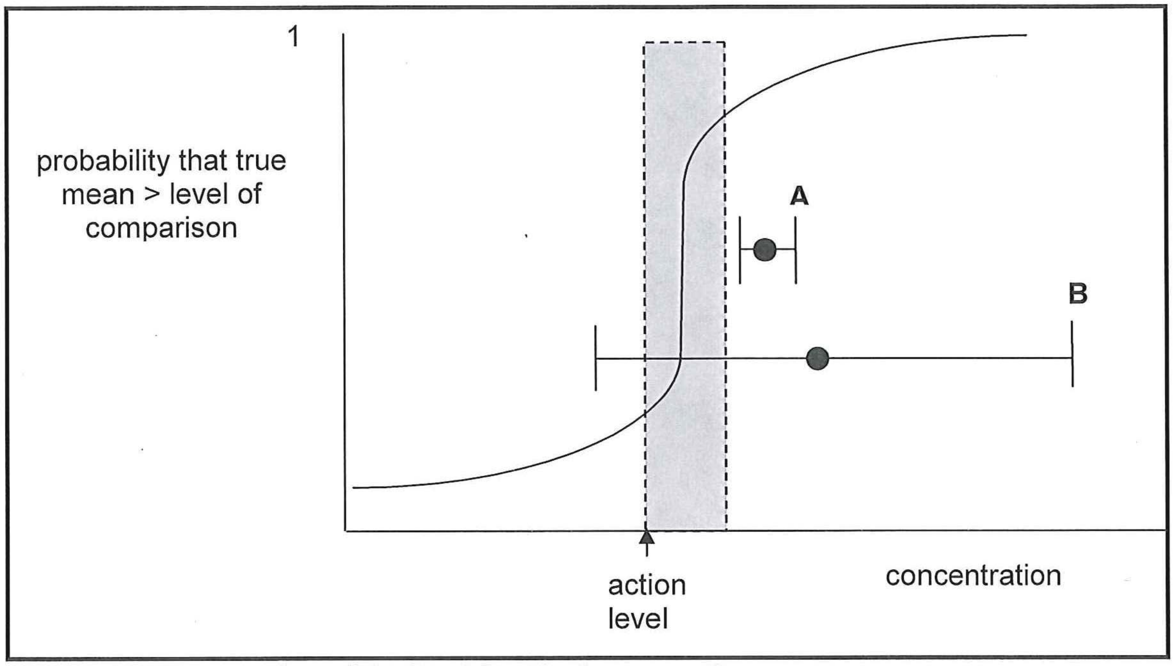

Figure 4-3: Gray region of the Decision Performance Curve

Assign a tolerable probability of a false rejection of the null hypothesis – As discussed earlier, we have adopted the EPA guidance that recommends 1% as the starting point for the tolerable probability of false rejection of the null hypothesis.

For the purpose of defining the gray region we will assume that the sampling site is dirty (i.e. accept the null hypothesis). This assumption puts the gray region *below* the action level (instead of above it as in Figure 4-3), and hence the width of the gray region controls the probability of falsely accepting the null hypothesis instead of falsely rejecting it. The tolerable probabilities that will be used to define the gray region are tabulated in Table 4-7, where μ is the analyte true mean concentration at the survey site and μ_{ref} is the analyte true mean concentration at the background (reference) site. The gray region width defined by the gray colored entry in Table 4-7 will be used for all analytes. Note that specifying the single ratio μ/μ_{ref} instead of comparing *each* μ to *each* μ_{ref} allows us to define a single *fractional* gray region that applies to all analytes.

Table 4-7: Values Used for Defining the Gray Region

reported μ/μ_{ref}	decision	**true** μ/μ_{ref}	error type	aversion	tolerable probability
> 1	cleanup	0. 0 - 0. 2	false acceptance	high ($)	0. 10
> 1	cleanup	0. 2 - 0. 4	false acceptance	moderate ($)	0. 20
> 1	cleanup	0. 4 – 1. 0	false acceptance	minor ($)	gray region
< 1	no action	1. 0 - 1. 2	false rejection	minor (health)	0. 20
< 1	no action	1. 2 – 2. 0	false rejection	moderate (health)	0. 10
< 1	no action	2. 0 - 4. 0	false rejection	high (health)	0. 05
< 1	no action	> 4. 0	false rejection	severe (health)	0. 01

The fractional uncertainty $\mathbf{s}_{\text{field}}/\mathbf{c}$, where $\mathbf{s}_{\text{field}}$ is the field sampling contribution to the uncertainty in the *sample mean* analyte concentration **c**, is always much greater than the fractional uncertainty $\mathbf{s}_{\text{lab}}/\mathbf{c}$, where $\mathbf{s}_{\text{lab}}$ is the laboratory contribution to the uncertainty in **c** (Pulsipher et al. 2003). Thus $\mathbf{s}_{\text{field}}$ is the primary contributor to the uncertainty in **c**, and $\mathbf{s}_{\text{lab}}$ need not be considered when determining the necessary sample size. Based on reported values of $\mathbf{s}_{\text{field}}$ for soil sampling (Ramsey and Argyraki 1997), we will use a constant value of $\mathbf{s}_{\text{field}}/\mathbf{c} = 0.4$ in our calculations of the necessary sample size. However, despite the fact that $\mathbf{s}_{\text{lab}}$ has no significant bearing on the calculated sample size, we will still require that the precision of laboratory methods be estimated in order to assess the degree of reproducibility of the sample preparation and analytical methods (see Section 6.4.1).

An important quantity is the ratio $\Delta/\mathbf{s}$, where Δ is the width of the gray region and **s** is the overall sample uncertainty i.e. the *sample standard deviation.* As $\Delta/\mathbf{s}$ increases, i.e. as Δ increases relative to **s**, the number of samples required to adequately characterize the sampling site decreases, and as $\Delta/\mathbf{s}$ decreases, i.e. as Δ decreases relative to **s**, the number of samples required to adequately characterize the site increases. Thus there is a trade-off between the tolerable decision error rate and the size of the sample population. The required number of samples is *very sensitive* to the value of $\Delta/\mathbf{s}$, and hence the range of $\Delta/\mathbf{s}$ used in a sampling plan is a compromise between minimizing decision error rates and limiting cost. EPA guidelines suggest that the appropriate range of $\Delta/\mathbf{s}$ in environmental sampling is $1 \leq \Delta/\mathbf{s} \leq 3$ (EPA 2001b). This sampling plan will use $\Delta/\mathbf{s} = 1$ to maintain maximum stringency within the guidelines. This is equivalent to requiring that the width of the gray region not exceed the sampling uncertainty. Note that the gray entry in Table 4-7 is consistent with *both* $\mathbf{s}_{\text{field}}/\mathbf{c} = 0.4$ and $\Delta/\mathbf{s} = 1$.

4.7 *Step 7 – Optimize the Design for Obtaining Data*

Optimization of the SAP design in conjunction with the DQOs is an iterative process. As the SAP is designed it will likely become evident that these DQOs need modification, and as the DQOs are modified the SAP design will necessarily have to change. The following tools are available for this process:

1. VSP software
2. Results of the UMCDF CMP
3. U. S. Army Corps of Engineers Remedial Investigation Reports
4. Usage history of the region surrounding UMCD
5. Human health data for COPCs

5 Sampling Design Summary

5.1 *Required Inputs to Visual Sampling Plan*

The location and number of sampling points is determined with Visual Sampling Plan (VSP) using the DQOs from Section 4 as inputs. VSP requires the following user provided information:

1. An accurate ArcGIS shapefile map of the depot with correctly embedded coordinates
2. Method for generating locations of sampling points
3. The selected survey areas
4. Sampling goals i.e. what statistical model describes the population to be sampled
5. The null hypothesis
6. Estimated uncertainties of mean analyte concentrations
7. The width of the gray region
8. Decision action levels
9. The acceptable false rejection rate (α) and the acceptable false acceptance rate (β)

These inputs are discussed below.

5.1.1 UMCD map

Coordinates (WGS 1984, decimal degrees to seven decimal places) of UMCD features were obtained via Google Earth. These coordinates were used in ArcMap to create a shapefile map of the UMCD. This WGS 1984 map was projected into a UTM NAD 1983 map for use in VSP.

5.1.2 Method for generating locations of sampling points

VSP allows the user to specify either random sample placement or placement along a uniform grid. We have specified random sample placement for this SAP.

5.1.3 Selected survey areas

Two individual sampling areas (**1** and **2**) (see Figure 5-1) have been defined:

- **Area 1**, roughly centered on the UMCDF common-stack, is positioned to contain 99+% of the predicted emissions deposited on the ground as indicated by the results of the deposition modeling software *AERMOD*. Appendix B provides the meteorological data used in the *AERMOD* analysis. Appendix C provides the details on the *AERMOD* model inputs to simulate the UMCDF Stacks. Note, as was discussed in Section 4.4, that the area inside the UMCDF fence line has been excluded from area 1.

- **Area 2** is positioned to provide and area adjacent to the UMCD fence line and downwind from the UMCDF common stack. Sampling in area 2 will allow determination of the maximum spatial extent of contamination within the UMCD.

VSP generated an independent set of random sampling points within each individual area. Thus the sampling points for this SAP were generated by both judgmental and probabilistic means: the choice of areas **1** and **2** is judgmental and the random generation of sampling points *within* each area is probabilistic.

Another important criterion is that none of the sampling areas should fall within the existing UMCD CERCLA operable units, as is the case for the selected areas. Finally, both survey areas are about the same area (2.8-3.0 km^2), so that the average density of sampling points is approximately the same in both areas.

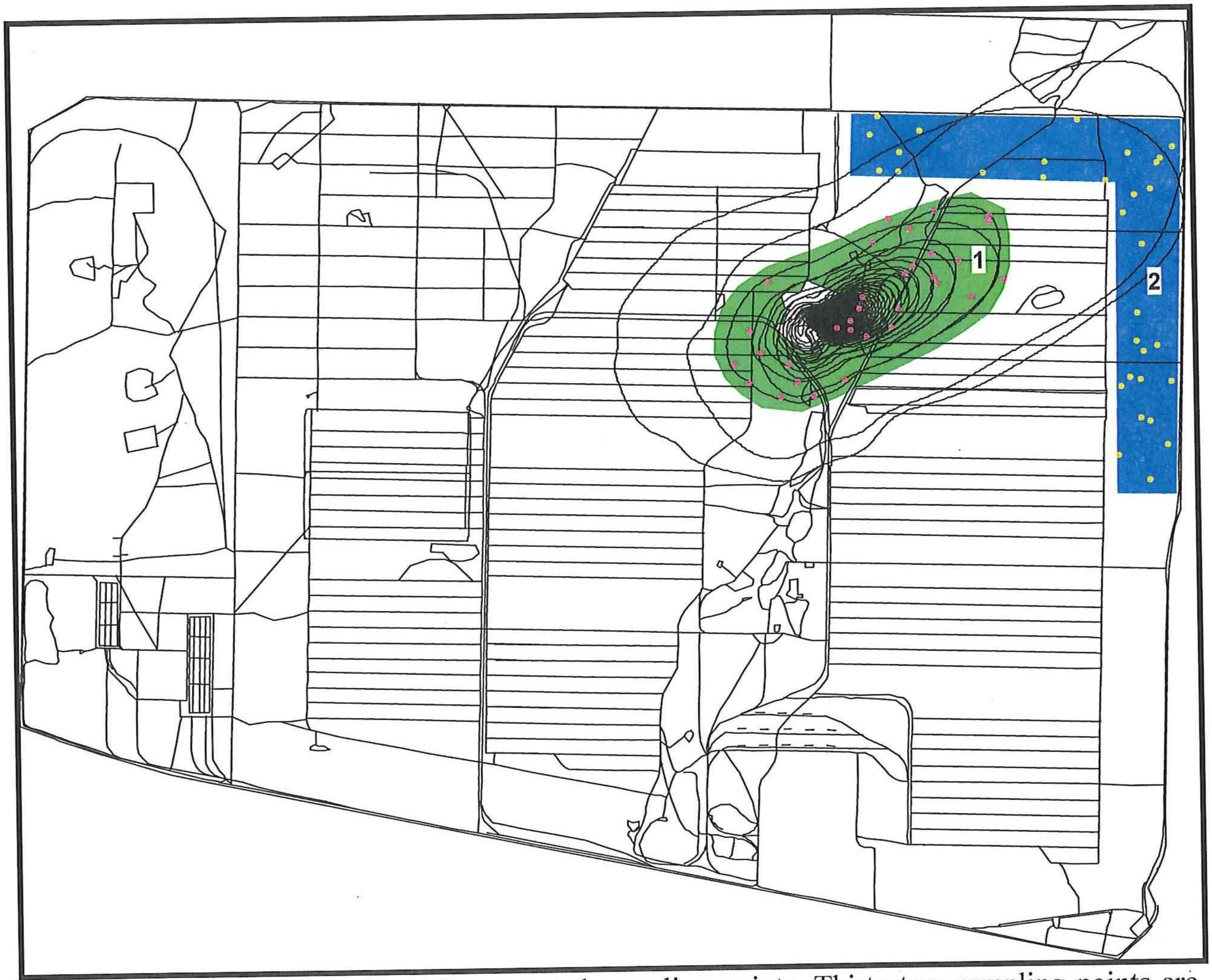

Figure 5-1: UMCD map with VSP generated sampling points. Thirty two sampling points are indicated for each of the two sampling areas (labeled "1" and "2")

5.1.4 Sampling goals

The term "sampling goals" refers to the statistical model used to determine the sampling population. Essentially, an appropriate statistical model is chosen by considering the expected spatial distribution of analyte concentrations *and* what information decision makers require from the sampling data. For this SAP, two criteria were used to choose the sampling goals:

- There is no evidence supporting the supposition that the data will be normally distributed.
- For the purpose of decision making, the mean analyte concentrations in each UMCD survey site will have to be compared to mean analyte concentrations at the reference

(background) site external to UMCD. This requirement is equivalent to comparing two different populations, each with a characteristic mean and uncertainty.

The statistical model built into VSP that satisfies the above two criteria is the *Wilcoxon rank sum test.* This model is accessed in VSP by choosing the following options from the *Sampling Goals* drop down menu: **Compare Average to Reference Average → Data not required to be normally distributed → Ordinary sampling – no distributional assumption**.

5.1.5 The null hypothesis

VSP allows the user to assume the survey site is either dirty or clean. As discussed in the DQOs, the site is assumed to be dirty. For the sampling goals discussed above, this assumption is equivalent to the null hypothesis that the difference between the *true mean* concentration for the survey site (μ) and the *true mean* concentration for the reference (background) site (μ_{ref}), $\mu - \mu_{ref}$, exceeds some specified action level. The selection of this action level is discussed is Section 5.1.8.

5.1.6 Estimated uncertainties of mean analyte concentrations

As discussed in the DQOs, uncertainty due to field sampling is typically much greater than uncertainty introduced in the laboratory. As such, the statistical model used in VSP neglects laboratory uncertainty. Field activities in environmental sampling can contribute fractional uncertainties as high as 55% of the mean analyte concentration (Ramsey and Argyraki 1997), i.e. $\mathbf{s/c} = 0.55$, where **c** is the *sample* mean concentration and **s** is the *sample* standard deviation due to uncertainties introduced by field activities. As the number of samples increases, **s** decreases, thus increasing our confidence that the *true* (population) mean falls within the range $\mathbf{c} \pm \mathbf{s}$.

It is important to provide VSP with a reasonable estimate of **s**: If we severely overestimate **s**, VSP will recommend many more samples than are needed to adequately characterize the site, thus increasing cost unnecessarily. If we severely underestimate **s**, VSP will recommend far fewer samples than are needed to adequately characterize the site, thus increasing the possibility of unnecessary human health risk. Unnecessary cost is considered a more acceptable risk than unnecessary health risk, and thus we set **s/c** at 0.4, closer to the high side of the $\mathbf{s/c} = 0$ - 0.55 range. This value was used for all analytes.

Consider an analyte concentration at a survey site with fractional uncertainty **s/c**. *With all other inputs to VSP being equal*, one can specify $\mathbf{s} = 0.1$ and $\mathbf{c} = 0.04$, *or* $\mathbf{s} = 1.0$ and $\mathbf{c} = 0.4$, and VSP will generate the same number of required samples for both cases. Thus the number of samples required depends on the fractional uncertainty **s/c** and *not* on **s** and **c** individually. This removes the necessity for pre-sampling estimation of the *individual* values of **s** for each analyte.

In addition, consideration of fractional uncertainties also removes the necessity for pre-sampling estimation of analyte levels at the background site. Consider a background site with fractional uncertainty $\mathbf{s}_{ref}/\mathbf{c}_{ref}$. Now, $\mathbf{s/c} \approx \mathbf{s}_{ref}/\mathbf{c}_{ref}$ is a reasonable expectation provided that the same numbers of samples were taken *and* the same sampling methods were used at both sites. Thus the required samples can be determined without prior knowledge of *absolute* analyte levels at the background site, since the required samples depend on $\mathbf{s}_{ref}/\mathbf{c}_{ref}$ and we have already specified that

$\mathbf{s}_{ref}/\mathbf{c}_{ref} \approx \mathbf{s}/\mathbf{c} = 0.4$. In this way, the SAP can be designed in advance of actually measuring analyte concentrations at the background site.

It should be noted that absolute analyte levels at the survey and background sites will have to be compared for the purpose of decision making, and thus individual values of **s, c**, $\mathbf{s}_{ref}$, and $\mathbf{c}_{ref}$ for each analyte will eventually be required.

5.1.7 The width of the gray region

We set $\Delta/\mathbf{s} = 1$, where Δ is the width of the gray region. As discussed in the DQOs, the choice $\Delta/\mathbf{s} = 1$ is in accordance with guidance that $1 \leq \Delta/\mathbf{s} \leq 3$ *and* the necessity for stringent protection of human health within accepted guidelines. Note that $\mathbf{s}/\mathbf{c} = 0.4$ *and* $\Delta/\mathbf{s} = 1$ require that $\Delta = 0.4\mathbf{c}$.

In reality, the required sample population actually depends on the ratio $\Delta/\mathbf{s}$ and not on Δ and **s** individually. For example, *with all other inputs to VSP being equal*, one can specify $\mathbf{s} = 0.1$ and $\Delta = 0.04$, *or* $\mathbf{s} = 1.0$ and $\Delta = 0.4$, and VSP will generate the same number of required samples for both cases. Thus, as discussed in the DQOs, it is very clear that the sample size is very sensitive to the width of the gray region *relative* to the size of the experimental uncertainty.

5.1.8 Analyte action levels

VSP requests that analyte action levels be specified. For the chosen sampling goals, specification of action levels is equivalent to answering the question: *For what difference between the sample mean concentration at the survey site* (**c**) *and the sample mean concentration at the background site* ($\mathbf{c}_{ref}$) *can we say that the true mean concentration at the survey site* (μ) *is greater than the true mean concentration at the reference site* (μ_{ref}) *with an acceptable level of confidence i.e. so that the null hypothesis* ($\mu > \mu_{ref}$) *can be accepted with an acceptable level of confidence*? Thus the action level for this SAP is the value of $\mathbf{c} - \mathbf{c}_{ref}$ such that the null hypothesis can be accepted at the required confidence level.

What is the required confidence level for this SAP? We specified in the DQOs that the acceptable rate of null hypothesis false rejection is 1%; thus the null hypothesis must be able to be accepted at the 99% confidence level. The action level is thus the value of $\mathbf{c} - \mathbf{c}_{ref}$ that allows acceptance of the null hypothesis as the 99% confidence level.

It should be noted that the action level $\mathbf{c} - \mathbf{c}_{ref}$ input into VSP has no bearing on the results generated by VSP i.e. changing $\mathbf{c} - \mathbf{c}_{ref}$ doesn't change the number of samples recommended by VSP. Apparently, once the width of the gray region is specified, VSP automatically adjusts the position of the gray region so that the upper bound coincides with the new action level while keeping $\Delta/\mathbf{s}$ constant (Pulsipher 2009). This makes sense since, as discussed previously, the required number of samples actually depends on the ratio $\Delta/\mathbf{s}$ and *not* on Δ and **s** individually.

So, if the results generated by VSP are independent of specified action levels, does this SAP actually require carefully considered action levels? If criteria for proper decision making are to be established, the answer to this question is in the affirmative. Once analyte concentration data at both the survey and background sites are available, appropriate statistical tests for acceptance or rejection of the null hypothesis will be required for decision making. These tests will be outlined in the Methodology and Quality Assurance Project Plan document (see Section 6).

5.1.9 Acceptable false rejection (α) and false acceptance (β) rates

As discussed in the DQOs, EPA guidance recommends 1% as the starting point for assigning decision error rates. This guidance could be applied to both the false rejection rate and the false acceptance rate, however, the consequences of a false rejection (concluding the survey site is clean when it is actually dirty) are considered more serious than a false acceptance (concluding the survey site is dirty when it is actually clean). We thus set the acceptable false rejection rate at 1% ($\alpha = 0.01$) and the acceptable false acceptance rate an order of magnitude higher at 10% ($\beta = 0.1$).

5.2 Visual Sampling Plan Results for Survey Sites 1 and 2

Using the inputs specified above, VSP calculated that 32 samples are required in each *individual* survey area in order to meet the DQOs. It should be stressed that, in order for the statistical model chosen to be valid, the 32 required samples also applies to the background site. Thus it is vital that the same number of samples be taken at each site, particularly if we allow that $\mathbf{s}/\mathbf{c} \approx \mathbf{s}_{ref}/\mathbf{c}_{ref}$. Selection of the 32 sampling points within the background site is accomplished using the same sampling goals and sample placement algorithm as for the survey sites. Details of the background site are discussed in Section 5.3.

The site map with the sample points generated by VSP is shown in Figure 5-1, and the NAD 1983 UTM coordinates of the sample points are listed in Table 5-1. The closed curved surfaces approximately centered on the incinerator in Figure 5-1 are contours of constant surface contaminant concentration generated by *AERMOD* and superimposed on the map via an ArcMap splining routine. Quality assurance procedures dealing with sample points that fall on features where sampling cannot be accomplished (e.g. roads) will be discussed in a later section. The decision performance curve generated by VSP is in Figure 5-2.

Note that the number of samples required is consistent with the EPA statement *"data sets with 20 to 30 samples provide fairly consistent estimates of the mean"*. Our sample size slightly exceeds 30 samples, possibly because non-parametric models such as the one used in the sampling goals of this SAP typically generate higher required sample sizes than models based on the normal distribution. For example, 28 samples are recommended by VSP if a model assuming a normal distribution is used. Clearly, about thirty samples per survey area are required to meet the DQOs, and we will retain 32 samples for each survey area.

