Risk Assessment for Lead Emissions of the Wolverine Clean Energy Venture (WCEV) (permit app. # 317-07)

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Summary

Lead is recognized as a potent developmental toxicant in children. Air emission sources of lead often raise concerns for potential exposure via direct inhalation, as well as depositional impacts and subsequent indirect exposure pathways (e.g., soil, indoor dust). The Wolverine Clean Energy Venture (WCEV) proposed facility was modeled to have ambient air lead impacts which are far below the National Ambient Air Quality Standard for lead. Nevertheless, the general concerns frequently raised for lead emissions, and the quantity of emissions (683 lb/yr) suggested that it would be prudent to evaluate the potential exposure (indirect and direct) utilizing the U.S. EPA's Integrated Exposure Uptake Biokinetic (IEUBK) lead model (EPA, 2006, 2008).

The lead emission rate was assumed to be equal to the maximum (proposed) permitted rate, and the deposition impacts were estimated for an accumulated impact of 30 years at areas most highly impacted which may be residential. Assuming this level of incremental soil impact, and with assumed continuing air emissions and ambient air impacts, childhood exposure (blood lead level) was modeled. Residential scenarios with and without the facility's impact, and with and without lead-based paint in the home, were evaluated.

The impact of the WCEV facility lead emissions on the ambient (outdoor) air level was determined to be 0.0001 micrograms per cubic meter (ug/m^3). This may be compared to the estimated background level of 0.00318 ug/m^3, and to the National Ambient Air Quality Standard (NAAQS) of 1.5 ug/m^3. The deposition (fallout) of lead from the ambient air to the topsoil, with 30 years of facility emissions and accumulation, was modeled to be 0.017 milligrams per kilogram (mg/kg). This may be compared to the estimated background topsoil lead concentration of 21 mg/kg.

The results of the IEUBK model indicate that the presence of lead-based paint can have a substantial effect on the average blood lead level (BLL) and on the percent of children with BLLs above levels of concern (5 or 10 micrograms per deciliter (ug/dL)). The small incremental impact of the WCEV lead emissions on air and soil lead levels did not have an effect on the average BLL detectable by the model, whether or not lead paint was assumed to be present in homes. The model also did not detect any change in the percentage of children with BLLs above 10 ug/dL due to the facility emissions. The model detected a slight increase in the percentage of children exceeding 5 ug/dL due to the facility's emissions, in the absence of lead paint (an increase from 0.996% to 0.997%) and in the presence of lead paint (an increase from 10.976% to 10.977%). For each of those situations (with or without lead paint), the increase in the percentage of children exceeding 5 ug/dL due to the facility emissions was 0.001%. In other words, if 100,000 children were in the maximum impact residential scenario modeled, an additional one child would be estimated to exceed 5 ug/dL due to the facility emission impacts.

BLL impacts can be interpreted by referring to published relationships between BLL and neurological development impacts (IQ deficits). Those relationships may be summarized as follows. In the BLL range of 1 to 10 ug/dL, the IQ impact for every 1 ug/dL increase in concurrent BLL has been estimated to be -0.4 to -1.8 per ug/dL. The IQ impact per ug/dL BLL increase may be relatively greater at lower BLLs; a value of -2.94 IQ deficit per ug/dL BLL increase has been estimated. Based on these relationships, and the modeled incremental impacts of the facility's lead emissions on BLLs, it may be reasonably concluded that the facility lead emissions would have a minimal effect on children's exposure and would not have any significant impact on children's neurological development.

Methodology

1. The IEUBK Model: an Overview

The Integrated Exposure Uptake Biokinetic (IEUBK) model was developed by the U.S. EPA (2006, 2008). The model accounts for the exposure of children to lead in their environment. This includes the lead which is normally present, at some level, in air, soil, indoor dust, drinking water, and food. The model also accounts for the variability that may be expected in a group of children, in terms of their activities, behaviors, and metabolism, which affect their exposure, intake, and blood levels of lead. Based on those factors, the model provides an estimate of the blood lead levels (BLLs) that may be associated with specific environmental exposure scenarios. The model user provides input information on the levels of lead in the environment, and the model provides estimates of the BLLs for a hypothetical population of children for that exposure scenario. For the present exercise, the model can estimate children's BLLs reflecting the "background" situation without the facility's impacts, and with the added environmental impacts from the facility's emissions. This comparison indicates if the facility's impacts may significantly increase children's lead intakes, and therefore provides a basis for judging if the impacts may be harmful to children's health.

2. Emission rate

The applicant (10/26/07 update to Table 5-21) provided a CFB Boiler lead emission rate of 1.3E-05 lb/MMBtu, annual average. That emission rate is a draft permitted emission limit. The heat input is 3030 MMBtu/hr/boiler (Table 3-1 of application), for 2 boilers. Operation is assumed for 8760 hr/yr operation. The maximum permitted emission rate modeled for each boiler was 0.0049139 grams per second (g/s) (0.039 lb/hr). Therefore, the total modeled emission rate is **683 lb/year**. That emission rate was used for impact modeling.

3. Modeled ambient air impacts

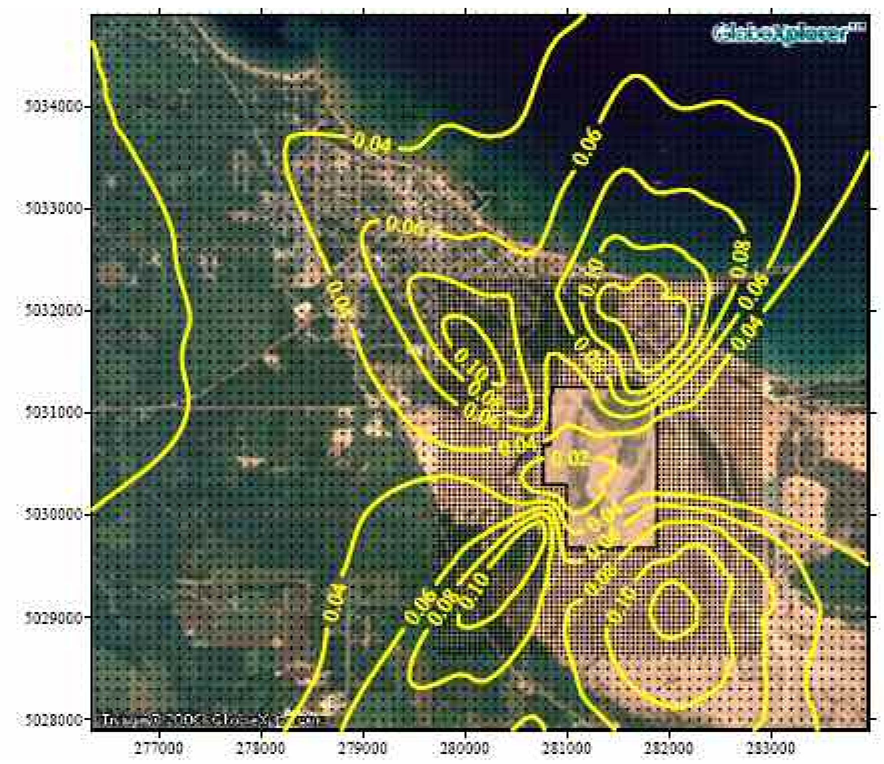
The applicant provided (Appendix 31) modeled ambient air impacts for the maximum impacted location. These impacts were adjusted by the reviewers based on the updated lead emission rate noted above ((1.3E-05)/(1.12E-04) = 0.116 adjustment factor). The averaging time is annual, because the appropriate IEUBK model input is the long-term ambient air impact. The maximum modeled impact and NAAQS standard for comparison are in Table 1.

