9.0 UNCERTAINTY

This section presents a qualitative assessment of the uncertainties associated with the risk assessment. The actual risk measures presented in this risk assessment are not precise estimates of risk, but rather, estimates of the upper bound risks given a considerable number of assumptions about exposure and toxicity. In general, the risk measures should be considered upper bound worst case estimates given the use of conservative assumptions in the risk assessment. As such, the methods by which uncertainties in the risk assessment are addressed are such that they tend to overestimate rather than underestimate the actual risk. The purpose of the uncertainty assessment is to fully clarify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective. The following presents a brief discussion of the uncertainties associated with the risk assessment.

9.1 UNCERTAINTIES IN STACK EMISSIONS CHARACTERIZATION

In general, the uncertainty in characterizing stack emissions has been minimized by conducting stack measurements. The remaining uncertainty, therefore, is related to the relatively small uncertainty associated with sampling and analytical techniques that are subject to quality assurance/quality control procedures, and the variability associated with waste feed over time. Uncertainty in organic emissions also occurs as a result of changing operating conditions (i.e., temperature) of the kiln. However, the emissions testing was done over a range of temperature conditions varying from low to high temperatures. Stack gas sampling was conducted over this range of temperature conditions and the results of the stack sampling under these varying conditions were used in the risk assessment in order to minimize the potential uncertainties associated with varying operating conditions.

9.2 UNCERTAINTIES IN THE EXPOSURE ASSESSMENT

In estimating the exposure dose for the exposed populations, several exposure factors such as inhalation rate, soil ingestion rate, and body weights were used. In general, in

order to account for the variability in these factors, high-end 90th percentile values for each of the exposure factors were used.
This risk assessment has also relied on fate and transport models to predict how chemicals will migrate in the environment after their release from the ESSROC facility. These models, while based on fundamental scientific principles, likely represent an oversimplification of the processes that will determine the concentrations of chemicals in environmental media. These models, therefore, are likely to overestimate chemical concentrations in the environment given the conservative input parameters for these models.

The models used to predict chemical concentrations in surface water, soil, meat, and plants are based primarily on the principles of mass balance and chemical partitioning. Chemical partitioning dictates what fraction of the total mass will be transferred from one medium to another and is based on such factors as biotransfer factors and bioconcentration factors. Many of the biotransfer factors have not been directly measured for certain chemicals, but rather, have been extrapolated using regression equations based on data for other chemicals. Other uncertainties associated with these principles are due to incomplete knowledge in several areas including the nature, rate, and extent of chemical degradation in the environment, the types of chemicals produced by such degradation, and the chemical, physical, and biological factors that determine the movement of a chemical from one environmental medium to another. These data gaps introduce uncertainty in the model results.

As described previously, the model used to predict methyl mercury concentrations in fish likely overestimates the actual methyl mercury concentrations in fish tissues. Specifically, the risk assessment model of exposure to mercury through fish ingestion is based on exposure to the methyl mercury form of mercury present in fish tissue. The methylation of mercury is viewed as the key step in entrance of mercury into the food chain, since; methyl mercury tends to bioaccumulate to a greater degree in biota relative to other forms of mercury. The uptake of methyl mercury by fish is estimated by multiplying the dissolved phase water concentration of methyl mercury by a fish bioconcentration factor. The 1998 HHRAP guidance, however, recommends that the dissolved phase water concentrations for both the divalent and methyl mercury forms of mercury are summed and the resultant sum multiplied by the bioconcentration factor for methyl mercury to estimate the methyl mercury concentration in fish. However, as described in the December 1997 U.S. EPA report titled *Mercury Report to Congress Volume III: Fate and Transport of Mercury in the Environment* (U.S. EPA mercury report), available measurement data for mercury in fish tissue samples indicates that nearly 100% of the mercury found in fish tissue is found in the methylated form. For the ESSROC risk assessment, the estimated dissolved phase water concentrations for divalent and methyl mercury in the Wabash River under the typical exposure scenario were 3.16 E^{-9} mg/L and 5.45 E^{-11} mg/L, respectively. Therefore, for the ESSROC risk assessment, the estimated concentration of methyl mercury in water is less than 2% of the total mercury in the water body modeled in this risk assessment. Clearly, the model used to estimate the uptake of methyl mercury by fish is highly conservative and likely overestimates the actual risks associated with exposure to mercury in fish.

9.3 UNCERTAINTIES IN THE TOXICITY ASSESSMENT

The toxicity data used to evaluate human health risks in risk assessments is derived primarily from experimental animal data. There may be differences in chemical absorption, metabolism, excretion, and toxic response between humans and the species for which the experimental toxicity data are available. Uncertainties in using animal data to predict potential human health effects are introduced when routes of exposure differ between humans and the experimental animals, when there is a difference in exposure periods (i.e., subchronic versus chronic), and when effects seen at relatively high levels of animal exposure are used to predict effects at much lower levels of exposure in the environment.

To account for many of these uncertainties, the U.S. EPA typically bases the toxicity values used in risk assessment on the toxicological response from the most sensitive animal species. The dose is then adjusted by application of safety factors in order to account for the uncertainty associated with interspecies extrapolation and to protect against the possibility that humans may be more sensitive than the most sensitive animal species. The resulting toxicity factors, therefore, incorporate a substantial margin of safety.

For many chemicals that are carcinogenic in animals, it is unknown whether these chemicals are carcinogenic in humans. While many chemicals are carcinogenic in one or more animal species, only a few chemicals are known to be carcinogenic in humans. Regulatory agencies generally assume that humans are as sensitive to carcinogens as the most sensitive animal species.

9.4 UNCERTAINTIES IN RISK CHARACTERIZATION

In conducting the risk characterization, several assumptions about the characteristics of the general population and individual behavior patterns were made. General characteristics of the population include the identification of different sub-groups that constitute the population in the vicinity of the site as well as the activity patterns of the subgroups. For this risk assessment, typical and high-end exposure factors were used to evaluate exposures for the following populations: residents (adult and child), farmers (adult and child) and fishermen (adult and child). Although all populations may not be represented in the analysis, the range of exposures that have been evaluated were selected to constitute such a wide range, that exposures by a particular sub-group are likely to be represented with the exposure range evaluated.

The exposure factors used to evaluate the farmer and fisher populations were selected so as to represent conservative, high-end estimates of potential risks for these populations. The U.S. EPA also typically requires that exposures for potential subsistence populations (i.e., farmer and fisherman) be modeled in indirect risk assessments. Although there is no available information to indicate the presence of subsistence populations in the study area, an evaluation of the potential carcinogenic risks associated with indirect exposures to ESSROC emissions for these populations was conducted.

Tables 9-1 through 9-3 present the estimated carcinogenic risks for the hypothetical subsistence farmer and fisher populations. These tables present estimated carcinogenic risks for consumption of homegrown vegetables, consumption of homegrown animal products, and consumption of fish. For each of these populations, high-end consumption rates were used and it was assumed that these populations obtained 100% of their vegetable, animal product, and fish diets from products grown or caught within the maximum exposure area modeled in this risk assessment. Therefore, the fraction ingested from contaminated source for these populations was set at 1.0.

Table 9-1 presents the carcinogenic risks for consumption of homegrown vegetables for the subsistence child and adult farmer populations. As shown on the table, the total carcinogenic risks for the child and adult populations were 4.6 x 10^{-7} and 1.25 x 10^{-6}, respectively. Table 9-2 presents the carcinogenic risks for consumption of homegrown animal products for the subsistence child and adult farmer populations. As shown on the table, the total carcinogenic risks for the child and adult populations were 9.6 x 10^{-7} and 2.27 x 10^{-6}, respectively. When combining the risks for the plant and animal product consumption pathways, the total carcinogenic risks for the subsistence farmer populations are 1.42 x 10^{-6} (child) and 3.53 x 10^{-6} (adult).

Table 9-3 presents the carcinogenic risks for the subsistence fisher populations (adult and child). As shown on Table 9-3, the total carcinogenic risks for the child and adult subsistence fisher populations are 6.32 x 10^{-8} and 4.94 x 10^{-7}, respectively.