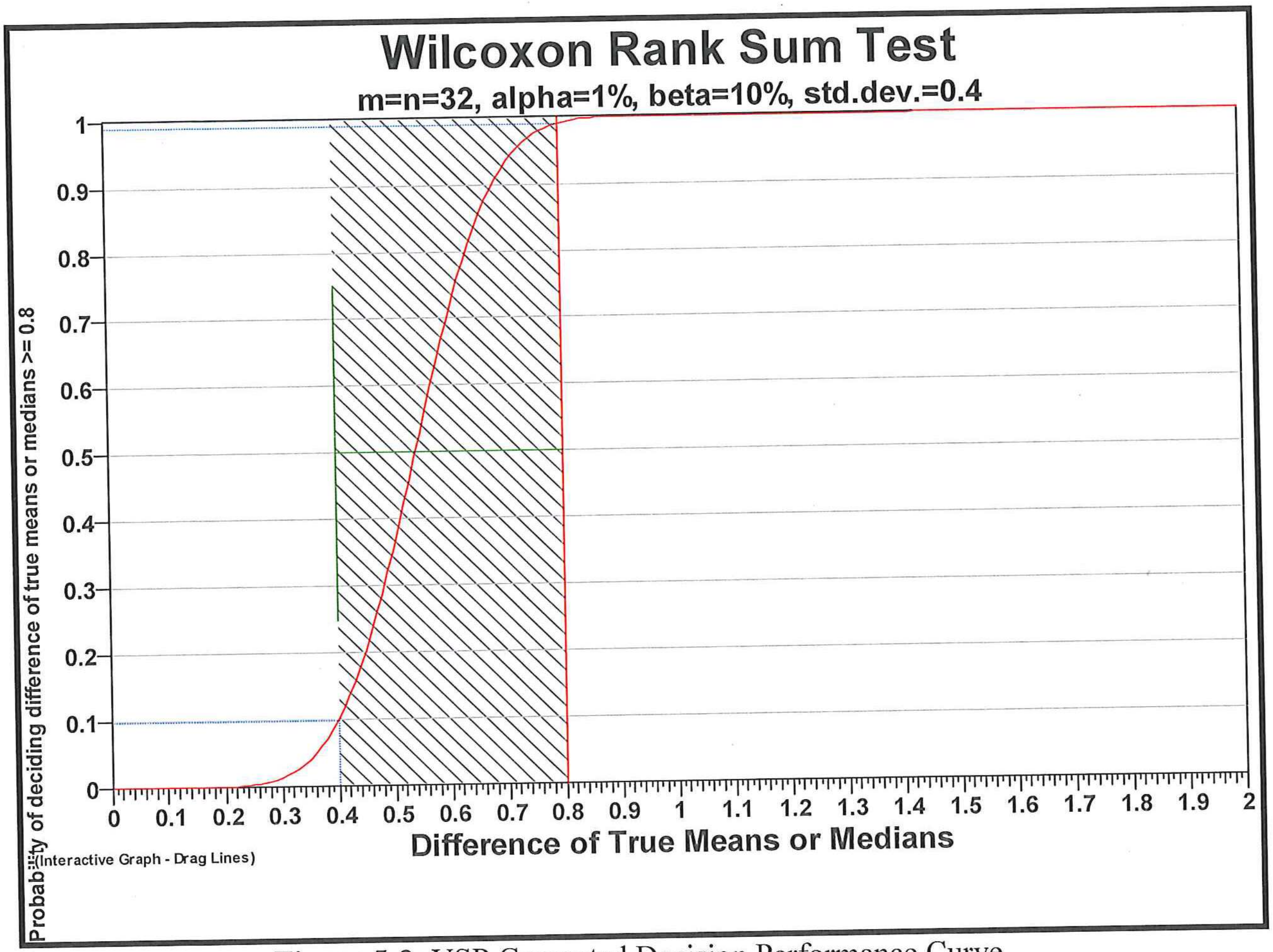

Figure 5-2: VSP Generated Decision Performance Curve

Table 5-1: UTM (NAD 1983) Coordinates of VSP Generated Sampling Points

Survey Area 1		**Survey Area 2**		**Background Area**[†]	
x	y	x	y	x	y
311198.38	5079726.29	314634.53	5079229.21	273722.77	5059190.00
311874.29	5079444.63	314474.88	5079491.40	273615.93	5058128.42
312324.66	5079945.73	314367.54	5081245.95	273565.02	5058442.35
312597.12	5080167.23	314705.55	5079199.65	274349.20	5059041.39
312707.36	5080853.52	312446.15	5081805.23	273073.25	5057907.22
312725.19	5080531.77	314603.96	5079874.57	273807.96	5058424.31
313223.68	5080270.26	314607.52	5081121.37	273246.41	5059332.87
312391.67	5080733.58	314891.00	5079531.21	273693.90	5059095.91
313115.33	5080574.59	314736.91	5081161.84	274385.04	5058585.34
312532.41	5080021.70	312615.60	5081340.81	273453.17	5059340.76
312934.58	5080389.59	313859.12	5081405.83	273606.47	5059041.68
312524.53	5080932.19	314513.54	5080959.68	272907.62	5058411.86
312075.33	5080015.44	314703.03	5078702.79	273468.66	5057861.12
312651.34	5080463.64	312450.78	5081347.56	274375.07	5058016.31
311596.44	5079438.15	314135.89	5081759.18	273585.36	5059409.01
311656.96	5079713.02	314554.32	5081472.57	273363.99	5057996.70
311734.55	5079561.00	314444.75	5078914.15	274098.68	5058218.59
312130.84	5079579.45	314925.86	5081516.77	273388.28	5058569.46
312261.93	5080176.14	314799.79	5081382.23	273160.47	5057914.15
313371.74	5080903.59	314829.06	5081419.26	273325.24	5058946.16
311339.65	5079996.57	314773.93	5079836.64	273883.93	5059216.82
312186.72	5080071.95	312627.74	5081496.17	273745.24	5059030.23
311326.56	5079561.69	313852.13	5081271.27	274119.62	5058695.32
312888.37	5080636.50	314853.72	5078994.74	273744.66	5058091.65
313379.10	5080952.21	314629.72	5079547.56	273917.34	5058286.58
312911.37	5081004.79	314549.23	5079571.35	273998.32	5058792.99
312890.61	5080436.67	314615.28	5080118.39	273629.54	5058459.97
311436.61	5079821.54	314665.00	5079790.08	273536.20	5059317.42
312184.16	5080003.37	313336.56	5081316.96	274197.45	5059025.07
312294.81	5080272.06	312797.39	5081684.33	272937.75	5058636.32
311501.05	5080423.94	312377.28	5081653.39	273992.66	5058690.13
313491.94	5080413.14	314658.39	5080698.44	273737.34	5058000.56

[†] See Section 5.3 for details on the background site

5.3 *The Background Site*

Choice of a background site *within* the UMCD fence line require selection of a site whose soils were sampled prior to when UMCDF incinerator operations began. The *Final Report for Background Soils Investigation at the Umatilla Chemical Agent Disposal Facility* provides background data for soils sampled prior to the start of incinerator operations (UMCDF 1998b). The UMCDF background soil investigation consisted of sampling from eight points within the current UMCDF fence line. This data, however, is inadequate for the purpose of meeting the DQOs of this SAP for three reasons:

- The design of this SAP requires that the number of points sampled within the background site and within the survey site be the same (i.e. 32 points).
- The area covered by the UMCDF background soil investigation partially overlaps with survey area 1 in Figure 5-1, i.e. the background and survey areas are not independent.
- The UMCDF background soil investigation addresses an area that is completely inside the current UMCDF fence line; it thus inadequate for assessing deposition of UMCDF emissions beyond the UMCDF fence line.

Given elimination of the UMCDF background soils investigation as a candidate for background data for this SAP, there is no area within the UMCD fence line or outside *and* adjacent to the UMCD fence line that is adequate for background sampling for the following reasons:

- Deactivation furnace (DF) emissions and open burning of explosives in the ADA area have exposed downwind soils to contamination. Since the DF was located in southwestern corner of the UMCD, and the ADA area comprises the bulk of the western end of the UMCD, contamination of soils by these sources is potentially site-wide because the prevailing winds are from the southwest. (see Figure 3-1).
- Farming activity is present on all sides of the UMCD directly adjacent to the UMCD fence line
- Interstate 84 is present adjacent to *and* upwind from the UMCD southern fence line. It is hypothesized that the large number of greater-than-baseline hits at Zone 1 site 6 of the CMP is due to emissions from traffic on I-84 (see Figure 4-1 and Table 4-8).

Since the shrub steppe lands that became the UMCD in the 1940s was a previously untouched area, a similar "pristine" background site will eventually be required for the site-wide closure SAP of the UMCD. Incorporation of the UMCDF RCRA closure into the base-wide closure is an efficient use of resources. As such, the background area recommended in this SAP is the Boardman Grasslands Preserve (BGP) approximately 20 miles southwest of the UMCD. The BGP is a relatively untouched area of shrub steppe that can also serve as the background site for the base-wide CERCLA closure. The selection of sampling points within the BGP uses the same VSP sampling goals and sample placement algorithm used for survey sites 1 and 2. The average density of sampling points in the background site (roughly 3 km^2 in area) is approximately the same as that in survey areas 1 and 2. The 32 sampling points selected by VSP are listed in Table 5-1. The geographic relationship of the background site to the UMCD is shown in Figure 5-3.

Figure 5-3: Geographic Relationship of the Background Site to the UMCD

Finally, it might be argued that BGP is not an unbiased background site because it is upwind of the PGE Boardman coal plant while the UMCD is downwind of it i.e. the potential for UMCD to receive contamination from the PGE plant emissions is much greater. This concern is believed to not be an issue since, while the southwest corner of the UMCD is almost 17 miles from the PGE plant, the contamination plume "staining" the ground downwind of the PGE plant is clearly visible in aerial photographs and barely extends 3 miles northeast from the plant. This "ground plume" is evidence that semi- and non-volatile organic emissions from the plant are deposited on the ground well before reaching the UMCD. Semi- and non-volatile compounds comprise the bulk of the chemical compounds that this SAP is concerned with.

6 Methodology and Quality Assurance Project Plan (QAPP)

This section addresses the details necessary for a complete SAP including:

- Analytical methods, detection limits, reporting limits, and reporting of non-detects
- Sample handling and chain-of-custody
- Field sampling methods and quality assurance objectives
- Laboratory methods and quality assurance objectives
- Reporting toxic equivalency factors for dioxins, furans, and PCBs
- Data Management
- Data Validation
- Statistical treatment of data

6.1 *Analytical Methods, Detection Limits, and Reporting Limits*

Appropriate analytical methods are listed in Section 4.3. It should be recognized that, of the methods listed, the enhanced method 8270 (enhanced GC/MS) for organic analytes, method

8310 (HPLC/FL) for PAHs, and method 6020 (ICP/MS) for metals are more sensitive than might be necessary for cleanup to industrial and some residential standards. It should be reiterated that the ultimate purpose of this sampling and analysis program is to generate a HHRA that the CTUIR can use to confidently assess risk to subsistence users of the land. Thus analytical methods which can detect analytes at concentrations down to *traditional tribal subsistence lifestyle* human health action levels for *individual* analytes, and possibly below these action levels for *cumulative* exposures, are required. CTUIR risk assessors will provide guidance on appropriate analytical methods well in advance of the date projected for UMCDF post-closure sampling.

The UMCDF CMP SAP lists analyte reporting limits based on practical quantitation limits (PQLs) for analytes in surface soils (UMCDF 2008). This SAP will retain those reporting limits *provided that* the analytical method used by the CMP is the same as that recommended by the CTUIR. PQLs and reporting limits for analytes and analytical methods not considered in the CMP will be established by the UMCDF contract lab in advance of the date projected for UMCDF post-closure sampling.

The UMCDF CMP has protocols for reporting concentrations and concentrations corresponding to non-detects based on established PQLs and reporting limits (UMCDF 2008). This SAP will retain those protocols.

6.2 *Sample Handling and Chain of Custody*

The UMCDF CMP SAP has established protocols for sample handling and chain-of-custody (UMCDF 2008). This SAP will retain those protocols.

6.3 *Field Sampling Requirements*

6.3.1 Field Sampling Quality Assurance Objectives

The UMCDF CMP has established field soil sampling quality assurance objectives each with a set of protocols covering the issues of duplicate sampling, field blanks, data representativeness, and data completeness (UMCDF 2008). This SAP will retain these protocols with the exception noted below.

The CMP SAP requires that field duplicates be collected at 10% of the sampling points. Thus the *degree of reproducibility* determined for *only one sampling point in ten* is applied to *all* the sampling points. Since cleanup decisions will be made using the analytical data obtained from these samples, failure to establish a degree of reproducibility for *each* sampling point within a survey area can contribute to the possibility of an incorrect decision. For example, suppose an anomalously high analyte concentration at a certain sampling point within the survey area is indicated. Knowledge of the degree of reproducibility for that particular sampling point can aid in determining whether the analyte concentration is indeed high at that point or whether systematic and/or gross uncertainties are present as a result of uncontrolled analytical methods. As such, this SAP recommends that duplicate soil samples be collected at *each* sampling point, and that these duplicate samples be identically processed and assayed for the same analytical parameters. This will require that a total of 192 soil samples (3 sampling areas x 32 points/area x 2 samples/point) be collected.

6.3.2 Field Sampling Methods

6.3.2.1 Sample Collection Protocols

The UMCDF CMP SAP has well established protocols for field sampling (UMCDF 2008). This SAP will retain these procedures, with the exceptions noted in 6.2.2.2-6.4.2.4 below.

6.3.2.2 Sampling Depth

Assuming that surface deposition began at the start of incinerator operations, maximum contaminant depths can theoretically be estimated via analyte soil mobilities. However, soil mobility depends on highly variable conditions such as the physical properties of the soil, moisture content, pH, and temperature. As such, this SAP recommends sampling depths based on projected CTUIR use of the UMCD land rather than on theoretical estimates.

Use of the UMCD by the CTUIR land will include the gathering and consumption of edible roots. While the edible part of these roots are at fairly shallow depths, the plant's tap root typically extends to a depth exceeding 25 cm (www.plants.sagebud.com). This SAP thus recommends a sampling depth of 25 cm.

6.3.2.3 Soil Sampling Techniques

The UMCDF background soils investigation QAPP (UMCDF 1998a) has established procedures for soil sampling from boreholes. This SAP will retain these procedures.

Sample cores from boreholes will be obtained to a depth of 25 cm. The duplicate sample at each sampling point will be obtained from a second borehole that is as close *as is practically possible* to the first borehole. The exact coordinates of both duplicate boreholes should be recorded.

It is *not necessary* to determine analyte concentrations in the borehole cores as a *function of depth*. Each core may be processed in the laboratory as a *single sample*.

6.3.2.4 Impractical Sampling Points Chosen by Visual Sampling Plan

Some of the sampling points in Table 5-1 might fall in places where sampling in impractical, e.g. roads, excessively rocky terrain, and structures. In these cases, the sampling point should be moved to an alternate point that is as close *as is practically possible* to the original point. The exact coordinates of the alternate sampling point should be recorded and the reason for moving the sampling point should be documented.

6.3.2.5 Inappropriate Sampling Points Chosen by Visual Sampling Plan

This SAP only considers deposition of UMCDF stack emissions *outside* of CERCLA operable units and the UMCDF fence line (Section 4.4). Sampling points chosen by VSP that fall within CERCLA operable units or on the UMCDF fence line should be moved to an appropriate alternate point that is as close *as is practically possible* to the original point. The exact coordinates of the alternate sampling point should be recorded and the reason for moving the sampling point should be documented.

6.4 *Analytical Laboratory Requirements*

6.4.1 Laboratory Quality Assurance Objectives

The UMCDF CMP has established laboratory quality assurance objectives each with a set of protocols covering the issues of data precision, accuracy, representativeness, completeness, and comparability (UMCDF 2008). This SAP will retain these protocols.

6.4.2 Laboratory Methods

The UMCDF CMP SAP had established laboratory protocols covering matrix spikes, sample extraction and preparation, sample splits, holding times, and preservation, calibration of instrumentation, method blanks, and surrogate/internal standard spikes (UMCDF 2008). This SAP will retain those protocols.

Analytical results from duplicate field samples, laboratory sample splits, and duplicate matrix spikes should be reported *individually* for evaluation by the CTUIR.

6.5 *Reporting Toxic Equivalency Factors (TEFs) for Dioxins, Furans, and PCBs*

The UMCDF CMP SAP has established methods for calculating TEFs (UMCDF 2008). These methods include protocols for calculating TEFs for congeners which co-elute during chromatographic analysis. This SAP will retain these methods for calculating TEFs.

6.6 *Data Management*

The UMCDF CMP SAP has established procedures by which data is recorded, stored, reviewed, and reported (UMCDF 2008). This SAP will retain these procedures.

6.7 *Data Validation*

The UMCDF CMP SAP has three levels of procedures by which sampling data is validated (UMCDF 2008). This SAP will retain these procedures.

6.8 *Statistical Treatment of Data*

6.8.1 Reporting of Individual Detects and Non-detects

Individual detects in the laboratory will be reported as a mean, relative standard deviation (RSD), and 95% confidence interval (CI) for the particular analyte and analytical method being considered. *Individual* non-detects in the laboratory will be reported along with the PQL, the RSD of the PQL, and the 95% CI of the PQL for the particular analyte and analytical method being considered. This information will be used to determine appropriate analyte concentrations for input into the hypothesis testing method described in Section 6.8.2.

It is important to stress that concentrations reported without corresponding RSDs and CIs cannot be adequately used by the CTUIR. *Complete reports of individual sample concentrations consist of the mean, RSD, and 95% CI.*

6.8.2 Hypothesis Testing

The final step in decision making is to determine whether or not analyte concentrations at the survey site exceed those at the background site. This requires that the predicted true mean analyte concentrations at both sites be compared using an appropriate statistical test.

The comparison approach to be used, the *Wilcoxon Signed Rank Test* (WSRT), is designed to compare the *medians* of two populations when functional forms for the population distributions are unknown. The hypothesis to be tested was stated in terms of comparing *means* rather than *medians,* which would suggest that the WSRT is not applicable here. However, while the WSRT sampling goals used by VSP (Section 5.1.4) do not assume a specific functional form for the distribution of the data, they do assume that the data is *symmetric about some central value.* Thus, as is the case for all symmetric distributions, the mean and median are assumed to be equal (see the x-axis label on Figure 5-2), and the WSRT may be used to test a hypothesis comparing two means. The treatment outlined below requires sample sizes greater than twenty and assumes the same number of sampling points in the survey and background areas, which is indeed the case for this SAP.

Each sampling point in the survey area is paired with a sampling point in the background area. The difference in the sample mean concentrations (as determined from the information discussed in Section 6.8.1), $c - c_{ref}$, is calculated for each pair of points. This is illustrated in Table 6-1 for six hypothetical samples in each area.

Table 6-1: Example Sample Set for Illustrating the WSRT

point #	c (ppm)	c_{ref} (ppm)	$c - c_{ref}$ (ppm)
1	12	4	8
2	10	8	2
3	17	18	-1
4	39	37	2
5	27	27	0
6	32	33	-1

The *absolute values* of the differences in the last column of Table 6-1 are ranked in ascending order, omitting any differences equal to zero. Values that appear more than once are included as many times as they appear:

absolute values of difference:	1	1	2	2	8
rank:	1	2	3	4	5

The *sum of the ranks* for each absolute value of the difference is then calculated, with the ranks for values that appear more than once arithmetically averaged:

absolute value of difference:	1	2	8
sum of ranks:	½ (1+2) = 1.5	½ (3+4) = 3.5	5

The results thus far are summarized in Table 6-2.

Table 6-2: Sum of Ranks for the Example Sample Set in Table 6-1

point #	$c - c_{ref}$ (ppm)	sum of ranks
1	8	5
2	2	3.5
3	-1	1.5
4	2	3.5
5	0	omit
6	-1	1.5

Add up the sum of ranks belonging to differences with positive signs. This sum is given the symbol W_+ i.e. $W_+ = 5 + 3.5 + 3.5 = 12$. Add up the sums of ranks belonging to differences with negative signs. This sum is given the symbol W_- i.e. $W_- = 1.5 + 1.5 = 3$. As a check, it should be verified that $W_+ + W_- = ½\, n\, (n+1)$, where n is the number of pairs with non-zero differences. W_+ is the quantity to be used for hypothesis testing.

It can be shown that the mean and standard deviation of W_+, μ_W and σ_W respectively, are given by:

$$\mu_W = ¼\, n\, (n+1)$$

$$\sigma_W = [n\,(n+1)\,(2n+1)\,/24]^{1/2}$$

and that the test statistic

$$z = (W_+ - \mu_W)\,/\,\sigma_W$$

is nearly normally distributed as $N(\mu_W, \sigma_W)$ for *sufficiently large sample sizes* ($n > 20$). Given the null hypothesis H_0: $\mu > \mu_{ref}$ and the alternate hypothesis H_a: $\mu \leq \mu_{ref}$ (Section 4.6), the value of the test statistic Z allows quantitative assessment of the evidence against H_0 i.e. to determine whether there is sufficient evidence to reject H_0 and accept H_a.

Recall that the DQOs specified that the probability of falsely rejecting H_0, α, not exceed $\alpha = 0.01$ (Section 4.6). Specifying $\alpha = 0.01$ is equivalent to requiring that the data be capable of providing evidence strong enough to reject H_0 only 1% of the time *when H_0 is actually true*. This is referred to as *testing H_0 against H_a at the $\alpha = 0.01$ level of significance.*

To carry out this test, the test statistic z is calculated and compared to the standard normal Z, $Z_\alpha = Z_p = Z_{0.01}$. The *P-value*, p, is the probability, assuming H_0 is true, that the test statistic z would take on a value as extreme or more extreme than that calculated from the data. If the p-value is less than the significance level α, the null hypothesis is rejected; if the p-value is greater than or equal to the significance level, the null hypothesis is not rejected.

For the particular manner in which H_0 and H_a have been stated in this SAP, if $z < Z_{0.01}$, then $p < \alpha$ and H_0 is rejected; if $z \geq Z_{0.01}$, then $p \geq \alpha$ and H_0 is not rejected. If H_0 is indeed rejected, the evidence against H_0 is said to have "*reached the standard set by α*" (Moore and McCabe 1999).

It should be stressed that this procedure for comparing Z and $Z_{0.01}$ is only specifically applicable for the particular manner in which the null and alternative hypotheses have been stated in this SAP i.e. a *one-tail* comparison in which the true mean at the survey site is *less than or equal to* the true mean at the background site *under the alternative hypothesis*. The criteria for comparing Z and $Z_{0.01}$ change as the manner in which H_0 and H_a are stated changes (Moore and McCabe 1999; Berenson, Levine, Krehbiel 2005).

7 Data Management for Human Health Risk Assessment

The environmental state of the potentially impacted area will be assessed uniformly across the facility by applying the 95% upper confidence limit (95% UCL) on the mean concentration for each of the 88 contaminants (Tables 4-1 through 4-3) measured in the surface soils to the Native American human health risk assessment scenario (CTUIR, 2008). Data from sampling regions 1 and 2 will be combined into a single data set to compute the 95% UCL. Non-detected compounds will be included at the 95% UCL of the background reference site. If reference site levels are also below the detection limits, then they will be excluded from the risk evaluation. A companion risk assessment using the reference site concentrations (95% UCL) for each compound will also be assessed. The incremental risk between the impacted site and reference site will be identified and discussed.

All risk calculations will follow the procedure detailed in the 2005 EPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities as implemented by the CTUIR in the commercial software IRAP-h (Lakes Environmental, 2008; CTUIR, 2008). Figure 7-1 provides a simplified depiction of the information necessary to complete this closure human health risk assessment. Table 7-1 details the exposure pathways that will be evaluated for the Native American scenario. Parameters that describe the extent of each exposure pathway are listed in Table 7-2, while Table 7-3 lists the site parameters required for the risk evaluation. Note that since the UMCD does not have a year-round source of surface water, the groundwater from the explosive lagoon operable unit, assumed cleaned to the CERCLA target level, will be used as the source for water for drinking, bathing, and sweat lodge use. This water source was chosen since it represents the most contaminated water on the base and thus provides an upper estimate of the risk of tribal use of the property. Table 7-4 lists the target chemical composition for the groundwater from this area (USACE 2004).

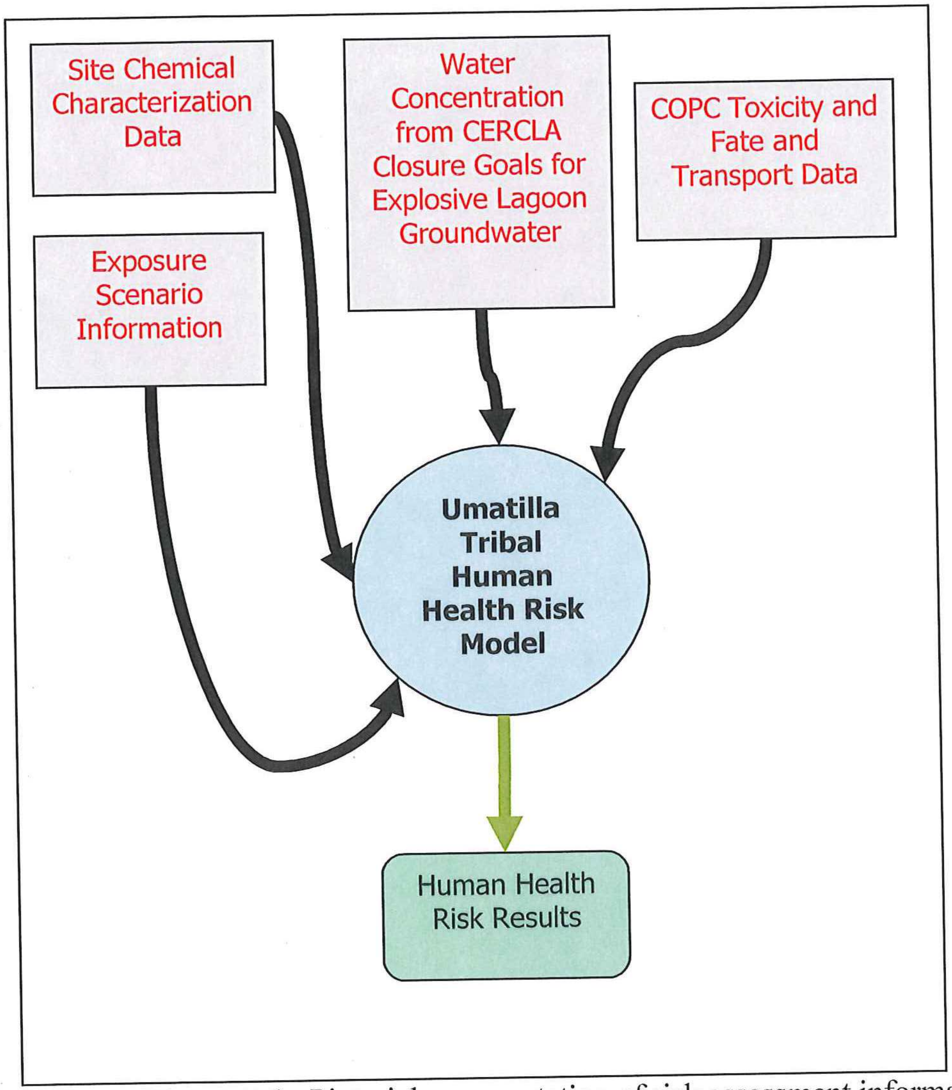

Figure 7-1: Pictorial representation of risk assessment information.

A COPC database containing most of the chemical and toxicological input required for all 88 compounds of concern is provided in Appendix A. Values within this data set were developed using the protocol outlined in "*Development of Fate and Transport Datasets for Use in Environmental Health Risk Assessments*" which is provided in Appendix D (USACHPPM, 2007). Missing data will need to be incorporated prior to finalizing the human health risk assessment protocol.

Table 7-1: Exposure Pathways Evaluated for Each Receptor Type.

Exposure Pathway	**Native American Adult**	**Native American Child**	**Breast-Feeding Infant**
Inhalation of vapors and particles [a]	No	No	No
Ingestion of soil and dust	Yes	Yes	No
Dermal contact with soil	Yes	Yes	No
Ingestion of groundwater [c]	Yes	Yes	No
Dermal contact with surface water [c]	Yes	Yes	No
Ingestion of local produce [d]	Yes	Yes	No
Ingestion of local animals [e]	Yes	Yes	No
Ingestion of local fish	No	No	No
Inhalation and dermal adsorption during sweat lodge use	Yes	No	No
Ingestion of breast milk	No	No	Yes

[a] Pathway not included for any scenario since this is a post-operations risk assessment

[b] Exposure as an infant to mothers milk containing dibenzo-p-dioxins and polychlorinated dibenzofurans and co-planar, dioxin-like polychlorinated biphenyls (PCBs) is included in the adult scenarios. The pathway is then evaluated separately.

