MIXED WASTE FACILITY RISK ASSESSMENT FOR A COMMERCIAL PLASMA-BASED GASIFICATION AND VITRIFICATION (GASVIT™) SYSTEM

Moses Jaraysi[1], Catherine Massimino[2], David Domingo[2], Fred Feizollahi[3],
Steve Goldenberg[3] and William J. Smith[3]
[1] Washington Department of Ecology, [2] US EPA Region 10, [3] Allied Technology Group

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ABSTRACT

The Allied Technology Group (ATG) has submitted to the Washington State Department of Ecology and the US EPA Region 10 a Preliminary Risk Assessment (PRA) of the potential risks resulting from exposure to both chemical and radioactive constituents. These constituents may be released from a proposed thermal facility for treating low level and mixed waste. The thermal facility will include a plasma-based gasification and joule-heated vitrification process. The multi-pathway risk assessment evaluated potential risks posed by the emission of over 150 chemicals and 100 radionuclides that may be emitted by the facility's operations. Transport pathways evaluated include gaseous deposition, air to plant transfer, and resuspension. Lifestyles assessed included Native American, subsistence, and urban. Several ecological habitats, including soil, shrub-steppe, surface water in the Columbia and Yakima Rivers, and riparian were included. Ecological receptors living in these habitats were evaluated, including soil organisms, aquatic life, plants, bald eagles, coyotes and deer mice.

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ATG, Inc., dba Allied Technology Group (ATG), has submitted a RCRA/TSCA permit application for a mixed waste facility (MWF) at its Richland Environmental Technology Center (RETC), a 45 acre facility in Richland, Washington. The RETC applies technologies to safely recycle and manage wastes.

The RCRA/TSCA permit application requires that a risk assessment be conducted before the facility is built and after the facility is tested. This paper summarizes the methodology and results of the preliminary, or preconstruction, risk assessment (PRA). The PRA is an integral part of both the facility design process and of planning for the demonstration test. Methodology for preparing both the PRA and the final, or post-test, risk assessment (FRA), is documented in a risk assessment work plan submitted as part of the initial RCRA/TSCA permit application.

ATG Inc. first submitted a risk assessment work plan (RAWP) (1) for the MWF to the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA) in 1996. In October of 1998, these agencies conditionally approved a revised RAWP for the MWF. These two agencies are jointly reviewing the MWF permit application pursuant to the Washington State Dangerous Waste (DW) and the U.S. Toxic Substances Control Act (TSCA) regulations.

The RAWP defined the methodology, procedures and assumptions used to conduct a screening level human health and ecological risk assessment for operation of the MWF. Pursuant to this approval, ATG completed a Preliminary Risk Assessment (PRA) (2). This paper describes the results of the PRA and their integration into the larger permitting process. The PRA incorporated many recent changes in EPA guidance, most notably for mercury, found in the recently issued “Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities” (HHRAP) (3).

The PRA is comprehensive. The PRA evaluates risks posed by the potential emission from the MWF of over 150 chemicals **(Figure 1)** and 100 radionuclides and assesses the potential for exposure via multiple direct and indirect pathways to those living urban, subsistence and Native American lifestyles. The PRA is one of only a few risk assessments to assess exposure via resuspension of dust and via gaseous deposition onto plants and surfaces.