9.5 POINT OF MAXIMUM EXPOSURE

The potential risks associated with exposure to ESSROC emissions for the land-based indirect exposure pathways (i.e., soil direct contact exposures and plant and animal product consumption) were evaluated by establishing a maximum area of exposure. This area was defined as a 4.0 kilometer radius extending out from the ESSROC kiln stack. Given the variability in potential exposures, this 4.0 kilometer radius provides a reasonable estimate of the potential upper bound risks associated with exposures to ESSROC emissions. However, as noted in Section 4.5.3, several discrete receptor points within the 4.0 kilometer radius have higher deposition rates than the deposition rates used to model the maximum exposure area. Therefore, in order to evaluate the potential risks at the point of maximum total deposition, carcinogenic risks were estimated using the air model parameter values at the point of maximum total deposition for the off-site receptors. These values are as follows:

Cyp:	mass-weighted	0.00089
	Surface area-Weighted	0.00088
Dywp:	mass-weighted	0.03943
	Surface area-Weighted	0.02108
Dydp:	mass-weighted	0.00006
	Surface area-Weighted	0.00001

Dytwp: mass-weighted 0.03948

Surface area-Weighted 0.02109

Cyv: 0.00088

Dywv: 0.03749

The point of maximum total deposition is located just beyond the ESSROC property boundary to the east. Table 9-4 presents the estimated carcinogenic risks for the direct soil contact, plant consumption and animal product consumption pathways modeled at the point of maximum total deposition. The exposure factors (e.g., consumption rates, etc.) used to evaluate the exposures for these pathways represent the values used for the typical exposure scenario. As shown on Table 9-4, the total carcinogenic risks for the direct soil contact pathway for the child and adult are 2.09×10^{-7} and 1.22×10^{-7}, respectively.

The total carcinogenic risks for the plant consumption pathway for the child and adult are 2.6×10^{-7} and 2.86×10^{-7}, respectively. The total carcinogenic risks for the animal products consumption pathway for the child and adult are 3.96×10^{-7} and 7.91×10^{-7}, respectively. The total carcinogenic risks for each of these pathways are below the one in one million excess lifetime risk level.

Table 9-1
Carcinogenic Risks from Plant Consumption
Subsistence Farmer
ESSROC
Logansport, IN

Chemical	Maximum Exposure Area Subsistence Farmer	
	Adult	Child
2,3,7,8 TCDD	2.70E-07	2.54E-07
2,3,7,8-PeCDD	2.88E-08	6.04E-09
2,3,7,8-HxCDD	2.62E-08	5.50E-09
2,3,7,8-HpCDD	3.93E-09	8.25E-10
OCDD	7.95E-11	1.67E-11
2,3,7,8-TCDF	3.35E-08	7.04E-09
1,2,3,7,8-PeCDF	1.02E-08	2.15E-09
2,3,4,7,8-PeCDF	1.27E-07	2.68E-08
2,3,7,8-HxCDF	1.68E-08	3.53E-09
2,3,7,8-HpCDF	1.60E-08	3.37E-09
OCDF	1.01E-11	2.13E-12
Arsenic	2.66E-09	5.53E-10
Beryllium	2.63E-10	5.44E-11
Benzo(a)pyrene	7.14E-08	1.50E-08
Benzo(a)anthracene	2.26E-09	4.80E-10
Benzo(b)fluoranthene	6.20E-09	1.30E-09
Bis(2-ethyl hexyl)phthalate	4.34E-07	9.12E-08
Dibenz(a,h)anthracene	1.94E-07	4.07E-08
1,4-dichlorobenzene	7.27E-11	1.97E-11
2,4-Dinitrotoluene	1.82E-09	4.93E-10
2,6-Dinitrotoluene	2.44E-09	6.62E-10
Hexachlorobenzene	1.12E-09	2.52E-10
Hexachlorobutadiene	8.49E-11	1.83E-11
Hexachloroethane	4.94E-12	1.34E-12
n-Nitroso-di-n-propylamine	1.12E-10	2.97E-11
Pentachlorophenol	2.25E-10	6.54E-11
3,3'-Tetra CB	5.80E-14	1.54E-14
2,3,4,4','5-Penta CB	1.76E-13	4.65E-14
2,3',4,4',5-Penta CB	3.75E-14	9.93E-15
2',3,3',4,4'-Penta CB	1.45E-15	3.84E-16
2,3,3',4,4'-Penta CB	6.28E-15	1.66E-15
3,3',4,4',5-Penta CB	1.55E-12	4.15E-13
2,3',4,4',5,5'-Hexa CB	2.05E-15	5.44E-16
2,3,3'4,4',5-Hexa CB	2.05E-13	5.44E-14
2,3,3',4,4',5'_Hexa CB	6.28E-14	1.66E-14
3.3',4,4',5,5'-Hexa CB	3.27E-13	8.67E-14
2,2',3,4,4',5,5'-Hepta CB	1.07E-13	2.83E-14
2,2'3,3'4,4',5-Hepta CB	1.07E-12	2.82E-13
2,3,3',4,4',5,5'-Hepta CB	4.52E-15	1.20E-15
Total Carcinogenic Risk	**1.25E-06**	**4.60E-07**

Table 9-2
Carcinogenic Risks from Beef Consumption
Subsistence Farmer
ESSROC
Logansport, IN

Chemical	Maximum Exposure Area Subsistence Farmer Adult	Maximum Exposure Area Subsistence Farmer Child
2,3,7,8 TCDD	1.22E-07	4.30E-08
2,3,7,8-PeCDD	1.27E-07	4.83E-08
2,3,7,8-HxCDD	8.24E-08	3.19E-08
2,3,7,8-HpCDD	3.33E-09	1.26E-09
OCDD	1.52E-10	5.64E-11
2,3,7,8-TCDF	9.09E-08	3.18E-08
1,2,3,7,8-PeCDF	1.35E-08	4.94E-09
2,3,4,7,8-PeCDF	8.77E-07	3.19E-07
2,3,7,8-HxCDF	1.13E-07	4.18E-08
2,3,7,8-HpCDF	2.95E-09	1.26E-09
OCDF	4.01E-11	2.41E-11
Arsenic	5.33E-10	1.60E-10
Beryllium	3.92E-11	9.90E-12
Benzo(a)pyrene	1.43E-07	7.75E-08
Benzo(a)anthracene	5.95E-09	3.56E-09
Benzo(b)fluoranthene	2.87E-08	1.67E-08
Bis(2-ethyl hexyl)phthalate	5.35E-08	2.68E-08
Dibenz(a,h)anthracene	5.90E-07	2.99E-07
1,4-dichlorobenzene	1.64E-12	1.10E-12
2,4-Dinitrotoluene	1.83E-13	1.31E-13
2,6-Dinitrotoluene	1.79E-13	1.29E-13
Hexachlorobenzene	1.85E-08	1.04E-08
Hexachlorobutadiene	2.87E-10	1.59E-10
Hexachloroethane	7.01E-13	4.83E-13
n-Nitroso-di-n-propylamine	9.23E-15	6.49E-15
Pentachlorophenol	2.60E-11	1.70E-11
3,3'-Tetra CB	5.13E-12	3.60E-12
2,3,4,4','5-Penta CB	1.55E-11	1.09E-11
2,3',4,4',5-Penta CB	3.31E-12	2.33E-12
2',3,3',4,4'-Penta CB	1.28E-13	8.99E-14
2,3,3',4,4'-Penta CB	5.55E-13	3.89E-13
3,3',4,4',5-Penta CB	1.41E-10	9.88E-11
2,3',4,4',5,5'-Hexa CB	1.82E-13	1.27E-13
2,3,3'4,4',5-Hexa CB	1.82E-11	1.27E-11
2,3,3',4,4',5'_Hexa CB	5.55E-12	3.89E-12
3.3',4,4',5,5'-Hexa CB	2.89E-11	2.03E-11
2,2',3,4,4',5,5'-Hepta CB	9.44E-12	6.63E-12
2,2'3,3'4,4',5-Hepta CB	9.42E-11	6.61E-11
2,3,3',4,4',5,5'-Hepta CB	4.00E-13	2.81E-13
Total Carcinogenic Risk	**2.27E-06**	**9.58E-07**

Table 9-3
Carcinogenic Risks from Fish Consumption
Subsistence Fisherman
ESSROC
Logansport, IN