Table 1. Modeled maximum ambient air impact and NAAQS standard.

Maximum receptor impact of WCEV emissions (ug/m^3, annual average)	Current NAAQS (ug/m^3, quarterly average)	EPA (11/1/07) Staff Paper: recommended consideration of revised NAAQS (monthly, or quarterly, average)
0.0001 (2005 met. data)	1.5	0.1-0.2 ug/m^3 (current urban levels); 0.02-0.05 ug/m^3 (lowest levels evaluated in risk assessment)

A plot of the modeled ambient air impacts by AQD (Figure 1, in nanograms per cubic meter (ng/m^3)) indicates that there are residential or potentially residential areas near the facility with a maximum impact of approximately 0.10 ng/m^3 (**0.0001 ug/m^3)** (Haywood, personal communication). This value was utilized for the IEUBK model. It was not considered necessary to further refine this assessment by modeling exact coordinates and modeled ambient air impacts.

Figure 1. Lead ambient air impact isopleth plot (ng/m^3, 2005 meteorology).



4. Modeled deposition impacts

The deposition of the lead emissions was modeled by AQD using the AERMOD model and meteorological data for 2005 and 2006. Total deposition (wet and dry deposition processes) was determined. Relatively greater impacts were found for 2005. The Rogers City area generally had deposition rates of 10-15 micrograms per cubic meter per year (ug/m^2-yr). The most impacted areas which may be residential to the SW and north of the facility had approximately **17 ug/m^2-yr** (Figure 2) (Haywood, personal communication). That value was utilized for estimating the cumulative soil deposition impact for the residential exposure scenario of the IEUBK model.

Figure 2. Lead deposition impact isopleth plot (ug/m^2-yr, 2005 meteorology).

5. Estimated topsoil impact

The incremental topsoil impact in milligrams per kilogram (mg/kg) is estimated from the deposition rate, based on key assumptions utilized for multipathway risk assessment, as provided by USEPA (HHRAP guidance, 2005). Those key assumptions include an assumed operating life of 30 years, an untilled topsoil mixing depth of 2 cm, and a soil bulk density of 1.5 grams per cubic centimeter (g/cm^3). The calculation of the incremental topsoil lead impact is as follows:

topsoil loading = (17 ug/m^2-yr)(30 yrs)(mg/1000 ug)(m^2/10,000cm^2) = 5.1E-05 mg/cm^2

incremental topsoil conc. = (5.1E-05 mg/cm^2)(cm^3/1.5 g)(1/2 cm)(1000g/kg) = **0.017 mg/kg**

6. Background topsoil lead concentration

Review of the MDEQ-WHMD data for topsoil lead data in statewide background topsoil samples and urban park samples indicates a lack of data for the Rogers City area. Therefore, the assumed value is **21 mg/kg**, which is the MDEQ-RRD statewide default background topsoil level, based on the statewide topsoil mean + one standard deviation (SD). This is consistent with the available data from the Michigan background soil survey: the Michigan Glacial Lobe mean = 7.4; mean + 1 SD = 13.7; mean + 2 SD = 24.8 mg/kg; the northern lower peninsula counties mean = 3.3; mean + 1 SD = 9.6; mean + 2 SD = 29.6 mg/kg (Slayton, personal communication).

7. Background ambient air lead concentration

Recent background ambient air monitoring data for lead are not available for Rogers City, Presque Isle County, or adjacent counties. Annual air quality reports for the most recent three years (MDEQ, 2004-2006) indicate that ambient air lead monitoring data are available for individual locations in Houghton Lake, Flint, Grand Rapids, and Ypsilanti, and for several locations in the Detroit area. The Houghton Lake monitor (actually located west of Houghton Lake, in Missaukee County) is geographically the closest to the area of interest, and, may be assumed to provide ambient air lead levels which are more representative for the area of interest than would the monitors near the large urban areas. Therefore, the Houghton Lake monitoring data were chosen as the most appropriate. The Houghton Lake data (which are presented as quarterly mean values in the reference reports) are summarized in Table 2.

Table 2. Ambient air lead monitoring data for Houghton Lake, 2004-2006.

Year	**Lowest quarter (ug/m^3)**	**Highest quarter (ug/m^3)**	**Arithmetic average of all calendar quarters (ug/m^3)**
2004	0.00226	0.00325	0.00274
2005	0.00270	0.00562	0.00375
2006	0.00238	0.00377	0.00304
Average of all annual averages	-	-	**0.00318**

The value utilized in the model for the background ambient air lead concentration was **0.00318 ug/m^3**.

8. Background drinking water lead concentration

The most representative data are for the Rogers City municipal drinking water system. The most recent data (9/14/07) provide an average lead concentration of 3.8 micrograms per liter (ug/l) (ppb) in tap water. The 90th percentile for the 20 samples was 10 ug/l. The previous sampling (September, 2004) provided an average of 1.4 ug/l with a 90th percentile level (20 samples) of 4 ug/l. Although future changes in the well water sources and chlorine treatment may be anticipated for this system, the most recent data cited above are the most representative data for the current and near-future conditions (Renken, personal communication). The value chosen for IEUBK modeling was **3.8 ug/l**, based on the average level from the most recent sampling.