[c] Site groundwater at the target cleanup levels will be used as the injected source.

[d] Native gathered (unirrigated) and garden (irrigated) plants will be included both exclusively and in combination.

[e] Local game foraging on depot plants and drinking the same water as the human population will be assumed.

Table 7-2: Exposure Scenario Parameters

Parameter	Unit	Native Adult	Native Child
Adherence factor of soil to skin	mg-soil/cm^2-event	0.1	0.2
Averaging time for carcinogens	yr	70	70
Averaging time for noncarcinogens	yr	70	6
Consumption rate of BEEF (WILD GAME for Natives)	kg/kg-day FW	0.00198	0.00131
Body weight	kg	70	15
Consumption rate of POULTRY (FOWL for Natives)	kg/kg-day FW	0.000154	0.000105
Consumption rate of ABOVEGROUND PRODUCE	kg/kg-day DW	0.00124	0.00124
Consumption rate of BELOWGROUND PRODUCE	kg/kg-day DW	0.000706	0.000706
Consumption rate of DRINKING WATER	L/day	3	1.5
Consumption rate of PROTECTED ABOVEGROUND PRODUCE	kg/kg-day DW	0.00183	0.00183
Consumption rate of SOIL	kg/d	0.0002	0.0002
Exposure duration	yr	70	6
Exposure frequency	day/yr	365	365
Exposure frequency of bathing	day/year	365	365
Exposure frequency during sweat lodge use	events/year	365	0
Exposure frequency of dermal contact with soil	events/year	365	365
Exposure frequency of swimming	day/year	10.95	10.95
Consumption rate of EGGS	kg/kg-day FW	0.0003	0.000216
Exposure time during sweat lodge use	hr/event	2	0
Event frequency of dermal contact with water and soil	events/day	1	1
The number of sweat lodge use	events/day	1	1
Fraction contaminated ABOVEGRD PRODUCE	--	1	1
Fraction of contaminated DRINKING WATER	--	1	1
Fraction contaminated SOIL	--	1	1
Consumption rate of FISH	kg/kg-day FW	0.00849	0.00598
Fraction of contaminated FISH	--	1	1
Consumption rate of GOAT	kg/kg-day FW	0	0
Inhalation exposure duration	yr	10	6

Parameter	**Unit**	**Native Adult**	**Native Child**
Inhalation exposure frequency	day/yr	365	365
Inhalation exposure time	hr/day	24	24
Fraction of contaminated BEEF (WILD GAME for Natives)	--	1	1
Fraction of contaminated POULTRY (FOWL for Natives)	--	1	1
Fraction of contaminated EGGS	--	1	1
Fraction of contaminated GOAT	--	1	1
Fraction of contaminated MILK	--	1	1
Fraction of contaminated PORK	--	1	1
Inhalation rate	m^3/hr	1.25	0.5
Consumption rate of MILK	kg/kg-day FW	0.0044	0.0073
Consumption rate of PORK	kg/kg-day FW	0	0
Skin surface area available for contact with soil	cm^2	5700	2800
Skin surface area available for contact with water	cm^2	18000	6900
Body surface area available for contact during a sweat	m^2	1.8	0
Time period at the beginning of combustion	yr	0	0
Length of exposure duration	yr	70	6

Table 7-3: Site Parameters Required for the Risk Evaluation.

Description	**Symbol**	**Units**	**Value**
Soil dry bulk density	bd	g/cm^3	1.5
Forage fraction grown on contaminated soil eaten by CATTLE	beef_fi_forage	--	1
Grain fraction grown on contaminated soil eaten by CATTLE	beef_fi_grain	--	1
Silage fraction grown on contaminated eaten by CATTLE	beef_fi_silage	--	1
Qty of forage eaten by CATTLE each day	beef_qp_forage	kg DW/day	11.3
Qty of grain eaten by CATTLE each day	beef_qp_grain	kg DW/day	0.47
Qty of silage eaten by CATTLE each day	beef_qp_silage	kg DW/day	0
Grain fraction grown on contaminated soil eaten by CHICKEN	chick_fi_grain	--	1
Qty of grain eaten by CHICKEN each day	chick_qp_grain	kg DW/day	0.2
Average annual evapotranspiration	e_v	cm/yr	81.3
Duration of bathing event	event_t_bathing	hr/event	0.58
Duration of swimming event	event_t_swimming	hr/event	1
Fish lipid content	f_lipid	--	0.07
Fraction of CHICKEN's diet that is soil	fd_chicken	--	0.11
Fraction of skin area (SA) in contact with water during a sweat	fsa	--	1
Universal gas constant	gas_r	atm-m^3/mol-K	0.0000821
Forage fraction grown on contaminated soil eaten by GOAT	goat_fi_forage	--	1
Grain fraction grown on contaminated soil eaten by GOAT	goat_fi_grain	--	1
Silage fraction grown on contaminated eaten by GOAT	goat_fi_silage	--	1
Qty of forage eaten by GOAT each day	goat_qp_forage	kg DW/day	0.98
Qty of grain eaten by GOAT each day	goat_qp_grain	kg DW/day	0.041
Qty of silage eaten by GOAT each day	goat_qp_silage	kg DW/day	0
Average annual irrigation	i	cm/yr	55
Plant surface loss coefficient	kp	yr^{-1}	18
Fraction of mercury emissions NOT lost to the global cycle	merc_q_corr	--	0.48
Fraction of mercury speciated into methyl mercury in produce	mercmethyl_ag	--	0.22
Fraction of mercury speciated into methyl mercury in soil	mercmethyl_sc	--	0.02
Forage fraction grown contaminated soil, eaten by MILK CATTLE	milk_fi_forage	--	1
Grain fraction grown contaminated soil, eaten by MILK CATTLE	milk_fi_grain	--	1
Silage fraction grown contaminated soil, eaten by MILK CATTLE	milk_fi_silage	--	1
Qty of forage eaten by MILK CATTLE each day	milk_qp_forage	kg DW/day	17.3
Qty of grain eaten by MILK CATTLE each day	milk_qp_grain	kg DW/day	3

Description	Symbol	Units	Value
Qty of silage eaten by MILK CATTLE each day	milk_qp_silage	kg DW/day	0
Averaging time	milkfat_at	yr	1
Body weight of infant	milfat_bw_infant	kg	9.4
Exposure duration of infant to breast milk	milkfat_ed	yr	1
Proportion of ingested dioxin that is stored in fat	milkfat_f1	--	0.9
Proportion of mothers weight that is fat	milkfat_f2	--	0.3
Fraction of fat in breast milk	milkfat_f3	--	0.04
Fraction of ingested contaminant that is absorbed	milkfat_f4	--	0.9
Half-life of dioxin in adults	milkfat_h	days	2560
Ingestion rate of breast milk	milkfat_ir_milk	kg/day	0.688
Viscosity of air corresponding to air temp.	mu_a	g/cm-s	0.000181
Average annual precipitation	p	cm/yr	21.59
Fraction of grain grown on contaminated soil eaten by PIGS	pork_fi_grain	--	1
Fraction of silage grown on contaminated soil and eaten by PIGS	pork_fi_silage	--	1
Qty of grain eaten by PIGS each day	pork_qp_grain	kg DW/day	3.3
Qty of silage eaten by PIGS each day	pork_qp_silage	kg DW/day	1.4
Qty of soil eaten by CATTLE	qs_beef	kg/day	0.5
Qty of soil eaten by CHICKEN	qs_chick	kg/day	0.022
Qty of soil eaten by GOAT	qs_goat	kg/day	0.04
Qty of soil eaten by DAIRY CATTLE	qs_milk	kg/day	0.4
Qty of soil eaten by PIGS	qs_pork	kg/day	0.37
Average annual runoff	r	cm/yr	2.54
Density of air	rho_a	g/cm^3	0.0012
Solids particle density	rho_s	g/cm^3	2.7
Interception fraction - edible portion ABOVEGROUND	rp	--	0.39
Interception fraction - edible portion FORAGE	rp_forage	--	0.5
Interception fraction - edible portion SILAGE	rp_silage	--	0.46
Radius of sweat lodge	slr	m	1
Ambient air temperature	t	K	285
Temperature correction factor	theta	--	1.026
Soil volumetric water content	theta_s	mL/cm^3	0.244
Length of plant exposure to deposition - ABOVEGROUND	tp	Yr	0.16
Length of plant exposure to deposition - FORAGE	tp_forage	Yr	0.12

Description	**Symbol**	**Units**	**Value**
Length of plant exposure to deposition - SILAGE	tp_silage	Yr	0.16
Average annual wind speed	u	m/s	3.9
Dry deposition velocity	vdv	cm/s	0.5
Volume of water used in a sweat lodge (nonvolatile)	vw_nonvol	liters	0.34
Volume of water used in a sweat lodge (volatile)	vw_vol	liters	4
Wind velocity	w	m/s	4.5
Yield/standing crop biomass - edible portion ABOVEGROUND	yp	kg DW/m^2	2.24
Yield/standing crop biomass - edible portion FORAGE	yp_forage	kg DW/m^2	0.24
Yield/standing crop biomass - edible portion SILAGE	yp_silage	kg DW/m^2	0.8
Soil mixing zone depth	z	cm	2

Table 7-4: Assumed Concentrations of Contaminants in Groundwater for Risk Assessment.

Compound	**Concentration (µg/L).**
RDX	2.1
TNT	2.8
DNB	4.0
TNB	1.8
2,4-DNT	0.6
2,6-DNT	1.2
HMX	350

8 References

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Appendix A – COPC Fate, Transport, and Toxicology Data

Table A-1: COPC Parameter Set 1

CAS_NUMBER	COPC_NAME	MW (g/mol)	T_m (°K)	V_p (atm)	S (mg/L)	H (atm-m3/mol)	D_a (cm2/sec)	Dw (cm2/sec)
7429-90-5	Aluminum compounds	2.70E+01	6.60E+02	0.00E+00	9.50E+04	0.00E+00	0.00E+00	0.00E+00
7440-36-0	Antimony compounds	1.25E+02	9.03E+02	9.00E-01	2.30E+04	2.50E-02	7.72E-02	9.57E-06
7440-38-2	Arsenic compounds	7.80E+01	1.09E+03	3.30E-12	3.47E+04	7.70E-01	7.72E-02	9.57E-06
7440-39-3	Barium compounds	1.39E+02	1.00E+03	5.58E-12	5.48E+04	0.00E+00	7.72E-02	9.57E-06
7440-41-7	Beryllium compounds	9.01E+00	1.57E+03	5.58E-12	1.49E+05	1.50E-02	7.72E-02	9.57E-06
7440-43-9	Cadmium compounds	1.12E+02	5.93E+02	5.45E-12	1.23E+05	3.10E-02	7.72E-02	9.57E-06
18540-29-9	Chromium compounds	5.20E+01	2.17E+03	5.58E-12	8.67E+04	0.00E+00	1.27E-01	1.41E-05
7440-50-8	Copper compounds	6.40E+01	1.10E+03	0.00E+00	5.70E+02	0.00E+00	7.72E-02	9.57E-06
7439-92-1	Lead compounds	2.09E+02	6.03E+02	3.97E-12	9.58E+03	2.50E-02	7.72E-02	9.57E-06
7439-96-5	Manganese compounds	5.50E+01	1.20E+03	0.00E+00	1.10E+03	0.00E+00	0.00E+00	0.00E+00
7439-97-6	Mercury compounds	2.01E+02	2.34E+02	2.63E-06	6.00E-02	7.10E-03	1.09E-02	3.01E-05
7440-02-0	Nickel compounds	5.87E+01	1.77E+03	5.58E-12	4.22E+05	2.50E-02	7.72E-02	9.57E-06
7782-49-2	Selenium compounds	7.90E+01	4.93E+02	1.87E-13	2.06E+03	9.70E-03	7.72E-02	9.57E-06
7440-22-4	Silver compounds	1.08E+02	1.23E+03	5.58E-12	7.05E+04	0.00E+00	7.72E-02	9.57E-06
7440-28-0	Thallium compounds	2.05E+02	5.73E+02	5.58E-12	2.65E+04	0.00E+00	7.72E-02	9.57E-06
7440-62-2	Vanadium compounds	5.10E+01	1.90E+03	0.00E+00	7.00E+02	0.00E+00	0.00E+00	0.00E+00
7440-66-6	Zinc compounds	6.54E+01	6.93E+02	5.09E-12	3.44E+05	2.50E-02	7.72E-02	9.57E-06
7440-48-4	Cobalt compounds	5.90E+01	1.50E+03	0.00E+00	1.70E+03	0.00E+00	0.00E+00	0.00E+00
7440-31-5	Tin compounds	1.19E+02	5.05E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7440-42-8	Boron compounds	1.10E+01	2.10E+03	1.56E-05	3.60E+04	0.00E+00	0.00E+00	0.00E+00
91-57-6	2-Methylnaphthalene	1.40E+02	3.08E+02	8.94E-05	2.50E+01	5.18E-04	7.05E-02	8.16E-06
118-96-7	2,4,6-Trinitrotoluene	2.27E+02	3.53E+02	2.66E-09	1.24E+02	4.87E-09	1.00E-03	1.00E-05
121-14-2	2,4-Dinitrotoluene	1.82E+02	3.42E+02	1.93E-07	2.70E+02	9.26E-08	2.03E-01	7.06E-06
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	3.22E+02	5.79E+02	1.97E-12	1.93E-05	3.29E-05	1.04E-01	5.60E-06
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	4.61E+02	5.99E+02	1.09E-15	7.40E-08	6.75E-06	8.69E-02	8.00E-06
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	3.27E+02	0.00E+00	1.18E-08	1.34E-02	2.88E-04	4.00E-02	4.64E-06
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	2.92E+02	0.00E+00	2.15E-08	5.69E-04	1.10E-02	4.32E-02	5.00E-06
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	3.26E+02	0.00E+00	8.57E-09	3.40E-03	8.25E-04	4.01E-02	4.64E-06
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	3.61E+02	0.00E+00	2.11E-09	5.33E-03	1.43E-04	3.75E-02	4.34E-06

CAS_NUMBER	COPC_NAME	MW (g/mol)	T_m (°K)	V_p (atm)	S (mg/L)	H (atm-m3/mol)	D_a (cm2/sec)	Dw (cm2/sec)
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	4.45E+02	5.32E+02	4.93E-15	1.16E-06	1.88E-06	1.95E-02	8.00E-06
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	3.95E+02	0.00E+00	1.71E-10	7.53E-04	5.07E-05	3.53E-02	4.09E-06
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.06E+02	5.01E+02	1.97E-11	4.19E-04	1.44E-05	2.35E-02	6.01E-06
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	4.09E+02	4.95E+02	4.04E-13	1.40E-06	1.40E-05	2.03E-02	8.00E-06
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	4.09E+02	5.10E+02	4.61E-14	1.35E-06	1.41E-05	2.03E-02	8.00E-06
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	3.26E+02	3.71E+02	7.18E-09	1.60E-02	9.24E-05	4.01E-02	4.64E-06
50-29-3	DDT	3.54E+02	3.83E+02	2.11E-10	2.50E-02	8.10E-06	1.00E-03	1.00E-05
50-32-8	Benzo[a]pyrene	2.52E+02	4.53E+02	7.24E-12	1.60E-03	1.10E-06	4.30E-02	9.00E-06
53-70-3	Dibenzo[a,h]anthracene	2.78E+02	5.43E+02	1.32E-13	2.50E-03	1.50E-08	1.00E-03	1.00E-05
56-55-3	Benzo[a]anthracene	2.28E+02	3.57E+02	1.45E-10	9.40E-03	3.40E-06	5.10E-02	9.00E-06
57-74-9	Chlordane	4.10E+02	3.83E+02	1.29E-08	5.60E-02	4.90E-05	1.00E-03	1.00E-05
57-97-6	1,12-Dimethylbenz[a]anthracene	2.56E+02	3.96E+02	8.95E-10	6.10E-02	3.76E-06	5.85E-02	6.78E-07
72-54-8	DDD, 4,4'-	3.20E+02	3.83E+02	8.82E-10	9.00E-02	4.00E-06	1.00E-03	1.00E-05
72-55-9	DDE, 4,4'-	3.18E+02	3.62E+02	7.89E-09	1.20E-01	2.10E-05	1.00E-03	1.00E-05
83-32-9	Acenaphthene	1.54E+02	3.66E+02	3.29E-06	3.60E+00	1.60E-04	1.00E-03	1.00E-05
85-01-8	Phenanthrene	1.78E+02	3.72E+02	1.45E-07	1.10E+00	2.30E-05	1.00E-03	1.00E-05
86-73-7	Fluorene	1.66E+02	3.83E+02	8.29E-07	2.00E+00	6.40E-05	1.00E-03	1.00E-05
91-94-1	3,3'-Dichlorobenzidine	2.53E+02	4.05E+02	4.88E-11	3.10E+00	4.00E-09	1.00E-03	1.00E-05
92-67-1	4-Aminobiphenyl	1.69E+02	3.26E+02	1.54E-07	2.24E+02	3.89E-10	6.11E-02	7.07E-07
92-87-5	Benzidine	1.84E+02	4.01E+02	1.18E-09	3.22E+02	5.17E-11	5.77E-02	6.68E-07
93-76-5	2,4,5-T	2.56E+02	4.26E+02	4.93E-08	2.78E+02	4.66E-08	4.72E-02	5.46E-06
98-95-3	Nitrobenzene	1.23E+02	2.79E+02	3.22E-04	2.09E+03	2.40E-05	7.60E-02	8.60E-06
99-35-4	1,3,5-Trinitrobenzene	2.13E+02	3.93E+02	8.42E-09	2.80E+02	3.30E-10	1.00E-03	1.00E-05
99-65-0	1,3-Dinitrobenzene	1.68E+02	3.63E+02	1.18E-06	8.60E+02	2.30E-07	1.00E-03	1.00E-05
119-93-7	3.3'-Dimethylbenzidine	2.12E+02	4.05E+02	7.92E-08	1.30E+03	6.29E-11	5.34E-02	6.18E-06
120-12-7	Anthracene	1.78E+02	4.93E+02	3.55E-09	4.30E-02	6.50E-05	1.00E-03	1.00E-05
121-82-4	RDX	2.22E+02	4.06E+02	5.39E-12	5.97E+01	6.32E-08	5.18E-02	6.00E-06
129-00-0	Pyrene	2.02E+02	4.23E+02	6.05E-09	1.40E+00	1.10E-05	1.00E-03	1.00E-05
189-64-0	Dibenzo[a,h]pyrene	3.02E+02	5.90E+02	8.43E-15	5.54E-04	7.91E-08	4.22E-02	4.89E-06
191-30-0	Dibenzo[a,l]pyrene	3.02E+02	4.35E+02	9.25E-14	2.40E-04	7.91E-08	4.22E-02	4.89E-06
192-65-4	Dibenzo[a,e]pyrene	3.02E+02	5.07E+02	9.25E-14	2.40E-04	7.91E-08	4.22E-02	4.89E-06
193-39-5	Indeno[1,2,3-cd]pyrene	2.76E+02	4.33E+02	1.32E-13	2.20E-05	1.60E-06	1.00E-03	1.00E-05
205-82-3	Benzo[j]fluoranthene	2.53E+02	4.39E+02	3.45E-09	2.50E-03	2.03E-07	4.76E-02	5.51E-06
205-97-0	Dibenzo[b,k]fluoranthene	3.02E+02	4.88E+02	1.51E-13	5.50E-04	8.00E-08	4.22E-02	4.88E-06

CAS_NUMBER	COPC_NAME	MW (g/mol)	T_m (°K)	V_p (atm)	S (mg/L)	H (atm-m3/mol)	D_a (cm2/sec)	Dw (cm2/sec)
205-99-2	Benzo[b]floranthene	2.52E+02	4.41E+02	6.58E-10	1.50E-03	1.11E-04	1.00E-03	1.00E-05
206-44-0	Fluoranthene	2.02E+02	3.83E+02	1.03E-08	2.10E-01	1.60E-05	1.00E-03	1.00E-05
207-08-9	Benzo[k]floranthene	2.52E+02	4.93E+02	2.63E-12	8.00E-04	8.30E-07	1.00E-03	1.00E-05
218-01-9	Chrysene	2.28E+02	5.33E+02	8.16E-12	6.30E-03	9.50E-05	1.00E-03	1.00E-05
479-45-8	Tetryl	2.87E+02	1.31E+02	5.28E-15	7.50E+01	2.00E-12	4.37E-02	5.05E-06
606-20-2	2,6-Dinitrotoluene	1.82E+02	3.44E+02	7.46E-07	1.82E+02	7.47E-07	1.00E-03	1.00E-05
1746-01-6	2,3,7,8-TCDD	3.22E+02	5.79E+02	1.97E-12	1.93E-05	3.29E-05	1.04E-01	5.60E-06
2691-41-0	HMX	2.96E+02	5.69E+02	3.17E-11	1.40E+02	3.70E-12	4.28E-02	4.95E-06
3268-87-9	OCDD	4.61E+02	5.99E+02	1.09E-15	7.40E-08	6.75E-06	8.69E-02	8.00E-06
19408-74-3	1,2,3,7,8,9-HxCDD	3.91E+02	5.17E+02	6.45E-14	4.40E-06	1.10E-05	9.44E-02	8.00E-06
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	3.61E+02	4.19E+02	7.65E-10	5.10E-04	6.85E-05	3.75E-02	4.34E-06
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	3.95E+02	4.37E+02	8.26E-10	3.47E-03	9.00E-06	3.53E-02	4.08E-06
35822-46-9	1,2,3,4,6,7,8-HpCDD	4.25E+02	5.38E+02	7.37E-15	2.40E-06	1.20E-05	9.05E-02	8.00E-06
39227-28-6	1,2,3,4,7,8-HxCDD	3.91E+02	5.47E+02	5.00E-14	4.42E-06	1.07E-05	9.44E-02	8.00E-06
40321-76-4	1,2,3,7,8-PeCDD	3.56E+02	5.14E+02	5.79E-13	1.18E-04	2.60E-06	9.88E-02	8.00E-06
57117-31-4	2,3,4,7,8-PeCDF	3.40E+02	4.69E+02	3.42E-12	2.36E-04	4.98E-06	2.23E-02	8.00E-06
57117-41-6	1,2,3,7,8-PeCDF	3.40E+02	4.99E+02	2.23E-12	2.40E-04	5.00E-06	2.23E-02	8.00E-06
57117-44-9	1,2,3,6,7,8-HxCDF	3.75E+02	5.06E+02	2.89E-13	1.77E-05	7.31E-06	2.12E-02	8.00E-06
57653-85-7	1,2,3,6,7,8-HxCDD	3.91E+02	5.59E+02	4.73E-14	4.40E-06	1.10E-05	9.44E-02	8.00E-06
60851-34-5	2,3,4,6,7,8-HxCDF	3.75E+02	5.13E+02	2.63E-13	1.30E-05	1.10E-05	2.12E-02	8.00E-06
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	3.26E+02	4.08E+02	7.20E-09	9.40E-03	9.20E-05	4.01E-02	4.64E-06
70648-26-9	1,2,3,4,7,8-HxCDF	3.75E+02	4.99E+02	3.16E-13	8.25E-06	1.43E-05	2.12E-02	8.00E-06
72918-21-9	1,2,3,7,8,9-HxCDF	3.75E+02	5.21E+02	3.68E-13	1.30E-05	1.10E-05	2.12E-02	8.00E-06