	Wabash River	
Chemical	Adult	Child
2,3,7,8 TCDD	2.35E-08	2.70E-09
2,3,7,8-PeCDD	1.30E-08	1.50E-09
2,3,7,8-HxCDD	4.03E-09	4.65E-10
2,3,7,8-HpCDD	1.13E-10	1.30E-11
OCDD	1.03E-13	1.19E-14
2,3,7,8-TCDF	6.22E-08	7.14E-09
1,2,3,7,8-PeCDF	8.93E-09	1.03E-09
2,3,4,7,8-PeCDF	1.01E-07	1.16E-08
2,3,7,8-HxCDF	7.51E-09	8.66E-10
2,3,7,8-HpCDF	2.98E-11	3.44E-12
OCDF	1.15E-14	1.37E-15
Arsenic	2.27E-08	2.45E-09
Beryllium	3.00E-09	2.84E-10
Benzo(a)pyrene	9.35E-09	1.26E-09
Benzo(a)anthracene	9.70E-09	1.36E-09
Benzo(b)fluoranthene	4.63E-09	6.45E-10
Bis(2-ethyl hexyl)phthalate	1.28E-10	1.51E-11
Dibenz(a,h)anthracene	1.23E-09	1.54E-10
1,4-dichlorobenzene	1.69E-09	2.61E-10
2,4-Dinitrotoluene	1.16E-09	1.80E-10
2,6-Dinitrotoluene	1.48E-09	2.29E-10
Hexachlorobenzene	5.48E-08	7.02E-09
Hexachloroethane	5.59E-10	8.58E-11
n-Nitroso-di-n-propylamine	1.85E-10	2.82E-11
Pentachlorophenol	1.19E-08	1.83E-09
3,3'-Tetra CB	1.15E-09	1.68E-10
2,3,4,4','5-Penta CB	3.48E-09	5.07E-10
2,3',4,4',5-Penta CB	7.42E-10	1.08E-10
2',3,3',4,4'-Penta CB	2.87E-11	4.18E-12
2,3,3',4,4'-Penta CB	1.24E-10	1.81E-11
3,3',4,4',5-Penta CB	3.15E-08	4.60E-09
2,3',4,4',5,5'-Hexa CB	4.07E-11	5.93E-12
2,3,3'4,4',5-Hexa CB	4.07E-09	5.93E-10
2,3,3',4,4',5'_Hexa CB	1.24E-09	1.81E-10
3.3',4,4',5,5'-Hexa CB	6.48E-09	9.45E-10
2,2',3,4,4',5,5'-Hepta CB	2.12E-09	3.08E-10
2,2'3,3'4,4',5-Hepta CB	2.11E-08	3.08E-09
2,3,3',4,4',5,5'-Hepta CB	8.96E-11	1.31E-11
Total Carcinogenic Risk	**4.15E-07**	**5.16E-08**

Table 9-4
Carcinogenic Risks for Indirect Pathways at the Point of Maximum Total Deposition
ESSROC
Logansport, IN

	Maximum Point of Total Deposition					
	Direct Soil Contact		Plant Consumption		Animal Prod. Consum.	
Chemical	Adult	Child	Adult	Child	Adult	Child
2,3,7,8 TCDD	4.79E-09	8.26E-09	2.51E-07	2.50E-07	3.55E-08	1.72E-08
2,3,7,8-PeCDD	5.54E-09	9.56E-09	1.45E-09	4.05E-10	5.40E-08	2.63E-08
2,3,7,8-HxCDD	7.34E-09	1.27E-08	2.26E-09	6.33E-10	4.53E-08	2.20E-08
2,3,7,8-HpCDD	2.05E-09	3.55E-09	6.49E-10	1.82E-10	2.18E-09	1.06E-09
OCDD	1.05E-10	1.82E-10	3.49E-11	9.76E-12	1.13E-10	5.48E-11
2,3,7,8-TCDF	1.33E-08	2.29E-08	1.37E-09	3.81E-10	3.16E-08	1.54E-08
1,2,3,7,8-PeCDF	3.16E-09	5.45E-09	6.25E-10	1.74E-10	5.76E-09	2.81E-09
2,3,4,7,8-PeCDF	4.99E-08	8.60E-08	1.13E-08	3.17E-09	4.24E-07	2.06E-07
2,3,7,8-HxCDF	1.44E-08	2.49E-08	4.48E-09	1.25E-09	7.50E-08	3.65E-08
2,3,7,8-HpCDF	5.12E-10	8.84E-10	1.60E-10	4.49E-11	5.65E-10	2.76E-10
OCDF	1.09E-11	1.88E-11	4.46E-12	1.25E-12	1.86E-11	1.14E-11
Arsenic	8.46E-09	1.54E-08	2.70E-09	7.52E-10	3.19E-09	1.49E-09
Beryllium	1.29E-09	2.34E-09	2.60E-10	7.25E-11	2.17E-10	1.01E-10
Benzo(a)pyrene	3.84E-09	5.70E-09	2.73E-09	7.62E-10	4.25E-08	2.50E-08
Benzo(a)anthracene	7.98E-10	1.19E-09	1.56E-10	4.31E-11	1.97E-09	1.25E-09
Benzo(b)fluoranthene	1.04E-09	1.54E-09	1.74E-10	4.83E-11	8.56E-09	5.39E-09
Bis(2-ethyl hexyl)phthalate	1.16E-12	1.73E-12	7.89E-11	2.21E-11	5.89E-10	3.05E-10
Dibenz(a,h)anthracene	1.70E-09	2.53E-09	1.17E-09	3.27E-10	5.32E-08	3.09E-08
1,4-dichlorobenzene	8.49E-12	1.26E-11	7.49E-11	2.04E-11	5.57E-13	3.57E-13
2,4-Dinitrotoluene	9.58E-12	1.42E-11	1.96E-09	5.33E-10	6.59E-14	4.24E-14
2,6-Dinitrotoluene	1.05E-11	1.56E-11	2.63E-09	7.17E-10	6.43E-14	4.15E-14
Hexachlorobenzene	3.76E-09	5.58E-09	7.86E-10	2.16E-10	5.93E-09	3.82E-09
Hexachlorobutadiene	2.58E-10	3.83E-10	9.02E-11	2.44E-11	8.81E-11	5.72E-11
Hexachloroethane	2.99E-12	4.45E-12	5.59E-12	1.52E-12	2.59E-13	1.67E-13
n-Nitroso-di-n-propylamine	8.35E-13	1.24E-12	4.38E-11	1.24E-11	3.04E-15	1.96E-15
Pentachlorophenol	1.34E-11	2.00E-11	5.87E-11	1.79E-11	8.79E-12	5.65E-12
3,3'-Tetra CB	2.04E-13	3.51E-13	3.41E-14	8.64E-15	1.95E-12	1.24E-12
2,3,4,4','5-Penta CB	6.17E-13	1.06E-12	1.03E-13	2.61E-14	5.91E-12	3.77E-12
2,3',4,4',5-Penta CB	1.41E-13	2.27E-13	2.20E-14	5.58E-15	1.26E-12	8.04E-13
2',3,3',4,4'-Penta CB	5.09E-15	8.76E-15	8.51E-16	2.16E-16	4.88E-14	3.11E-14
2,3,3',4,4'-Penta CB	2.21E-14	3.80E-14	3.69E-15	9.35E-16	2.11E-13	1.35E-13
3,3',4,4',5-Penta CB	5.59E-12	9.63E-12	9.34E-13	2.37E-13	5.36E-11	3.41E-11
2,3',4,4',5,5'-Hexa CB	7.21E-15	1.24E-14	1.21E-15	3.06E-16	6.91E-14	4.40E-14
2,3,3'4,4',5-Hexa CB	7.21E-13	1.24E-12	1.21E-13	3.06E-14	6.91E-12	4.40E-12
2,3,3',4,4',5'_Hexa CB	2.19E-13	3.80E-13	3.69E-14	9.35E-15	2.11E-12	1.35E-12
3.3',4,4',5,5'-Hexa CB	1.15E-12	1.98E-12	1.92E-13	4.87E-14	1.10E-11	7.02E-12
2,2',3,4,4',5,5'-Hepta CB	3.75E-13	6.46E-13	6.27E-14	1.59E-14	3.60E-12	2.29E-12
2,2'3,3'4,4',5-Hepta CB	1.37E-12	6.44E-12	6.25E-13	1.59E-13	3.59E-11	2.28E-11
2,3,3',4,4',5,5'-Hepta CB	1.57E-14	2.74E-14	2.66E-15	6.73E-16	1.52E-13	9.70E-14
Total Carcinogenic Risk	**1.22E-07**	**2.09E-07**	**2.86E-07**	**2.60E-07**	**7.90E-07**	**3.96E-07**

10.0 SUMMARY

This document presents the results of an evaluation of potential human health risks associated with air emissions from cement kiln operations at the ESSROC Inc. facility in Logansport, Indiana. The ESSROC facility uses liquid and solid hazardous wastes as a supplemental fuel in the production of Portland cement in two rotary kilns. The direct and indirect risk assessment was completed to evaluate the potential risks associated with long term air emissions from cement kiln operations.

10.1 AIR EMISSIONS

The ESSROC facility conducted multiple emission test measurements during their RCRA trial burn tests completed in March 1999. Parameters subject to chemical analyses during the trial burn emissions testing included metals (arsenic, antimony, barium, beryllium, cadmium, total and hexavalent chromium, lead, mercury, nickel, selenium, silver, and thallium), a list of 47 volatile organic chemicals, a list of 55 semi-volatile chemicals, dioxins and furans, a list of 13 carcinogenic co-planar PCBs, and total PCB for ten congener classes (i.e., total mono through total deca PCBs). In addition to kiln stack emissions, non-kiln stack emissions associated with handling of hazardous wastes at the facility were also estimated. These non-kiln stack emissions included fugitive volatile organic emissions from the storage and handling of liquid hazardous wastes and the fugitive particulate matter emissions from the handling of cement kiln dust at the facility.