9. Indoor dust lead concentration

The concentration of lead in indoor dust is affected by the ambient (outdoor) air lead concentration, and by the topsoil lead concentration. It is also impacted by the presence of indoor house paint containing lead. Information is not available on the potential presence of lead house paint in the area of interest. However, it may be assumed that existing housing may or may not have lead house paint, and that potential future housing would not have lead house paint. In order to account for these possible situations, modeling was performed under both assumptions: that lead house paint is not present, and that lead house paint is present and is in good condition. EPA guidance (1990, 1991) indicates that lead levels in indoor dust of homes with lead paint can be 2000 micrograms per gram (ug/g), however, the IEUBK model default is 200 ug/g (EPA, 2006, 2008, 1994) which is considered a reasonable assumption if lead house paint is present and is in good condition. Therefore, the present assessment includes scenarios without lead based paint (where the indoor dust lead level is affected only by the ambient air and soil lead levels) and with an assumed indoor dust lead level of 200 ug/g due to the presence of lead paint.

Table 3 indicates the indoor dust lead levels for the modeling scenarios, including the “background” situations with and without lead house paint present, and also with and without the incremental impact of the facility’s emissions on the indoor dust lead level via air lead deposition in the home and from track-in of topsoil. The impact of soil and ambient air lead on indoor dust lead levels is calculated by the IEUBK model via the Multiple Source Analysis function (EPA, 2006, 2008).

Table 3. Soil, indoor dust and air lead levels utilized in IEUBK modeling.

Medium / Scenario	**Background**	**Incremental facility impact**	**Model input (background + facility impact)**
topsoil lead (mg/kg)	**21**	0.017	**21.017**
Indoor dust lead (no lead paint; tracked soil) (mg/kg)[1]	**15.018[1]**	0.0219[1]	**15.0399[1]**
Indoor dust lead (lead paint; tracked soil) (mg/kg)	**200**	None assumed, because dust lead is high due to lead paint	**200**
Air lead conc. (ug/m^3)	**0.00318**	0.0001	**0.00328**

[1] Indoor dust lead calculated by the IEUBK model (Multiple Source Analysis): (0.70 X topsoil lead conc.) + (air lead contribution at rate of 100 mg/kg per 1 ug/m^3 air lead).

10. Lead Effects, Action Level, Dose-Response, and IEUBK “Cutoff” Level

Lead exposure can result in multiple adverse health effects, with neurological effects in children and cardiovascular effects in adults appearing to be of greatest public health concern (EPA, 2007). Neurological effects in children: appear to be at least as sensitive as effects in adults; pose a high public health significance; appear to be irreversible; can occur over a relatively shorter time frame; and, can be heightened by certain childhood behaviors which increase exposure. Therefore, for environmental health risk assessments of ambient air lead exposure, the consensus health endpoint of focus is developmental neurotoxicity of children, particularly IQ decrement (EPA, 2007). Although the adverse developmental effects of lead exposure are believed to encompass a variety of endpoints, the effects on IQ are generally regarded as being one of the most significant. The blood lead level (BLL) is extensively used as the index or biomarker of exposure.

The Action Level established by the Centers for Disease Control is a BLL of 10 ug/dL (CDC, 1991). This has been a benchmark conventionally utilized in IEUBK modeling by MDEQ and EPA (2008, 2002), for characterizing the significance of incremental impacts of facility emissions on children’s exposures. This value does not represent a “safe” level. There is no demonstrated threshold below which lead is known to be safe for development. The CDC (1991) regards BLLs below 10 ug/dL as not lead poisoned. However, children with blood lead levels of 5 to 10 ug/dL are at notable risk (EPA, 2007). Some analyses appear to show lead effects on intellectual attainment in young children with blood lead levels ranging from 2 to 8 ug/dL (EPA, 2007).

The Lead Panel of the EPA Clean Air Scientific Advisory Committee (CASAC, 2007) noted that IQ decrements of 1-2 IQ points or more would be of great concern, as EPA considers the level of health protection of potential NAAQS revisions. They advised EPA staff to investigate alternative NAAQS levels around this level, including much lower levels, to provide guidance as to how alternative standards would lead to changes in health. They provided the example that, if a 0.1 ug/m^3 standard would lead to a decrease in IQ of one point or less for 95% of the children in the U.S., then staff should assess other levels of the standard near 0.1 ug/m^3, both above and below, as well as much lower levels. The Panel found that epidemiologic data indicate that the slope of the dose-response line below 7.5 ug/dL is approximately minus three (-3) IQ decrements per 1 ug/dL blood lead. On a population level, they advised that the mean blood lead level from airborne lead would generally be up to, but not exceeding, 7.5 ug/dL; this approach should also account for sensitive subpopulations of children.

EPA (2007) based their quantitative risk assessment on a pooled analysis that estimated a decline of 6.2 IQ points (with 95% confidence interval of 3.8 to 8.6 IQ points) in full scale IQ occurring between approximately 1 and 10 ug/dL BLL, measured concurrent with the IQ test (Lanphear et al., 2005). On a change in IQ per ug/dL basis, estimates of IQ decrement associated with BLLs below 10 ug/dL range from -0.4 to -1.8 per ug/dL (EPA, 2007). For a smaller subset of children with peak BLLs < 7.5 ug/dL, the slope of the concurrent BLL and IQ was reported by Lanphear et al. (2005) to be -2.94 per ug/dL (EPA, 2007).

In the present exercise, the IEUBK model was run to characterize the potential impacts of the facility lead emissions, with particular focus on the impact on the mean BLL and the percentage of children with BLL above a “cutoff” level. Consistent with previous AQD modeling with IEUBK, the model was run with a “cutoff” of **10 ug/dL**. This means that the results indicate the percent of children estimated to fall above and below that value. This is of key interest, because 10 ug/dL is the CDC action level above which children are regarded as lead poisoned. These modeling results also indicate the impact of the facility emissions on the geometric mean BLL, which is useful in assessing any impacts to IQ as discussed above; this information is provided by the model independently of the selection of the “cutoff” level. However, in recognition that adverse effects on neurological development may occur at BLLs of 5 ug/dL or possibly lower, model runs were also repeated with a cutoff of **5 ug/dL** to indicate if the facility emissions could affect the estimate of the percentage of children above that level of concern.

11. Age group evaluated

The IEUBK model allows the user to select an age group, from among age ranges within the range of zero to 84 months (7 years), or the overall age range up to 7 years. The potential for susceptibility of children to lead exposure and cognitive development appears to emphasize the importance of the first 3 years of life, and extends to school-age (EPA, 2007). In one key study (Lanphear et al., 2005), concurrent and lifetime averaged BLLs were considered stronger predictors of lead-associated intellectual deficits than was the peak BLL or early childhood (e.g., 6-25 months) (EPA, 2007). Concurrent levels reflect both ongoing exposure and preexisting body burden, and it is unclear if the cognitive defects observed by such studies were due to lead exposure that occurred during early childhood or were a function of concurrent exposure (EPA, 2007). Based on the concern for children throughout the age range 0-84 months, and consistent with previous AQD modeling with IEUBK, the age group **0-84 months** was utilized.