Table A-2: COPC Parameter Set 2

CAS_NUMBER	COPC_NAME	K_ow (unitless)	K_oc (mL/g)	Kd_s (cm3/g)	Kd_sw (L/kg)	Kd_bs (cm3/g)	K_sg (per year)	f_v (unitless)
7429-90-5	Aluminum compounds	0.00E+00	0.00E+00	9.90E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7440-36-0	Antimony compounds	5.37E+00	0.00E+00	4.50E+01	4.50E+01	4.50E+01	0.00E+00	0.00E+00
7440-38-2	Arsenic compounds	4.79E+00	0.00E+00	2.90E+01	2.90E+01	2.90E+01	0.00E+00	0.00E+00
7440-39-3	Barium compounds	1.70E+00	0.00E+00	4.10E+01	4.10E+01	4.10E+01	0.00E+00	0.00E+00
7440-41-7	Beryllium compounds	2.69E-01	0.00E+00	7.90E+02	7.90E+02	7.90E+02	0.00E+00	0.00E+00
7440-43-9	Cadmium compounds	8.51E-01	0.00E+00	7.50E+01	7.50E+01	7.50E+01	0.00E+00	0.00E+00
18540-29-9	Chromium compounds	1.70E+00	0.00E+00	1.90E+01	1.90E+01	1.90E+01	0.00E+00	9.00E-03
7440-50-8	Copper compounds	2.69E-01	0.00E+00	4.30E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7439-92-1	Lead compounds	5.37E+00	0.00E+00	9.00E+02	9.00E+02	9.00E+02	0.00E+00	0.00E+00
7439-96-5	Manganese compounds	1.70E+00	0.00E+00	6.50E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7439-97-6	Mercury compounds	4.17E+00	0.00E+00	1.00E+03	1.00E+03	3.00E+03	0.00E+00	8.50E-01
7440-02-0	Nickel compounds	2.69E-01	0.00E+00	6.50E+01	6.50E+01	6.50E+01	0.00E+00	0.00E+00
7782-49-2	Selenium compounds	1.74E+00	0.00E+00	5.00E+00	5.00E+00	5.00E+00	0.00E+00	0.00E+00
7440-22-4	Silver compounds	1.70E+00	0.00E+00	8.30E+00	8.30E+00	8.30E+00	0.00E+00	0.00E+00
7440-28-0	Thallium compounds	1.70E+00	0.00E+00	7.10E+01	7.10E+01	7.10E+01	0.00E+00	0.00E+00
7440-62-2	Vanadium compounds	0.00E+00	0.00E+00	1.00E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7440-66-6	Zinc compounds	3.39E-01	0.00E+00	6.20E+01	6.20E+01	6.20E+01	0.00E+00	0.00E+00
7440-48-4	Cobalt compounds	1.70E+00	0.00E+00	4.50E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7440-31-5	Tin compounds	0.00E+00	0.00E+00	2.50E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7440-42-8	Boron compounds	0.00E+00	0.00E+00	3.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
91-57-6	2-Methylnaphthalene	7.94E+03	6.82E+03	9.50E+02	5.12E+02	2.73E+02	0.00E+00	1.00E+00
118-96-7	2,4,6-Trinitrotoluene	3.98E+01	3.74E+01	3.70E-01	2.80E+00	1.50E+00	1.41E+00	9.40E-01
121-14-2	2,4-Dinitrotoluene	9.55E+01	8.84E+01	8.80E-01	6.63E+00	3.54E+00	1.41E+00	9.99E-01
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	6.31E+06	3.89E+06	3.89E+04	2.92E+05	1.56E+05	3.00E-02	6.64E-01
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	1.58E+08	9.77E+07	9.77E+05	7.33E+06	3.91E+06	3.00E-02	2.00E-03
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	1.32E+07	9.98E+06	9.98E+04	7.49E+05	3.99E+05	2.77E-02	0.00E+00
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	4.27E+06	3.29E+06	3.29E+04	2.47E+05	1.32E+05	2.77E-02	0.00E+00
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	6.17E+06	4.73E+06	4.73E+04	3.55E+05	1.89E+05	2.77E-02	0.00E+00
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	3.98E+07	2.96E+07	2.96E+05	2.22E+06	1.18E+06	2.77E-02	0.00E+00
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.00E+08	6.17E+07	6.17E+05	4.62E+06	2.47E+06	3.00E-02	2.00E-03
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	1.86E+08	1.35E+08	1.35E+06	1.01E+07	5.39E+06	2.77E-02	0.00E+00
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	1.26E+06	7.76E+05	7.76E+03	5.82E+04	3.10E+04	3.00E-02	7.70E-01
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	2.51E+07	1.55E+07	1.55E+05	1.16E+06	6.20E+05	3.00E-02	5.70E-02
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-02	0.00E+00
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.51E+07	1.55E+07	1.55E+05	1.16E+06	6.20E+05	3.00E-02	1.00E-02

CAS_NUMBER	COPC_NAME	K_ow (unitless)	K_oc (mL/g)	Kd_s (cm3/g)	Kd_sw (L/kg)	Kd_bs (cm3/g)	K_sg (per year)	f_v (unitless)
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-02	0.00E+00
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	9.55E+06	7.27E+06	7.27E+04	5.45E+05	2.91E+05	2.77E-02	9.85E-01
50-29-3	DDT	2.51E+06	6.78E+05	4.00E+05	5.09E+04	2.71E+04	4.00E-02	7.11E-01
50-32-8	Benzo[a]pyrene	1.00E+06	9.69E+05	1.60E+05	7.27E+04	3.88E+04	4.80E-01	2.94E-01
53-70-3	Dibenzo[a,h]anthracene	3.16E+06	1.79E+06	5.80E+05	1.34E+05	7.16E+04	2.70E-01	5.50E-02
56-55-3	Benzo[a]anthracene	5.01E+05	3.58E+05	6.00E+04	2.69E+04	1.43E+04	3.70E-01	4.83E-01
57-74-9	Chlordane	3.16E+05	5.13E+04	2.40E+02	3.85E+03	2.05E+03	1.80E-01	9.93E-01
57-97-6	1,12-Dimethylbenz[a]anthracene	4.17E+06	2.06E+05	2.06E+03	1.55E+04	8.25E+03	**ND**	6.01E-01
72-54-8	DDD, 4,4'-	1.00E+06	4.58E+04	1.50E+05	3.44E+03	1.83E+03	4.00E-02	9.11E-01
72-55-9	DDE, 4,4'-	5.01E+05	8.64E+04	6.80E+05	6.48E+03	3.46E+03	4.00E-02	9.83E-01
83-32-9	Acenaphthene	7.94E+03	4.90E+03	1.10E+03	3.68E+02	1.96E+02	2.48E+00	1.00E+00
85-01-8	Phenanthrene	3.16E+04	2.65E+04	3.70E+03	1.99E+03	1.06E+03	1.26E+00	9.99E-01
86-73-7	Fluorene	1.58E+04	7.71E+03	2.10E+03	5.78E+02	3.08E+02	4.22E+00	1.00E+00
91-94-1	3,3'-Dichlorobenzidine	3.24E+03	7.21E+02	7.21E+00	5.41E+01	2.88E+01	1.41E+00	4.82E-01
92-67-1	4-Aminobiphenyl	6.03E+02	2.09E+02	2.09E+00	1.56E+01	8.35E+00	**ND**	9.96E-01
92-87-5	Benzidine	4.57E+01	2.79E+01	2.79E-01	2.09E+00	1.12E+00	**ND**	6.65E-01
93-76-5	2,4,5-T	2.71E+01	4.86E+01	4.86E-01	3.65E-01	1.95E+00	**ND**	9.88E-01
98-95-3	Nitrobenzene	7.08E+01	1.19E+02	1.19E+00	8.93E+00	4.76E+00	1.28E+00	1.00E+00
99-35-4	1,3,5-Trinitrobenzene	1.58E+01	1.51E+01	2.20E+00	1.13E+00	6.10E-01	0.00E+00	9.92E-01
99-65-0	1,3-Dinitrobenzene	3.16E+01	2.98E+01	4.40E+00	2.24E+00	1.19E+00	1.41E+00	1.00E+00
119-93-7	3.3'-Dimethylbenzidine	1.04E+01	9.98E+00	9.98E-02	7.49E-02	3.99E-01	**ND**	9.93E-01
120-12-7	Anthracene	3.16E+04	2.35E+04	4.50E+03	1.76E+03	9.40E+02	5.50E-01	9.98E-01
121-82-4	RDX	1.97E+00	1.95E+00	1.95E-02	1.46E-02	7.81E-02	**ND**	8.99E-03
129-00-0	Pyrene	7.94E+04	6.80E+04	9.50E+03	5.10E+03	2.72E+03	1.30E-01	9.94E-01
189-64-0	Dibenzo[a,h]pyrene	1.45E+03	1.28E+03	1.28E+01	9.62E+00	5.13E+01	**ND**	1.42E-05
191-30-0	Dibenzo[a,l]pyrene	2.23E+03	1.96E+03	1.96E+01	1.47E+01	7.83E+01	**ND**	1.55E-04
192-65-4	Dibenzo[a,e]pyrene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	1.55E-04
193-39-5	Indeno[1,2,3-cd]pyrene	3.98E+06	3.08E+06	5.30E+05	2.31E+05	1.23E+05	3.50E-01	5.00E-03
205-82-3	Benzo[j]fluoranthene	1.29E+06	1.02E+06	1.02E+04	7.62E+03	4.06E+04	**ND**	8.53E-01
205-97-0	Dibenzo[b,k]fluoranthene	1.91E+07	1.43E+07	1.43E+05	1.08E+05	5.74E+05	**ND**	2.54E-04
205-99-2	Benzo[b]floranthene	1.33E+06	1.05E+06	1.05E+04	7.86E+04	4.19E+04	4.10E-01	9.66E-01
206-44-0	Fluoranthene	1.00E+05	4.91E+04	1.10E+04	3.68E+03	1.96E+03	5.70E-01	9.92E-01
207-08-9	Benzo[k]floranthene	1.26E+06	9.92E+05	1.90E+05	7.44E+04	3.97E+04	1.20E-01	2.73E-01
218-01-9	Chrysene	5.01E+05	4.01E+05	6.00E+04	3.01E+04	1.60E+04	2.50E-01	7.44E-01
479-45-8	Tetryl	2.51E+02	2.29E+02	2.29E+00	1.72E+00	9.15E+00	**ND**	8.87E-06
606-20-2	2,6-Dinitrotoluene	5.25E+01	4.91E+01	4.90E-01	3.68E+00	1.96E+00	1.41E+00	1.00E+00

CAS_NUMBER	COPC_NAME	K_ow (unitless)	K_oc (mL/g)	Kd_s (cm3/g)	Kd_sw (L/kg)	Kd_bs (cm3/g)	K_sg (per year)	f_v (unitless)
1746-01-6	2,3,7,8-TCDD	6.31E+06	3.89E+06	3.89E+04	2.92E+05	1.56E+05	3.00E-02	6.64E-01
2691-41-0	HMX	2.27E+00	2.24E+00	2.24E-02	1.68E-02	8.96E-02	ND	5.06E-02
3268-87-9	OCDD	1.58E+08	9.77E+07	9.77E+05	7.33E+06	3.91E+06	3.00E-02	2.00E-03
19408-74-3	1,2,3,7,8,9-HxCDD	2.00E+07	1.23E+07	1.23E+05	9.23E+05	4.92E+05	3.00E-02	1.60E-02
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	2.57E+07	1.92E+07	1.92E+05	1.44E+05	7.70E+05	ND	5.63E-01
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	1.86E+08	1.35E+08	1.35E+06	1.01E+06	5.39E+06	ND	5.81E-01
35822-46-9	1,2,3,4,6,7,8-HpCDD	1.00E+08	6.17E+07	6.17E+05	4.62E+06	2.47E+06	3.00E-02	3.00E-03
39227-28-6	1,2,3,4,7,8-HxCDD	6.31E+07	3.89E+07	3.89E+05	2.92E+06	1.56E+06	3.00E-02	2.40E-02
40321-76-4	1,2,3,7,8-PeCDD	4.37E+06	2.69E+06	2.69E+04	2.02E+05	1.08E+05	3.00E-02	1.17E-01
57117-31-4	2,3,4,7,8-PeCDF	3.16E+06	1.95E+06	1.95E+04	1.46E+05	7.80E+04	3.00E-02	2.21E-01
57117-41-6	1,2,3,7,8-PeCDF	6.17E+06	3.80E+06	3.80E+04	2.85E+05	1.52E+05	3.00E-02	2.68E-01
57117-44-9	1,2,3,6,7,8-HxCDF	1.00E+07	6.17E+06	6.17E+04	4.62E+05	2.47E+05	3.00E-02	5.20E-02
57653-85-7	1,2,3,6,7,8-HxCDD	2.00E+07	1.23E+07	1.23E+05	9.23E+05	4.92E+05	3.00E-02	2.90E-02
60851-34-5	2,3,4,6,7,8-HxCDF	1.00E+07	6.17E+06	6.17E+04	4.62E+05	2.47E+05	3.00E-02	5.50E-02
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	9.55E+06	7.27E+06	7.27E+04	5.45E+04	2.91E+05	ND	9.24E-01
70648-26-9	1,2,3,4,7,8-HxCDF	1.00E+07	6.17E+06	6.17E+04	4.62E+05	2.47E+05	3.00E-02	4.90E-02
72918-21-9	1,2,3,7,8,9-HxCDF	1.00E+07	6.17E+06	6.17E+04	4.62E+05	2.47E+05	3.00E-02	9.00E-02

Table A-3: COPC Parameter Set 3

CAS_NUMBER	COPC_NAME	RCF ([µg/g DW plant]/[µg/ml soil water])	br_root_veg ([µg/g DW plant]/[µg/g soil])	br_leafy_veg ([µg/g DW plant]/[µg/g soil])	br_forage ([µg/g DW plant]/[µg/g soil])	bv_leafy_veg ([µg/g DW plant]/[µg/g air])	bv_forage ([µg/g DW plant]/[µg/g air])	ba_milk (day/kg FW tissue)
7429-90-5	Aluminum compounds	0.00E+00	6.50E-04	6.50E-04	6.50E-04	0.00E+00	0.00E+00	2.00E-04
7440-36-0	Antimony compounds	0.00E+00	3.00E-02	3.19E-02	3.19E-02	0.00E+00	0.00E+00	1.00E-04
7440-38-2	Arsenic compounds	0.00E+00	8.00E-03	6.33E-03	6.33E-03	0.00E+00	0.00E+00	6.00E-05
7440-39-3	Barium compounds	0.00E+00	1.50E-02	3.22E-02	3.22E-02	0.00E+00	0.00E+00	3.50E-04
7440-41-7	Beryllium compounds	0.00E+00	1.50E-03	2.58E-03	2.58E-03	0.00E+00	0.00E+00	9.00E-07
7440-43-9	Cadmium compounds	0.00E+00	6.40E-02	1.25E-01	1.25E-01	0.00E+00	0.00E+00	6.50E-06
18540-29-9	Chromium compounds	0.00E+00	4.50E-03	4.88E-03	4.88E-03	0.00E+00	0.00E+00	1.50E-03
7440-50-8	Copper compounds	0.00E+00	2.50E-01	2.50E-01	2.50E-01	0.00E+00	0.00E+00	1.50E-03
7439-92-1	Lead compounds	0.00E+00	9.00E-03	1.36E-02	1.36E-02	0.00E+00	0.00E+00	2.50E-04
7439-96-5	Manganese compounds	0.00E+00	5.00E-02	5.00E-02	5.00E-02	0.00E+00	0.00E+00	3.50E-04
7439-97-6	Mercury compounds	0.00E+00	2.00E-01	2.00E-01	2.00E-01	0.00E+00	0.00E+00	4.50E-04
7440-02-0	Nickel compounds	0.00E+00	8.00E-03	9.31E-03	9.31E-03	0.00E+00	0.00E+00	1.00E-03
7782-49-2	Selenium compounds	0.00E+00	2.20E-02	1.95E-02	1.95E-02	0.00E+00	0.00E+00	5.86E-03
7440-22-4	Silver compounds	0.00E+00	1.00E-01	1.38E-01	1.38E-01	0.00E+00	0.00E+00	2.00E-02
7440-28-0	Thallium compounds	0.00E+00	4.00E-04	8.58E-04	8.58E-04	0.00E+00	0.00E+00	2.00E-03
7440-62-2	Vanadium compounds	0.00E+00	3.00E-03	3.00E-03	3.00E-03	0.00E+00	0.00E+00	2.00E-05
7440-66-6	Zinc compounds	0.00E+00	9.00E-01	9.70E-02	9.70E-02	0.00E+00	0.00E+00	3.25E-05
7440-48-4	Cobalt compounds	0.00E+00	7.00E-03	7.00E-03	7.00E-03	0.00E+00	0.00E+00	2.00E-03
7440-31-5	Tin compounds	0.00E+00	6.00E-03	6.00E-03	6.00E-03	0.00E+00	0.00E+00	1.00E-03
7440-42-8	Boron compounds	0.00E+00	2.00E+00	2.00E+00	2.00E+00	0.00E+00	0.00E+00	1.50E-03
91-57-6	2-Methylnaphthalene	3.04E+01	3.20E-02	2.16E-01	2.16E-01	1.54E+00	1.54E+00	5.12E-03
118-96-7	2,4,6-Trinitrotoluene	1.03E+01	2.74E+01	4.60E+00	4.60E+00	5.81E+02	5.81E+02	3.17E-04
121-14-2	2,4-Dinitrotoluene	1.41E+01	1.59E+01	2.78E+00	2.78E+00	7.75E+01	7.75E+01	5.92E-04
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	4.00E+04	1.03E+00	4.55E-03	4.55E-03	6.55E+04	6.55E+04	5.50E-03
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	4.79E+05	4.90E-01	7.05E-04	7.05E-04	2.36E+06	2.36E+06	1.44E-03
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	9.17E+03	9.19E-02	2.97E-03	2.97E-03	7.43E+03	7.43E+03	4.38E-03
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	3.85E+03	1.17E-01	5.70E-03	5.70E-03	5.83E+01	5.83E+01	6.09E-03
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	5.11E+03	1.08E-01	4.61E-03	4.61E-03	1.15E+03	1.15E+03	5.53E-03
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	2.15E+04	7.26E-02	1.57E-03	1.57E-03	4.85E+04	4.85E+04	2.86E-03
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	4.79E+05	7.76E-01	9.20E-04	9.20E-04	2.28E+06	2.28E+06	1.85E-03
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	7.05E+04	5.23E-02	6.43E-04	6.43E-04	7.08E+05	7.08E+05	1.44E-03
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	1.16E+04	1.49E+00	1.15E-02	1.15E-02	4.57E+04	4.57E+04	7.68E-03
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.16E+05	7.48E-01	2.05E-03	2.05E-03	8.30E+05	8.30E+05	3.46E-03
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00

CAS_NUMBER	COPC_NAME	RCF ([µg/g DW plant]/[µg/ml soil water])	br_root_veg ([µg/g DW plant]/[µg/g soil])	br_leafy_veg ([µg/g DW plant]/[µg/g soil])	br_forage ([µg/g DW plant]/[µg/g soil])	bv_leafy_veg ([µg/g DW plant]/[µg/g air])	bv_forage ([µg/g DW plant]/[µg/g air])	ba_milk (day/kg FW tissue)
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.16E+05	7.48E-01	2.05E-03	2.05E-03	8.30E+05	8.30E+05	3.46E-03
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	7.15E+03	9.84E-02	3.58E-03	3.58E-03	1.64E+04	1.64E+04	4.87E-03
50-29-3	DDT	1.97E+04	4.92E-02	7.74E-03	7.74E-03	4.52E+04	4.52E+04	6.84E-03
50-32-8	Benzo[a]pyrene	9.68E+03	6.05E-02	1.32E-02	1.32E-02	1.25E+05	1.25E+05	7.91E-03
53-70-3	Dibenzo[a,h]anthracene	2.35E+04	4.05E-02	6.78E-03	6.78E-03	3.12E+07	3.12E+07	6.52E-03
56-55-3	Benzo[a]anthracene	5.69E+03	9.48E-02	1.97E-02	1.97E-02	1.93E+04	1.93E+04	8.41E-03
57-74-9	Chlordane	3.99E+03	1.66E+01	2.56E-02	2.56E-02	8.22E+02	8.22E+02	8.56E-03
57-97-6	1,12-Dimethylbenz[a]anthracene	2.91E+04	1.41E+01	5.78E-03	5.78E-03	1.67E+05	1.67E+05	3.31E-02
72-54-8	DDD, 4,4'-	9.68E+03	6.46E-02	1.32E-02	1.32E-02	3.43E+04	3.43E+04	7.91E-03
72-55-9	DDE, 4,4'-	5.69E+03	8.37E-03	1.97E-02	1.97E-02	3.13E+03	3.13E+03	8.41E-03
83-32-9	Acenaphthene	2.34E+02	2.13E-01	2.16E-01	2.16E-01	4.97E+00	4.97E+00	5.12E-03
85-01-8	Phenanthrene	6.78E+02	1.83E-01	9.70E-02	9.71E-02	1.51E+02	1.51E+02	7.12E-03
86-73-7	Fluorene	3.98E+02	1.90E-01	1.45E-01	1.45E-01	2.60E+01	2.60E+01	6.16E-03
91-94-1	3,3'-Dichlorobenzidine	1.17E+02	1.62E+01	3.62E-01	3.62E-01	7.65E+04	7.65E+04	3.79E-03
92-67-1	4-Aminobiphenyl	3.84E+01	1.84E+01	9.58E-01	9.58E-01	1.31E+05	1.31E+05	4.79E-06
92-87-5	Benzidine	1.07E+01	3.84E+01	4.25E+00	4.25E+00	6.33E+04	6.33E+04	3.63E-07
93-76-5	2,4,5-T	3.83E-01	1.05E+00	5.75E+00	5.75E+00	4.03E+01	4.03E+01	0.00E+00
98-95-3	Nitrobenzene	1.25E+01	1.05E+01	3.30E+00	3.30E+00	2.17E-01	2.17E-01	4.82E-04
99-35-4	1,3,5-Trinitrobenzene	8.26E+00	3.75E+00	7.84E+00	7.84E+00	3.21E+03	3.21E+03	1.53E-04
99-65-0	1,3-Dinitrobenzene	9.63E+00	2.19E+00	5.26E+00	5.26E+00	9.62E+00	9.62E+00	2.66E-04
119-93-7	3.3'-Dimethylbenzidine	1.83E-01	2.44E+00	1.00E+01	1.00E+01	1.07E+04	1.07E+04	4.17E+06
120-12-7	Anthracene	6.78E+02	1.51E-01	9.71E-02	9.71E-02	5.33E+01	5.33E+01	7.12E-03
121-82-4	RDX	3.37E-01	2.30E+01	2.61E+01	2.61E+01	1.82E+00	1.82E+00	7.08E+02
129-00-0	Pyrene	1.38E+03	1.45E-01	5.70E-02	5.70E-02	8.40E+02	8.40E+02	8.09E-03
189-64-0	Dibenzo[a,h]pyrene	8.21E+00	8.54E-01	5.76E-01	5.76E-01	1.65E+03	1.65E+03	6.39E+05
191-30-0	Dibenzo[a,l]pyrene	1.14E+01	7.79E-01	4.49E-01	4.49E-01	2.60E+03	2.60E+03	1.01E+06
192-65-4	Dibenzo[a,e]pyrene	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
193-39-5	Indeno[1,2,3-cd]pyrene	2.81E+04	5.29E-02	5.93E-03	5.93E-03	3.73E+05	3.73E+05	6.19E-03
205-82-3	Benzo[j]fluoranthene	1.53E+03	2.01E-01	1.14E-02	1.14E-02	8.86E+05	8.86E+05	3.44E+08
205-97-0	Dibenzo[b,k]fluoranthene	1.22E+04	1.13E-01	2.40E-03	2.40E-03	3.96E+07	3.96E+07	1.54E+10
205-99-2	Benzo[b]floranthene	1.21E+04	1.15E+00	1.12E-02	1.12E-02	1.68E+03	1.68E+03	7.62E-03
206-44-0	Fluoranthene	1.64E+03	1.50E-01	4.99E-02	4.99E-02	7.38E+02	7.38E+02	8.26E-03
207-08-9	Benzo[k]floranthene	1.16E+04	6.09E-02	1.15E-02	1.15E-02	2.11E+05	2.11E+05	7.68E-03
218-01-9	Chrysene	5.69E+03	9.48E-02	1.97E-02	1.97E-02	6.92E+02	6.92E+02	8.41E-03

CAS_NUMBER	COPC_NAME	RCF ([µg/g DW plant]/[µg/ml soil water])	br_root_veg ([µg/g DW plant]/[µg/g soil])	br_leafy_veg ([µg/g DW plant]/[µg/g soil])	br_forage ([µg/g DW plant]/[µg/g soil])	bv_leafy_veg ([µg/g DW plant]/[µg/g air])	bv_forage ([µg/g DW plant]/[µg/g air])	ba_milk (day/kg FW tissue)
479-45-8	Tetryl	2.13E+00	1.24E+00	1.59E+00	1.59E+00	1.01E+07	1.01E+07	3.90E+09
606-20-2	2,6-Dinitrotoluene	1.12E+01	2.28E+01	3.93E+00	3.93E+00	5.08E+00	5.08E+00	3.89E-04
1746-01-6	2,3,7,8-TCDD	4.00E+04	1.03E+00	4.55E-03	4.55E-03	6.55E+04	6.55E+04	5.50E-03
2691-41-0	HMX	5.68E-02	3.38E+00	2.41E+01	2.41E+01	3.62E+04	3.62E+04	1.40E+07
3268-87-9	OCDD	4.79E+05	4.90E-01	7.05E-04	7.05E-04	2.36E+06	2.36E+06	1.44E-03
19408-74-3	1,2,3,7,8,9-HxCDD	9.71E+04	7.89E-01	2.34E-03	2.34E-03	5.20E+05	5.20E+05	3.78E-03
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	1.53E+04	1.06E-01	2.02E-03	2.02E-03	6.36E+04	6.36E+04	2.47E+07
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	7.05E+04	6.97E-02	6.43E-04	6.43E-04	3.99E+06	3.99E+06	1.55E+09
35822-46-9	1,2,3,4,6,7,8-HpCDD	3.36E+05	5.45E-01	9.20E-04	9.20E-04	9.10E+05	9.10E+05	1.85E-03
39227-28-6	1,2,3,4,7,8-HxCDD	2.36E+05	6.05E-01	1.20E-03	1.20E-03	5.20E+05	5.20E+05	2.32E-03
40321-76-4	1,2,3,7,8-PeCDD	3.01E+04	1.12E+00	5.62E-03	5.62E-03	2.39E+05	2.39E+05	6.05E-03
57117-31-4	2,3,4,7,8-PeCDF	2.35E+04	1.21E+00	6.78E-03	6.78E-03	9.75E+04	9.75E+04	6.52E-03
57117-41-6	1,2,3,7,8-PeCDF	3.93E+04	1.03E+00	4.61E-03	4.61E-03	9.75E+04	9.75E+04	5.53E-03
57117-44-9	1,2,3,6,7,8-HxCDF	5.70E+04	9.25E-01	3.48E-03	3.48E-03	1.62E+05	1.62E+05	4.80E-03
57653-85-7	1,2,3,6,7,8-HxCDD	9.71E+04	7.89E-01	2.34E-03	2.33E-03	5.20E+05	5.20E+05	3.78E-03
60851-34-5	2,3,4,6,7,8-HxCDF	5.70E+04	9.25E-01	3.48E-03	3.48E-03	1.62E+05	1.62E+05	4.80E-03
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	7.15E+03	1.31E-01	3.58E-03	3.58E-03	1.65E+04	1.65E+04	6.40E+06
70648-26-9	1,2,3,4,7,8-HxCDF	5.70E+04	9.25E-01	3.48E-03	3.48E-03	1.62E+05	1.62E+05	4.80E-03
72918-21-9	1,2,3,7,8,9-HxCDF	5.70E+04	9.25E-01	3.48E-03	3.48E-03	1.62E+05	1.62E+05	4.80E-03