10.2 AIR DISPERSION/DEPOSITION MODELING

Air modeling was used to predict the dispersion and deposition of emissions from the ESSROC facility. The ISC3 model was used to predict ambient air concentrations and deposition flux rates for the chemicals of concern. The emissions modeling was conducted by establishing a radial grid of receptors located at 10 degree intervals. The modeling domain extended out 50 kilometers from the ESSROC stack.

The results of the air dispersion and deposition modeling was combined with the emissions test data to estimate chemical-specific air concentrations and wet and dry deposition rates. The modeling results were segregated into three different areas of chemical impact surrounding the facility. Specifically, a maximum area of impact was determined by establishing area weighted averages for the five-year average total deposition modeling output for the surface area weighted and mass weighted modeling runs for receptor points located within an area extending 4 kilometers from the ESSROC stack (excluding receptor points within the ESSROC facility boundary). Surface water exposures to the Wabash and Eel rivers were determined by establishing area weighted averages for the five year average total deposition modeling output for surface area weighted and mass weighted modeling runs for receptor points located east of the ESSROC kiln stack to a distance of 30 kilometers. Surface water exposures were also modeled using modeling output for a discrete receptor point located at the France Park recreational area.

10.3 DETERMINATION OF ENVIRONMENTAL MEDIA CONCENTRATIONS

The results of the air dispersion and deposition modeling were used in various fate, transport, and uptake models to estimate exposure point concentrations of chemicals of concern in environmental media surrounding the facility. Chemical concentrations were estimated for air, soil, and surface water. Using the estimated chemical concentrations for these three environmental media, various uptake models were used to predict the uptake of chemicals from the environmental media by fish, plants, and livestock.

10.4 EXPOSED POPULATIONS AND EXPOSURE SCENARIOS

The media-specific chemical concentrations were used to calculate chemical intakes for various exposure populations. The exposed populations included typical residents (both adult and child populations), farmers, and fishermen under typical and high end exposure scenarios. The typical exposure scenario was established using exposure assumptions set at their central tendencies for the populations being evaluated. The high end exposure scenario was defined by setting one or more of the exposure assumptions to upper bound or maximum values while keeping other exposure assumptions at their typical values.

The pathways of exposure evaluated for the typical and high end scenarios included: inhalation of air, inadvertent ingestion of and dermal contact with soil, ingestion of and dermal contact with surface water while swimming, and ingestion of bioaccumulated chemicals of concern in fish, plant, and animal tissue.

10.5 RISK CHARACTERIZATION

The estimated chemical intakes for the various pathways of exposure were combined with toxicity data to develop estimates of individual chemical risk associated with air emissions from the ESSROC facility. Both noncarcinogenic and carcinogenic risks associated with exposure to chemicals of concern were evaluated. The noncarcinogenic risks were presented as comparisons of chemical intakes to oral and inhalation reference doses (Rfd) while the carcinogenic risks were presented as probabilities that individuals will develop cancer over a lifetime of exposure to the chemical.

The results of the characterization of noncarcinogenic risks for exposures to chemicals of concern in air, soil, surface water, fish, plant, and animal products for all populations and exposure scenarios evaluated indicates that for all pathways of exposure, with the exception of the fish ingestion pathway, the hazard index is at or below 0.010. These hazard indices are well below the 0.25 level used by U.S. EPA to ensure protection of human health from chemical emissions from combustion sources. The hazard quotient for exposure to methyl mercury via the fish ingestion pathway exceeds one. However, as described previously, the model used to estimate methyl mercury concentrations in fish is highly conservative and likely results in an overestimation of the actual risks associated with exposure to methyl mercury in fish.

The results of the characterization of carcinogenic risks indicates that, for the air, soil, animal products, and drinking water exposure pathways, the total high end carcinogenic risks for each of the pathways combined are at the 1×10^{-6} risk level. The carcinogenic risks for each of the individual pathways are below the 1×10^{-6} risk level.

It is noted that the risks presented and discussed in this report are representative conservative upper-bound risks and are not actual risks. The estimated risk level (for all pathways combined) of 1×10^{-6} associated with ESSROC emissions means that an individual would increase his or her probability of developing cancer in their lifetime by one in one million (0.000001), as a result of exposure to ESSROC emissions. However, the background probability of an individual developing cancer during his or her lifetime is one in three (0.333333). Therefore, the incremental probability of developing cancer in a lifetime as a result of exposure to ESSROC emissions is 0.333334. Clearly, the incremental lifetime cancer risk associated with exposure to ESSROC emissions is insignificant relative to an individual's background incidence of developing cancer.

11.0 REFERENCES

Air Pollution Characterization and Control, Ltd. 1999. RCRA Trial Burn for the Burning of Waste Derived Fuels for Energy Recovery at ESSROC Cement Corp. Logansport, Indiana March 1999.

Atkinson, D., and Lee, R.F. 1992. Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models. U.S. Environmental Protection Agency.

Auer, Jr., A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, 17(5): 636-643.

Bacci, E., M.J. Cerejeira, C. Gaggi, G. Chemello, D. Calamari, and M. Vighi. 1992. Chlorinated Dioxins: Volatilization from Soils and Bioconcentration in Plant Leaves. Bulletin of Environmental Contamination and Toxicology 48(3):401-408.

Baes, C.F., R.D. Sharp, A.L Sjoreen and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radio nuclides Through Agriculture. Prepared for the U.S. Department of Energy under contract No. DE-AC05-84OR21400.

Callaghan, M., M Slimak, N. Gabel, I. May, C. Fowler, R. Freed, P. Jennings, R. Durfee, F. Whitmore, B. Maestri, W. Mabey, B. Holt, and C. Gould. 1979. Water-Related Fate of 129 Priority Pollutants. U.S. Environmental Protection Agency, Monitoring and Data Support Division. Washington, D.C. EPA/440/4-79-029.

Cass County Plan Commission (CCPC). 1985. Comprehensive Plan for Cass County, Indiana. Portions Amended 1993.

Howard, Philip H. et al. 1991. Handbook of Environmental Degradation Rates, Lewis Publishers, Inc.

Indiana Agricultural Statistics Service (IASS), 1993. Indiana Agricultural Statistics 1992-93. Purdue University, West Lafayette, IN.

Indiana Board of Health, 1993. Population Statistics.

Irwin, J.S. 1978. Proposed Criteria for Selection of Urban Versus Rural Dispersion Coefficients. (Draft Staff Report). Meteorology and Assessment Division, U.S. Environmental Protection Agency, Research Triangle Park, NC. Docket No. A-80-46, II-B-8.

Logansport/Cass County Chamber of Commerce (LCCCC). 1993. Community Profile, Logansport/Cass County, Indiana.

Ryan, E.A., E.T. Hawkins, B. Magee, and S.L. Santos. 1987. Assessing Risk from Dermal Exposure at Hazardous Waste Sites. Superfund Proceedings of the Eighth National Conference, Washington, D.C., November 16-18.

SCI-TECH, Inc. 2000. Air Emissions from LWDF Facility and CKD Operations ESSROC Cement Corp. January 2000.

Stewart, James A, Charles R. Keeton, Brian L. Benedict, and Lowell E. Hammil. 1992. Water Resources Data, Indiana. Water Year 1992. U.S. Geological Survey Water-Data Report IN-92-1.

U.S. Department of Agriculture. 1981. Soil Survey of Cass County Indiana. Soil Conservation Service.

U.S. Environmental Protection Agency. 1989a. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C. 20460. EPA/540/1-89/002.

U.S. Environmental Protection Agency. 1990. Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/6-90/003. November 1993.

U.S. Environmental Protection Agency. 1991a. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual. Supplemental Guidance. Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03. March 25, 1991.

U.S. Environmental Protection Agency. 1992a. Estimating Exposure to Dioxin-Like Compounds. Draft Report. Office of Research and Development, Washington, D.C. EPA/600/6-88-005B

U.S. Environmental Protection Agency. 1993a. Addendum to Methodology for assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. External Review Draft. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/AP-93/003 November 1993.

U.S. Environmental Protection Agency. 1993b. Implementation of Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities. Draft. Internal Memorandum, September 24, 1993.

U.S. Environmental Protection Agency. 1994a. Revised Draft of Risk Assessment Implementation Guidance for Hazardous Waste Combustion Facilities . Internal Memorandum. May 5, 1994.