12. IEUBK model version
The most recent version of the Integrated Exposure Uptake Biokinetic (IEUBK) Model (ieubk win32 v.1.0.264) was utilized, to characterize the BLLs in children under appropriately representative exposure scenarios (EPA, 2008).

13. Existing BLLs in children in Presque Isle County
MDCH data for Presque Isle County in 2006 show that 96/832 (11.5%) of children under the age of six were tested for blood lead levels. Of those tested, 8.3% had levels of 5-9 ug/dL; 0% had BLLs of 10 ug/dL or greater. Preliminary data for children tested in 2007 indicate that 5/126 (3.9%) had BLLs of 10 or greater (Hudson, personal communication).

Results

The IEUBK key modeling results are summarized in Table 4. Scenario 1 represents the "background" situation, including lead levels in air, soil, and indoor dust without any impacts from the WCEV project, and without lead paint in homes. Scenario 2 is the same as scenario 1, except that it is assumed that the indoor dust lead level is 200 mg/kg due to the presence of lead paint in the homes. Scenario 3 includes the incremental impact of the WCEV project emissions on the lead level in air, soil (after 30 years of accumulated impact) and in indoor dust (via track-in of soil and due to air impacts), without the presence of lead house paint. In scenario 4, the WCEV project impacts are also included (in addition to background levels), plus it is assumed that the indoor dust lead level is 200 mg/kg due to the presence of lead paint in the homes. For each scenario, the Table 4 presents the average (mean) blood lead level (BLL) for a population of children ages 0-7 under the modeled conditions. The last two columns of the table indicate the percentage of children estimated to have BLLs above the CDC level of concern (10 ug/dL) and above 5 ug/dL, which has been associated with adverse effects on development.

Table 4. IEUBK key modeling results for selected scenarios.

Scenario modeled	Description of lead paint in homes	Mean BLL (ug/dL)	% above 10 ug/dL	% above 5 ug/dL
1. Background	none	1.674	0.007	0.996
2. Background	lead paint in good condition	2.808	0.344	10.976
3. Background plus incremental impact of WCEV	none	1.674	0.007	0.997
4. Background plus incremental impact of WCEV	lead paint in good condition	2.808	0.344	10.977

Appendix A includes graphs for each of the model runs with key findings summarized in Table 4. The graphs present the probability distribution of BLLs for each scenario. The distribution curves indicate the percentage of children estimated to have BLLs greater than the BLL indicated on the X-axis. The graphs also indicate the chosen BLL cutoff (5 or 10 ug/dL) and the percentage of children predicted to be above that cutoff level.

Discussion

In order to estimate the reasonable maximum potential impact of the facility lead emissions, the lead emission rate was assumed to be equal to the maximum (proposed) permitted rate, and the deposition impacts were estimated for an accumulated impact of 30 years at areas which may be residential. Assuming this level of incremental soil impact, and with assumed continuing air emissions and ambient air impacts, childhood exposure (BLL) was modeled. The results indicate that the presence of lead-based paint (even if in good condition) can have a substantial effect on the average (mean) BLL and on the percentage of children with BLLs above levels of concern (5 or 10 ug/dL). The incremental impact of the WCEV lead emissions on air and soil lead levels was very small and did not have an effect on the average BLL detectable by the model, whether or not lead paint is present in homes. The model also did not detect any change in the percentage of children with BLLs above 10 ug/dL due to the facility emissions. The model detected a slight increase in the percentage of children exceeding 5 ug/dL due to the facility emissions, in the absence of lead paint (increase from 0.996% to 0.997%) and in the presence of lead paint (increase from 10.976% to 10.977%). For each of those situations (with and without lead paint), the increase in the percentage of children exceeding 5 ug/dL due to the facility emissions was 0.001%. In other words, if 100,000 children were in the maximum impact residential scenario modeled, an additional one child would be estimated to exceed 5 ug/dL due to the facility emission impacts.

BLL impacts can be interpreted by referring to published relationships between BLL and neurological development impacts (IQ deficits). Those relationships may be summarized as follows. In the BLL range of 1 to 10 ug/dL, the IQ impact for every 1 ug/dL increase in concurrent BLL has been estimated to be -0.4 to -1.8 per ug/dL. The IQ impact per ug/dL BLL increase may be relatively greater at lower BLLs; a value of -2.94 IQ deficit per ug/dL BLL increase has been estimated. Based on these relationships, and the modeled incremental impacts of the facility's lead emissions on BLLs, it may be reasonably concluded that the facility lead emissions would have a minimal effect on children's exposure and would not have any significant impact on children's neurological development.

References

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Appendix A. Graphs of Blood Lead Level Distribution for the Modeled Scenarios