Table A-4: COPC Parameter Set 4

CAS_NUMBER	COPC_NAME	ba_beef (day/kg FW tissue)	ba_pork (day/kg FW tissue)	BCF_fish (L/kg FW)	BAF_fish (L/kg FW tissue)	BSAF_fish (unitless)
7429-90-5	Aluminum compounds	1.50E-03	0.00E+00	0.00E+00	0.00E+00	1.00E+00
7440-36-0	Antimony compounds	1.00E-03	0.00E+00	0.00E+00	0.00E+00	4.00E+01
7440-38-2	Arsenic compounds	2.00E-03	0.00E+00	0.00E+00	0.00E+00	1.14E+02
7440-39-3	Barium compounds	1.50E-04	0.00E+00	0.00E+00	0.00E+00	6.33E+02
7440-41-7	Beryllium compounds	1.00E-03	0.00E+00	0.00E+00	0.00E+00	6.20E+01
7440-43-9	Cadmium compounds	1.20E-04	1.91E-04	0.00E+00	0.00E+00	9.07E+02
18540-29-9	Chromium compounds	5.50E-03	0.00E+00	0.00E+00	0.00E+00	1.90E+01
7440-50-8	Copper compounds	1.00E-02	0.00E+00	0.00E+00	0.00E+00	3.16E+00
7439-92-1	Lead compounds	3.00E-04	0.00E+00	0.00E+00	0.00E+00	9.00E-02
7439-96-5	Manganese compounds	4.00E-04	0.00E+00	0.00E+00	0.00E+00	3.16E+00
7439-97-6	Mercury compounds	2.50E-01	0.00E+00	0.00E+00	0.00E+00	3.16E+00
7440-02-0	Nickel compounds	6.00E-03	0.00E+00	0.00E+00	0.00E+00	7.80E+01
7782-49-2	Selenium compounds	2.27E-03	1.88E-01	0.00E+00	0.00E+00	1.29E+02
7440-22-4	Silver compounds	3.00E-03	0.00E+00	0.00E+00	0.00E+00	8.77E+01
7440-28-0	Thallium compounds	4.00E-02	0.00E+00	0.00E+00	0.00E+00	1.00E+04
7440-62-2	Vanadium compounds	2.50E-03	0.00E+00	0.00E+00	0.00E+00	1.00E+00
7440-66-6	Zinc compounds	9.00E-05	1.28E-04	0.00E+00	0.00E+00	2.06E+03
7440-48-4	Cobalt compounds	2.00E-02	0.00E+00	0.00E+00	0.00E+00	3.16E+00
7440-31-5	Tin compounds	8.00E-02	0.00E+00	0.00E+00	0.00E+00	1.00E+00
7440-42-8	Boron compounds	8.00E-04	0.00E+00	0.00E+00	0.00E+00	1.00E+00
91-57-6	2-Methylnaphthalene	2.43E-02	2.94E-02	0.00E+00	0.00E+00	2.01E+02
118-96-7	2,4,6-Trinitrotoluene	1.50E-03	1.82E-03	0.00E+00	0.00E+00	3.40E+00
121-14-2	2,4-Dinitrotoluene	2.81E-03	3.41E-03	0.00E+00	0.00E+00	6.68E+00
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	2.61E-02	3.16E-02	0.00E+00	0.00E+00	3.44E+04
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	6.85E-03	8.30E-03	0.00E+00	0.00E+00	1.47E+03
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	2.08E-02	2.52E-02	0.00E+00	0.00E+00	4.42E+04
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	2.89E-02	3.50E-02	0.00E+00	0.00E+00	2.54E+04
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	2.63E-02	3.18E-02	0.00E+00	0.00E+00	3.38E+04
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	1.36E-02	1.64E-02	0.00E+00	0.00E+00	9.73E+03
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	8.77E-03	1.06E-02	0.00E+00	0.00E+00	2.75E+03
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	6.85E-03	8.30E-03	0.00E+00	0.00E+00	1.18E+03
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.65E-02	4.42E-02	0.00E+00	0.00E+00	9.93E+03
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.64E-02	1.99E-02	0.00E+00	0.00E+00	1.83E+04
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.64E-02	1.99E-02	0.00E+00	0.00E+00	1.83E+04
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	2.31E-02	2.80E-02	0.00E+00	0.00E+00	4.73E+04
50-29-3	DDT	3.25E-02	3.93E-02	9.33E+00	0.00E+00	1.69E+04

CAS_NUMBER	COPC_NAME	ba_beef (day/kg FW tissue)	ba_pork (day/kg FW tissue)	BCF_fish (L/kg FW)	BAF_fish (L/kg FW tissue)	BSAF_fish (unitless)
50-32-8	Benzo[a]pyrene	3.76E-02	4.55E-02	1.07E+01	0.00E+00	8.32E+03
53-70-3	Dibenzo[a,h]anthracene	3.10E-02	3.75E-02	2.80E+01	0.00E+00	2.02E+04
56-55-3	Benzo[a]anthracene	3.99E-02	4.83E-02	3.79E+00	0.00E+00	4.89E+03
57-74-9	Chlordane	4.06E-02	4.92E-02	6.88E+00	0.00E+00	3.43E+03
57-97-6	1,12-Dimethylbenz[a]anthracene	1.05E-01	6.88E-01	**ND**	**ND**	7.54E+04
72-54-8	DDD, 4,4'-	3.76E-02	4.55E-02	1.05E+01	0.00E+00	8.32E+03
72-55-9	DDE, 4,4'-	3.99E-02	4.83E-02	1.43E+01	0.00E+00	4.89E+03
83-32-9	Acenaphthene	2.43E-02	2.94E-02	7.32E-02	0.00E+00	2.01E+02
85-01-8	Phenanthrene	3.38E-02	4.09E-02	2.82E-01	0.00E+00	5.82E+02
86-73-7	Fluorene	2.93E-02	3.54E-02	1.17E-01	0.00E+00	3.42E+02
91-94-1	3,3'-Dichlorobenzidine	1.80E-02	2.18E-02	2.99E-02	0.00E+00	1.01E+02
92-67-1	4-Aminobiphenyl	1.51E-05	9.94E-05	**ND**	**ND**	7.63E+01
92-87-5	Benzidine	1.15E-06	7.54E-06	**ND**	**ND**	1.08E+01
93-76-5	2,4,5-T	1.12E-03	1.35E-03	**ND**	**ND**	1.01E+00
98-95-3	Nitrobenzene	2.29E-03	2.77E-03	5.40E-04	0.00E+00	5.30E+00
99-35-4	1,3,5-Trinitrobenzene	7.25E-04	8.77E-04	1.20E-04	0.00E+00	1.67E+00
99-65-0	1,3-Dinitrobenzene	1.26E-03	1.53E-03	2.46E-04	0.00E+00	2.85E+00
119-93-7	3.3'-Dimethylbenzidine	5.06E-04	6.12E-04	**ND**	**ND**	1.21E+00
120-12-7	Anthracene	3.38E-02	4.09E-02	2.34E-01	0.00E+00	5.82E+02
121-82-4	RDX	1.06E-04	1.29E-04	**ND**	**ND**	3.16E+00
129-00-0	Pyrene	3.84E-02	4.65E-02	7.98E-01	0.00E+00	1.18E+03
189-64-0	Dibenzo[a,h]pyrene	1.29E-02	1.57E-02	**ND**	**ND**	2.26E+02
191-30-0	Dibenzo[a,l]pyrene	1.55E-02	1.88E-02	**ND**	**ND**	3.15E+02
192-65-4	Dibenzo[a,e]pyrene	**ND**	**ND**	**ND**	**ND**	**ND**
193-39-5	Indeno[1,2,3-cd]pyrene	2.94E-02	3.56E-02	6.53E+01	0.00E+00	2.41E+04
205-82-3	Benzo[j]fluoranthene	3.63E-02	4.40E-02	ND	ND	3.06E+04
205-97-0	Dibenzo[b,k]fluoranthene	1.83E-02	2.21E-02	ND	ND	2.43E+05
205-99-2	Benzo[b]floranthene	3.62E-02	4.38E-02	1.27E+01	0.00E+00	1.04E+04
206-44-0	Fluoranthene	3.92E-02	4.75E-02	9.65E-01	0.00E+00	1.41E+03
207-08-9	Benzo[k]floranthene	3.65E-02	4.42E-02	1.26E+01	0.00E+00	9.93E+03
218-01-9	Chrysene	3.99E-02	4.83E-02	4.35E+00	0.00E+00	4.89E+03
479-45-8	Tetryl	5.21E-03	6.30E-03	**ND**	**ND**	1.41E+01
606-20-2	2,6-Dinitrotoluene	1.85E-03	2.23E-03	6.12E-04	0.00E+00	4.21E+00
1746-01-6	2,3,7,8-TCDD	2.61E-02	3.16E-02	5.96E-02	3.32E+00	3.44E+04
2691-41-0	HMX	1.22E-04	5.15E-05	**ND**	**ND**	3.16E+00
3268-87-9	OCDD	6.85E-03	8.30E-03	9.90E-03	5.00E-02	1.47E+03
19408-74-3	1,2,3,7,8,9-HxCDD	1.79E-02	2.17E-02	2.33E-02	6.30E-01	2.51E+04
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	1.63E-02	1.97E-02	**ND**	**ND**	7.38E+04
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	6.26E-03	7.58E-03	**ND**	**ND**	4.90E+03

CAS_NUMBER	COPC_NAME	ba_beef (day/kg FW tissue)	ba_pork (day/kg FW tissue)	BCF_fish (L/kg FW)	BAF_fish (L/kg FW tissue)	BSAF_fish (unitless)
35822-46-9	1,2,3,4,6,7,8-HpCDD	8.77E-03	1.06E-02	2.55E-02	3.90E-01	2.75E+03
39227-28-6	1,2,3,4,7,8-HxCDD	1.10E-02	1.33E-02	4.53E-02	1.83E+00	5.18E+03
40321-76-4	1,2,3,7,8-PeCDD	2.88E-02	3.48E-02	4.71E-02	2.50E+00	2.59E+04
57117-31-4	2,3,4,7,8-PeCDF	3.10E-02	3.75E-02	5.61E-02	3.28E+00	2.02E+04
57117-41-6	1,2,3,7,8-PeCDF	2.63E-02	3.18E-02	0.00E+00	0.00E+00	3.38E+04
57117-44-9	1,2,3,6,7,8-HxCDF	2.28E-02	2.76E-02	4.53E-02	1.62E+00	4.90E+04
57653-85-7	1,2,3,6,7,8-HxCDD	1.79E-02	2.17E-02	3.70E-02	1.17E+00	2.51E+04
60851-34-5	2,3,4,6,7,8-HxCDF	2.28E-02	2.76E-02	2.71E-02	7.90E-01	4.90E+04
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	2.31E-02	2.80E-02	**ND**	**ND**	1.97E+05
70648-26-9	1,2,3,4,7,8-HxCDF	2.28E-02	2.76E-02	4.51E-02	1.58E+00	4.90E+04
72918-21-9	1,2,3,7,8,9-HxCDF	2.28E-02	2.76E-02	0.00E+00	0.00E+00	4.90E+04

Table A-5: COPC Parameter Set 5

CAS_NUMBER	COPC_NAME	RfD (mg/kg-day)	Oral_csf (per mg/kg-day)	RfC (mg/m3)	inhalation_urf (per µg/m3)	inhalation_csf (per mg/kg-day)	Chemical_type (unitless)	Chemical_subtype (unitless)
7429-90-5	Aluminum compounds	1.00E+00	0.00E+00	5.00E-03	0.00E+00	0.00E+00	I	Metal
7440-36-0	Antimony compounds	4.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-38-2	Arsenic compounds	3.00E-04	1.50E+00	3.00E-05	4.30E-03	1.50E+01	I	Metal
7440-39-3	Barium compounds	2.00E-01	0.00E+00	5.00E-04	0.00E+00	0.00E+00	I	Metal
7440-41-7	Beryllium compounds	2.00E-03	0.00E+00	2.00E-05	2.40E-03	8.40E+00	I	Metal
7440-43-9	Cadmium compounds	5.00E-04	0.00E+00	2.00E-05	1.80E-03	6.30E+00	I	Metal
18540-29-9	Chromium compounds	1.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-50-8	Copper compounds	3.70E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7439-92-1	Lead compounds	0.00E+00	8.50E-03	0.00E+00	1.20E-05	4.20E-02	I	Metal
7439-96-5	Manganese compounds	1.40E-01	0.00E+00	5.00E-05	0.00E+00	0.00E+00	I	Metal
7439-97-6	Mercury compounds	3.00E-04	0.00E+00	3.00E-04	0.00E+00	0.00E+00	I	Metal
7440-02-0	Nickel compounds	2.00E-02	0.00E+00	9.00E-05	2.40E-04	8.40E-01	I	Metal
7782-49-2	Selenium compounds	5.00E-03	0.00E+00	2.00E-02	0.00E+00	0.00E+00	I	Metal
7440-22-4	Silver compounds	5.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-28-0	Thallium compounds	8.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-62-2	Vanadium compounds	9.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-66-6	Zinc compounds	3.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-48-4	Cobalt compounds	0.00E+00	0.00E+00	1.00E-04	0.00E+00	0.00E+00	I	Metal
7440-31-5	Tin compounds	6.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	I	Metal
7440-42-8	Boron compounds	2.00E-01	0.00E+00	2.00E-02	0.00E+00	0.00E+00	I	Metal
91-57-6	2-Methylnaphthalene	4.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	O	None
118-96-7	2,4,6-Trinitrotoluene	5.00E-04	3.00E-02	0.00E+00	0.00E+00	0.00E+00	O	None
121-14-2	2,4-Dinitrotoluene	2.00E-03	3.10E-01	0.00E+00	8.90E-05	3.10E-01	O	None
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.00E+00	1.50E+05	0.00E+00	3.80E+01	1.30E+05	O	D
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.00E+00	4.50E+01	0.00E+00	0.00E+00	3.90E+01	O	None
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	0.00E+00	1.50E+01	0.00E+00	0.00E+00	1.30E+01	O	PCB
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.00E+00	4.50E+01	0.00E+00	0.00E+00	3.90E+01	O	F
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	0.00E+00	1.50E+04	0.00E+00	0.00E+00	1.30E+04	O	F
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.00E+00	1.50E+03	0.00E+00	0.00E+00	1.30E+03	O	F
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	1.50E+04	0.00E+00	0.00E+00	1.30E+04	O	PCB
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.00E+00	1.50E+03	0.00E+00	0.00E+00	1.30E+03	O	F

CAS_NUMBER	COPC_NAME	RfD (mg/kg-day)	Oral_csf (per mg/kg-day)	RfC (mg/m3)	inhalation_urf (per µg/m3)	inhalation_csf (per mg/kg-day)	Chemical_type (unitless)	Chemical_subtype (unitless)
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	0.00E+00	4.50E+00	0.00E+00	0.00E+00	3.90E+00	O	PCB
50-29-3	DDT	5.00E-04	3.40E-01	1.80E-03	9.70E-05	3.40E-01	O	P
50-32-8	Benzo[a]pyrene	0.00E+00	7.30E+00	0.00E+00	1.10E-03	7.30E+00	O	PAH
53-70-3	Dibenzo[a,h]anthracene	0.00E+00	7.30E+00	0.00E+00	1.20E-03	7.30E+00	O	PAH
56-55-3	Benzo[a]anthracene	0.00E+00	7.30E-01	0.00E+00	1.10E-04	7.30E-01	O	PAH
57-74-9	Chlordane	5.00E-04	3.50E-01	7.00E-04	1.00E-04	3.50E-01	O	P
57-97-6	1,12-Dimethylbenz[a]anthracene	ND	ND	ND	ND	ND	O	PAH
72-54-8	DDD, 4,4'-	0.00E+00	2.40E-01	0.00E+00	6.90E-05	2.40E-01	O	None
72-55-9	DDE, 4,4'-	0.00E+00	3.40E-01	0.00E+00	9.70E-05	3.40E-01	O	None
83-32-9	Acenaphthene	6.00E-02	0.00E+00	2.10E-01	0.00E+00	0.00E+00	O	PAH
85-01-8	Phenanthrene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	O	PAH
86-73-7	Fluorene	4.00E-02	0.00E+00	1.40E-01	0.00E+00	0.00E+00	O	PAH
91-94-1	3,3'-Dichlorobenzidine	0.00E+00	4.50E-01	0.00E+00	3.40E-04	4.50E-01	O	None
92-67-1	4-Aminobiphenyl	ND	ND	ND	ND	ND	O	None
92-87-5	Benzidine	3.00E-03	2.30E+02	1.05E-02	6.70E-02	2.30E+02	O	None
93-76-5	2,4,5-T	ND	ND	ND	ND	ND	O	None
98-95-3	Nitrobenzene	5.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	O	None
99-35-4	1,3,5-Trinitrobenzene	3.00E-02	0.00E+00	1.10E-01	0.00E+00	0.00E+00	O	None
99-65-0	1,3-Dinitrobenzene	1.00E-04	0.00E+00	3.50E-04	0.00E+00	0.00E+00	O	None
119-93-7	3.3'-Dimethylbenzidine	ND	ND	ND	ND	ND	O	None
120-12-7	Anthracene	3.00E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	O	PAH
121-82-4	RDX	ND	ND	ND	ND	ND	O	None
129-00-0	Pyrene	3.00E-02	0.00E+00	1.10E-01	0.00E+00	0.00E+00	O	PAH
189-64-0	Dibenzo[a,h]pyrene	ND	ND	ND	ND	ND	O	PAH
191-30-0	Dibenzo[a,l]pyrene	ND	ND	ND	ND	ND	O	PAH
192-65-4	Dibenzo[a,e]pyrene	ND	ND	ND	ND	ND	O	PAH
193-39-5	Indeno[1,2,3-cd]pyrene	0.00E+00	7.30E-01	0.00E+00	1.10E-04	7.30E-01	O	PAH
205-82-3	Benzo[j]fluoranthene	ND	ND	ND	ND	ND	O	PAH
205-97-0	Dibenzo[b,k]fluoranthene	ND	ND	ND	ND	ND	O	PAH
205-99-2	Benzo[b]floranthene	0.00E+00	7.30E-01	0.00E+00	1.10E-04	7.30E-01	O	PAH
206-44-0	Fluoranthene	4.00E-02	0.00E+00	1.40E-01	0.00E+00	0.00E+00	O	PAH
207-08-9	Benzo[k]floranthene	0.00E+00	7.30E-02	0.00E+00	1.10E-04	7.30E-02	O	PAH
218-01-9	Chrysene	0.00E+00	7.30E-03	0.00E+00	1.10E-05	7.30E-03	O	PAH
479-45-8	Tetryl	ND	ND	ND	ND	ND	O	None
606-20-2	2,6-Dinitrotoluene	0.00E+00	6.80E-01	0.00E+00	0.00E+00	6.80E-01	O	None

CAS_NUMBER	COPC_NAME	RfD (mg/kg-day)	Oral_csf (per mg/kg-day)	RfC (mg/m3)	inhalation_urf (per µg/m3)	inhalation_csf (per mg/kg-day)	Chemical_type (unitless)	Chemical_subtype (unitless)
1746-01-6	2,3,7,8-TCDD	1.00E-09	1.50E+05	0.00E+00	0.00E+00	1.50E+05	O	D
2691-41-0	HMX	**ND**	**ND**	**ND**	**ND**	**ND**	O	None
3268-87-9	OCDD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+02	O	D
19408-74-3	1,2,3,7,8,9-HxCDD	0.00E+00	6.20E-03	0.00E+00	1.30E+00	1.50E+04	O	D
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	**ND**	**ND**	**ND**	**ND**	**ND**	O	PCB
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	**ND**	**ND**	**ND**	**ND**	**ND**	O	PCB
35822-46-9	1,2,3,4,6,7,8-HpCDD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+03	O	D
39227-28-6	1,2,3,4,7,8-HxCDD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+04	O	D
40321-76-4	1,2,3,7,8-PeCDD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.50E+04	O	D
57117-31-4	2,3,4,7,8-PeCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.50E+04	O	F
57117-41-6	1,2,3,7,8-PeCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.50E+03	O	F
57117-44-9	1,2,3,6,7,8-HxCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+04	O	F
57653-85-7	1,2,3,6,7,8-HxCDD	0.00E+00	6.20E-03	0.00E+00	1.30E+00	1.50E+04	O	D
60851-34-5	2,3,4,6,7,8-HxCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+04	O	F
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	**ND**	**ND**	**ND**	**ND**	**ND**	O	PCB
70648-26-9	1,2,3,4,7,8-HxCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+04	O	F
72918-21-9	1,2,3,7,8,9-HxCDF	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+04	O	F

Table A-6: COPC Parameter Set 6

CAS_NUMBER	COPC_NAME	br_grain ([µg/d DW plant]/[µg/g soil])	ba_egg (day/kg FW tissue)	ba_chicken (day/kg FW tissue)	inhalation_rfd (mg/kg/day)	tef (unitless)	abs (unitless)	t_b (°K)
7429-90-5	Aluminum compounds	6.50E-04	0.00E+00	0.00E+00	1.00E-03	0.00E+00	1.00E+00	2.60E+03
7440-36-0	Antimony compounds	3.19E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-01	1.91E+03
7440-38-2	Arsenic compounds	6.33E-03	0.00E+00	0.00E+00	9.00E-06	0.00E+00	1.00E+00	8.88E+02
7440-39-3	Barium compounds	3.22E-02	0.00E+00	0.00E+00	1.00E-04	0.00E+00	7.00E-02	1.91E+03
7440-41-7	Beryllium compounds	2.58E-03	0.00E+00	0.00E+00	6.00E-06	0.00E+00	7.00E-03	3.24E+03
7440-43-9	Cadmium compounds	1.25E-01	2.50E-03	1.06E-01	6.00E-06	0.00E+00	2.50E-02	1.04E+03
18540-29-9	Chromium compounds	4.88E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-02	2.91E+03
7440-50-8	Copper compounds	2.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	2.87E+03
7439-92-1	Lead compounds	1.36E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	2.01E+03
7439-96-5	Manganese compounds	5.00E-02	0.00E+00	0.00E+00	1.00E-05	0.00E+00	4.00E-02	2.37E+03
7439-97-6	Mercury compounds	2.00E-01	0.00E+00	0.00E+00	9.00E-05	0.00E+00	7.00E-02	6.30E+02
7440-02-0	Nickel compounds	9.31E-03	0.00E+00	0.00E+00	3.00E-05	0.00E+00	4.00E-02	3.00E+03
7782-49-2	Selenium compounds	1.95E-02	1.13E+00	1.13E+00	6.00E-03	0.00E+00	1.00E+00	9.58E+02
7440-22-4	Silver compounds	1.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-02	2.48E+03
7440-28-0	Thallium compounds	8.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.74E+03
7440-62-2	Vanadium compounds	3.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-02	3.68E+03
7440-66-6	Zinc compounds	9.70E-02	8.75E-03	8.75E-03	0.00E+00	0.00E+00	1.00E+00	1.18E+03
7440-48-4	Cobalt compounds	7.00E-03	0.00E+00	0.00E+00	3.00E-05	0.00E+00	1.00E+00	3.14E+03
7440-31-5	Tin compounds	6.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	2.54E+03
7440-42-8	Boron compounds	2.00E+00	0.00E+00	0.00E+00	6.00E-03	0.00E+00	1.00E+00	2.82E+03
91-57-6	2-Methylnaphthalene	2.16E-01	1.02E-02	1.79E-02	0.00E+00	0.00E+00	1.00E+00	5.14E+02
118-96-7	2,4,6-Trinitrotoluene	4.60E+00	6.33E-04	1.11E-03	0.00E+00	0.00E+00	1.00E+00	5.13E+02
121-14-2	2,4-Dinitrotoluene	2.78E+00	1.18E-03	2.07E-03	0.00E+00	0.00E+00	1.00E+00	5.73E+02
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	4.55E-03	1.10E-02	1.92E-02	0.00E+00	1.00E+00	1.00E+00	7.73E+02
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	7.05E-04	2.89E-03	5.05E-03	0.00E+00	3.00E-04	1.00E+00	7.83E+02
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	2.97E-03	8.76E-03	1.53E-02	0.00E+00	3.00E-05	1.00E+00	2.73E+02
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	5.70E-03	1.22E-02	2.13E-02	0.00E+00	1.00E-04	1.00E+00	2.73E+02
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	4.61E-03	1.11E-02	1.94E-02	0.00E+00	3.00E-05	1.00E+00	2.73E+02
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	1.57E-03	5.71E-03	1.00E-02	0.00E+00	3.00E-05	1.00E+00	2.73E+02
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	9.20E-04	3.69E-03	6.46E-03	0.00E+00	3.00E-04	1.00E+00	8.10E+02
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	6.43E-04	2.89E-03	5.05E-03	0.00E+00	3.00E-05	1.00E+00	2.73E+02
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	1.15E-02	1.54E-02	2.69E-02	0.00E+00	1.00E-01	1.00E+00	7.11E+02
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	2.05E-03	6.92E-03	1.21E-02	0.00E+00	1.00E-02	1.00E+00	7.80E+02
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	1.00E+00	1.00E+00	0.00E+00	1.00E-01	1.00E+00	2.73E+02