U.S. Environmental Protection Agency. 1994b. Integrated Exposure Uptake Biokinetic Model for Lead in Children. February 1994.

U.S. Environmental Protection Agency. 1995. PCRAMMET User's Guide. Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division, Research, Triangle Park, NC.

U.S. Environmental Protection Agency. 1997 Office of Air Quality Planning and Standards and Office of Research and Development. Mercury Study Report to Congress Volume III: Fate and Transport of Mercury in the Environment

U.S. Environmental Protection Agency. 1997a. Exposure Factors Handbook. Volumes I-III. EPA/600/P-95/002FC August 1997.

U.S. Environmental Protection Agency 1998a Peer Review Draft Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. EPA530-D-98-001C.

U.S. Environmental Protection Agency. 1998b. Guideline on Air Quality Models (Revised). Office of Air Quality Planning and Standards. EPA-450/2-78-027R.

U.S. Environmental Protection Agency. 1999. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models. Office of Air Quality Planning and Standards, Emissions, Monitoring, and Analysis Division, Research, Triangle Park, NC. EPA-454/B-95-003a.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses -- A Guide to Conservation Planning. USDA Handbook No. 537. U.S. Dept. of Agriculture, Washington, D.C.

Table A-1
Summary of Metals Emissions Data - 10/15/98 and 10/16/98
ESSROC

Chemical	Phase 2 Tests			Phase 3B			Average Emissions	
	Test 02-HM-04 10/15/98 g/s	Test 02-HM-05 10/15/99 g/s	Test 02-HM-06 10/15/98 g/s	Test 3B-HM-10 10/16/98 g/s	Test 3B-HM-11 10/16/98 g/s	Test 3B-HM-12 10/16/98 g/s	Phase 2 Average g/s	Phase 3B Average g/s
Inorganics								
Antimony	1.66E-04	1.01E-04	1.62E-04	1.02E-04	1.34E-04	1.37E-04	1.43E-04	1.24E-04
Arsenic	7.44E-05	1.59E-04	2.57E-04	6.47E-05	5.37E-05	6.72E-05	1.63E-04	6.19E-05
Barium	1.47E-03	1.37E-03	1.72E-03	1.04E-03	1.15E-03	2.09E-03	1.52E-03	1.43E-03
Beryllium	1.17E-05	6.41E-06	5.32E-06	1.49E-06	1.50E-06	1.52E-06	7.81E-06	1.50E-06
Cadmium	2.70E-03	1.67E-03	2.16E-03	1.07E-03	8.57E-04	1.14E-03	2.18E-03	1.02E-03
Chromium (VI)	3.46E-06	7.26E-06	1.08E-05	5.80E-06	5.36E-06	8.56E-06	7.17E-06	6.57E-06
Chromium, total	4.56E-04	2.81E-04	4.75E-04	2.88E-04	3.56E-04	3.51E-04	4.04E-04	3.32E-04
Lead	3.72E-02	2.62E-02	2.86E-02	1.50E-02	1.35E-02	1.89E-02	3.07E-02	1.58E-02
Mercury	2.38E-03	2.54E-03	4.33E-03	1.56E-03	1.21E-03	1.32E-03	3.08E-03	1.36E-03
Nickel	6.13E-04	1.83E-04	4.45E-04	2.37E-04	3.96E-04	3.35E-04	4.14E-04	3.23E-04
Selenium	8.13E-04	3.03E-04	4.86E-04	8.65E-04	7.28E-04	4.16E-04	5.34E-04	6.70E-04
Silver	8.72E-05	3.88E-05	1.13E-04	6.31E-05	4.32E-05	3.57E-05	7.97E-05	4.73E-05
Thallium	2.11E-04	1.96E-04	1.68E-04	9.30E-05	1.03E-04	2.27E-04	1.92E-04	1.41E-04

Table A-2
Summary of Volatile Organic Emissions - 10/13, 10,14, 10/17, and 10/18/98
ESSRC

Volatile Organic Compounds	Phase 1			Phase 3A			Average Emissions	
	Test 01-VO-01 10/13/98 g/s	Test 01-VO-02 10/13/98 g/s	Test 01-VO-03 10/14/98 g/s	Test 3A-VO-07 10/17/98 g/s	Test 3A-VO-08 10/17/98 g/s	Test 3A-VO-09 10/18/98 g/s	Phase 1 Average g/s	Phase 3A Average g/s
Acetone	5.32E-03	1.73E-02	3.20E-03	3.86E-03	3.30E-03	4.20E-05	8.61E-03	2.40E-03
Acrylonitrile	3.16E-03	1.70E-03	2.33E-03	3.99E-03	3.82E-03	4.84E-05	2.40E-03	2.62E-03
Allyl Chloride	7.19E-04	2.04E-04	1.84E-04	9.38E-04	8.97E-04	9.24E-06	3.69E-04	6.15E-04
Benzene	6.72E-03	5.56E-02	5.05E-02	6.73E-03	5.86E-03	4.57E-05	3.76E-02	4.21E-03
Bromodichloromethane	9.90E-06	5.75E-06	6.75E-06	7.75E-06	8.70E-06	1.14E-07	7.47E-06	5.52E-06
Bromomethane	7.18E-04	6.64E-04	5.93E-04	1.07E-03	8.45E-04	3.15E-05	6.58E-04	6.49E-04
Bromoform	1.89E-05	1.06E-05	1.21E-05	1.55E-05	1.61E-05	2.70E-07	1.38E-05	1.06E-05
1,3-Butadiene	4.66E-03	7.19E-03	8.87E-03	2.48E-02	2.01E-02	2.02E-04	6.91E-03	1.50E-02
2-Butanone	4.49E-04	1.43E-04	7.70E-05	3.23E-04	3.39E-04	3.25E-06	2.23E-04	2.22E-04
Carbon disulfide	2.42E-03	2.60E-03	2.89E-03	2.38E-03	1.58E-03	1.54E-05	2.64E-03	1.33E-03
Carbon tetrachloride	1.40E-04	1.67E-04	1.72E-04	1.07E-04	1.10E-04	9.20E-07	1.60E-04	7.26E-05
Chlorobenzene	1.85E-04	4.77E-04	7.61E-04	5.18E-04	5.92E-04	3.12E-06	4.74E-04	3.71E-04
Chloroethane	5.05E-05	2.00E-05	4.28E-04	1.19E-03	1.35E-03	2.75E-06	1.66E-04	8.48E-04
Chloroform	1.18E-04	1.56E-04	1.14E-04	4.04E-04	2.59E-04	3.45E-06	1.29E-04	2.22E-04
Chloromethane	7.03E-03	5.09E-03	1.29E-02	8.87E-03	6.03E-03	5.00E-05	8.34E-03	4.98E-03
Cumene (isopropylbenzene)	6.40E-06	3.36E-05	1.28E-05	8.40E-06	2.71E-06	1.24E-07	1.76E-05	3.74E-06
1,2-Dichloropropane	1.63E-05	9.45E-06	1.21E-05	1.29E-05	1.49E-05	2.05E-07	1.26E-05	9.34E-06
Dibromochloromethane	1.21E-05	6.40E-06	7.10E-06	1.00E-05	1.09E-05	1.47E-07	8.53E-06	7.00E-06
Dibromomethane	2.04E-05	1.24E-05	1.48E-05	1.63E-05	1.94E-05	2.62E-07	1.59E-05	1.20E-05
1,2-Dibromomethane	1.46E-05	9.10E-06	1.06E-05	1.21E-05	1.28E-05	1.92E-07	1.14E-05	8.36E-06
1,2-Dichlorobenzene	7.40E-06	1.67E-05	2.92E-05	3.84E-05	1.13E-05	1.37E-07	1.78E-05	1.66E-05
1,3-Dichlorobenzene	5.65E-05	6.75E-05	2.59E-05	3.66E-05	1.28E-05	1.24E-07	5.00E-05	1.65E-05
1,4-Dichlorobenzene	9.07E-05	9.81E-05	8.23E-05	9.35E-05	1.36E-05	1.25E-07	9.04E-05	3.57E-05
1,1-Dichloroethane	9.90E-06	6.40E-06	7.25E-06	9.35E-06	8.70E-06	1.02E-07	7.85E-06	6.05E-06