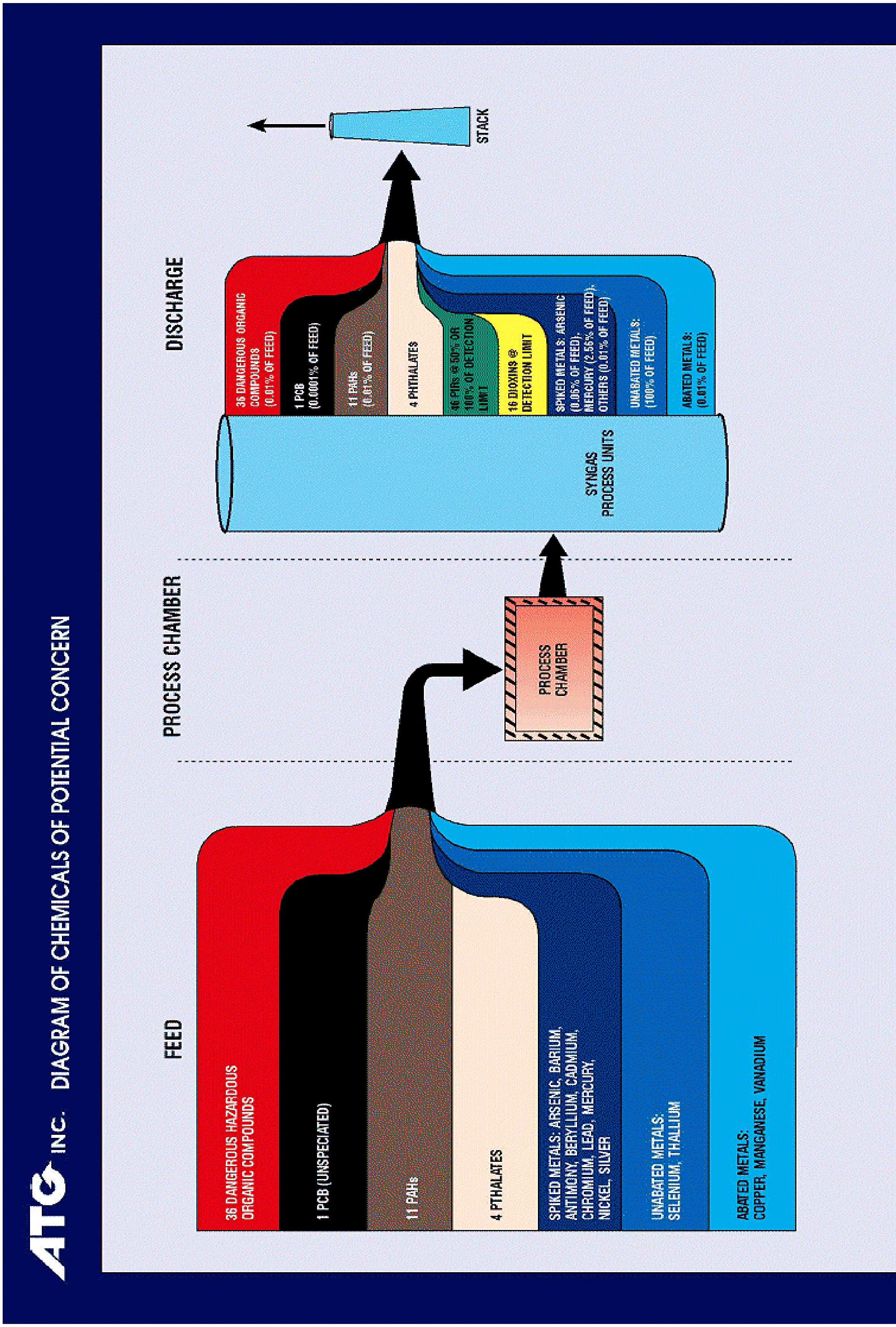

Figure 1. Chemicals of Potential Concern

To minimize the possibility of underestimating risks, the PRA used EPA default values, which tend to overestimate risks, rather than site-specific information. The only site-specific information used in the PRA included meteorological data and associated air dispersion modeling; structure of local ecosystems; locations of site-specific sensitive receptors (such as nearby child care centers); and site-specific emissions information based on facility design and process knowledge. Site-specific emission information generated during the demonstration test will be used in the FRA.

This overview presents a description of the facility, the wastes to be processed, and the permitting process, then estimates of the emissions rates, the basis of the air modeling, and the results of the risk assessment modeling. The overview concludes with an evaluation of uncertainties in the risk assessment methodology that may effectively restrict the formal application of screening level risk assessments to small thermal treatment facilities such as ATG’s.

FACILITY AND MIXED WASTE DESCRIPTIONS

The main function of the proposed MWF is to treat contact-handled low-level radioactive and hazardous materials that are commonly referred to as low-level mixed waste (LLMW). The MWF would prepare such materials either for recovery and reuse, or for safe disposal. The facility will use both non-thermal and thermal technologies. No wastes will be disposed of at the MWF.

LLMW generally consists of materials discarded from governmental, institutional, and industrial facilities which are subject to controls under the Atomic Energy Act (AEA), Resource Conservation and Recovery Act (RCRA), Clean Air Act, and Toxic Substances Control Act (TSCA). The handling and treatment of these materials requires permits from several state and federal agencies. These permits include a DW permit from the Washington State Department of Ecology (WDOE), a radioactive material license from the Washington State Department of Health (WDOH), an air permit from the Benton County Clean Air Authority, and a TSCA permit from the EPA.

The RETC is located in the Heavy Industrial section of the West Campus of Tri-Cities Science and Technology Park, which is adjacent to the Department of Energy’s (DOE’s) Hanford site in Richland, Washington **(Figure 2).** Major occupants of the West Campus are the Nuclear Division of Siemens Power Corporation, Interstate Nuclear Services, Plastic Injection Modeling, Inc., and International Hearth Melting LLC. The RETC is approximately 3.5 kilometers away from the northern Richland residential community. A child care center is located in an adjacent Medium Industrial-zoned park, at a distance of approximately 1.75 kilometers from the proposed MWF buildings.