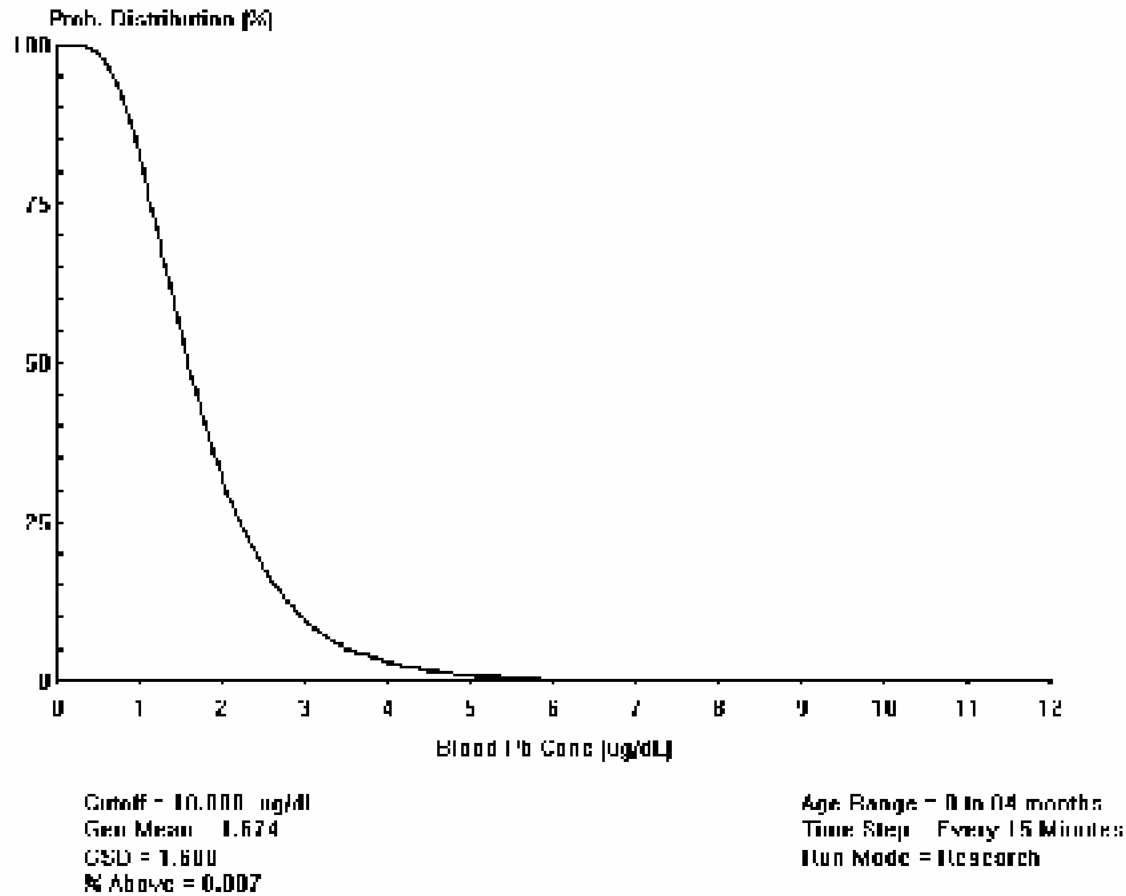

Figure 1a. Blood lead level distribution for Scenario 1: Background exposures only, no lead paint in homes; BLL cutoff set at 10 ug/dL.

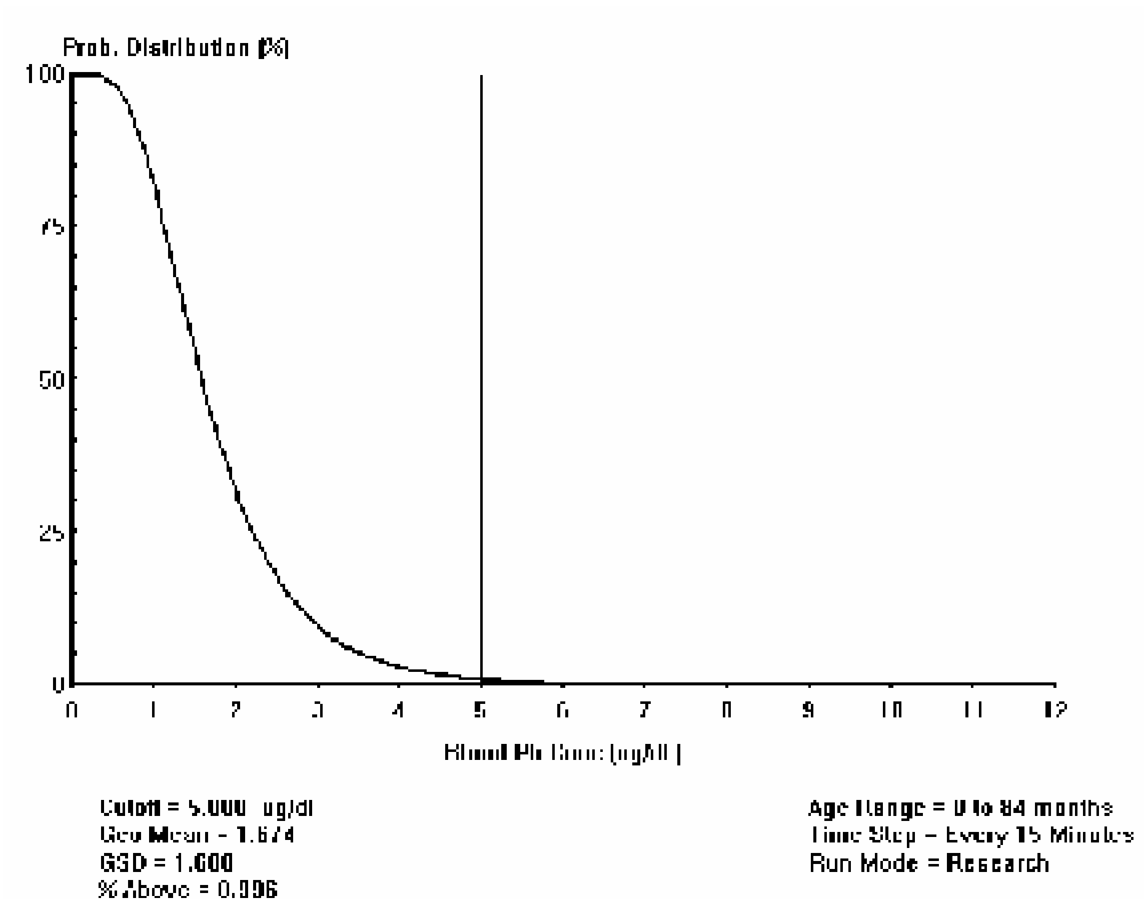

Figure 1b. Blood lead level distribution for Scenario 1: Background exposures only, no lead paint in homes; BLL cutoff set at 5 ug/dL.

