CDM

Port of Portland

Hillsboro Airport Lead Study

September 1, 2010

Final Report

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Executive Summary

The Oregon Department of Environmental Quality (ODEQ) recently completed an analysis of lead emissions from airports located in the state. Dispersion modeling was then completed using the CALPUFF model, a non-steady-state dispersion model that simulates the effects of long distance pollutant transport. The results indicated that a high concentration of lead that could exceed the National Ambient Air Quality Standard (NAAQS) was located over Hillsboro Airport (HIO). As a result, the Port of Portland requested that a parallel study be completed to evaluate lead emissions and dispersion using the Federal Aviation Administration's (FAA's) required model, the Emission & Dispersion Modeling System (EDMS). While EDMS generates emission sources based on the airport layout, EDMS uses the AERMOD modeling system, a steady-state plume model, to complete the dispersion analysis.

An emissions inventory for lead was completed for existing conditions (2007) using aircraft operation information from the Draft Hillsboro Airport Parallel Runway 12L/30R Environmental Assessment. EDMS estimated lead emissions to be approximately 0.632 tons per year for piston aircraft; all turbine aircraft were excluded from the study[1]. Further review of the data indicated that approximately five percent of the airport's emissions are from ground-level sources associated with taxiing and idling at the airport. It would therefore be overly conservative to consolidate all of an airport's emissions into a ground-level source because emissions would disperse differently at a higher release height.

EDMS typically generates several hundred emission sources for a given airport. ODEQ requested that these sources be simplified into no more than ten sources, which could then be imported into the CALPUFF model. Several dispersion analyses were completed to accomplish the following goals:

1. Complete dispersion modeling using EDMS-generated sources directly to serve as a comparison for the simplified AERMOD dispersion.

2. Complete modeling using the simplified sources for eventual use in CALPUFF.

3. Complete sensitivity analyses to evaluate how modifying the sources affects the modeling.

    a. Evaluate the effects of lowering the release heights of the emission sources.

    b. Evaluate the effects of merging all of the emission sources into a ground-level source, equal to the area of the taxiways and runways.

It should be noted that AERMOD version 09292 was used to complete the modeling for all of the emission dispersion scenarios (full EDMS sources, simplified sources, and sensitivity runs). The simplified modeling indicates that the average modeled

[1] The emissions inventory completed by ODEQ estimated lead emissions to be 0.715 tons per year in 2005.

concentration was approximately 17 percent less than the EDMS-source model, whereas the maximum concentration was approximately four percent less than EDMS sources. The maximum concentration from the ODEQ's CALPUFF modeling, however, was found to be approximately 60 times greater than the peak concentration from the EDMS modeling. The results indicate that the original CALPUFF modeling is overly conservative and that the lead emissions from HIO should not exceed the NAAQS level of 0.15 µg/m^3, based on a three-month rolling average.

The results of the modeling are provided in Table ES-1.

Table ES-1
Results of AERMOD Air Dispersion Modeling

Scenario	***Concentration (µg/m^3)***	***Difference (Compared to EDMS) (µg/m^3)***	***Percentage Difference***
Maximum Concentration			
EDMS	0.00405	n/a	n/a
Simplified AERMOD Run	0.00389	-0.00016	-4%
Sensitivity Analyses			
Adjusted Release Height	0.00766	0.00361	89%
Ground-Based Sources	0.06567	0.61620	1,521%
Average Concentrations			
EDMS	0.00082	n/a	n/a
Simplified AERMOD Run	0.00068	-0.00014	-17%
Sensitivity Analyses			
Adjusted Release Height	0.00104	0.00022	26%
Ground-Based Sources	0.01007	0.00925	1,127%

Key:
µg/m^3 = micrograms per cubic meter
AERMOD = AMS/EPA Regulatory Model
AMS = American Meteorological Society
EDMS = Emission & Dispersion Modeling System
EPA = Environmental Protection Agency

Section 1
Overview

The ODEQ recently completed an inventory of lead emissions from airports located in the state. Air dispersion modeling was then completed using the CALPUFF modeling system to evaluate if there were any localized concentrations of lead in the state. The dispersion modeling completed by ODEQ suggested that a high concentration of lead could be centered near HIO. Figure 1-1 shows the results of the modeling completed by ODEQ. Although the maximum concentration determined by ODEQ is not explicitly provided, based on the results of the figure, it appears as though the peak concentration of lead near HIO is approximately 0.25 μg/m^3.