CAS_NUMBER	COPC_NAME	br_grain ([µg/d DW plant]/[µg/g soil])	ba_egg (day/kg FW tissue)	ba_chicken (day/kg FW tissue)	inhalation_rfd (mg/kg/day)	tef (unitless)	abs (unitless)	t_b (°K)
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.05E-03	6.92E-03	1.21E-02	0.00E+00	1.00E-02	1.00E+00	7.80E+02
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	1.00E+00	1.00E+00	0.00E+00	3.00E-05	1.00E+00	2.73E+02
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	3.58E-03	9.74E-03	1.70E-02	0.00E+00	3.00E-05	1.00E+00	2.73E+02
50-29-3	DDT	7.74E-03	1.37E-02	2.39E-02	5.00E-04	0.00E+00	3.00E-02	6.41E+02
50-32-8	Benzo[a]pyrene	1.32E-02	1.58E-02	2.77E-02	0.00E+00	0.00E+00	1.30E-01	7.68E+02
53-70-3	Dibenzo[a,h]anthracene	6.78E-03	1.30E-02	2.28E-02	0.00E+00	0.00E+00	1.30E-01	7.97E+02
56-55-3	Benzo[a]anthracene	1.97E-02	1.68E-02	2.94E-02	0.00E+00	0.00E+00	1.30E-01	7.11E+02
57-74-9	Chlordane	2.56E-02	1.71E-02	2.99E-02	2.00E-04	0.00E+00	4.00E-02	6.24E+02
57-97-6	1,12-Dimethylbenz[a]anthracene	5.78E-03	3.31E+01	8.38E-02	**ND**	**0.00E+00**	**1.30E-01**	**6.95E+02**
72-54-8	DDD, 4,4'-	1.32E-02	1.58E-02	2.77E-02	0.00E+00	0.00E+00	1.00E-01	6.23E+02
72-55-9	DDE, 4,4'-	1.97E-02	1.68E-02	2.94E-02	0.00E+00	0.00E+00	1.00E-01	6.09E+02
83-32-9	Acenaphthene	2.16E-01	1.02E-02	1.79E-02	6.00E-02	0.00E+00	1.30E-01	5.52E+02
85-01-8	Phenanthrene	9.71E-02	1.42E-02	2.49E-02	0.00E+00	0.00E+00	1.30E-01	6.13E+02
86-73-7	Fluorene	1.45E-01	1.23E-02	2.16E-02	4.00E-02	0.00E+00	1.30E-01	5.68E+02
91-94-1	3,3'-Dichlorobenzidine	3.62E-01	7.57E-03	1.32E-02	0.00E+00	0.00E+00	1.00E-01	6.41E+02
92-67-1	4-Aminobiphenyl	9.58E-01	4.79E-03	1.21E-05	**ND**	0.00E+00	1.00E-01	5.75E+02
92-87-5	Benzidine	4.25E+00	3.63E-04	9.19E-07	**ND**	0.00E+00	1.00E-01	6.74E+02
93-76-5	2,4,5-T	5.75E+00	4.71E-04	8.25E-04	**ND**	0.00E+00	1.00E-01	6.21E+02
98-95-3	Nitrobenzene	3.30E+00	9.63E-04	1.69E-03	5.71E-04	0.00E+00	1.00E-01	4.84E+02
99-35-4	1,3,5-Trinitrobenzene	7.84E+00	3.05E-04	5.34E-04	3.00E-02	0.00E+00	1.00E-01	5.88E+02
99-65-0	1,3-Dinitrobenzene	5.26E+00	5.31E-04	9.30E-04	1.00E-04	0.00E+00	1.00E-01	5.64E+02
119-93-7	3.3'-Dimethylbenzidine	1.00E+01	2.13E-04	3.73E-04	**ND**	0.00E+00	1.00E-01	6.12E+02
120-12-7	Anthracene	9.71E-02	1.42E-02	2.49E-02	3.00E-01	0.00E+00	1.30E-01	6.13E+02
121-82-4	RDX	2.61E+01	4.47E-05	7.83E-05	**ND**	0.00E+00	0.00E+00	6.26E+02
129-00-0	Pyrene	5.70E-02	1.62E-02	2.83E-02	3.00E-02	0.00E+00	1.30E-01	6.77E+02
189-64-0	Dibenzo[a,h]pyrene	5.76E-01	5.45E-03	9.54E-03	**ND**	0.00E+00	1.30E-01	7.87E+02
191-30-0	Dibenzo[a,l]pyrene	4.49E-01	6.55E-03	1.15E-02	**ND**	0.00E+00	1.30E-01	7.87E+02
192-65-4	Dibenzo[a,e]pyrene	**ND**	**ND**	**ND**	**ND**	0.00E+00	1.30E-01	8.09E+02
193-39-5	Indeno[1,2,3-cd]pyrene	5.93E-03	1.24E-02	2.17E-02	0.00E+00	0.00E+00	1.30E-01	7.16E+02
205-82-3	Benzo[j]fluoranthene	1.14E-02	1.53E-02	2.68E-02	**ND**	0.00E+00	1.30E-01	7.87E+02
205-97-0	Dibenzo[b,k]fluoranthene	2.40E-03	7.69E-03	1.35E-02	**ND**	0.00E+00	1.30E-01	7.16E+02
205-99-2	Benzo[b]floranthene	1.12E-02	1.52E-02	2.67E-02	0.00E+00	0.00E+00	1.30E-01	6.57E+02
206-44-0	Fluoranthene	4.99E-02	1.65E-02	2.89E-02	4.00E-02	0.00E+00	1.30E-01	7.53E+02
207-08-9	Benzo[k]floranthene	1.15E-02	1.54E-02	2.69E-02	0.00E+00	0.00E+00	1.30E-01	7.21E+02
218-01-9	Chrysene	1.97E-02	1.68E-02	2.94E-02	0.00E+00	0.00E+00	1.30E-01	7.21E+02

CAS_NUMBER	COPC_NAME	br_grain ([µg/d DW plant]/[µg/g soil])	ba_egg (day/kg FW tissue)	ba_chicken (day/kg FW tissue)	inhalation_rfd (mg/kg/day)	tef (unitless)	abs (unitless)	t_b (°K)
479-45-8	Tetryl	1.59E+00	2.19E-03	3.84E-03	0.00E+00	0.00E+00	0.00E+00	7.05E+02
606-20-2	2,6-Dinitrotoluene	3.93E+00	7.77E-04	1.36E-03	1.00E-03	0.00E+00	0.00E+00	5.73E+02
1746-01-6	2,3,7,8-TCDD	4.55E-03	1.10E-02	1.92E-02	0.00E+00	1.00E+00	0.00E+00	7.20E+02
2691-41-0	HMX	2.41E+01	5.15E-05	9.01E-05	**ND**	0.00E+00	1.00E-01	7.75E+02
3268-87-9	OCDD	7.05E-04	2.89E-03	5.05E-03	0.00E+00	1.00E-04	0.00E+00	7.83E+02
19408-74-3	1,2,3,7,8,9-HxCDD	2.34E-03	7.56E-03	1.32E-02	0.00E+00	1.00E-01	0.00E+00	6.90E+02
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	2.02E-03	6.85E-03	1.20E-02	0.00E+00	0.00E+00	1.40E-01	6.70E+02
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	6.43E-04	2.64E-03	4.61E-03	0.00E+00	0.00E+00	1.40E-01	6.89E+02
35822-46-9	1,2,3,4,6,7,8-HpCDD	9.20E-04	3.69E-03	6.46E-03	0.00E+00	1.00E-02	0.00E+00	7.80E+02
39227-28-6	1,2,3,4,7,8-HxCDD	1.20E-03	4.63E-03	8.11E-03	0.00E+00	1.00E-01	0.00E+00	6.90E+02
40321-76-4	1,2,3,7,8-PeCDD	5.62E-03	1.21E-02	2.12E-02	0.00E+00	1.00E+00	0.00E+00	6.71E+02
57117-31-4	2,3,4,7,8-PeCDF	6.78E-03	1.30E-02	2.28E-02	0.00E+00	5.00E-01	0.00E+00	6.75E+02
57117-41-6	1,2,3,7,8-PeCDF	4.61E-03	1.11E-02	1.94E-02	0.00E+00	5.00E-02	0.00E+00	6.75E+02
57117-44-9	1,2,3,6,7,8-HxCDF	3.48E-03	9.60E-03	1.68E-02	0.00E+00	1.00E-01	0.00E+00	6.88E+02
57653-85-7	1,2,3,6,7,8-HxCDD	2.34E-03	7.56E-03	1.32E-02	0.00E+00	1.00E-01	1.00E-01	6.88E+02
60851-34-5	2,3,4,6,7,8-HxCDF	3.48E-03	9.60E-03	1.68E-02	0.00E+00	1.00E-01	0.00E+00	6.88E+02
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	3.58E-03	9.74E-03	1.70E-02	**ND**	1.00E-04	1.40E-01	6.51E+02
70648-26-9	1,2,3,4,7,8-HxCDF	3.48E-03	9.60E-03	1.68E-02	0.00E+00	1.00E-01	0.00E+00	6.88E+02
72918-21-9	1,2,3,7,8,9-HxCDF	3.48E-03	9.60E-03	1.68E-02	0.00E+00	1.00E-01	1.00E-01	6.93E+02

Table A-7: COPC Parameter Set 7

CAS_NUMBER	COPC_NAME	fa (unitless)	p_c (cm/hr)	kpv (cm/hr)
7429-90-5	Aluminum compounds	0.00E+00	1.00E-03	0.00E+00
7440-36-0	Antimony compounds	0.00E+00	1.00E-03	0.00E+00
7440-38-2	Arsenic compounds	0.00E+00	1.00E-03	0.00E+00
7440-39-3	Barium compounds	0.00E+00	1.00E-03	0.00E+00
7440-41-7	Beryllium compounds	0.00E+00	1.00E-03	0.00E+00
7440-43-9	Cadmium compounds	0.00E+00	1.00E-03	0.00E+00
18540-29-9	Chromium compounds	0.00E+00	1.00E-03	0.00E+00
7440-50-8	Copper compounds	0.00E+00	1.00E-03	0.00E+00
7439-92-1	Lead compounds	0.00E+00	1.00E-04	0.00E+00
7439-96-5	Manganese compounds	0.00E+00	1.00E-03	0.00E+00
7439-97-6	Mercury compounds	0.00E+00	1.00E-03	0.00E+00
7440-02-0	Nickel compounds	0.00E+00	2.00E-04	0.00E+00
7782-49-2	Selenium compounds	0.00E+00	1.00E-03	0.00E+00
7440-22-4	Silver compounds	0.00E+00	6.00E-04	0.00E+00
7440-28-0	Thallium compounds	0.00E+00	1.00E-03	0.00E+00
7440-62-2	Vanadium compounds	0.00E+00	1.00E-03	0.00E+00
7440-66-6	Zinc compounds	0.00E+00	6.00E-04	0.00E+00
7440-48-4	Cobalt compounds	0.00E+00	4.00E-04	0.00E+00
7440-31-5	Tin compounds	0.00E+00	1.00E-03	0.00E+00
7440-42-8	Boron compounds	0.00E+00	1.00E-03	0.00E+00
91-57-6	2-Methylnaphthalene	1.00E+00	9.77E-02	0.00E+00
118-96-7	2,4,6-Trinitrotoluene	1.00E+00	9.66E-04	0.00E+00
121-14-2	2,4-Dinitrotoluene	1.00E+00	3.10E-03	0.00E+00
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	5.00E-01	8.10E-01	0.00E+00
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	1.00E-01	1.07E+00	0.00E+00
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	5.00E-01	1.17E+00	0.00E+00
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	6.00E-01	8.72E-01	0.00E+00
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	7.00E-01	7.17E-01	0.00E+00
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	3.00E-01	1.56E+00	0.00E+00
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.00E-01	9.73E-01	0.00E+00
39635-31-9	2,3,4,5,3',4',5'-Heptachlorobiphenyl	2.00E-01	2.79E+00	0.00E+00
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	8.00E-01	3.25E-01	0.00E+00
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	4.00E-01	6.22E-01	0.00E+00
57465-28-8	3,4,5,3',4'-Pentachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	4.00E-01	6.22E-01	0.00E+00

CAS_NUMBER	COPC_NAME	fa (unitless)	p_c (cm/hr)	kpv (cm/hr)
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	0.00E+00	0.00E+00	0.00E+00
74472-37-0	2,3,4,4'5-Pentachlorobiphenyl	5.00E-01	9.58E-01	0.00E+00
50-29-3	DDT	**ND**	2.75E-01	**ND**
50-32-8	Benzo[a]pyrene	1.00E+00	5.58E-01	0.00E+00
53-70-3	Dibenzo[a,h]anthracene	6.00E-01	8.54E-01	0.00E+00
56-55-3	Benzo[a]anthracene	1.00E+00	4.83E-01	0.00E+00
57-74-9	Chlordane	**ND**	3.43E-02	**ND**
57-97-6	1,12-Dimethylbenz[a]anthracene	1.00E-01	1.36E+00	0.00E+00
72-54-8	DDD, 4,4'-	8.00E-01	2.33E-01	**ND**
72-55-9	DDE, 4,4'-	8.00E-01	1.52E-01	0.00E+00
83-32-9	Acenaphthene	1.00E+00	8.14E-02	0.00E+00
85-01-8	Phenanthrene	1.00E+00	1.49E-01	0.00E+00
86-73-7	Fluorene	1.00E+00	1.10E-01	0.00E+00
91-94-1	3,3'-Dichlorobenzidine	1.00E+00	1.26E-02	0.00E+00
92-67-1	4-Aminobiphenyl	1.00E+00	1.22E-02	0.00E+00
92-87-5	Benzidine	1.00E+00	1.84E-03	0.00E+00
93-76-5	2,4,5-T	**ND**	5.19E-04	**ND**
98-95-3	Nitrobenzene	1.00E+00	5.39E-03	1.19E+01
99-35-4	1,3,5-Trinitrobenzene	1.00E+00	6.29E-04	0.00E+00
99-65-0	1,3-Dinitrobenzene	1.00E+00	1.77E-03	0.00E+00
119-93-7	3.3'-Dimethylbenzidine	1.00E+00	4.81E-04	**ND**
120-12-7	Anthracene	9.70E-01	1.49E-01	0.00E+00
121-82-4	RDX	**ND**	1.42E-04	0.00E+00
129-00-0	Pyrene	9.30E-01	2.00E-01	0.00E+00
189-64-0	Dibenzo[a,h]pyrene	**ND**	3.94E-03	**ND**
191-30-0	Dibenzo[a,l]pyrene	**ND**	5.23E-03	**ND**
192-65-4	Dibenzo[a,e]pyrene	**ND**	**ND**	**ND**
193-39-5	Indeno[1,2,3-cd]pyrene	6.00E-01	1.02E+00	0.00E+00
205-82-3	Benzo[j]fluoranthene	6.00E-01	6.52E-01	0.00E+00
205-97-0	Dibenzo[b,k]fluoranthene	**ND**	2.05E+00	**ND**
205-99-2	Benzo[b]floranthene	1.00E+00	6.74E-01	0.00E+00
206-44-0	Fluoranthene	1.00E+00	2.33E-01	0.00E+00
207-08-9	Benzo[k]floranthene	6.00E-01	6.50E-01	0.00E+00
218-01-9	Chrysene	1.00E+00	4.83E-01	0.00E+00
479-45-8	Tetryl	**ND**	1.50E-03	0.00E+00
606-20-2	2,6-Dinitrotoluene	1.00E+00	2.07E-03	0.00E+00

CAS_NUMBER	COPC_NAME	fa (unitless)	p_c (cm/hr)	kpv (cm/hr)
1746-01-6	2,3,7,8-TCDD	5.00E-01	7.67E-01	0.00E+00
2691-41-0	HMX	**ND**	5.97E-05	**ND**
3268-87-9	OCDD	7.00E-02	1.08E+00	0.00E+00
19408-74-3	1,2,3,7,8,9-HxCDD	5.00E-02	6.75E-01	0.00E+00
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB169)	0.00E+00	1.17E+00	0.00E+00
35065-30-6	2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB170)	0.00E+00	2.78E+00	0.00E+00
35822-46-9	1,2,3,4,6,7,8-HpCDD	0.00E+00	1.25E+00	0.00E+00
39227-28-6	1,2,3,4,7,8-HxCDD	0.00E+00	1.44E+00	0.00E+00
40321-76-4	1,2,3,7,8-PeCDD	4.00E-01	3.86E-01	0.00E+00
57117-31-4	2,3,4,7,8-PeCDF	2.00E-01	3.83E-01	0.00E+00
57117-41-6	1,2,3,7,8-PeCDF	2.50E-01	5.96E-01	0.00E+00
57117-44-9	1,2,3,6,7,8-HxCDF	7.00E-02	5.26E-01	0.00E+00
57653-85-7	1,2,3,6,7,8-HxCDD	**ND**	6.75E-01	**ND**
60851-34-5	2,3,4,6,7,8-HxCDF	7.00E-02	5.26E-01	0.00E+00
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB123)	1.00E-01	9.52E-01	0.00E+00
70648-26-9	1,2,3,4,7,8-HxCDF	7.00E-02	5.26E-01	0.00E+00
72918-21-9	1,2,3,7,8,9-HxCDF	7.00E-02	5.26E-01	0.00E+00

Appendix B – UMCDF Meteorological Data

The UMCDF on-site meteorological data for the period between 1 July 2004 and 31 December 2008 is located in the accompanying compact disk under the Appendix_B directory.

Appendix C - Air Dispersion Modeling

8.1 *Topography*

Topographic information for air dispersion modeling was created using the AERMAP pre-processor for AERMOD with inputs from the United States Geological Service (USGS) 1-degree DEM files. These files are included on the companion CD to this report. The DEM data was used to generate estimates for the elevation of all receptors within the modeling domain as well as the base heights for the point sources and buildings. Hill height estimates were also calculated to determine plume/terrain interactions. The hill heights are computed within the model to determine the dividing streamline height to allow for either a terrain following plume or a plume that splits around a particular terrain feature.

8.2 *Meteorological Data*

The AERMOD pre-processor, AERMET, was applied to create the necessary meteorological data files. Three types of input data are required for AERMET. These data are hourly surface weather observations, twice daily upper-air data, and land use data for the 3-km region surrounding the surface observation stations. Surface data was provided for July 1, 2004 to December 31, 2008 time period from an on-site meteorological station that is equipped to monitor:

- Temperature (2, 10, and 30 m heights)
- Temperature Difference (2 to 10 m and 2 to 30 m)
- Wind Direction (10 and 30 m heights)
- Wind Speed (10 and 30 m heights)
- Wind Direction Standard Deviation – (10 and 30 m heights)
- Precipitation
- Barometric Pressure at 1.5 m height.
- Solar Radiation at 1.5 m height.

On-Site data was reviewed to ensure it was in the proper format for AERMET and that duplicate entries were not present. Data was collected and recorded every 15 minutes, but only a single reading was applied for each hour. The reading was selected as the first record having all data values within the QA limits indicated in Table C-1. Data completeness was 96.96% with 1200 hours having missing, or out of range data (total for the analysis period is 39,480 hours). All 15 minute data for an hour with a missing or out of range parameter were screened to determine if any of the 15 minute readings for that parameter were valid. If valid readings were present then they were composited to form a single reading for that hour. Only 279 of the 1200 missing hours remained incomplete after this compositing procedure was applied. Data from the corresponding hours for the nearest complete day were substituted as surrogate data for these 279 hours as indicated in Table C-2.

Table C-1: Allowed Data Range for On-Site Meteorological Data.

Parameter (Units)	**Allowed Minimum**	**Allowed Maximum**
Net Radiation (W/m^2)	-100	1000
Temperature Difference (°C)	-12.0	12.0
Precipitation Amount (cm)	0.0	100
Barometric Pressure (mbar*10)	9000	10999
Wind Speed (m/s)	0.0	60.0
Wind Direction (degrees)	0.0	360
Standard Deviation on Horizontal Wind (degrees)	0.0	100
Temperature (°C)	-30.0	60.0
Relative Humidity (%)	0.0	100

Table C-2: Data Substituted for Missing Hours

Missing or Incomplete Data	**Surrogate Data Substituted**
8 Nov 2004, hours 1-24	7 Nov 2004, hours 1-24
27 Dec 2004, hours 1-24	26 Dec 2004, hours 1-24
28 Dec 2004, hours 1-24	26 Dec 2004, hours 1-24
29 Dec 2004, hours 1-24	26 Dec 2004, hours 1-24
30 Dec 2004, hours 1-24	26 Dec 2004, hours 1-24
31 Dec 2004, hours 1-24	26 Dec 2004, hours 1-24
3 May 2005, hours 1-24	2 May 2005, hours 1-24
16 Jun 2005, hours 1-24	15 Jun 2005, hours 1-24
17 Jun 2005, hours 1-8	15 Jun 2005, hours 1-8
27 Jun 2005, hours 1-24	26 Jun 2005, hours 1-24
28 Jun 2005, hours 1-8	26 Jun 2005, hours 1-8
16 Aug 2005, hours 1-7	15 Aug 2005, hours 1-7
31 Dec 2005, hours 20-24	30 Dec 2005, hours 20-24
4 April 2006, hours 1-13	3 April 2006, hours 1-13
4 Oct 2007, hour 9	4 Oct 2007, hour 8
28 Nov 2007, hours 1-12	27 Nov 2007, hours 1-12
4 Jun 2008, hours 1-16	3 Jun 2008, hours 1-16
7 Jun 2008, hours 1-8	6 Jun 2008, hours 1-8

Upper air data for Spokane Washington for the period from 1 July 2004 through 31 December 2008 were obtained from http://raab.fsl.noaa.gov. This data was combined with the on-site surface data using AERMET to create the input files required by AERMOD (*.SCF and *.PFL files). Default values for desert shrub land were assumed for the Albedo, Bowen ratio, and Surface roughness factors for the 3-km region around the observation station (Table C-5). Unfortunately, the resulting *.PFL and *.SCF files created by AERMET would not run in AERMOD. Unidentified problems occurred with 54 of the 1645 days (3%) in the modeling period. The data for these days were substituted with the data from the nearest previous day that did not create AERMOD errors. Table C-3 provides a complete list of the problem days and those which were substituted for them in the *.SFC and *.PFL files. The final *.SFC and *.PFL files are provided on the companion CD to this report as UMCD04-08.SFC and UMCDF04-08.PFL.

Table C-3: Days That Created AERMOD Run-Time Errors

Problem Days	**Surrogate Day Substituted**
March 20, 2005	March 19, 2005
April 3, 2005	April 2, 2005
May 10, 2005	May 9, 2005
May 11, 2005	May 9, 2005
May 15, 2005	May 14, 2005
May 16, 2005	May 15, 2005
May 21, 2005	May 20, 2005
May 22, 2005	May 21, 2005
June 5, 2005	June 4, 2005
June 11, 2005	June 10, 2005
June 26-28, 2005	June 25, 2005
July 8, 2005	July 7, 2005
March 16-18, 2006	March 15, 2006
March 25, 2006	March 24, 2006
April 1, 2006	March 31, 2006
April 3, 2006	April 2, 2006
April 5, 2006	April 4, 2006
April 10, 2006	April 9, 2006
April 29, 2006	April 28, 2006
May 20, 2006	May 19, 2006
June 14, 2006	June 13, 2006
July 6, 2006	July 5, 2006
March 2-5, 2007	March 1, 2007
March 25-27, 2007	March 24, 2007
April 7, 2007	April 6, 2007
April 9, 2007	April 8, 2007
April 11-12, 2007	April 10, 2007
April 14, 2007	April 13, 2007
April 16, 2007	April 15, 2007
April 22, 2007	April 21, 2007
May 1, 2007	April 30, 2007
May 2, 2007	April 30, 2007
June 4, 2007	June 3, 2007
June 5, 2007	June 3, 2007
June 9, 2007	June 8, 2007
June 10, 2007	June 8, 2007
March 13, 2008	March 12, 2008
March 20, 2008	March 19, 2008
March 21, 2008	March 19, 2008
April 23, 2008	April 22, 2008
May 22, 2008	May 21, 2008
June 9, 2008	June 8, 2008
August 18, 2008	August 17, 2008

Figure C-1 provides a graphical depiction of the frequency, direction wind, and speed of the wind during this 4.5 year period. The average wind speed for this period was 4.7 and 3.9 m/s at 30 m and 10 m, respectively. All AERMET input and output files are provided on the companion CD to this report. Also provided on the CD are the intermediate files generated during the data editing process. Figure C-2 provides a description of the data editing steps and the input and output files from each step.