Table A-2

Summary of Volatile Organic Emissions - 10/13, 10,14, 10/17, and 10/18/98

ESSRC

Volatile Organic Compounds	Phase 1			Phase 3A			Average Emissions	
	Test 01-VO-01 10/13/98 g/s	Test 01-VO-02 10/13/98 g/s	Test 01-VO-03 10/14/98 g/s	Test 3A-VO-07 10/17/98 g/s	Test 3A-VO-08 10/17/98 g/s	Test 3A-VO-09 10/18/98 g/s	Phase 1 Average g/s	Phase 3A Average g/s
1,2-Dichloroethane	1.63E-05	9.60E-06	1.20E-05	1.29E-05	1.49E-05	1.88E-07	1.26E-05	9.33E-06
1,1-Dichloroethene	1.83E-05	1.04E-05	1.62E-05	1.58E-05	1.48E-05	1.92E-07	1.50E-05	1.02E-05
cis 1,2-Dichloroethene	1.83E-05	1.04E-05	1.06E-05	1.62E-05	1.51E-05	1.97E-07	1.31E-05	1.05E-05
trans 1,2-Dichloroethene	1.83E-05	1.04E-05	1.04E-05	1.44E-05	1.49E-05	1.75E-07	1.30E-05	9.81E-06
cis 1,3-Dichloropropene	9.90E-06	6.00E-06	7.00E-06	7.75E-06	1.03E-05	1.30E-07	7.63E-06	6.04E-06
trans 1,3-Dichloropropene	1.19E-05	7.60E-06	8.40E-06	9.35E-06	1.18E-05	1.47E-07	9.30E-06	7.08E-06
trans-1,4-Dichloro-2-butene	2.97E-05	1.40E-05	2.32E-05	5.23E-05	2.71E-05	4.00E-07	2.23E-05	2.66E-05
Dichlorodifluoromethane	2.80E-04	4.66E-05	6.35E-06	9.68E-05	1.23E-04	2.25E-06	1.11E-04	7.40E-05
Ethylbenzene	2.34E-04	4.19E-04	6.43E-04	6.15E-04	6.53E-04	4.64E-06	4.32E-04	4.24E-04
Methylene Chloride	1.82 E-2	7.98E-03	4.30E-03	1.04E-03	3.30E-03	1.48E-05	1.02E-02	1.45E-03
4-Methyl-2-Pentanone	2.37E-05	1.62E-05	1.91E-05	2.05E-05	2.32E-05	2.92E-07	1.97E-05	1.46E-05
n-Hexane	5.36E-04	3.19E-04	5.27E-04	4.12E-04	9.73E-04	3.98E-06	4.61E-04	4.63E-04
Styrene	6.89E-04	1.33E-03	1.96E-03	2.39E-03	2.57E-03	1.61E-05	1.33E-03	1.66E-03
1,1,2,2-Tetrachloroethane	1.92E-05	7.20E-06	1.56E-05	1.78E-05	1.78E-05	2.43E-07	1.40E-05	1.19E-05
Tetrachloroethylene	5.25E-05	8.85E-05	8.46E-05	1.05E-04	6.95E-05	4.27E-07	7.52E-05	5.83E-05
1,1,1-Trichloroethane	1.27E-04	1.22E-05	2.69E-05	2.60E-05	2.03E-05	2.23E-07	5.54E-05	1.55E-05
Trichloroethene	3.73E-05	3.40E-05	2.02E-05	3.20E-05	3.27E-05	3.70E-07	3.05E-05	2.17E-05
Trichlorofluoromethane	2.12E-04	1.10E-04	1.35E-04	7.58E-05	7.91E-05	8.16E-07	1.52E-04	5.19E-05
Toluene	7.47E-03	3.50E-02	1.51E-02	7.82E-03	9.16E-03	4.80E-05	1.92E-02	5.68E-03
Xylene (m/p)	4.90E-04	5.84E-04	5.24E-04	1.01E-03	9.89E-04	8.87E-06	5.33E-04	6.69E-04
o-Xylene	7.50E-05	1.99E-04	2.11E-04	3.98E-04	3.72E-04	3.42E-06	1.62E-04	2.58E-04
Vinyl acetate	1.69E-05	9.35E-06	9.80E-06	1.31E-05	2.65E-05	1.57E-07	1.20E-05	1.32E-05
Vinyl chloride	5.93E-04	6.53E-04	2.24E-03	9.25E-04	8.56E-04	1.20E-05	1.16E-03	5.98E-04

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Table A-3
Summary of Semi-Volatile Organic Emissions - 10/13, 10,14, 10/17, and 10/18/98
ESSRC

Semi-Volatile Compounds	Phase 1			Phase 3A			Average Emissions	
	Test 01-SV-01 10/13/98 g/s	Test 01-SV-02 10/13/98 g/s	Test 01-SV-03 10/14/98 g/s	Test 3A-SV-07 10/17/98 g/s	Test 3A-SV-08 10/17/98 g/s	Test 3A-SV-09 10/18/98 g/s	Phase 1 Average g/s	Phase 3A Average g/s
Acenaphthene	5.75E-05	3.92E-05	3.83E-05	2.44E-05	2.39E-05	2.57E-05	4.50E-05	2.47E-05
Acenaphthylene	3.12E-03	2.85E-03	4.27E-03	4.86E-04	5.31E-04	2.34E-04	3.41E-03	4.17E-04
Anthracene	1.95E-04	1.49E-04	2.90E-04	3.12E-05	3.87E-05	3.11E-05	2.11E-04	3.37E-05
Benzoic Acid	8.70E-04	1.08E-03	1.03E-03	5.35E-03	4.76E-03	3.33E-03	9.93E-04	4.48E-03
Benzo(a)pyrene	6.99E-05	6.83E-05	1.39E-04	1.19E-05	1.09E-05	1.25E-05	9.24E-05	1.17E-05
Benzo(a)anthracene	1.23E-04	7.95E-05	1.34E-04	1.11E-05	1.38E-05	1.20E-05	1.12E-04	1.23E-05
Benzo(b)fluoranthene	1.51E-04	1.13E-04	2.19E-04	1.31E-05	1.54E-05	8.95E-06	1.61E-04	1.25E-05
Benzo(k)fluoranthene	1.56E-05	3.58E-05	7.68E-05	1.18E-05	9.45E-06	1.24E-05	4.27E-05	1.12E-05
Benzo(g,h,i)perylene	4.05E-05	2.53E-05	3.77E-05	8.60E-06	1.80E-05	1.24E-05	3.45E-05	1.30E-05
Benzyl Alcohol	1.56E-04	1.03E-04	1.01E-04	6.50E-05	6.70E-05	7.10E-05	1.20E-04	6.77E-05
Bis(2-ethyl hexyl)phthalate	1.58E-02	1.02E-02	5.25E-03	3.90E-03	3.52E-03	3.87E-03	1.04E-02	3.76E-03
Butyl benzyl phthalate	2.16E-04	1.16E-04	8.03E-05	2.23E-05	2.50E-05	4.11E-05	1.37E-04	2.95E-05
4-Chloroaniline	8.20E-05	5.25E-05	5.15E-05	3.29E-05	3.25E-05	3.45E-05	6.20E-05	3.33E-05
2-Chloronaphthalene	3.58E-05	7.69E-05	3.54E-05	3.30E-05	3.06E-05	2.70E-05	4.94E-05	3.02E-05
4-Chloro-3-methylphenol	1.14E-04	7.45E-05	7.60E-05	5.05E-05	4.72E-05	4.99E-05	8.82E-05	4.92E-05
2-Chlorophenol	1.50E-04	2.03E-04	3.06E-04	2.52E-04	2.12E-04	1.78E-04	2.20E-04	2.14E-04
Chrysene	2.08E-04	1.52E-04	2.41E-04	2.27E-05	2.74E-05	2.33E-05	2.00E-04	2.45E-05
Dibenz(a,h)anthracene	3.87E-05	2.59E-05	2.64E-05	1.21E-05	1.12E-05	1.30E-05	3.03E-05	1.21E-05
Dibenzofuran	1.14E-03	1.25E-03	1.30E-03	1.11E-03	9.68E-04	7.98E-04	1.23E-03	9.59E-04
1,2-dichlorobenzene	1.01E-04	6.60E-05	6.50E-05	4.78E-05	4.91E-05	4.49E-05	7.72E-05	4.73E-05
1,3-dichlorobenzene	9.45E-05	6.20E-05	6.10E-05	4.97E-05	4.94E-05	4.25E-05	7.25E-05	4.72E-05
1,4-dichlorobenzene	5.24E-04	3.11E-04	5.11E-04	2.07E-04	2.69E-04	7.96E-04	4.49E-04	4.24E-04
3,3-Dichlorobenzidine	1.00E-04	6.90E-05	6.95E-05	3.46E-05	3.30E-05	3.83E-05	7.95E-05	3.53E-05
Dimethylphthalate	4.51E-05	3.06E-05	3.01E-05	1.96E-05	1.93E-05	2.06E-05	3.53E-05	1.98E-05