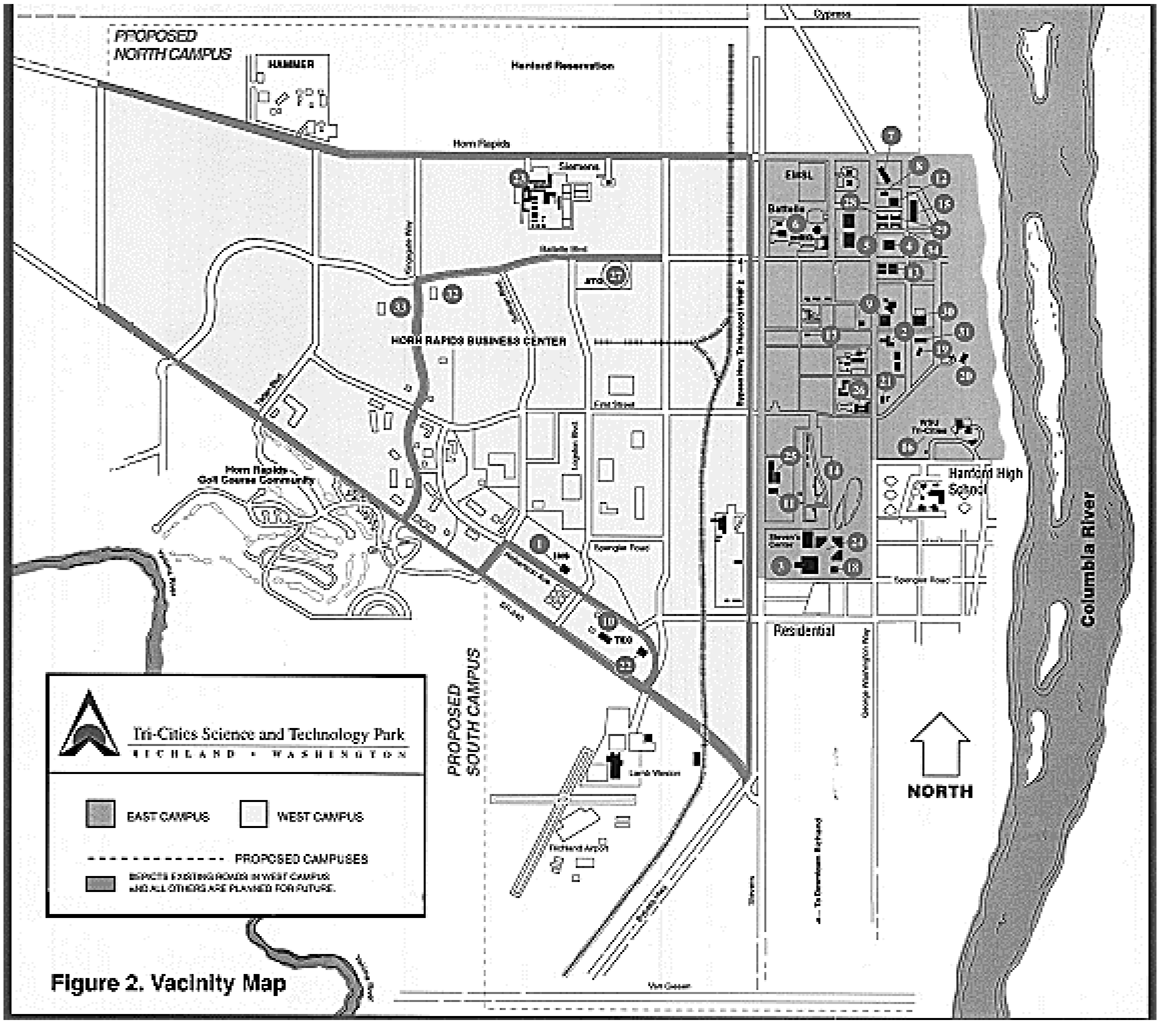

Figure 2. Vacinity Map

The MWF will have both non-thermal and thermal treatment systems. The non-thermal treatment systems consist of four treatment lines **(Figure 3)** that will stabilize solid and liquid wastes by mixing them with stabilization reagents (e.g., cement), cleaning solid wastes by physical extraction means (e.g., abrasive blasting), or macro-encapsulating solid wastes by compaction and placement in protective jackets. The MWF thermal treatment system will use a plasma-based gasification and vitrification (GASVIT™) technology to destroy organic materials (gasification) and convert the remaining inorganic matter into a glass-like material (vitrification). The overall facility will have a stabilization building, a GASVIT™ building, and a storage building **(Figure 4).**

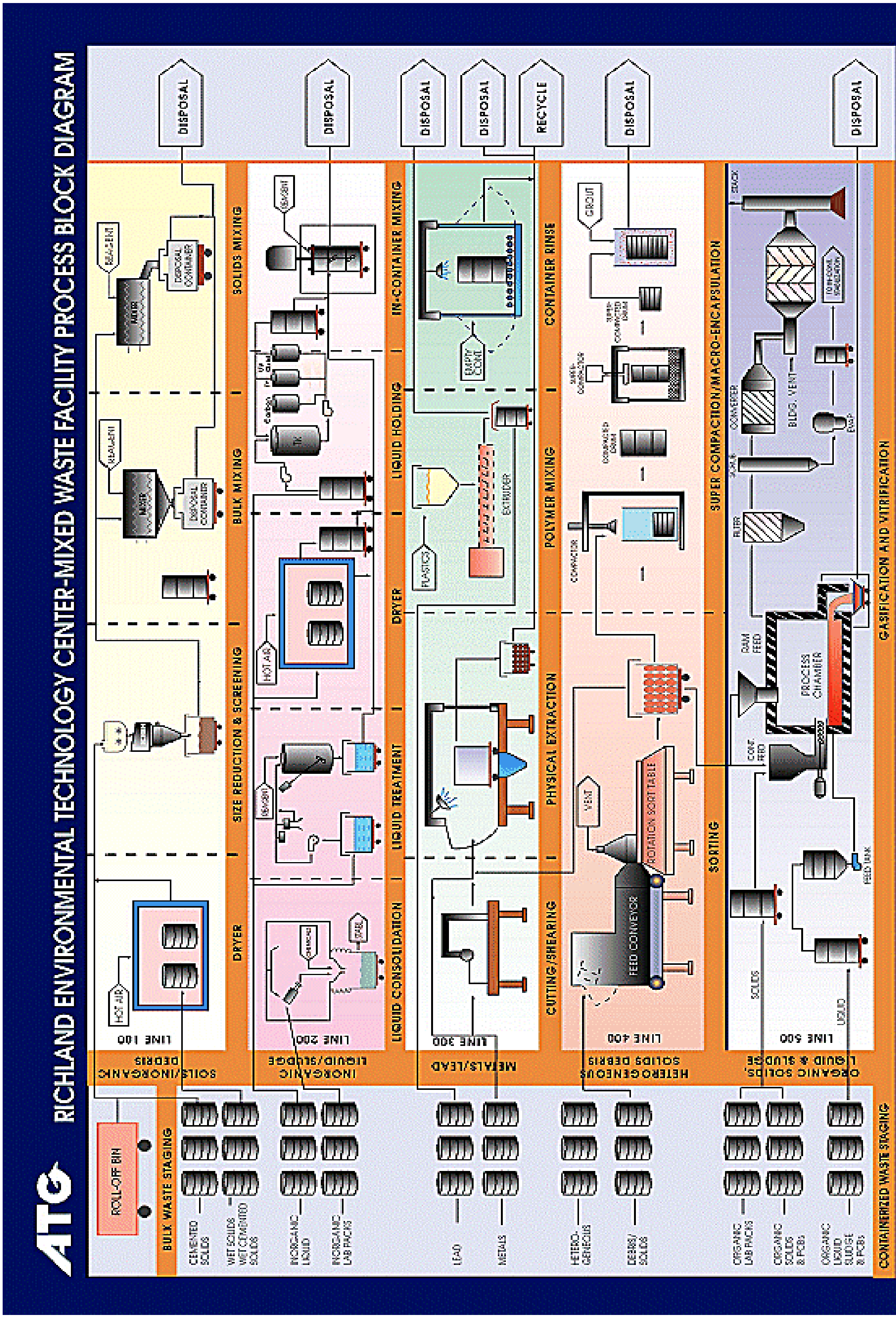

Figure 3. Richland Environmental Technology Center - Mixed Waste Facility Block Diagram.