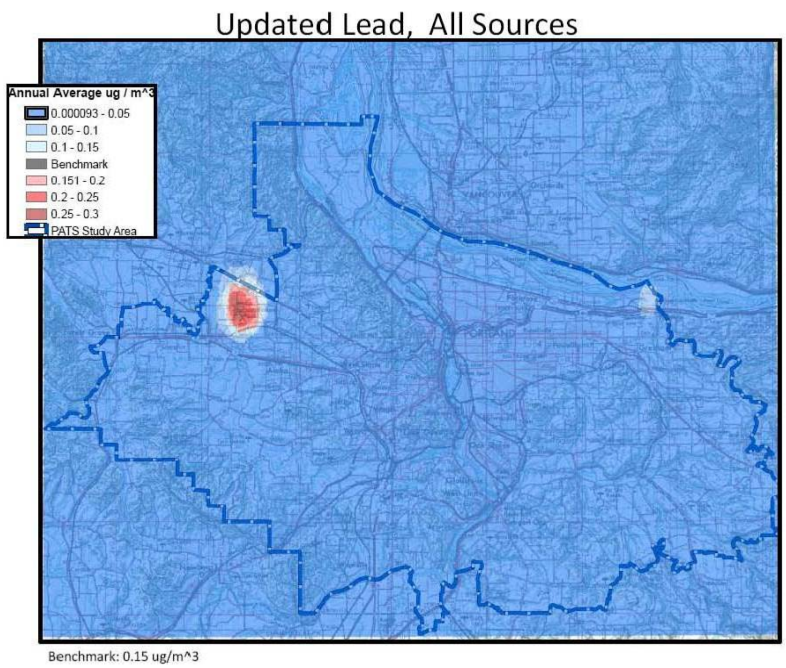

Figure 1-1
Results of ODEQ Modeling (provided by ODEQ)

An updated emissions inventory and refined dispersion modeling was completed using the FAA's EDMS to compare to the ODEQ CALPUFF results. EDMS creates a series of sources from the airport layout information provided in the model. The model then uses the Environmental Protection Agency's (EPA's) preferred refined dispersion model, AERMOD, to complete air dispersion modeling using the generated source information. Since EDMS will typically create several hundred or thousand emission sources for an airport, the emission sources were simplified so that the model would contain no more than ten emission sources. The results of the simplified model were then compared to the full EDMS model to verify the results.

Section 2
Methodology

This section describes the methodology used to complete the lead emissions inventory for the airport and to complete the air dispersion modeling.

2.1 Model Selection

The FAA's EDMS was used to estimate emissions of lead from general aviation aircraft operations at HIO. EDMS is a multi-component software that is capable of completing both an emissions inventory and air dispersion modeling for an airport. If dispersion modeling is enabled in the software, then system aircraft times in mode are performance based while sequence modeling is used to determine the taxi time in the model. In other words, EDMS dynamically determines emissions from the various modes of operation[2] by modeling the aircraft movements, rather than relying on default times-in-mode

EDMS generates a series of point, volume, and area sources suitable for use in AERMOD based on the airport layout specified in the study. For example, airport movements on the taxiways and runways are represented as a series of area sources. EDMS uses the EPA's AERMOD modeling system to complete the air dispersion element of the study. AERMOD is the EPA's recommended refined air dispersion model in 40 CFR 51, Appendix W. EDMS is also the FAA's required model for air quality analyses for aviation sources and was therefore selected for use in this study.

2.2 User-Created Aircraft

By default, EDMS creates emission inventories of criteria pollutants, including carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM_{10} and $PM_{2.5}$). To estimate emissions of lead (Pb) directly in EDMS, it was necessary to define user-created aircraft that specified a lead emissions index (EI).

The lead EI was calculated using the maximum lead content allowed in aviation gas (avgas) (0.56 grams per liter) and the average density of avgas (6 pounds per gallon). The lead EI was then calculated as approximately 0.78 grams of lead per kilogram of avgas (lead content divided by density).

The consolidated aircraft fleet mix for 2007 existing operations contained in Appendix C to the Draft Hillsboro Airport Parallel Runway 12L/30R Environmental Assessment ("Draft EA") was used as a starting point for the creation of user-specific aircraft. Each combination of representative aircraft and engine types was used to define the user-created aircraft; all turbine aircraft (turboprop, turbojet, and helicopter turbine) were

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[2] EDMS includes emissions from six modes of operation: 1) start-up, 2), taxi-out, 3) takeoff, 4) climb-out, 5) approach, and 6) taxi-in.

excluded from further analysis. Table 2-1 identifies the user-created aircraft and associated landing/takeoff operations (LTOs) and touch-and-go operations (TGOs).