Table A-3

Summary of Semi-Volatile Organic Emissions - 10/13, 10,14, 10/17, and 10/18/98

ESSRC

Semi-Volatile Compounds	Phase 1			Phase 3A			Average Emissions	
	Test 01-SV-01 10/13/98 g/s	Test 01-SV-02 10/13/98 g/s	Test 01-SV-03 10/14/98 g/s	Test 3A-SV-07 10/17/98 g/s	Test 3A-SV-08 10/17/98 g/s	Test 3A-SV-09 10/18/98 g/s	Phase 1 Average g/s	Phase 3A Average g/s
Diethyl phthalate	3.38E-04	8.70E-05	6.08E-05	2.26E-05	2.55E-05	2.72E-05	1.62E-04	2.51E-05
2,4-Dimethylphenol	1.03E-04	6.60E-05	6.45E-05	4.24E-05	4.26E-05	4.49E-05	7.78E-05	4.33E-05
Di-n-butylphthalate	1.82E-04	7.00E-05	9.25E-05	7.99E-05	5.11E-05	5.91E-05	1.15E-04	6.34E-05
Di-n-octyl phthalate	1.48E-04	7.21E-05	6.04E-05	8.10E-06	2.34E-05	2.42E-05	9.35E-05	1.86E-05
4,6-Dinitro-2-methylphenol	2.75E-04	1.75E-04	1.73E-04	1.14E-04	1.02E-04	1.17E-04	2.08E-04	1.11E-04
2,4-Dinitrophenol	3.60E-04	2.43E-04	2.40E-04	1.62E-04	1.57E-04	1.67E-04	2.81E-04	1.62E-04
2,4-Dinitrotoluene	1.69E-04	1.15E-04	1.13E-04	7.00E-05	6.90E-05	7.45E-05	1.32E-04	7.12E-05
2,6-Dinitrotoluene	2.16E-04	1.46E-04	1.44E-04	9.40E-05	9.25E-05	9.90E-05	1.68E-04	9.52E-05
Fluoranthene	1.97E-03	1.64E-03	2.11E-03	2.54E-04	3.22E-04	1.22E-04	1.91E-03	2.33E-04
Fluorene	2.63E-04	2.43E-04	1.52E-04	4.68E-05	4.58E-05	3.69E-05	2.19E-04	4.31E-05
Hexachlorobenzene	1.45E-04	9.20E-05	9.10E-05	6.50E-05	5.90E-05	6.70E-05	1.09E-04	6.37E-05
Hexachlorobutadiene	1.76E-04	1.12E-04	1.10E-04	7.95E-05	7.95E-05	8.30E-05	1.33E-04	8.07E-05
Hexachlorocyclopentadiene	1.59E-04	1.08E-04	1.06E-04	7.10E-05	7.15E-05	7.60E-05	1.24E-04	7.28E-05
Hexachloroethane	1.82E-04	1.20E-04	1.18E-04	7.75E-05	8.00E-05	8.40E-05	1.40E-04	8.05E-05
Indeno(1,2,3-cd)pyrene	3.51E-05	2.84E-05	5.70E-05	1.02E-05	1.66E-05	2.18E-05	4.02E-05	1.62E-05
2-Methylphenol	3.06E-04	2.77E-04	2.87E-04	3.05E-04	2.42E-04	2.37E-04	2.90E-04	2.61E-04
4-Methylphenol	3.61E-04	3.13E-04	3.32E-04	4.20E-04	3.43E-04	3.29E-04	3.35E-04	3.64E-04
2-Methylnaphthalene	4.20E-04	3.64E-04	4.09E-04	4.47E-04	4.57E-04	5.19E-04	3.98E-04	4.74E-04
Naphthalene	1.95E-02	1.65E-02	1.99E-02	5.36E-03	5.87E-03	3.40E-03	1.86E-02	4.88E-03
2-Nitroaniline	1.86E-04	1.27E-04	1.24E-04	7.90E-05	7.80E-05	8.40E-05	1.46E-04	8.03E-05
Nitrobenzene	1.04E-04	6.70E-05	6.55E-05	4.22E-05	4.22E-05	4.48E-05	7.88E-05	4.30E-05
n-Nitrosodiphenylamine	7.40E-05	4.72E-05	4.66E-05	3.14E-05	2.83E-05	3.24E-05	5.59E-05	3.07E-05
n-Nitroso-di-n-propylamine	1.52E-04	1.00E-04	9.80E-05	6.10E-05	6.30E-05	6.65E-05	1.17E-04	6.35E-05
2,2-oxybis(1-Chloropropane)	9.35E-05	6.15E-05	6.05E-05	3.97E-05	4.08E-05	4.31E-05	7.18E-05	4.12E-05

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Table A-3
Summary of Semi-Volatile Organic Emissions - 10/13, 10,14, 10/17, and 10/18/98
ESSRC

Semi-Volatile Compounds	Phase 1			Phase 3A			Average Emissions	
	Test 01-SV-01 10/13/98 g/s	Test 01-SV-02 10/13/98 g/s	Test 01-SV-03 10/14/98 g/s	Test 3A-SV-07 10/17/98 g/s	Test 3A-SV-08 10/17/98 g/s	Test 3A-SV-09 10/18/98 g/s	Phase 1 Average g/s	Phase 3A Average g/s
Pentachlorophenol	2.19E-04	1.39E-04	1.38E-04	9.20E-05	8.40E-05	9.60E-05	1.65E-04	9.07E-05
Phenanthrene	3.76E-03	2.90E-03	4.01E-03	7.36E-04	9.37E-04	5.18E-04	3.56E-03	7.30E-04
Phenol	5.01E-03	3.96E-03	5.57E-03	3.25E-03	2.35E-03	1.76E-03	4.85E-03	2.45E-03
Pyrene	9.05E-04	28.50	1.09E-03	1.63E-04	1.99E-04	3.83E-05	2.00E-03	1.33E-04
1,2,4-Trichlorobenzene	1.10E-04	7.00E-05	6.85E-05	5.25E-05	5.50E-05	5.10E-05	8.27E-05	5.28E-05
2,4,5-Trichlorophenol	1.45E-04	9.80E-05	9.65E-05	6.50E-05	6.20E-05	6.85E-05	1.13E-04	6.52E-05
2,4,6-Trichlorophenol	1.46E-04	9.90E-05	6.60E-05	1.16E-04	9.05E-05	1.29E-04	1.04E-04	1.12E-04

Table A-4
Dioxin and PCB Emission Summary
ESSROC

	Phase 1			Phase 2			Average Emissions	
Dioxins/Furans	Test 01-SV-01 10/13/98 g/s	Test 01-SV-02 10/13/98 g/s	Test 01-SV-03 10/14/98 g/s	Test 02-DF-04 10/13/98 g/s	Test 02-DF-05 10/13/98 g/s	Test 02-DF-06 10/14/98 g/s	Dioxins Phase 1& Phase 2 g/s	PCBs Phase 1 g/s
2,3,7,8-TCDD (equivalent)	2.60E-08	2.74E-08	2.38E-08	1.62E-08	5.06E-08	9.71E-08	4.02E-08	
2,3,7,8-TCDD	1.34E-09	8.98E-10	9.42E-10	6.95E-10	1.28E-09	1.82E-09	1.16E-09	
2,3,7,8-PeCDD	4.10E-09	4.13E-09	5.72E-09	2.09E-09	3.36E-09	5.21E-09	4.10E-09	
2,3,7,8-HxCDD	1.97E-08	2.63E-08	4.61E-08	1.49E-08	2.52E-08	5.04E-08	3.04E-08	
2,3,7,8-HpCDD	6.37E-08	6.53E-08	1.11E-07	4.40E-08	8.75E-08	1.56E-07	8.79E-08	
OCDD	5.94E-08	3.90E-08	4.60E-08	3.48E-08	4.21E-08	5.23E-08	4.56E-08	
2,3,7,8-TCDF	2.97E-08	2.15E-08	1.24E-08	1.34E-08	5.47E-08	8.17E-08	3.56E-08	
1,2,3,7,8-PeCDF	1.73E-08	1.28E-08	1.24E-08	5.39E-09	3.08E-08	4.87E-08	2.12E-08	
2,3,4,7,8-PeCDF	2.33E-08	2.56E-08	2.29E-08	1.11E-08	4.31E-08	8.74E-08	3.56E-08	
2,3,7,8-HxCDF	4.16E-08	5.23E-08	4.27E-08	2.29E-08	6.25E-08	1.38E-07	6.00E-08	
2,3,7,8-HpCDF	2.53E-08	2.75E-08	1.61E-08	1.09E-08	1.91E-08	3.09E-08	2.16E-08	
OCDF	8.35E-09	6.05E-09	7.07E-09	3.30E-09	4.60E-09	6.95E-09	6.05E-09	
Total 2,3,7,8 PCDD/PCDF	2.94E-07	2.81E-07	3.32E-07	1.64E-07	3.74E-07	9.71E-08	2.57E-07	
Polychlorinated Biphenyls								
3,3'-Tetra CB	5.12E-09	3.32E-09	3.26E-09					3.90E-09
2,3,4,4,'5-Penta CB	1.32E-08	1.06E-08	1.17E-08					1.18E-08
2,3',4,4',5-Penta CB	1.14E-08	1.34E-08	1.31E-08					1.26E-08
2',3,3',4,4'-Penta CB	8.20E-10	3.79E-10	2.61E-10					4.87E-10
2,3,3',4,4'-Penta CB	1.93E-09	2.85E-09	1.56E-09					2.11E-09
3,3',4,4',5-Penta CB	8.25E-10	4.02E-10	3.76E-10					5.34E-10
2,3',4,4',5,5'-Hexa CB	7.56E-09	6.44E-09	6.67E-09					6.89E-09
2,3,3'4,4',5-Hexa CB	1.41E-08	1.07E-08	1.66E-08					1.38E-08
2,3,3',4,4',5'_Hexa CB	1.15E-08	6.50E-10	5.20E-10					4.22E-09