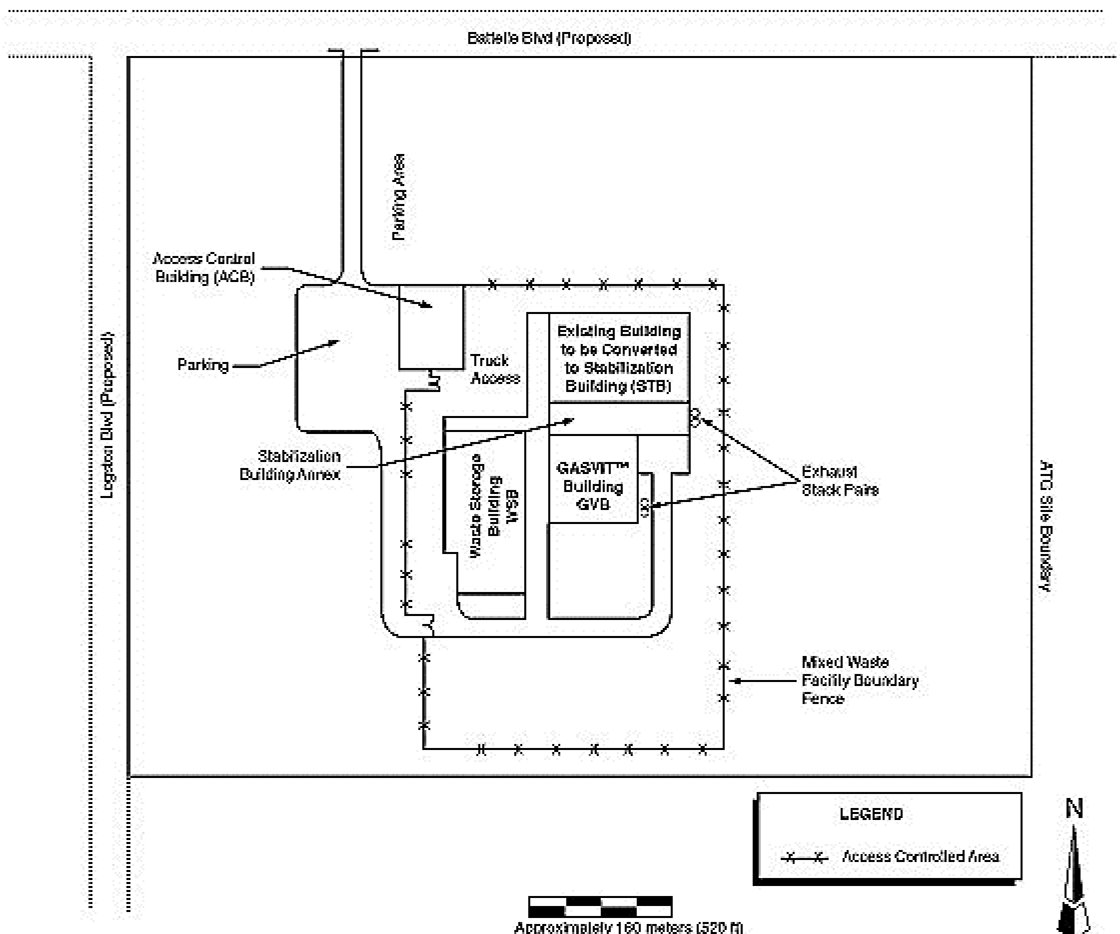

Figure 4. Site Location Map

The facility will receive untreated wastes from commercial and government establishments and convert the wastes into a form that is safe for long-term storage and/or disposal. This function will be accomplished by producing a stabilized waste form that meets or exceeds the disposal standards set by state and federal laws and regulations. For example, the GASVIT™ system produces a glass-like material that is highly durable, leach resistant, and safe for disposal.

Approximately eight-ninths ($^8/_9$) of the feed materials shipped to the MWF (the highest rate allowed will be approximately six 55 gallon drums per hour, or 7,600 metric tons per year) will be processed by non-thermal treatment systems. The remaining one-ninth ($^1/_9$) of the feed (the highest rate allowed will be approximately three-quarters of a 55 gallon drum per hour, or 950 metric tons per year) will be handled by the GASVIT™ system. Hence, the facility emission estimates take into account all potential airborne releases during the non-thermal processing as well as the thermal processing operations. The two release points from the facility are the stabilization building stack pair and the GASVIT™ building stack pair shown in Figure 4. All emission sources within the facility discharge through the building stacks.

Several emission control measures are incorporated in the facility design and will be installed and operated to protect the public, worker health and safety, and the environment. For example, all waste preparation and treatment operations will be conducted inside environmental enclosures or under vent hoods. Exhausts collected from the enclosures and hoods will be treated twice by particulate filters and carbon beds before they are released to the stack. These features ensure that few, if any, fugitive emissions are released from the building during normal operations. Also, ventilation units in the stabilization and GASVIT™ (process) buildings will keep the area inside the buildings at a negative pressure with respect to the outside air. This will minimize the release of potentially impacted air from inside the process buildings to the outside environment. The exhaust from the process building's ventilation units will be treated to remove particulate using high efficiency particulate air (HEPA) filters and carbon beds.

The GASVIT™ system destroys organics in the absence of free oxygen, which means that it requires no air for destruction. This approach generates a smaller quantity of exhaust gas - usually 10 to 20 percent of that of conventional combustion units. Also, the primary products of the GASVIT™ system differ markedly from those of a combustion system. The primary products of the GASVIT™ system are carbon monoxide and hydrogen with trace quantities of methane and other light alkanes. This mixture of gases is commonly referred to as synthesis gas or syngas. Pilot studies indicate that plasma systems similar to the GASVIT™ system produce fewer toxic secondary products than conventional combustion systems.