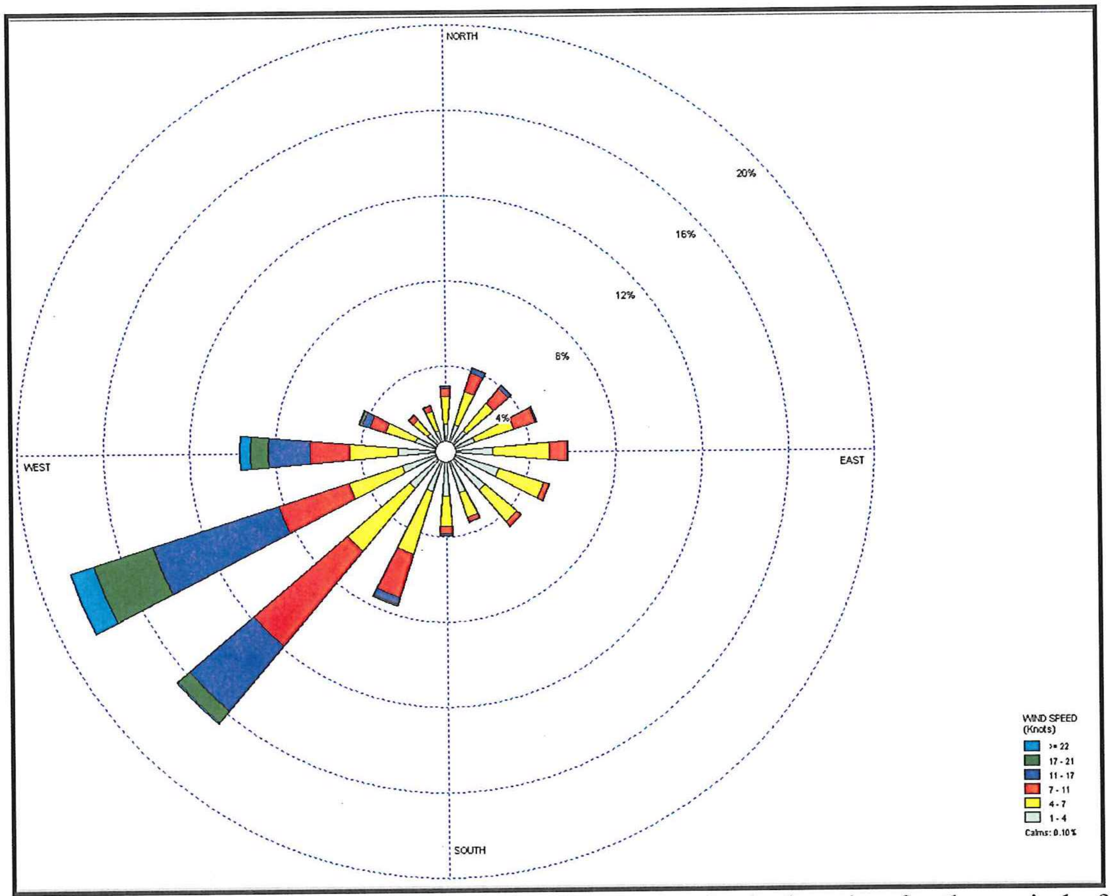

Figure C-1: Wind Rose calculated from the on-site meteorological station for the period of July 1, 2004 through December 31, 2008. Wind is indicated in the "blowing-from" direction. Calm winds were defined as those below 0.5 m/s (1.0 mi/hr).

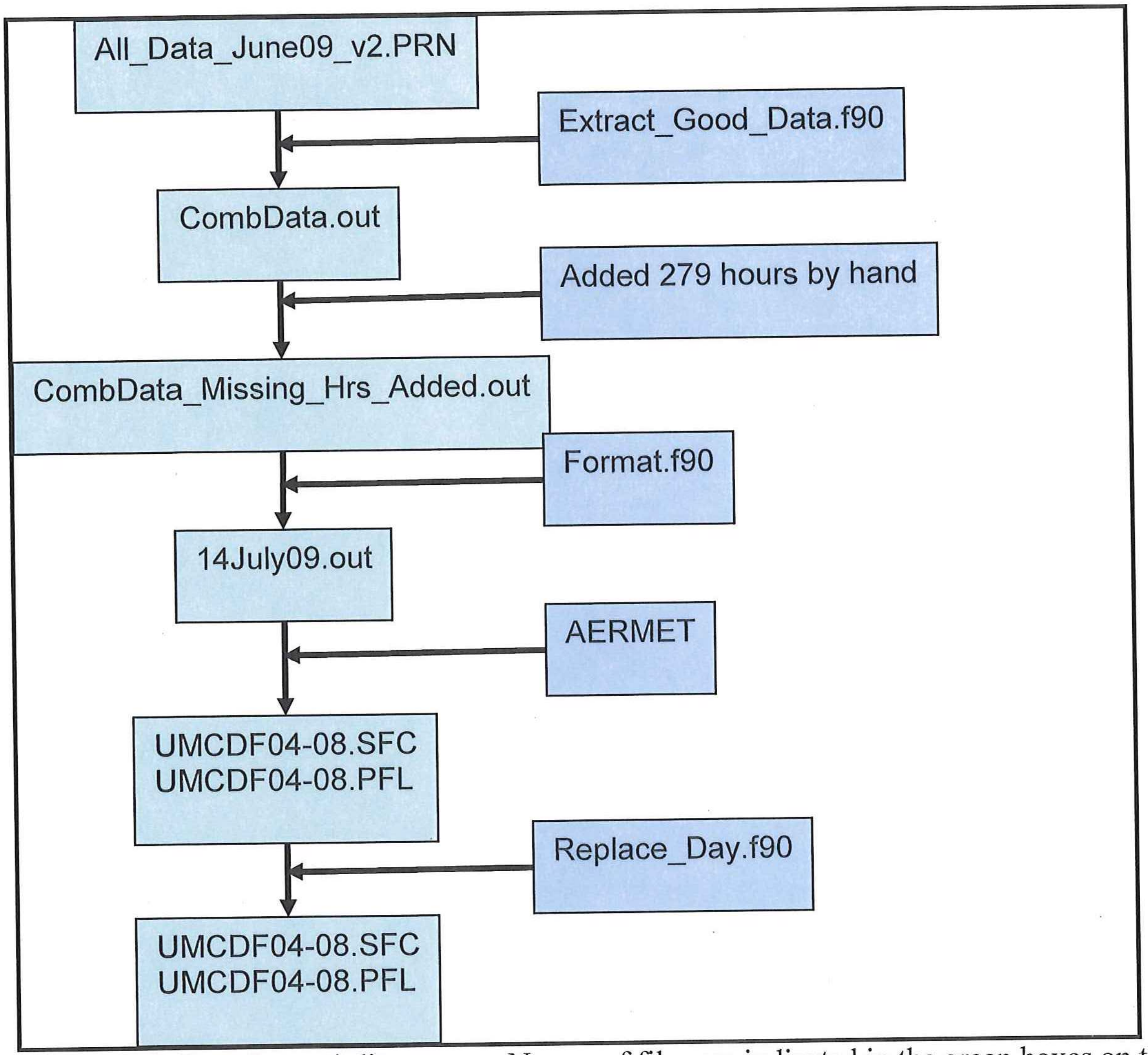

Figure C-2: Data format/edit process. Names of files are indicated in the green boxes on the left while the formatting method or program is indicated in the blue boxed on the right. All files and Fortran programs are provided on the companion CD.

8.3 *UMCDF Point Sources*

The Umatilla Chemical Agent Disposal Facility (UMCDF) is a multi-furnace processing plant designed to dispose of the chemical warfare agent stored at the Umatilla Chemical Depot (UMCD). The stockpile at the UMCD is comprised of two nerve agents (GB and VX) and one blister agent (HD) in a variety of weapons configurations. Weapons configurations stored at the UMCD included projectiles, bombs, rockets, mines, spray tanks, and ton containers.

Weapons disposal activities take place predominately within a highly contained building termed the Munitions Demilitarization Building (MDB). Within this structure individual weapons are disassembled, and their various components are treated to acceptable levels in one of four furnace systems. These systems are:

- Liquid Incinerator 1 (LIC1)
- Liquid Incinerator 2 (LIC2)
- Deactivation Furnace System (DFS)
- Metal Parts Furnace (MPF)

The off-gas from each of these furnaces are processed in separate wet pollution abatement systems, and are subsequently passed through carbon filters before being combined and released to the environment in the common stack (COMSTK). The liquid brine used in the pollution abatement systems is sent to storage tanks and ultimately dried in the Brine Reduction Area (BRA). The gases given off during the drying process are passed through a bag filter to remove particles and subsequently released to the atmosphere in the Brine Reduction Area stack (BRASTK).

The COMSTK and the BRASTK are two of the four point sources modeled in this UMCDF risk assessment. The remaining two point sources are the exhaust stack for the on-site laboratory where dilute chemical agents are handled (LABSTK), and the MDB ventilation stack (MDBSTK). Both the LABSTK and the MDBSTK emissions are passed through carbon filters before being released to the atmosphere. A summary of the characteristics of the four point sources are provided in Table C-4. Figure C-3 depicts the location and heights of the four point sources in relation to the UMCDF buildings. In this figure the point sources are indicated in red while the UMCDF Buildings are shown as shaded boxes and are to scale. Table C-5 provides the particle size distribution information for the BRASTK. For the other three sources it was assumed that less than 10% of the particle mass would have a diameter of 10 μm or larger since each is equipped with a HEPA (High-Efficency Particulate Air) filtration system. An average particle size of 0.1 μm was applied to each of these three sources since the HEPA filters are designed to remove 99.97% of particles greater than 0.3 μm. Both wet and dry particle deposition characteristics were tracked in the particulate AERMOD model runs.

Table C-4: Characteristics of the Four UMCDF Point Sources

Parameter	COMSTK	BRASTK	MDBSTK	LABSTK
UTM Eastling (m)	312042.7	311992.4	312077.4	311924.1
UTM Northing (m)	5079907	5079764	5080000	5079844
Elevation (m)	200	196	200	197
Stack Height (m)	30.5	19.8	36.6	12.2
Exit Temperature (K)	353.15	415	294	299
Exit Velocity (m/s)	3.5	14.7	12.7	21
Exit Diameter (m)	1.52	1.37	2.19	0.64
Exit Flow Rate (ACMM)	380	1301	2870	405

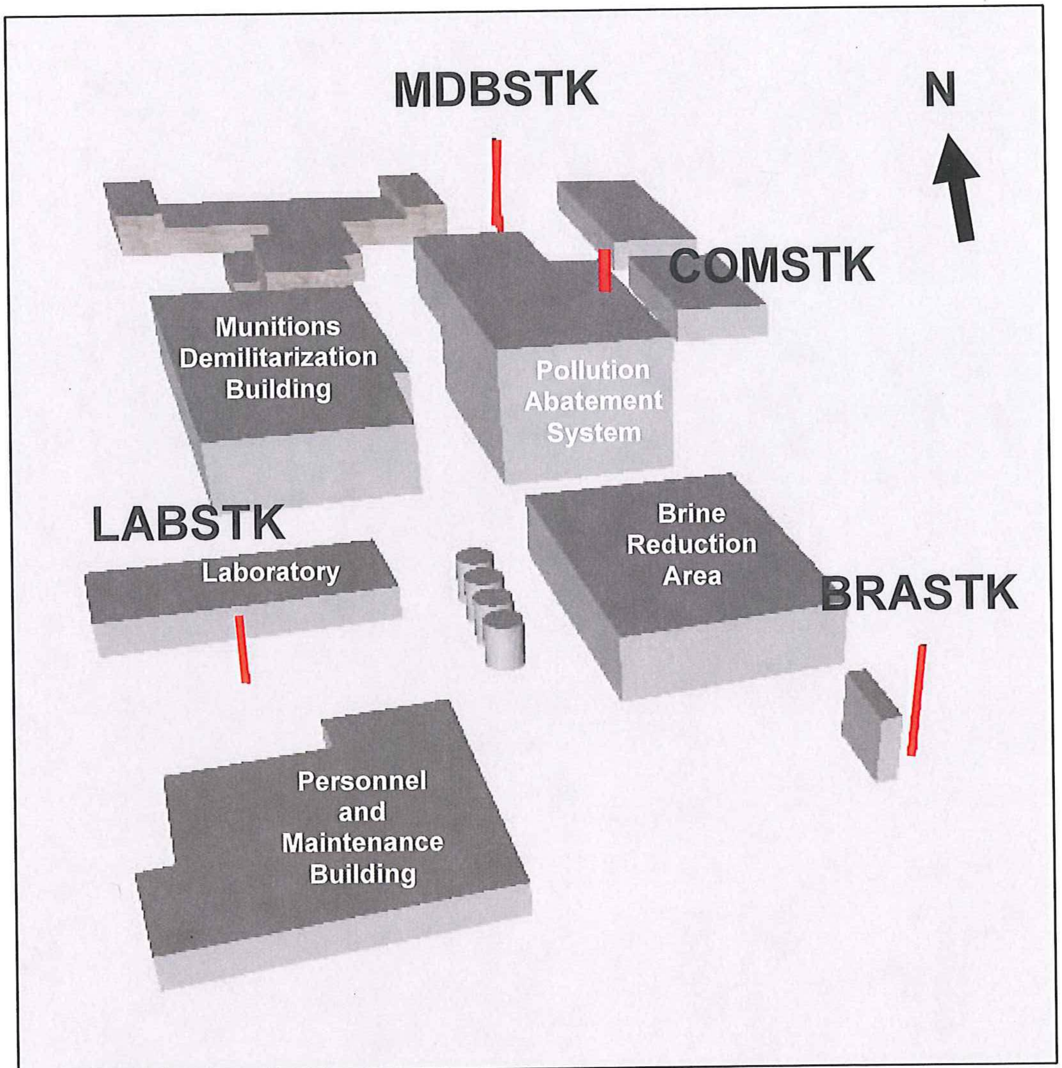

Figure C-3: General site layout for the UMCDF (to scale). Red lines indicate the four point sources while the gray boxes indicate site buildings.

Table C-5: BRA Stack Particle Size Distribution

Mean Particle Diameter (µm)	Mass Fraction (%)	Surface Area Fraction (%)
0.34	0.13	3.10
0.78	0.45	4.06
1.85	4.95	18.75
3.88	11.75	21.22
6.33	8.75	9.69
8.81	9.20	7.32
12.66	64.75	35.85

Wet and dry vapor deposition for the four point sources were also simulated in AERMOD using the input parameters outlined in Tables C-6 and C-7. The values in these tables are identical to those used in the 2008 HHRA and ecological risk assessment (ERA) for the UMCDF (CTUIR 2008). Tables C-8 and C-9 provide the micro-meteorological parameters for gas dispersion calculations associated with the land near the point sources. Values are consistent with the 2008 HHRA analysis (CTUIR 2008).

Table C-6: Vapor Deposition Input Parameters

Parameter (units)	Value
Diffusivity in Air (cm^2/sec)	0.203
Diffusivity in Water (cm^2/sec)	7.06e-6
Cuticular Resistance (s/cm)	2.56
Henry's Law Constant (Pa-m^3/mol)	0.00938
Pollutant Reactivity Factor	0 [a]
Fraction of Maximum Green Leaf Area Index in Autumn	0.5 [a]
Fraction of Maximum Green Leaf Area Index in Spring	0.25 [a]

[a] Default Value in ISCAERMOD-View

Table C-7: Seasonal Categories

Month	Midsummer	Autumn	Late Autumn	Winter	Transitional Spring
January				X	
February			X		
March					X
April					X
May					X
June	X				
July	X				
August	X				
September		X			
October		X			
November			X		
December				X	

Table C-8: Dispersion Parameters for Shrub Land

Parameter	Winter Value	Spring Value	Summer Value	Autumn Value
Albedo	0.45	0.30	0.28	0.28
Bowen Ratio	6.0	3.0	4.0	6.0
Surface Roughness (m)	0.15	0.30	0.30	0.30

Table C-9: Assumed Land Use Near the Depot

Sector (Degrees From North)	**Land Use Category**
5-15	Agricultural Land
15-25	Range Land
25-35	Agricultural Land
35-45	Agricultural Land
45-55	Agricultural Land
55-65	Range Land
65-75	Range Land
75-85	Range Land
85-95	Agricultural Land
95-105	Agricultural Land
105-115	Agricultural Land
115-125	Agricultural Land
125-135	Agricultural Land
135-145	Agricultural Land
145-155	Agricultural Land
155-165	Range Land
165-175	Range Land
175-185	Range Land
185-195	Agricultural Land
195-205	Agricultural Land
205-215	Agricultural Land
215-225	Agricultural Land
225-235	Agricultural Land
235-245	Range Land
245-25	Range Land
255-26	Range Land
265-27	Range Land
275-28	Range Land
285-295	Range Land
295-305	Agricultural Land
305-315	Agricultural Land
315-325	Agricultural Land
325-335	Agricultural Land
335-345	Agricultural Land
345-355	Agricultural Land
355-5	Agricultural Land

8.4 *Building Downwash*

The locations and heights of the UMCDF stacks are such that certain structures could cause aerodynamic downwash effects on emissions. A plan view of the site showing the four point sources (red dots) and the buildings is indicated in Figure C-4. Dimensional information for these structures is given in Table C-10. This information was applied in ISC-AERMOD View's application of EPA BPIP-PRIME[1] model to compute a direction-specific downwash analysis. The results of the analysis is provided in Tables C-11 through C-15. Building downwash is predicted to impact all the UMCDF point sources as each stack height is below the Good Engineering Practice stack height estimated by BPIP-PRIME (approximately 70 m for all cases as indicated in the *.pro file for each AERMOD analysis).

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[1] BPIP-PRIME is an acronym for Building Profile Input Program – Plume Rise Model Enhancements

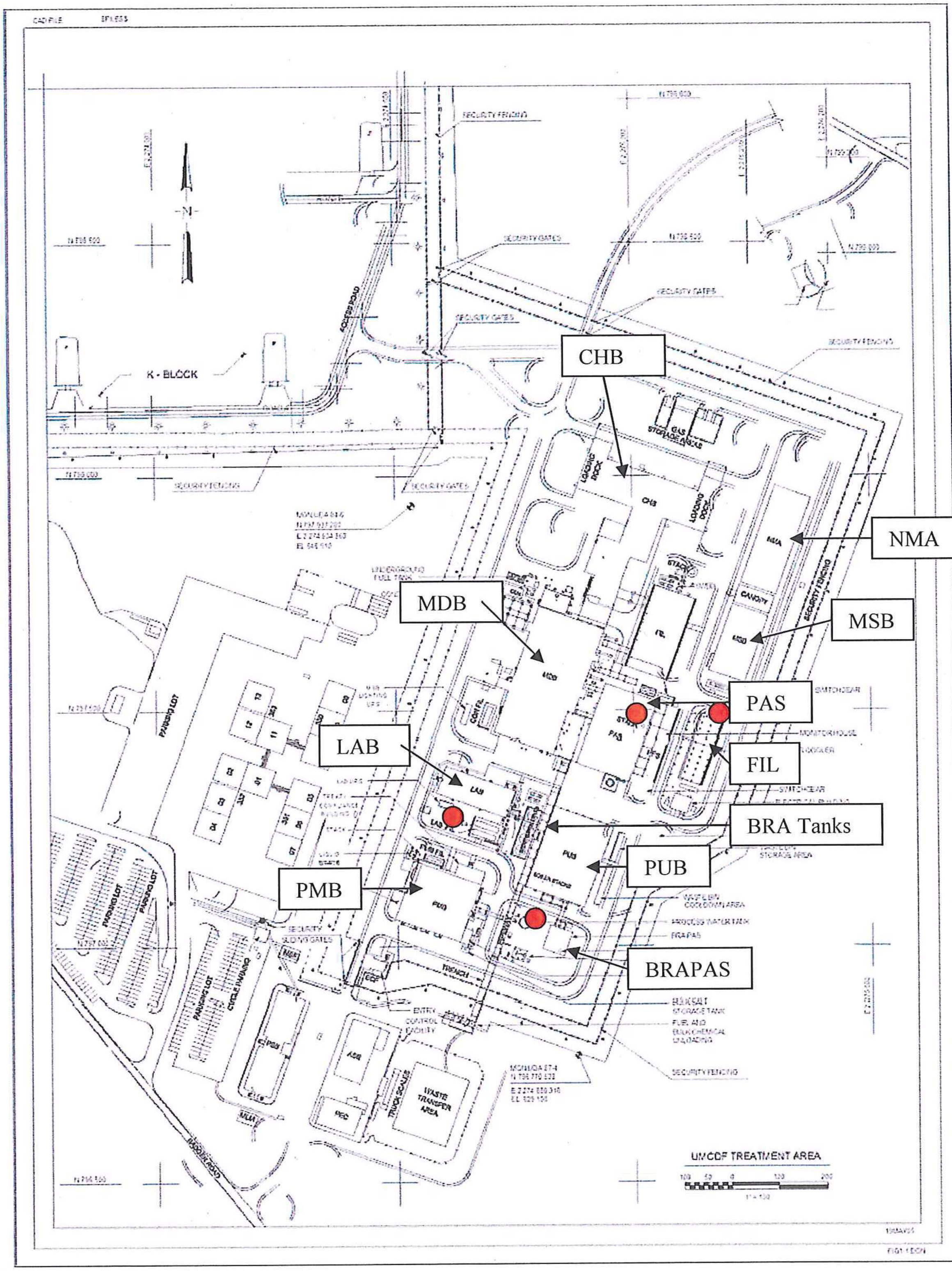

Figure C-4: Plan View of UMCDF Site Layout. Point sources are indicated as red dots.

C-10: UMCDF Building Coordinates and Dimensions

Structure	Base Elevation	Height	Number of Corners	UTM Easting (m)	TM Northing (m)
Container Handling Building	193.75	7.05	12	312006.9	5080010
				312029.8	5080002
				312036.6	5080019
				312045.8	5080016
				312056.5	5080046
				312073.2	5080040
				312081.6	5080063
				312022.2	5080085
				312013.8	5080062
				312038.2	5080053
				312029.9	5080030
				312016.1	5080034
MDB Filters	193.6	14.6	4	312051.9	5080001
				312032.1	5079948
				312059.5	5079938
				312078.6	5079992
Pollution Abatement System	193.6	28	4	312019.1	5079936
				312000.1	5079885
				312033.6	5079873
				312053.4	5079923
Laboratory	193.75	6.1	4	311916.2	5079883
				311910.2	5079865
				311954.3	5079849
				311960.4	5079867
Process and Utilities Building	193.75	11.95	4	311985.6	5079856
				311966.5	5079804
				312003.9	5079791
				312022.9	5079842
Personnel and Maintenance Building	194.82	5.4	8	311899.5	5079818
				311891.9	5079798
				311887.3	5079800
				311882	5079783
				311923.9	5079767
				311940.6	5079812
				311923.1	5079818
				311920.8	5079810

Table C-10: UMCDF Building Coordinates and Dimensions (continued).

Structure	Base Elevation	Height	Number of Corners	UTM Easting (m)	TM Northing (m)
West End of CHB	193.75	10.5	4	312003.1	5080066
				312013.8	5080062
				312026	5080095
				312014.5	5080099
East End of CHB	193.75	10.5	4	312073.2	5080040
				312083.9	5080036
				312096.1	5080070
				312084.6	5080073
Brine Reduction Area PAS	193.9	11.43	4	311987.6	5079774
				311982.1	5079761
				311985.4	5079760
				311990.9	5079773
NMA Building	192.99	8.23	4	312157.5	5080045
				312131.8	5079983
				312109.3	5079992
				312134.9	5080054
MSB Building	192.99	8.23	4	312126.1	5079969
				312108.6	5079927
				312086.1	5079936
				312103.6	5079978
Munitions Demilitarization Building	193.6	14.6	6	311977.2	5079988
				311948.3	5079904
				311984.8	5079891
				311995.5	5079917
				311998.5	5079916
				312018.4	5079972
South End of CHB	193.75	18.3	4	312012.3	5080008
				312000.8	5079979
				312018.4	5079972
				312029.8	5080002

Table C-10: UMCDF Building Coordinates and Dimensions (continued).

Structure	**Base Elevation**	**Height**	**Number of Corners**	**UTM Easting (m)**	**TM Northing (m)**
BRA Tank 201	193.9	7.92	32	311968.7	5079851
				311968	5079851
				311967.4	5079850
				311966.8	5079850
				311966.3	5079850
				311965.9	5079849
				311965.6	5079849
				311965.5	5079848
				311965.4	5079847
				311965.5	5079847
				311965.6	5079846
				311965.9	5079846
				311966.3	5079845
				311966.8	5079845
				311967.4	5079844
				311968	5079844
				311968.7	5079844
				311969.3	5079844
				311969.9	5079844
				311970.5	5079845
				311971	5079845
				311971.4	5079846
				311971.7	5079846
				311971.9	5079847
				311971.9	5079847
				311971.9	5079848
				311971.7	5079849
				311971.4	5079849
				311971	5079850
				311970.5	5079850
				311969.9	5079850
				311969.3	5079851

Table C-10: UMCDF Building Coordinates and Dimensions (continued).

Structure	**Base Elevation**	**Height**	**Number of Corners**	**UTM Easting (m)**	**TM Northing (m)**
BRA Tank 202	7.92	193.9	32	311965.6	5079843
				311965	5079843
				311964.4	5079843
				311963.8	5079843
				311963.3	5079842
				311962.9	5079842
				311962.6	5079841
				311962.4	5079841
				311962.4	5079840
				311962.4	5079839
				311962.6	5079839
				311962.9	5079838
				311963.3	5079838
				311963.8	5079837
				311964.4	5079837
				311965	5079837
				311965.6	5079837
				311966.3	5079837
				311966.9	5079837
				311967.4	5079837
				311967.9	5079838
				311968.3	5079838
				311968.7	5079839
				311968.8	5079839
				311968.9	5079840
				311968.8	5079841
				311968.7	5079841
				311968.3	5079842
				311967.9	5079842
				311967.4	5079843
				311966.9	5079843

Table C-10: UMCDF Building Coordinates and Dimensions (continued).

Structure	Base Elevation	Height	Number of Corners	UTM Easting (m)	TM Northing (m)
BRA Tank 101	193.9	7.92	32	311962.6	5079836
				311962	5079836
				311961.3	5079836
				311960.8	5079836
				311960.3	5079835
				311959.9	5079835
				311959.6	5079834
				311959.4	5079833
				311959.3	5079833
				311959.4	5079832
				311959.6	5079832
				311959.9	5079831
				311960.3	5079831
				311960.8	5079830
				311961.3	5079830
				311962	5079830
				311962.6	5079830
				311963.2	5079830
				311963.8	5079830
				311964.4	5079830
				311964.9	5079831
				311965.3	5079831
				311965.6	5079832
				311965.8	5079832
				311965.9	5079833
				311965.8	5079833
				311965.6	5079834
				311965.3	5079835
				311964.9	5079835
				311964.4	5079836
				311963.8	5079836
				311963.2	5079836

Table C-10: UMCDF Building Coordinates and Dimensions (continued).