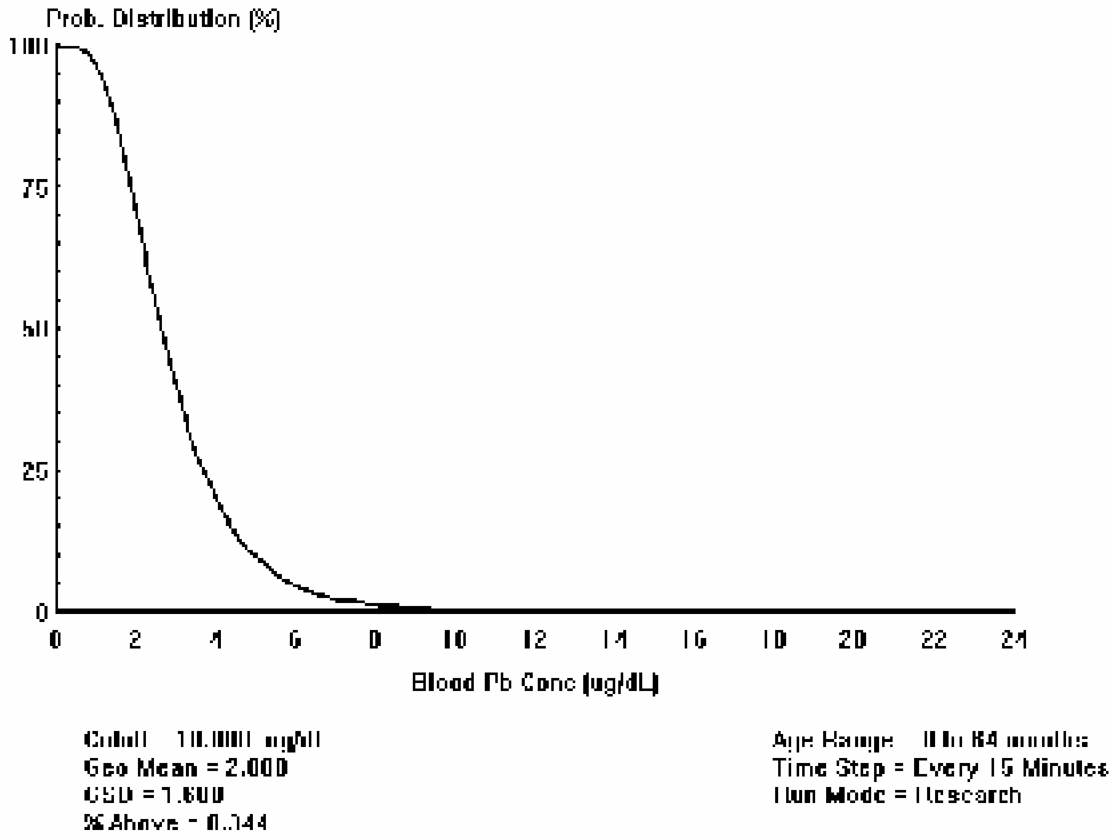

Figure 2a. Blood lead level distribution for Scenario 2: Background exposures only, lead paint in homes in good condition; BLL cutoff set at 10 ug/dL.

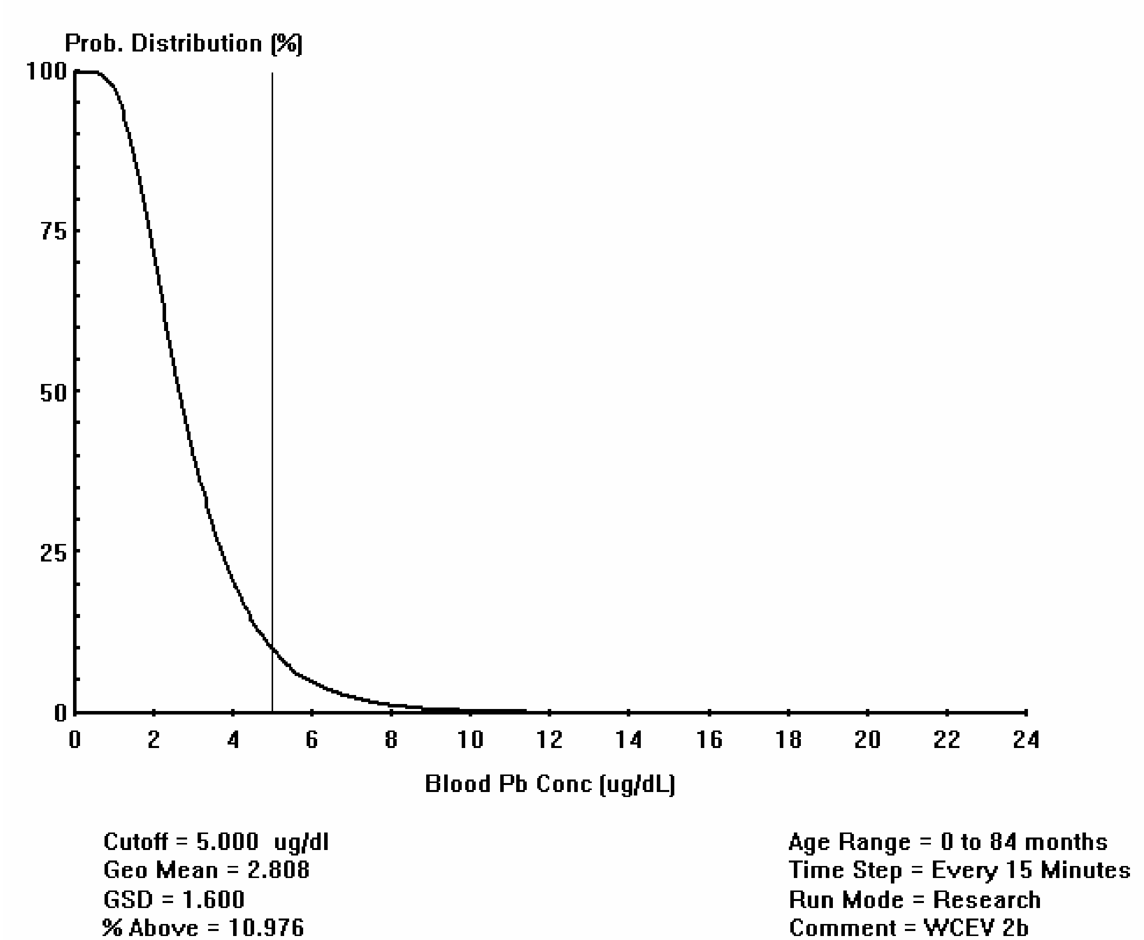

Figure 2b. Blood lead level distribution for Scenario 2: Background exposures only, lead paint in homes in good condition; BLL cutoff set at 5 ug/dL.