Emissions controls, especially for particulates, on product gases for a process treating radioactive wastes are more stringent than those for a process treating only chemical waste. The smaller volume of gas generated by the GASVIT™ process allows for a more efficient cleaning process. The GASVIT™ cleaning process consists of a three stage exhaust gas clean-up system using state-of-the-art technologies**.** The first stage applies a particulate filtration unit to remove particulate from the high temperature exhaust gas. The second stage incorporates two scrubbers, a high efficiency mist eliminator, a HEPA filter, and an impregnated carbon filter to remove particulate, acid gases, and mercury. The third stage uses a converter unit to stabilize the exhaust gas to form water and carbon dioxide before releasing it from the building. The third stage also includes cleaning the exhaust gas using the GASVIT™ building's HEPA and carbon filters.

SELECTION OF COPCS AND ROPCS AND ESTIMATION OF EMISSION RATES

Emissions from operations and equipment within the facility were grouped into 6 sources. These sources are:

1) Process vents in the Stabilization Building
2) A spill in the Stabilization Building
3) Process vents in the GASVIT™ Building
4) A spill in the GASVIT™ Building
5) Treated exhaust from the GASVIT™ system
6) Partially treated exhaust from the GASVIT™ system

The facility will not discharge liquids to the environment, hence there is no risk imposed from this pathway.

Emission rates from these sources were estimated for a list of over 150 chemicals of potential concern (COPCs) and over 100 radionuclides of potential concern (ROPCs). To avoid omitting chemicals or radionuclides that might contribute significantly to health effects of the emissions, the list includes a number of chemical and radioisotope species that may or may not be present in the feed or in the emissions. For example, many organic chemicals are included in the COPC list simply because they are target analytes for the demonstration tests. Any chemical that is a potential risk concern and is neither in the estimated feed nor anticipated in the emissions is included in the emissions estimate by setting its concentration in the emissions equal to the analytical detection limit.

The initial list of over 500 COPCs was narrowed down by taking into account several factors. These factors included the availability of toxicity values and the availability of approved sampling and analysis methods. Using these factors, the initial list of COPCs was reduced to approximately 160. The emission rates of COPCs included on the final list were doubled to account for emissions of COPCs omitted from the final list. All of the initial ROPCs were kept for quantitative analysis by the risk models.

Once the final COPC and ROPC lists were established, maximum emission rates were estimated from the highest allowed facility throughput. The estimates take into account all sources of air discharge from the MWF. To achieve this, both the stabilization building (non-thermal processes) and GASVIT™ building (thermal processes) ventilation systems' air discharges are considered. Estimates also include abnormal conditions, such as airborne releases from an accidental container drop or a temporary bypass of treatment units.

An adjustment factor was applied to increase the initial estimates to allow for any unforeseen transient conditions during the facility operation. The basic GASVIT™ emission rate estimates were increased by a factor of approximately 2.8 for the organics and 1.45 for the metals to account for any potential emission increase during start-up, shut-down, and routine process upsets.

Emission rates were also estimated for a short-term release scenario that poses a greater risk of potential acute health effects than routine operations. The scenario assumed an increase in emission rates from a potential GASVIT™ system malfunction and a partial bypass of the gas treatment system. The short-term emission rates were used to calculate acute risks to receptors due to an inhalation exposure in a one-hour period. Emissions of organics during this period are assumed to increase 100-times and of metals 10-times in comparison to routine operations.

Estimates of emission rates that include all of the adjustments for uncertainty discussed above are summarized in the PRA. The uncertainty factors include:

1) the doubling of emissions of COPCs on the final COPC list to account for emissions of COPCs omitted from the final list,

2) the adjustment factors for transient operations, and

3) emission estimates for compounds either not known to be either in the waste feed or to be produced by the system by assuming their concentrations in the offgas are either equal to or one-half the respective detection limit.

AIR DISPERSION AND DEPOSITION MODELING

COPCs and ROPCs emitted from the STB and GVB stacks disperse through the air and deposit on plants, soils, and water. The Industrial Source Complex Short-Term Model, Version 3.0 (ISCST3), as recommended by EPA guidance, was used to model both dispersion and deposition using site-specific meteorological and topographical data.

The air model predicted the transport of COPCs and ROPCs via several atmospheric transport mechanisms. These included: 1) atmospheric dispersion of particulates and vapors; 2) deposition of particulates under dry and wet conditions; and 3) gaseous deposition under dry and wet conditions. The model was also used to predict the contribution that resuspended particulate may make to atmospheric concentrations of COPCs. The validated version of ISCST3 does not include routines for estimating gaseous deposition rates. Hence, an unvalidated version of the ISCST3 model was used to predict only the gaseous deposition rates. The unvalidated version requires further development before it can be used for all air transport mechanisms.

Unit emissions factors calculated for various locations in the vicinity of the model were multiplied by the estimated emission rates provided in the PRA to estimate the concentration of COPCs and ROPCs. Unit emissions factors assume that 1 gram per second of a COPC is emitted from a stack.

Locations modeled included the high-impact area and plausible locations for urban residents, subsistence farmers and fishers, Native American hunter/gatherers and fishers, and several ecologically sensitive locations. The high-impact area was located in the general vicinity of the maximum estimated ground-level air concentrations and the maximum estimated deposition rates. These two locations were at neighboring, but distinctly separate locations to the northwest of the facility. The air concentration or deposition rate at the high-impact location was set equal to the highest corresponding concentration or rate at any modeled location. Thus concentrations and deposition rates estimated for the high-impact location may not have actually been predicted for that location by the model.

SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT METHODOLOGY AND RESULTS

The screening level human health risk assessment was based on the characterization of facility emissions, selected COPCs and ROPCs, and air modeling calculations described above. Air concentrations derived from the emissions estimates and air modeling were input into EPA-approved fate and transport models for COPCs to assess indirect as well as direct chemical and radionuclide pathways of exposure. Except for calculating the rate of surface runoff of radionuclides into neighboring waterbodies, the DOE-approved GENII model was used for estimating exposure to ROPCs. The EPA fate and transport models were used for estimating the rate of runoff of both ROPCs and COPCs into the waterbodies.