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Table A-4
Dioxin and PCB Emission Summary
ESSROC

Dioxins/Furans	Phase 1			Phase 2			Average Emissions	
	Test 01-SV-01 10/13/98 g/s	Test 01-SV-02 10/13/98 g/s	Test 01-SV-03 10/14/98 g/s	Test 02-DF-04 10/13/98 g/s	Test 02-DF-05 10/13/98 g/s	Test 02-DF-06 10/14/98 g/s	Dioxins Phase 1& Phase 2 g/s	PCBs Phase 1 g/s
3.3',4,4',5,5'-Hexa CB	2.85E-09	1.87E-10	2.66E-10					1.10E-09
2,2',3,4,4',5,5'-Hepta CB	3.77E-07	3.48E-07	3.51E-07					3.59E-07
2,2'3,3'4,4',5-Hepta CB	1.56E-07	1.49E-07	7.70E-07					3.58E-07
2,3,3',4,4',5,5'-Hepta CB	2.06E-09	1.26E-09	1.23E-09					1.52E-09
Total Mono CB	5.41E-07	4.39E-07	4.81E-07					4.87E-07
Total Di CB	3.88E-07	3.49E-07	3.04E-07					3.47E-07
Total Tri CB	6.26E-07	3.55E-07	3.61E-07					4.47E-07
Total Tetra CB	3.10E-07	3.49E-07	3.30E-07					3.30E-07
Total Penta CB	2.99E-07	3.07E-07	3.25E-07					3.10E-07
Total Hex CB	8.75E-07	1.18E-06	1.29E-06					1.12E-06
Total Hepta CB	1.90E-06	1.64E-06	1.63E-06					1.72E-06
Total Octa CB	3.53E-07	4.20E-07	4.00E-07					3.91E-07
Total Nona CB	1.20E-08	2.42E-08	2.33E-08					1.98E-08
Deca CB	8.40E-09	5.45E-10	9.30E-10					3.29E-09

Table A-4
Dioxin and PCB Emission Summary
ESSROC

Dioxins/Furans	Phase 3A			Phase 3B			Average Emissions	
	Test 3A-SV-07 10/17/98 g/s	Test 3A-SV-08 10/17/98 g/s	Test 3A-SV-09 10/18/98 g/s	Test 3B-DF-10 10/16/98 g/s	Test 3B-DF-11 10/16/98 g/s	Test 3B-DF-12 10/16/98 g/s	PCBs Phase 3A g/s	Dioxins Phase 3A Phase 3B g/s
2,3,7,8-TCDD (equivalent)	2.75E-08	3.06E-08	4.59E-08	2.61E-08	2.84E-08	4.29E-08		3.36E-08
2,3,7,8-TCDD	5.27E-10	8.78E-10	7.76E-10	7.81E-10	9.17E-10	9.63E-10		8.07E-10
2,3,7,8-PeCDD	3.57E-09	4.06E-09	7.95E-09	2.61E-09	1.99E-09	2.31E-09		3.75E-09
2,3,7,8-HxCDD	2.72E-08	3.59E-08	6.84E-08	2.11E-08	1.82E-08	2.74E-08		3.30E-08
2,3,7,8-HpCDD	1.12E-07	1.36E-07	2.87E-07	5.25E-08	6.14E-08	1.29E-07		1.30E-07
OCDD	3.70E-08	4.29E-08	7.09E-08	3.67E-08	5.53E-08	5.05E-08		4.89E-08
2,3,7,8-TCDF	2.77E-08	3.23E-08	3.71E-08	2.85E-08	3.30E-08	4.12E-08		3.33E-08
1,2,3,7,8-PeCDF	1.24E-08	1.37E-08	1.24E-08	1.14E-08	1.42E-08	2.32E-08		1.46E-08
2,3,4,7,8-PeCDF	2.90E-08	2.99E-08	4.20E-08	2.68E-08	2.97E-08	4.47E-08		3.37E-08
2,3,7,8-HxCDF	3.30E-08	3.65E-08	5.85E-08	4.38E-08	4.90E-08	8.74E-08		5.14E-08
2,3,7,8-HpCDF	1.08E-08	1.23E-08	1.50E-08	1.92E-08	1.95E-08	2.93E-08		1.77E-08
OCDF	4.14E-09	5.07E-09	3.94E-09	5.15E-09	5.15E-09	7.49E-09		5.16E-09
Total 2,3,7,8 PCDD/PCDF	2.98E-07	3.49E-07	6.04E-07	2.49E-07	2.88E-07	4.44E-07		3.72E-07
Polychlorinated Biphenyls								
3,3'-Tetra CB	7.52E-09	6.18E-09	8.63E-09				7.44E-09	
2,3,4,4,'5-Penta CB	3.75E-08	2.91E-08	3.92E-08				3.53E-08	
2,3',4,4',5-Penta CB	4.44E-08	3.20E-08	4.79E-08				4.14E-08	
2',3,3',4,4'-Penta CB	2.51E-10	1.04E-08	1.42E-09				4.02E-09	
2,3,3',4,4'-Penta CB	9.88E-09	7.92E-09	1.16E-08				9.80E-09	
3,3',4,4',5-Penta CB	8.80E-10	1.05E-09	1.42E-09				1.12E-09	
2,3',4,4',5,5'-Hexa CB	1.69E-08	1.25E-08	1.71E-08				1.55E-08	
2,3,3'4,4',5-Hexa CB	2.44E-08	1.86E-08	3.39E-08				2.56E-08	
2,3,3',4,4',5'_Hexa CB	1.19E-09	2.31E-08	3.08E-09				9.12E-09	

Table A-4
Dioxin and PCB Emission Summary
ESSROC

Dioxins/Furans	Phase 3A			Phase 3B			Average Emissions	
	Test 3A-SV-07 10/17/98 g/s	Test 3A-SV-08 10/17/98 g/s	Test 3A-SV-09 10/18/98 g/s	Test 3B-DF-10 10/16/98 g/s	Test 3B-DF-11 10/16/98 g/s	Test 3B-DF-12 10/16/98 g/s	PCBs Phase 3A g/s	Dioxins Phase 3A Phase 3B g/s
3.3',4,4',5,5'-Hexa CB	5.65E-10	7.40E-10	1.36E-09				8.88E-10	
2,2',3,4,4',5,5'-Hepta CB	8.52E-07	6.13E-07	8.51E-07				7.72E-07	
2,2'3,3'4,4',5-Hepta CB	3.48E-07	2.56E-07	3.48E-07				3.17E-07	
2,3,3',4,4',5,5'-Hepta CB	4.24E-09	3.83E-09	4.68E-09				4.25E-09	
Total Mono CB	8.77E-07	9.23E-07	8.65E-07				8.88E-07	
Total Di CB	7.89E-07	6.80E-07	8.84E-07				7.84E-07	
Total Tri CB	8.33E-07	5.98E-07	7.11E-07				7.14E-07	
Total Tetra CB	9.57E-07	8.16E-07	1.13E-06				9.68E-07	
Total Penta CB	1.07E-06	9.47E-07	1.08E-06				1.03E-06	
Total Hex CB	3.48E-06	2.75E-06	3.43E-06				3.22E-06	
Total Hepta CB	4.20E-06	3.06E-06	4.23E-06				3.83E-06	
Total Octa CB	1.02E-06	7.80E-07	9.19E-07				9.06E-07	
Total Nona CB	6.02E-08	4.64E-08	6.35E-08				5.67E-08	
Deca CB	2.70E-09	3.09E-09	2.90E-09				2.90E-09	