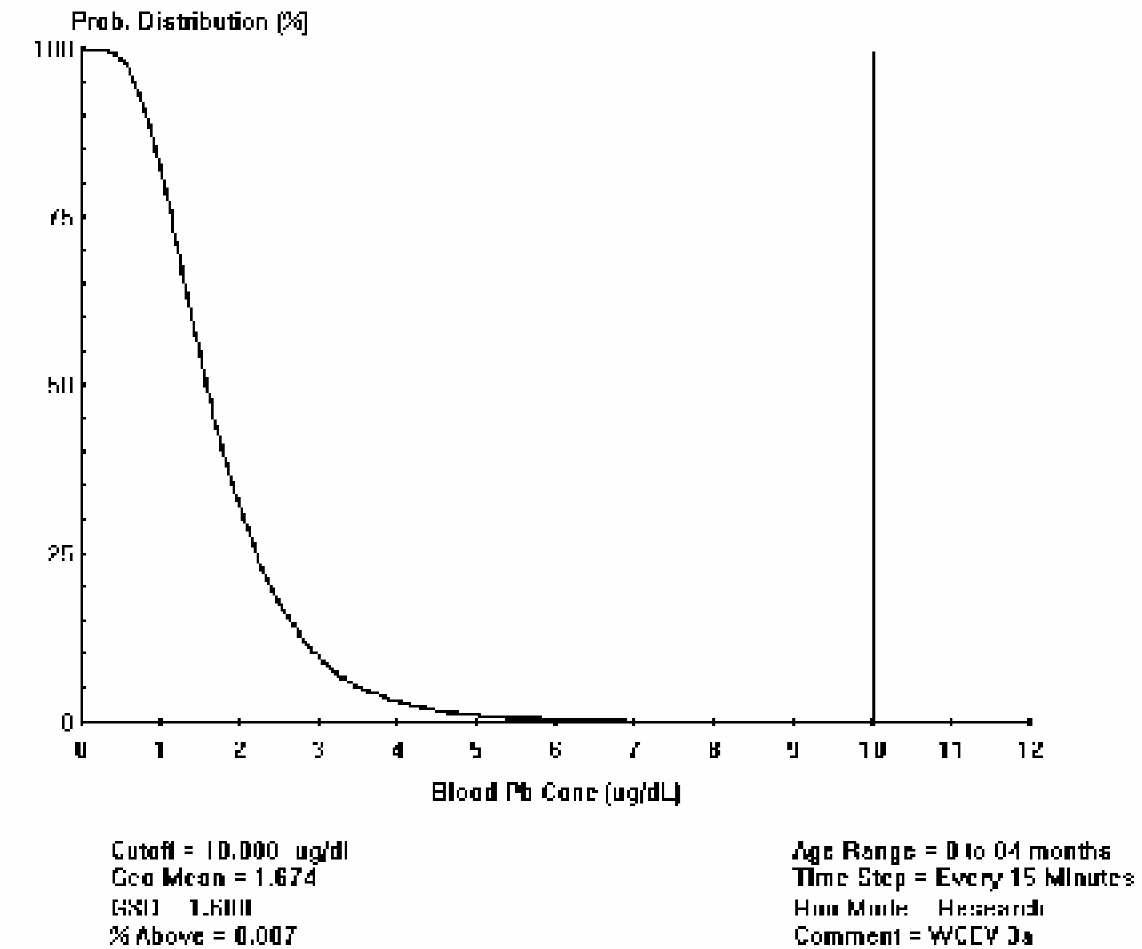

Figure 3a. Blood lead level distribution for Scenario 3: Background exposures plus incremental impact of WCEV, no lead paint in homes; BLL cutoff set at 10 ug/dL.

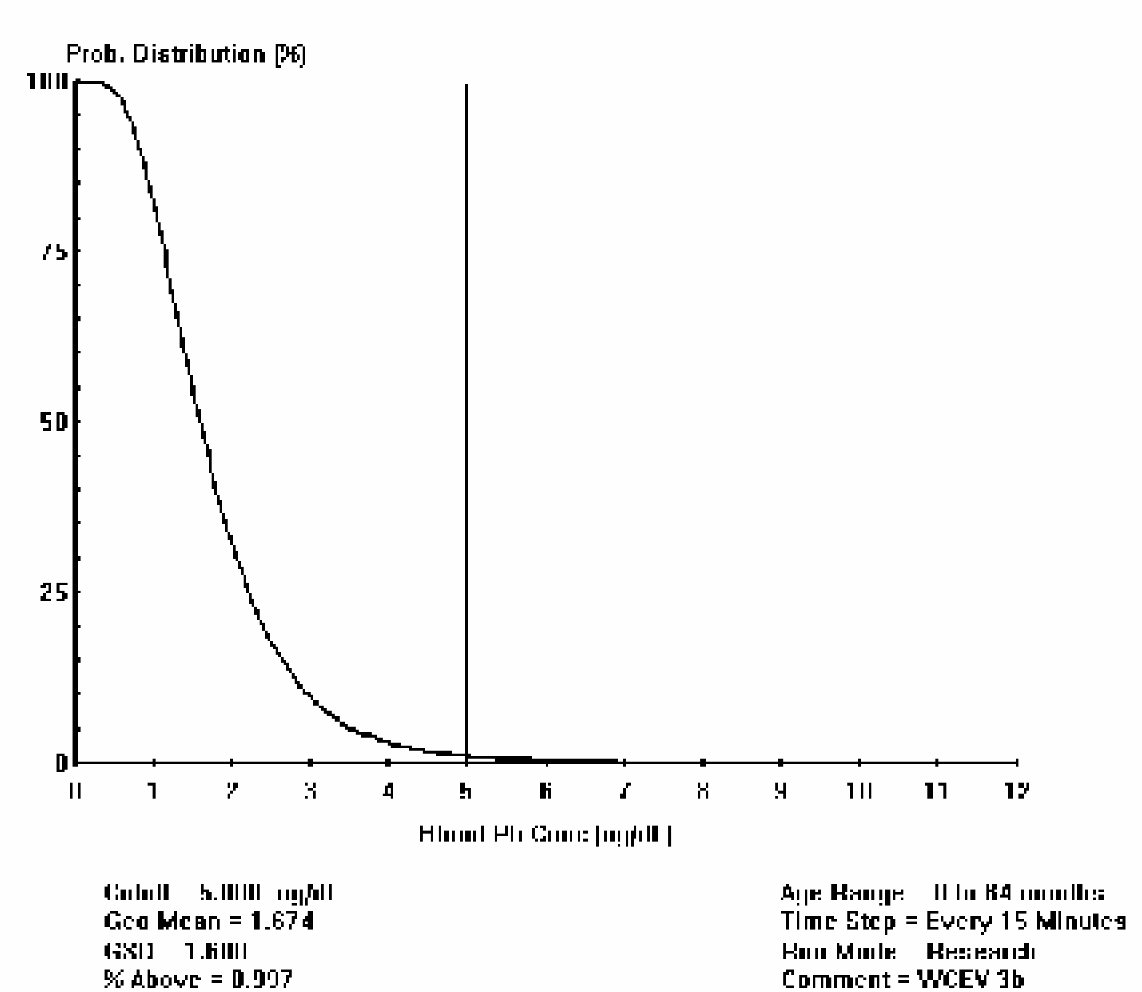

Figure 3b. Blood lead level distribution for Scenario 3: Background exposures plus incremental impact of WCEV, no lead paint in homes; BLL cutoff set at 5 ug/dL.