Potential health impacts of the emissions were estimated from the results of the multi-pathway exposure analysis using toxicity values derived from several standard sources (e.g. the EPA's Integrated Risk Information System [IRIS] computer database and *Health Effects Assessment Summary Table* [HEAST]). Less common sources of toxicity values utilized included values issued by the National Center for Exposure Assessment (NCEA) and obtained through the EPA Region 10 office. The primary source of toxicity values for acute health effects was the California EPA Air Toxics Hot Spots Program acute reference exposure levels (RELs) (CAL EPA 1995). Carcinogenic, non-carcinogenic and acute health effects were assessed.

Given the bias in the assumptions used in the PRA towards preventing the underestimation of risks, the calculated risk numbers must be considered as indicators and do not represent an actual impact associated with the MWF; nor will they predict the probability that an adverse impact may occur. The risk results will be used to decide whether the facility can be constructed as designed. If not, design modifications, or more site-specific risk characterization will be required, before the facility is constructed.

RECEPTOR LOCATIONS: The PRA evaluated risks to receptors at two types of locations. The first type, referred to as the "high-impact" location, was determined using the air modeling results as described above. This area is a hypothetical location where the predicted air concentrations and deposition rates of COPCs and ROPCs are equal to their maximum value anywhere in the study area. The second type, called the "plausible location", was determined by identifying the location with the highest air concentrations and deposition rates predicted by the air model runs within the current or plausible future land use patterns or zoning regulations consistent with the corresponding lifestyle. For example, for the lifestyle of a subsistence farmer the plausible location is within an area zoned for agricultural use at the point with the highest air concentrations and deposition rates as predicted by the air models. An example of an implausible location for a subsistence farmer is within any area zoned for heavy industry.

POTENTIAL EXPOSURE PATHWAYS: The PRA addressed all significant exposure pathways a COPC or ROPC will take from the stack to the point where a potential receptor may be exposed. The pathways included direct and indirect routes. The direct pathway is air inhalation by all receptors. Indirect pathways included exposure to the following media as recommended by the EPA:

- Incidental ingestion of surface soil;
- Inhalation of re-suspended soil;
- Consumption of drinking water;
- Consumption of above ground produce;
- Consumption of beef and milk;
- Consumption of fish;
- Consumption of breast milk by nursing infant;
- External exposure to ROPCs in soil; and
- External exposure to ROPCs in air.

Certain pathways were not included in the mathematical risk models because they are believed to have a very small impact on the overall risk. These included dermal contact from air, water, or soil. The choice of receptor locations corresponding to points of maximum exposure and the bias towards overestimating risks in selecting values for uncertain parameters for the models are believed to account for these pathways.

HUMAN RECEPTORS: The PRA estimated risks for human receptors assumed to be living one of three different lifestyles.

Native American: The Native American lifestyles are based on land use rights and cultural consideration of the local tribes (Nez Perce, Umatilla, and Yakama). Scenarios for these lifestyles are based on interviews with tribal members about their cultural and lifestyle practices and are focused on those subsistence activities that would occur as treaty-reserved rights are exercised. The Native American receptors analyzed in the scenarios include adults and children who subsist by either hunting and gathering or by fishing along with their infants who feed on breast milk. Additionally, a sweat lodge scenario, which is unique to traditional Native American culture, was evaluated.

Subsistence: The subsistence receptors analyzed in the PRA include farmers, fishers and their children. The risks posed to those living the lifestyle of a subsistence fisher assumed that the fish in their diet came from the most highly impacted water body with the capacity for producing significant numbers of fish near the MWF.

Urban: The urban receptors analyzed in the PRA include adult and child residents, and children at two childcare facilities within 2 km of the MWF.

RISK CHARACTERIZATION: The excess lifetime cancer risks (ELCRs) and non-cancer effects from long-term emissions of COPCs for all receptors at high-impact locations are summarized in Table I. The results show that potential health impacts satisfy regulatory screening criteria.

Table I
Summary of Potential Human Health Risks At High-Impact Locations

Lifestyle			**Excess Carcinogenic Risk**		**Hazard Index**
			Chemical	*Radiological*	*Chemical*
Native	Hunter/Gatherer	Adult	1 E-05	4 E-06	0.02
		Child	6 E-06	2 E-06	0.07
	(Breast Milk)	Infant	< background	3 E-12	< background
	Fisher	Adult	6 E-06	3 E-06	0.02
		Child	5 E-06	1 E-06	0.07
	Sweat Lodge	Adult	3 E-12	-	5E-8
Subsistence	Farmer	Adult	2 E-06	2 E-06	0.01
		Child	2 E-06	6 E-07	0.02
	Fisher	Adult	3 E-07	7 E-07	0.002
		Child	1 E-07	1 E-07	0.005
Urban	Resident	Adult	2 E-07	6 E-07	0.001
		Child	9 E-08	1 E-07	0.004
	Montessori	Child	5 E-09	3 E-08	0.0007
	Kinder-Care	Child	1 E-09	6 E-09	0.0001

ELCRs: The ELCRs (Excess Lifetime Cancer Risks) for adults and children living all modeled lifestyles at all modeled locations, including the hypothetical high-impact location, demonstrated potential excess cancer risks less than or equal to the EPA's screening criterion of 1E-5. An adult living the Native American hunter/gatherer lifestyle totally within the hypothetical highest-impact area faces the highest potential carcinogenic risk. However, even for this hypothetical and unlikely scenario, the calculated excess cancer risk (1E-5 in Table I) satisfies the EPA's screening criterion. Potential carcinogenic risks posed to local residents with urban lifestyles are ten to 100 times less than those posed to residents with native and subsistence lifestyles.