Structure	Base Elevation	Height	Number of Corners	UTM Easting (m)	TM Northing (m)
BRA Tank 102	193.9	7.92	32	311959.6	5079829
				311958.9	5079829
				311958.3	5079829
				311957.7	5079828
				311957.2	5079828
				311956.8	5079827
				311956.5	5079827
				311956.3	5079826
				311956.3	5079825
				311956.3	5079825
				311956.5	5079824
				311956.8	5079824
				311957.2	5079823
				311957.7	5079823
				311958.3	5079822
				311958.9	5079822
				311959.6	5079822
				311960.2	5079822
				311960.8	5079822
				311961.4	5079823
				311961.9	5079823
				311962.3	5079824
				311962.6	5079824
				311962.8	5079825
				311962.8	5079825
				311962.8	5079826
				311962.6	5079827
				311962.3	5079827
				311961.9	5079828
				311961.4	5079828
				311960.8	5079829
				311960.2	5079829

C-11: Building Down Wash Information, Building Height

Direction of Flow Vector (Degrees from North)	Direction Specific Building Heights by Source (m)			
	COMSTK	BRASTK	MDBSTK	LABSTK
10	28	11.43	28	6.1
20	28	11.43	18.3	6.1
30	28	11.43	14.6	0
40	28	28	14.6	6.1
50	28	11.43	14.6	28
60	28	11.43	14.6	11.95
70	28	0	28	5.4
80	28	11.43	18.3	6.1
90	28	11.95	14.6	0
100	28	28	14.6	14.6
110	28	11.43	14.6	28
120	28	11.95	14.6	0
130	28	11.95	28	6.1
140	28	11.43	18.3	0
150	28	11.95	14.6	6.1
160	28	11.95	14.6	14.6
170	28	11.43	14.6	11.95
180	28	11.95	14.6	6.1
190	28	11.43	28	6.1
200	28	11.43	18.3	0
210	28	11.95	14.6	6.1
220	28	11.43	14.6	28
230	28	11.43	14.6	11.95
240	28	11.95	14.6	6.1
250	28	11.43	28	6.1
260	28	11.43	14.6	0
270	28	11.95	14.6	6.1
280	28	11.43	14.6	28
290	28	11.43	14.6	11.95
300	28	11.43	14.6	6.1
310	28	11.43	18.3	6.1
320	28	11.43	14.6	0
330	28	28	14.6	6.1
340	28	11.43	14.6	28
350	28	11.43	14.6	11.95
360	28	11.43	14.6	6.1

C-12: Building Down Wash Information, Building Width

Direction of Flow Vector (Degrees from North)	Direction Specific Building Heights by Source (m)			
	COMSTK	BRASTK	MDBSTK	LABSTK
10	45.91	6.59	45.91	49.26
20	64.38	13.02	35.93	45.25
30	63.47	15.02	63.74	0
40	45.91	45.91	38.1	49.26
50	64.38	13.02	61.32	64.38
60	63.47	15.02	63.74	66.02
70	37.09	0	37.09	45.95
80	64.79	14.04	36.54	40.39
90	65.35	68.18	64.02	0
100	37.09	37.09	28.9	44.81
110	64.79	14.04	62.85	64.79
120	65.35	68.18	64.02	0
130	44.16	48.6	44.16	50.14
140	63.24	14.63	36.04	0
150	65.24	68.27	62.35	44.31
160	44.16	48.6	37.84	54.98
170	63.24	14.63	62.48	65.53
180	65.24	68.27	62.35	44.31
190	51.74	7.76	51.74	51.23
200	59.76	14.78	34.45	0
210	63.15	66.28	58.79	47.78
220	51.74	7.76	68.04	51.74
230	59.76	14.78	60.21	61.36
240	63.15	66.28	58.79	47.78
250	57.75	9.83	57.75	50.76
260	54.49	14.48	57.43	0
270	59.15	62.28	53.45	49.79
280	57.75	9.83	52.76	57.75
290	54.49	14.48	57.43	55.92
300	59.15	10.82	53.45	49.79
310	62.01	11.6	34.22	48.75
320	59.67	14.98	61.52	0
330	53.34	53.34	46.48	50.29
340	62.01	11.6	57.92	62.01
350	59.67	14.98	61.52	61.85
360	53.34	8.84	46.48	50.29

C-13: Building Down Wash Information, Building Length

Direction of Flow Vector (Degrees from North)	**Direction Specific Building Heights by Source (m)**			
	COMSTK	**BRASTK**	**MDBSTK**	**LABSTK**
10	59.76	14.78	59.76	27.15
20	63.15	12.48	35.13	47.78
30	51.74	7.76	46	0
40	59.76	59.76	60.21	27.15
50	63.15	12.48	58.79	63.15
60	51.74	7.76	46	56.13
70	54.49	0	54.49	47.98
80	59.15	10.82	32.57	49.79
90	57.75	61.96	52.76	0
100	54.49	54.49	57.43	119.54
110	59.15	10.82	53.45	59.15
120	57.75	61.96	52.76	0
130	59.67	61.85	59.67	26.46
140	53.34	8.84	29.03	0
150	62.01	65.9	57.92	48.75
160	59.67	61.85	61.52	125.24
170	53.34	8.84	46.48	56.39
180	62.01	65.9	57.92	48.75
190	63.47	15.02	63.47	33.49
200	45.91	6.59	24.61	0
210	64.38	67.83	61.32	45.25
220	63.47	15.02	127.13	63.47
230	45.91	6.59	38.1	48.79
240	64.38	67.83	61.32	45.25
250	65.35	14.61	65.35	39.5
260	37.09	4.14	28.9	0
270	64.79	67.71	62.85	40.39
280	65.35	14.61	64.02	65.35
290	37.09	4.14	28.9	39.78
300	64.79	14.04	62.85	40.39
310	65.24	13.75	36.61	44.31
320	44.16	5.46	37.84	0
330	63.24	63.24	62.48	34.29
340	65.24	13.75	62.35	65.24
350	44.16	5.46	37.84	48.6
360	63.24	14.63	62.48	34.29

C-14: Building Down Wash Information, Along Flow

Direction of Flow Vector (Degrees from North)	Direction Specific Building Heights by Source (m)			
	COMSTK	**BRASTK**	**MDBSTK**	**LABSTK**
10	-35.14	-4.81	-132.26	10.22
20	-47.57	-10.57	-79.13	-5.64
30	-36.84	-10.79	-20.48	0
40	-24.63	-174.68	3.02	-37.37
50	-15.58	-1.91	1.56	-148.78
60	-14.91	3.02	-25.52	-95.1
70	-35.15	0	-133.94	-71.96
80	-45.81	-10.62	-79.1	-9.94
90	-37.52	-75.39	-17.51	0
100	-19.34	-171.38	6.85	-184.82
110	-13.33	-0.2	0.21	-141.19
120	-20.23	13.44	-35.25	0
130	-40.28	21.76	-137.73	11.92
140	-42.66	-10.36	-76.66	0
150	-37.07	-83.68	-14.01	-37.99
160	-19.39	-83.61	6.1	-189.86
170	-10.68	1.52	-1.14	-98.83
180	-24.94	17.78	-43.91	-10.76
190	-44.18	-8.52	-137.34	7.75
200	-38.21	-9.78	-71.9	0
210	-35.49	-89.42	-10.08	-39.64
220	-19.29	-6.5	28.92	-144.19
230	-7.7	3.19	-2.46	-97.51
240	-28.89	21.58	-51.23	-5.61
250	-46.74	-9.5	-132.78	3.34
260	-32.6	-8.9	-24.85	0
270	-32.83	-92.44	-5.85	-40.1
280	-18.61	-5.11	4.08	-150.3
290	-4.49	4.77	-4.05	-93.23
300	-31.97	-2.38	-57	-0.29
310	-47.88	-10.19	-76.75	-1.17
320	-35.03	-9.71	-22.83	0
330	-29.17	-172.67	-1.44	-39.33
340	-17.36	-3.56	2.86	-151.85
350	-9.13	4.25	-15.01	-95.53
360	-34.07	-3.65	-61.04	5.04

C-15: Building Down Wash Information, Across Flow

Direction of Flow Vector (Degrees from North)	**Direction Specific Building Heights by Source (m)**			
	COMSTK	**BRASTK**	**MDBSTK**	**LABSTK**
10	15.26	6.49	33.36	-7.12
20	3.3	5.48	12.31	17.02
30	-12.45	-1.01	-37.03	0
40	-15.26	9.34	-16.59	7.12
50	-3.3	-5.48	20.57	-22.39
60	12.45	1.01	37.03	-29.71
70	14.06	0	15.02	-3.35
80	0.43	4.64	1.43	19.9
90	-14.07	40.01	-36.08	0
100	-14.06	-15.89	-10.4	22.89
110	-0.43	-4.64	25.58	-42.37
120	14.07	-40.01	36.08	0
130	12.95	27.97	-3.26	1.39
140	-2.45	3.66	-9.49	0
150	-15.26	31.74	-34.04	20.99
160	-12.95	-27.97	-3.91	1.24
170	2.45	-3.66	29.8	20.1
180	15.26	-31.74	34.04	-20.99
190	10.97	6.91	-21.92	5.68
200	-5.26	2.58	-20.12	0
210	-15.99	22.5	-30.96	18.25
220	-10.97	-6.91	-35.35	39.09
230	5.26	-2.58	33.12	7.53
240	15.99	-22.5	30.96	-18.25
250	8.65	6.63	-39.92	9.8
260	-7.91	1.41	-35.56	0
270	-16.24	12.59	-26.94	14.95
280	-8.65	-6.63	8.87	18.96
290	7.91	-1.41	35.56	-4.97
300	16.24	5.21	26.94	-14.95
310	6.06	6.14	22.82	13.61
320	-10.45	0.2	-36.86	0
330	-15.99	34.29	-22.1	11.2
340	-6.06	-6.14	14.95	-1.74
350	10.45	-0.2	36.86	-17.58
360	15.99	5.94	22.1	-11.2

8.5 *Description of Air Dispersion and Deposition Modeling*

Deposition modeling was accomplished through simulating the movement of vapors particles emitted from the four point sources. This prediction requires the use of air dispersion modeling software such as the EPA promulgated AERMOD model. AERMOD is a steady-state plume model that uses Gaussian distribution for plume growth in the vertical and horizontal directions in the near surface stable boundary layer. The upper convective boundary layer is modeled using a Gaussian distributions in the horizontal direction and a bi-Gaussian probability density function in the vertical dimension. The basic types of information necessary to implement AERMOD to predict contaminant transport are depicted in Figure C-5.

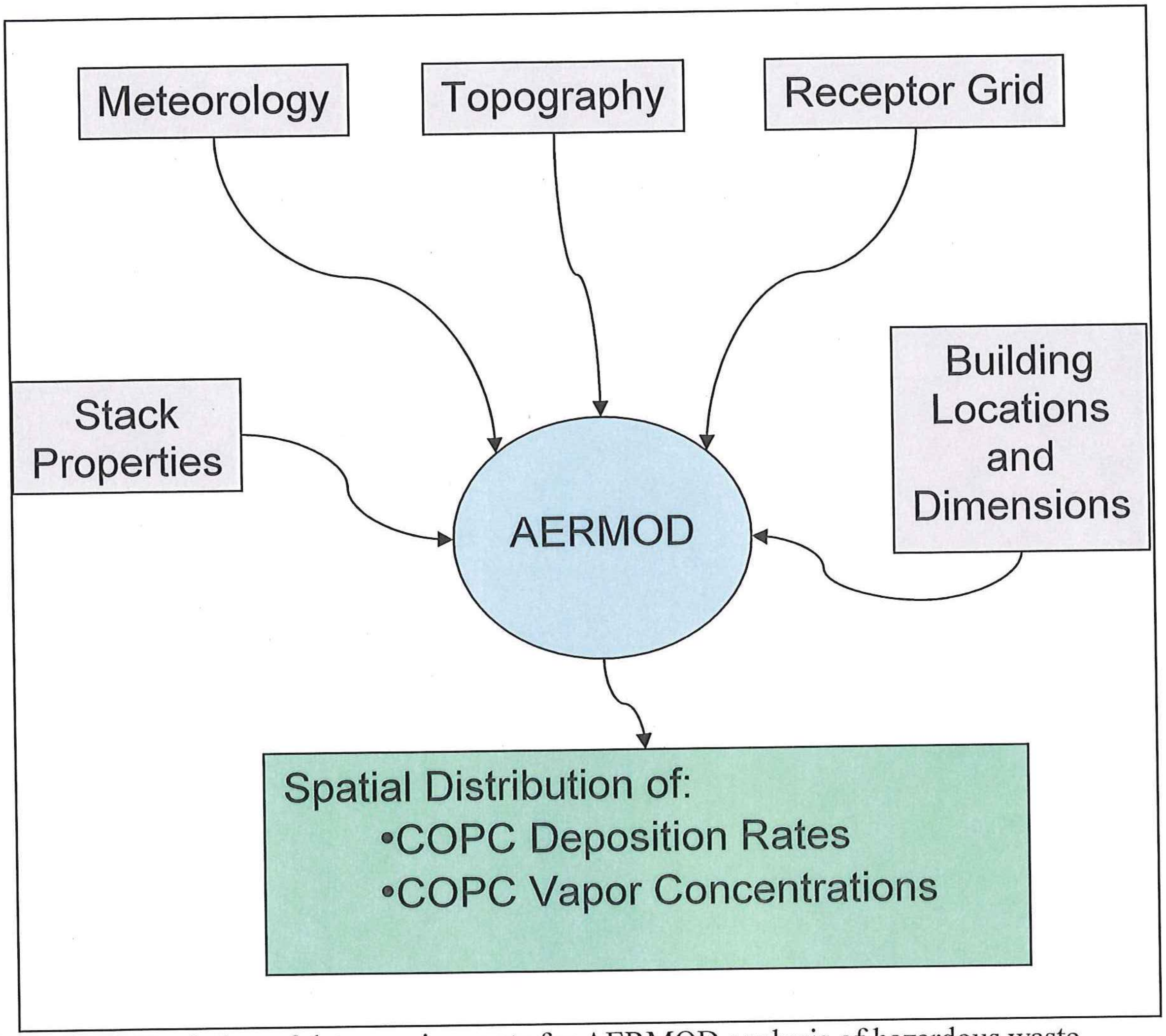

Figure C-5: Depiction of data requirements for AERMOD analysis of hazardous waste combustors.

As indicated in Figure C-5, the results of the modeling process are values for deposition rates and air concentrations at spatial-distributed calculation points throughout the region of interest.

A total of 10,201 uniform Cartesian nodes spaced at 100 m in both the horizontal dimensions for a total distance in each direction of 10 km. Figure C-6 depicts the spatial distribution of the calculation grid nodes.

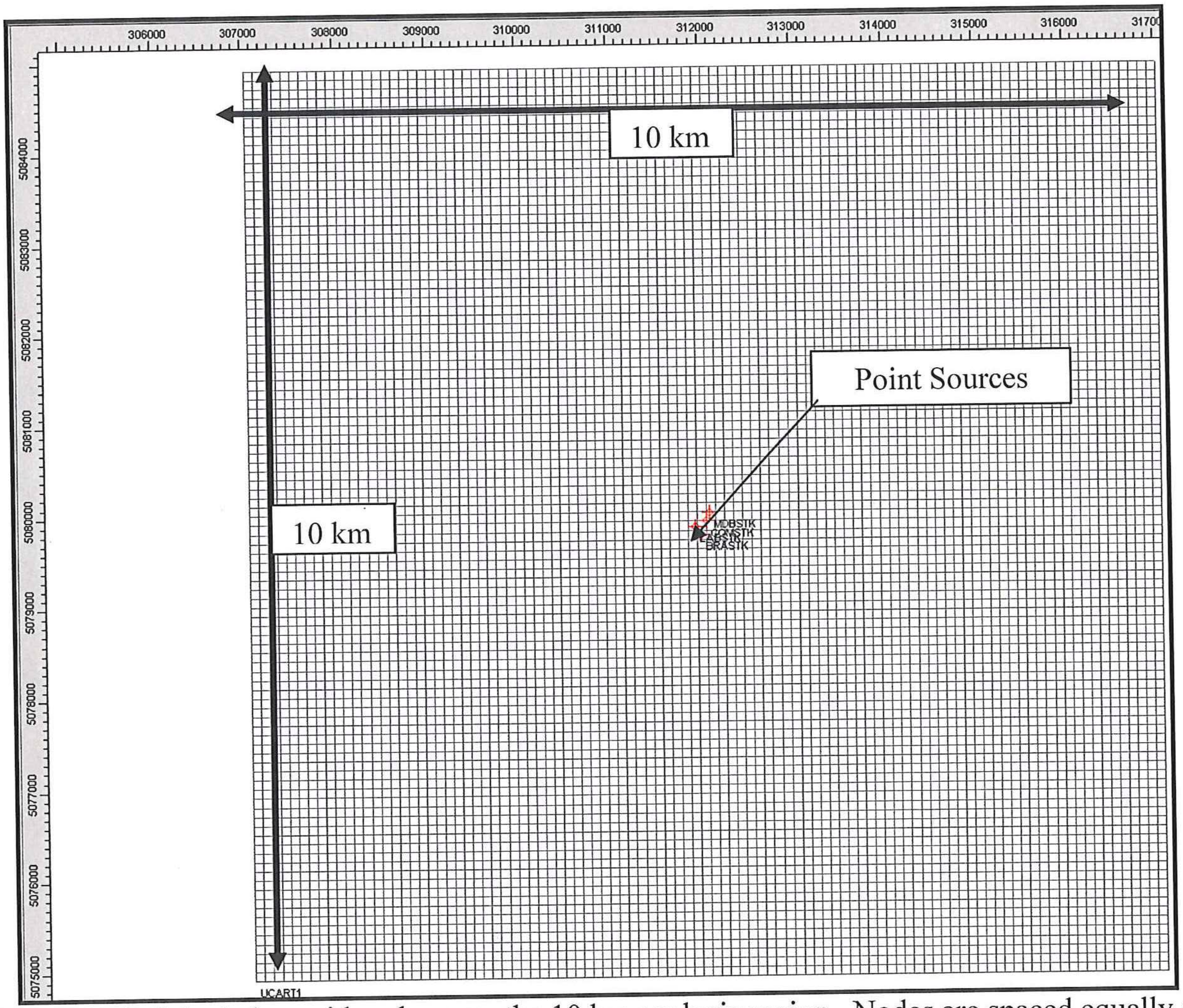

Figure C-6: Calculation grid nodes over the 10 km analysis region. Nodes are spaced equally at 100 m in both horizontal dimensions.

A description of the parameters computed by AERMOD at each calculation point is provided in Table C-16. As indicated in this table, there are two distinct phases (a vapor phase and a particle phase) necessary to examine the location for the highest quantity of deposition. These two phases are modeled in separate AERMOD runs. The vapor phase results are used in the risk assessment process to describe the movement of highly volatile compounds which will remain in the gas phase at ambient conditions. The mercury vapor phase results are used to describe the emission and movement of the volatile mercury containing compounds. The particle phase results describe the movement and deposition of compounds with low volatility. A particle-bound phase was not modeled for this application since the size of the deposition plume is bounded by the particle and vapor plumes and only the outer boundary that encompasses greater than 95% of the deposition was used to set the sampling region.

Table C-16: Deposition and Concentration Parameters Calculated by AERMOD

Description	**Symbol**	**Unit**
Average air concentration - particle phase	cyp	ug/ m^3
Average air concentration - vapor phase	cyv	ug/ m^3
Average dry deposition - particle phase	dydp	g/m^2-year
Average dry deposition - vapor phase	dydv	g/m^2-year
Average wet deposition - particle phase	dywp	g/m^2-year
Average wet deposition - vapor phase	dywv	g/m^2-year
Average total deposition - particle phase	dytp	g/m^2-year
Average total deposition - vapor phase	dytv	g/m^2-year

8.6 *Air Dispersion and Deposition Modeling Results*

The geographic distribution of average annual total deposition rates are presented in Figures C-7 and C-8 for the vapor and particle phases, respectively. Only the total deposition is represented since this was the parameter used to determine the maximum extent of residual soil contamination potentially derived from the UMCDF. Underlying data for these representations are presented in the companion CD to this report.

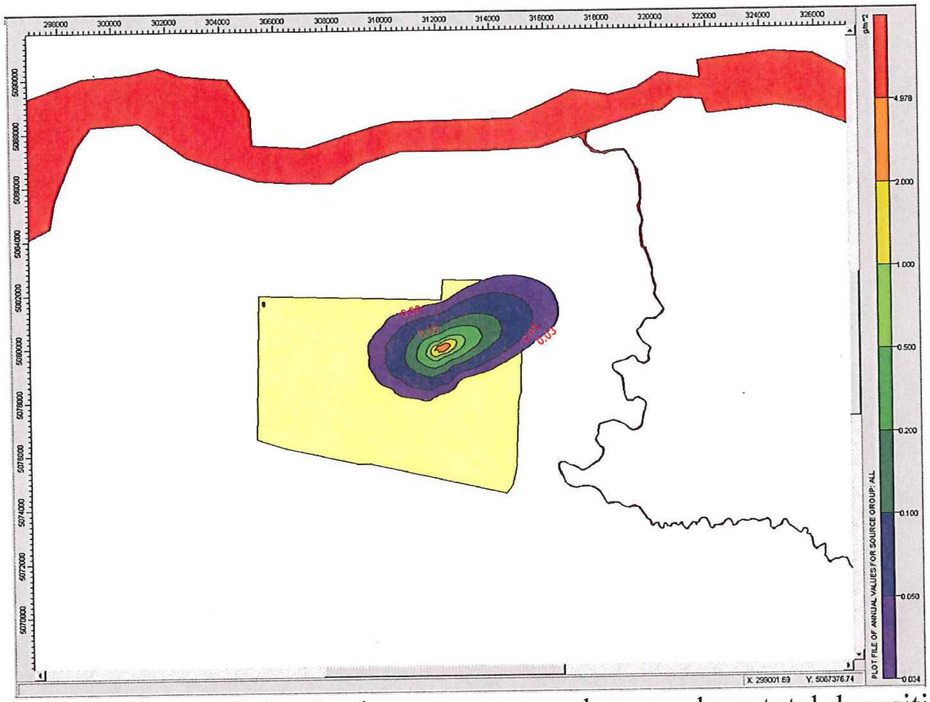

Figure C-7: Isopleths for the average annual vapor phase total deposition (g/m^2-yr) calculated from the five year composite meteorological data

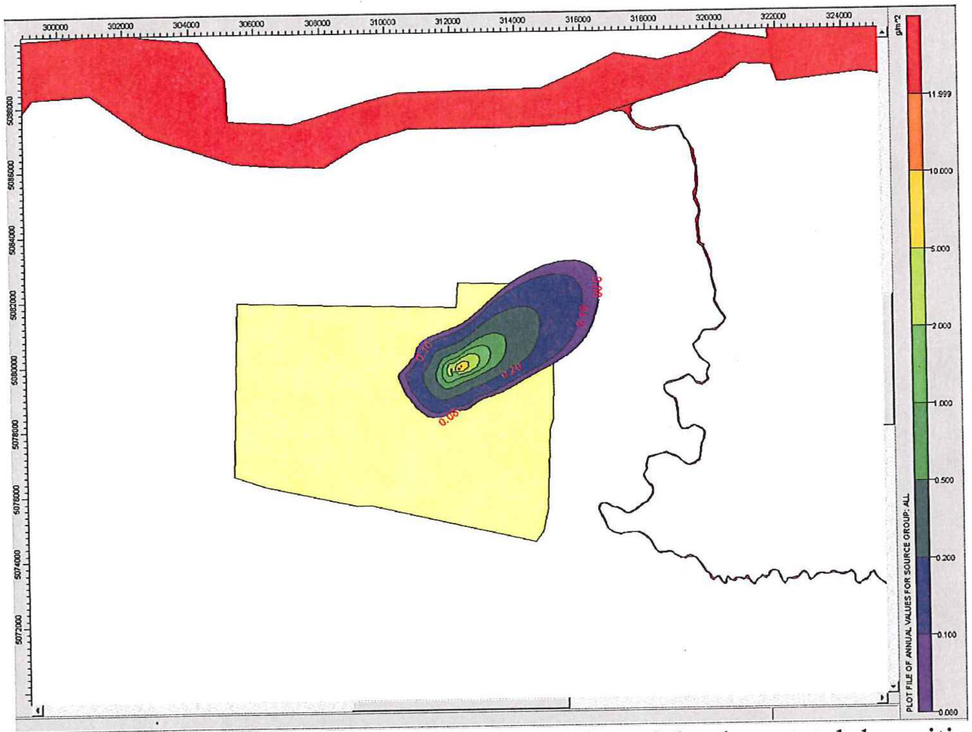

Figure C-8: Isopleths for the average annual particle phase total deposition (g/m^2-yr) calculated from the five year composite meteorological data

Appendix D – Development of Fate and Transport Datasets

All fate and transport properties were developed based on the protocol applied in the 2008 Human health and ecological risk assessment completed by the CTUIR. This protocol is described in "Development of Fate and Transport Parameter Datasets for Use in Environmental Health Risk Assessments, Version 4" dated March 21, 2007 and authored by the United States Army Center for Health Promotion and Preventative Medicine (USACHPPM). This document is Provided on the companion CD under the Appendix_D directory.