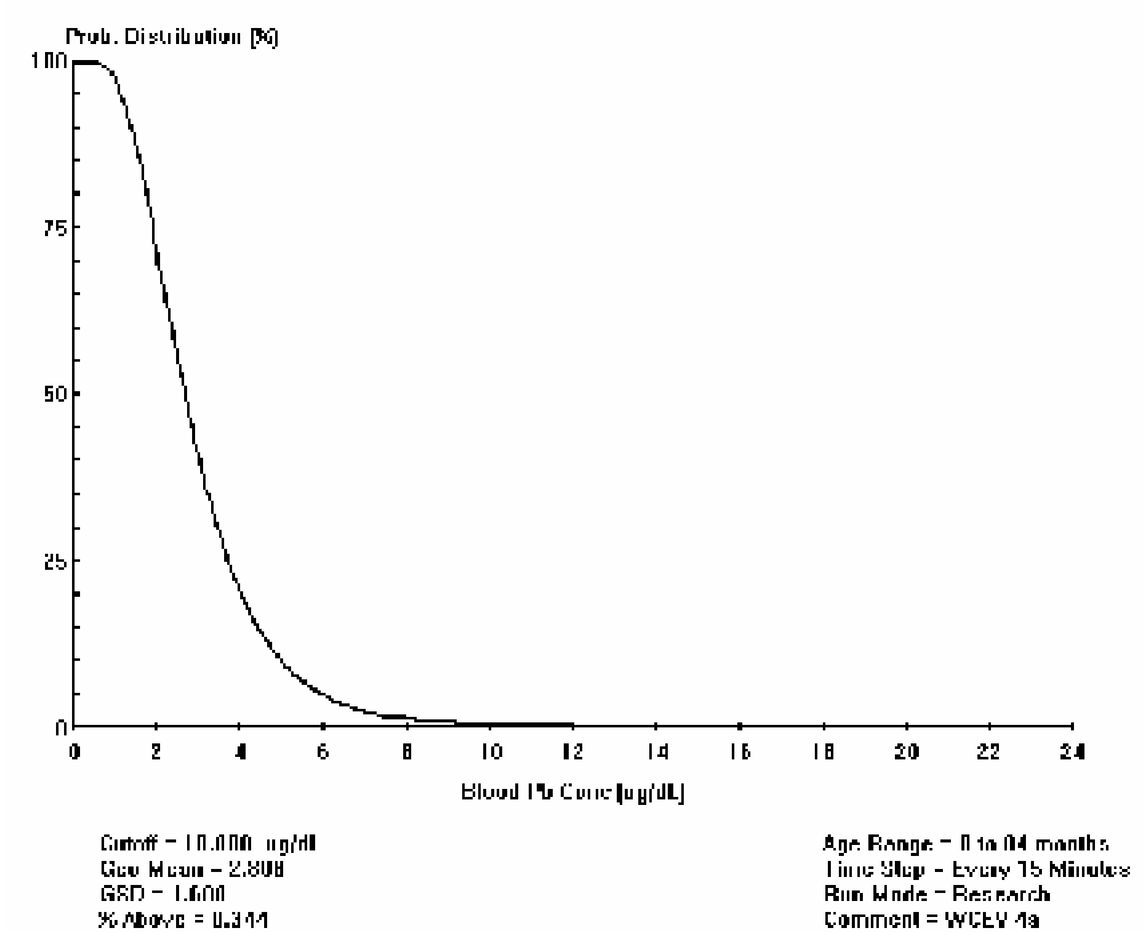

Figure 4a. Blood lead level distribution for Scenario 4: Background exposures plus incremental impact of WCEV, lead paint in homes in good condition; BLL cutoff set at 10 ug/dL.

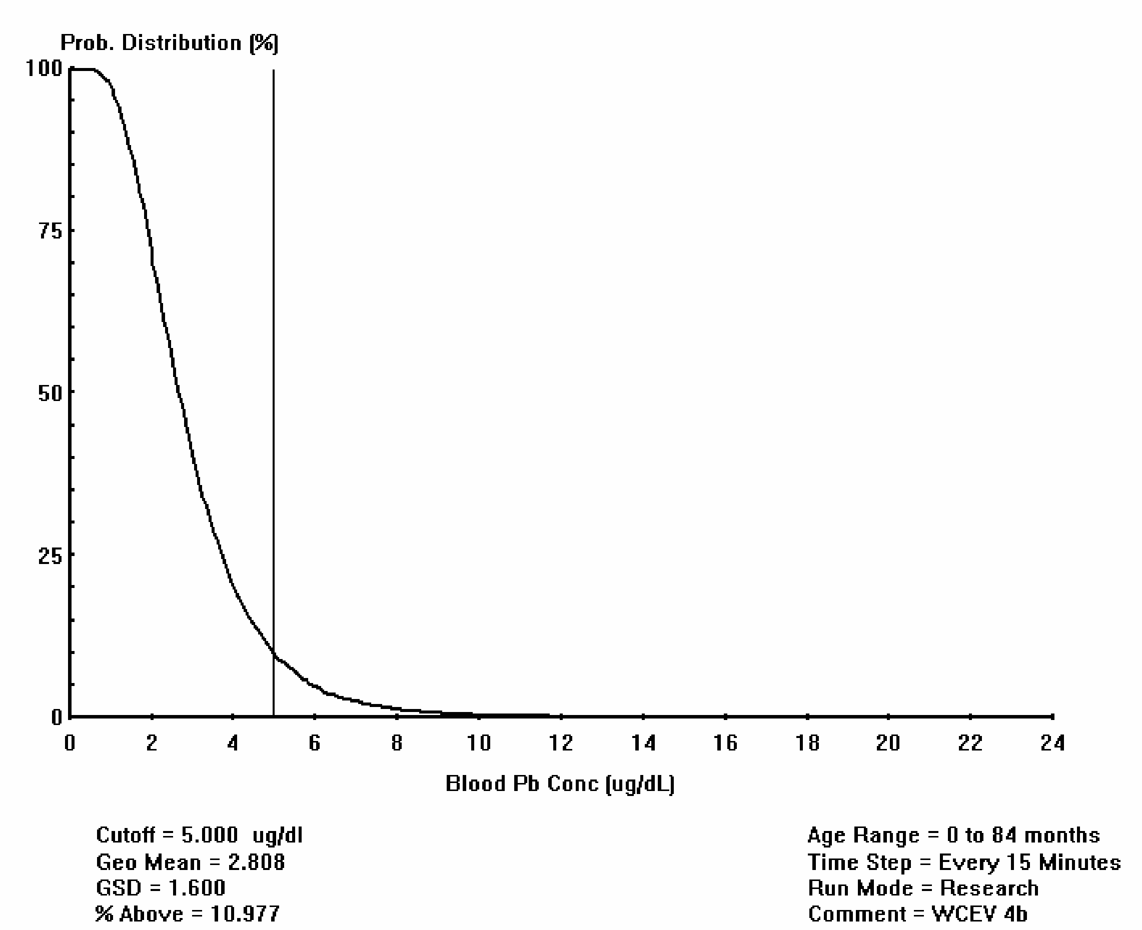

Figure 4b. Blood lead level distribution for Scenario 4: Background exposures plus incremental impact of WCEV, lead paint in homes in good condition; BLL cutoff set at 5 ug/dL.