Hazards: A child of an adult living the Native American hunter/gatherer lifestyle in the hypothetical highest-impact area faces the highest potential chemical hazard. The calculated excess hazard for this hypothetical and unlikely scenario (0.07) is approximately 3.5 times less than the EPA's screening criterion of 0.25. As with potential carcinogenic risks, chemical hazards to urban residents are less than those posed to residents with native and subsistence lifestyles.

Exposure Pathways: The majority of the potential for a small additional risk to the native/hunter gatherer and other receptors is posed by ingestion pathways. The pathways contributing the most to carcinogenic risk and chemical hazards are summarized in Table II. Ingestion of meat, organs, and milk were the most significant pathways.

Table II
Exposure Pathways Contributing Most To
Potential Excess Carcinogenic Risks and Hazards for Most Sensitive Receptor

Lifestyle			**Excess Carcinogenic Risk**		**Hazard Index**
			Chemicals	*Radionuclides*	*Chemicals*
Native	Hunter/Gatherer	Adult	Ingestion of Meat Ingestion of Organs Ingestion of Milk	Ingestion of Milk Ingestion of Fruit Inhalation of Air Ingestion of Meat Ingestion of Organs	Ingestion of Milk Ingestion of Meat Ingestion of Organs

Chemicals Closest to Levels of Potential Concern: The chemicals and radionuclides closest to levels of potential concern are listed in Table III. The chemicals will be carefully monitored during the demonstration test. Those chemicals closest to levels of potential concern include dioxins and furans, a polycyclic aromatic hydrocarbon dibenzo(a,h)anthracene, di-n-octylphthalate, and di-n-butylphthalate. All radionuclides were also below levels of potential concern with tritium, carbon-14 and iodine-129 being the closest to those levels.

Table III
Chemicals and Radionuclides Contributing Most To
Potential Excess Carcinogenic Risks and Hazards for Most Sensitive Receptor

Lifestyle			**Excess Carcinogenic Risk**		**Hazard Index**
			Chemicals	*Radionuclides*	*Chemicals*
Native	Hunter/Gatherer	Adult	Dioxins and Furans, Dibenzo(a,h)anthracene	Tritium (H-3) Carbon (C-14) Iodine (I-129)	Di-n-octylphthalate Di-n-butylphthalate

SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT METHODOLOGY AND RESULTS

As for the SLHHRA, the Screening Level Ecological Risk Assessment (SLERA) estimates health effects from the results of the emissions, air, and exposure modeling described earlier. Ecological receptors living in four ecological habitats were assessed. The four habitats are soil, water, shrub-steppe, and riparian. Exposures of receptors within these habitats were compared to toxicity-based screening levels to assess ecological impacts. The resulting Environmental Screening Quotients (ESQ) are presented in Table IV.

Table IV
Ecological Risk Assessment Summary for Maximum Contamination Zone

Habitat	Receptor	Ecological Screening Quotient	Largest Contributors to Screening Quotient	ESQ Level
Soil	Soil Organisms	0.021	Arsenic, mercury, methyl mercury	> .001
	Terrestrial Vegetation	0.22	Copper, lead, mercury, thallium, hexachloropentadiene	> .01
Water	Aquatic Life (1)	0.0012	Methyl mercury	> .0001
	Sediment Invertebrates (1)	0.0031	Hexachloropentadiene	> .0001
Shrub-Steppe	Sagebrush Vole	0.012	Copper, lead, PCBs	> .001
	Deer Mouse	0.12	Methyl mercury, PCBs, p-xylene	> .01
	Western Meadowlark	0.020	Methyl mercury, furans	> .001
	Coyote	0.058	Lead, methyl mercury, PCBs, dioxins & furans, p-xylene	> .001
	Red-tailed Hawk	0.19	Methyl mercury, furans	> .01
Riparian	Longtaile Vole (2)	0.000081	Copper, PCBs, dioxins	> .00001
	Marsh Wren (2,3)	0.015	PAHs, methyl mercury	> .001
	Mallard (2,3)	0.0010	PAHs, methyl mercury	> .0001
	Spotted Sandpiper (2,3)	0.0037	PAHs, methyl mercury, PCBs, furans	> .0001
	River Otter (2,3)	0.012	PCBs	> .001
	Great Blue Heron (3)	0.0036	PAHs, methyl mercury, PCBs, furans	> .0001
	Bald Eagle (3)	0.0021	Methyl mercury, PCBs, furans	> .00001

Notes: 1. Yakima River 2. Lower Yakima Riparian Zone 3. Yakima River Delta

Given the bias in the assumptions toward preventing the underestimation of risk, the calculated ESQs must be considered as indicators, and do not represent an actual impact associated with the MWF; nor do they predict the probability that an adverse impact may occur. The risk results will be used as a decision-making tool to support the permitting process as described above for the SLHHRA.

Ecosystems within a radius of 6.2 miles (10 km) of the MWF were characterized and evaluated along with information on threatened and endangered species and their habitat within a radius of 33 miles (50 km) of the MWF. This characterization data was used to identify receptors and develop exposure models. The area within the 10 km radius is generally characterized as a semi-desert region that occupies portions of eastern Oregon and southeastern Washington. The upland region is characterized as a shrub-steppe ecosystem, and the rivers and other water bodies are classified as aquatic/riparian ecosystems. The shrub-steppe ecosystem covers an area from the Columbia River plain up to the Rattlesnake Hills. The aquatic/riparian ecosystems cover areas along the Columbia and Yakima Rivers and along springs, streams, and artificial water bodies. The region is dominated by the undeveloped shrub-steppe land of the Hanford site; aquatic/riparian areas associated with the Yakima and Columbia Rivers; the urban and industrial areas of Richland; and agricultural lands including pastures, range-land, and cultivated land.

The climate of the region is semi-arid and cool, with an average temperature of about 50° F (10° C). Average annual precipitation ranges from 10 inches (260 mm) in the west and 20 inches (510 mm) in the east.

Vegetation at the MWF site is sparse and includes shrubs, sagebrush, and non-native weeds. Areas within a 10 km radius of the MWF are primarily characterized by bunch grass and sagebrush. Vegetation that occurs along the Columbia River shoreline includes emergent water milfoil, water smartweed, pondweed, sedge, reed canarygrass, bulbous bluegrass and a thin band of willows. Trees and shrubs that are found on the shoreline include Russian olive, mullberry, and Siberian elm.

The terrestrial vertebrate species observed on the Hanford site include approximately 40 species of mammals, 238 species of birds, three species of amphibians, and nine species of reptiles. No mammals or plants that occur within a 50 km radius of the proposed MWF are on the federal list of threatened or endangered wildlife and plants. The peregrine falcon and bald eagle are listed as endangered and threatened, respectively. The bull trout has been proposed to be listed. Although the U.S. Fish and Wildlife Service (USFWS) did not identify them as threatened or endangered species in the study area, the state of Oregon identified the Snake River steelhead trout, chinook and sockeye salmon, and the candidate Middle Columbia River steelhead trout as federally-listed species found within the study area.

ESQs: ESQs (Environmental Screening Quotients) for soil organisms and terrestrial vegetation in the shrub-steppe habitat, for aquatic life and sediment invertebrates in water habitat, and selected animal species in both the shrub-steppe and riparian habitats were below the EPA screening criterion of 0.25. Animal species assessed in the shrub-steppe include red-tailed hawks and deer mice. Animal species assessed in the riparian community include the bald eagle. The animal species potentially displaying the most sensitivity to emissions from the facility were terrestrial vegetation, the red-tailed hawk, and the deer mouse.

Chemicals Closest to Levels of Potential Concern: The chemicals closest to levels of potential concern will be carefully monitored during the demonstration test. These chemicals include metals, methyl mercury, PCBs, dioxins, furans, and p-xylene. Terrestrial vegetation is potentially sensitive to several metals and is insensitive to the emissions of organics. The red-tailed hawk is most sensitive to emissions of methyl mercury, PCBs, and one furan. The deer mouse is potentially sensitive to emissions of methyl mercury, PCBs, and p-xylene.

UNCERTAINTIES

Uncertainties associated with emissions estimates, exposure modeling, and toxicological properties affect the degree of confidence that can be placed in the risk characterization results. Assumptions were selected throughout the analysis so as not to underestimate the potential risk. Consequently, the risks are more likely overestimated than underestimated. Design features and operating principles of the GASVIT™ system increase the likelihood that risks will be overestimated rather than underestimated in comparison to the thermal treatment facilities for which the uncertainty factors were derived. These uncertainty factors include the assumed increases in emissions during spills and operational upsets, such as the partial bypass of the GASVIT™ system, and the transient operations factor discussed earlier.

Uncertainties in Emissions Estimates: Uncertainties associated with the estimation of fugitive emissions from spills and operational bypasses associated with operation of the GASVIT™ facility will be less than from other facilities. All fugitive emissions are captured by the building ventilation system, which maintains the pressure in the building below atmospheric, and treated before release to the atmosphere. Operational experience is expected to show that the increases in transient emissions during startup, shutdown, power outages and similar transients from which the transient operations factors are derived, will be less for a properly operated and maintained gasification and vitrification system. The large thermal mass and comparatively long residence times in plasma reaction chambers, like the GASVIT™ process chamber, will result in smaller increases in organic emissions during common operational upsets, such as power outages and temporary increases in gas flows. Increases in metals emissions during an upset where the bulk of the metals are captured in a viscous glass melt are expected to be less than corresponding increases for processes where the bulk of the metals are captured as a light and highly mobile ash.

Uncertainties in Air-to-Plant Transfers: The uncertainties associated with the modeling of air-to-plant transfer of chemicals are especially critical. These uncertainties affect the estimates of health effects for nearly every organic chemical near levels of concern. For instance, extremely low concentrations of dioxins and furans yielded risks approaching EPA screening criteria for several lifestyles, for birds, and for mammals. These low concentrations corresponded to concentrations in the emissions equal to the detection limit of the most sensitive analytical method accepted by the EPA. Larger facilities or facilities in areas with less favorable wind patterns may have difficulty satisfying the screening criteria using the methods specified in the latest guidance (3).

CONCLUSIONS

The risk assessment process proved to be a valuable tool. The process allowed facility designers and regulators to identify and minimize potential risks while the facility was being designed. The process has also identified the COPCs and ROPCs that will require close monitoring during the demonstration test.

The ATG facility needed to use the latest in thermal destruction and gas treatment technologies to satisfy the EPA screening criteria for health effects. These health effects were calculated using the most recent guidance. Without these technologies, the facility would have needed to reduce the facility’s thermal processing rate. Further improvements in treatment technologies, though, would not result in increases in the facility’s thermal processing rate. Better analytical methods with lower detection limits for dioxins and furans in the emissions would be required to significantly increase the facility throughput without changing other assumptions or methods.

The air to plant biotransfer factors for dioxins and furans, polycyclic aromatic hydrocarbons, and pthalates were the primary controlling factors for the estimation of both human health and ecological effects. Ingestion of terrestrial vegetation and animals feeding on that vegetation were the primary exposure pathways for humans and for mammals. Better estimates of the air to plant biotransfer factors could potentially enable ATG to increase the facility's thermal processing rate without conducting a site-specific risk assessment.

The unspeciated organic emissions factor measured during the demonstration test is the variable most likely to significantly change the estimates of the health effects in the FRA. Problems in measuring this factor during the demonstration test could lead to further reductions in permitted feed rates. The biggest problem in measuring this factor is that *inorganic* particulates in the emissions increase the measured value of the unspeciated *organic* emissions factor. The latest guidance (4) for collecting unspeciated organic emissions data during the demonstration test specifies methods that fail to distinguish between organic and inorganic emissions.

REFERENCES

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