Table 2-1
Fleet Mix for Hillsboro Airport (HIO) Lead Study

Representative Aircraft	***Representative Engine***	***EDMS User-Created Aircraft Name***	***TGOs***	***LTOs***	***Total***
Cessna 150 Series	O-200	HIO-FP-o 235	5,474	4,259	9,733
Cessna 172 Skyhawk	O-320	HIO-FP-o 320	18,042	14,037	32,079
Cessna 182	IO-360B	HIO-FP-o 360	2,770	2,156	4,926
Cessna 210 Centurion	TIO-540-J2B2	HIO-FP-tio 540	3,759	3,117	6,873
Raytheon Beech Bonanza 36	TIO-540-J2B2	HIO-VP-io 360	2,912	3,348	6,260
Cessna 337 Skymaster	IO-360B	HIO-MEP-o 360	293	1,557	1,850
Cessna 310	TIO-540-J2B2	HIO-MEP-tio 540	238	1,263	1,501
Robinson R22	IO-360-B	HIO-HP-o 360	35,145	10,177	45,322
Robinson R44 Raven	TIO-540-J2B2	HIO-HP-io 540	1,849	536	2,385
Total			**70,479**	**40,450**	**110,929**

The aircraft were created by defining the fuel flow rates and flight profiles as being equivalent to the representative aircraft/engine combinations. The emission indices for the specific engine were zeroed out with the exception of PM, which was changed to be equal to the calculated lead EI. Figure 2-1 shows a typical data entry screen for the user-created aircraft used in the study.

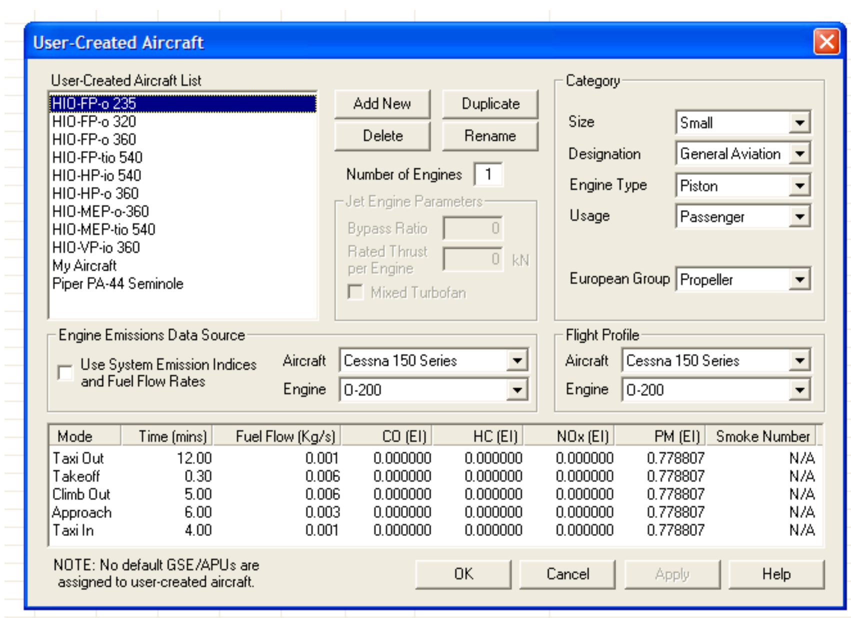


Figure 2-1
Screenshot of Example User-Created Aircraft Data Entry

2.3 Airport Layout and Configuration

A simplified airport layout, adapted from Figure 1-1 of the Draft EA, was developed for EDMS. The airport layout was simplified to only include the Main Apron;

Runway 12/30; Taxiways A, A1, and A8; and Charlie Helipad. The cross-runway 2/20 was not included in the analysis because of its limited use. The runway use percentages were derived from Table 1AA of the HIO Master Plan and were adjusted to reflect runway use assuming that only Runway 12/30 was operational. The runway usage by aircraft type was then averaged for input into the runway assignments section of EDMS. Table 2-2 summarizes the runway use percentages used in the modeling.

Table 2-2
Runway Use Percentages

Aircraft	***Runway Usage***	
	12	***30***
Itinerant Operations		
SEPF (Fixed Propeller)	7.29%	92.71%
SEPV (Variable Pitch Propeller)	7.29%	92.71%
MEP (Multi-Engine Piston)	18.95%	81.05%
Average	*11.18%*	*88.82%*
Local Operations		
SEPF (Fixed Propeller)	2.13%	97.87%
SEPV (Variable Pitch Propeller)	2.13%	97.87%
MEP (Multi-Engine Piston)	40.00%	60.00%
Average	*14.75%*	*85.25%*

EDMS requires the runway configuration to be identified for each size of aircraft (small, large, and heavy). In order to account for the proper runway configuration by aircraft type, it was necessary to complete two individual model runs for aircraft sources and for helicopters. Not doing so would result in an underestimation of emissions from the aircraft. For helicopter emissions on Charlie Helipad, all takeoffs were assumed to occur at the southeastern portion of the landing strip.

2.4 Receptors

Two main types of receptors were used in the modeling: plant boundary receptors and uniform polar grid receptors. A Cartesian plant boundary was placed along the property boundary of HIO. Intermediate receptors were then placed every 100 meters along the property boundary. A uniform polar grid was centered over the airport emission sources and extended approximately 2,000 meters from the airport boundary. Direction radials were spaced in increments of 10 degrees around the airport, while each spoke on the polar grid had 100-meter spacing. All receptors located on the airport property were removed from modeling. Figure 2-2 identifies the receptors that were used in the modeling.

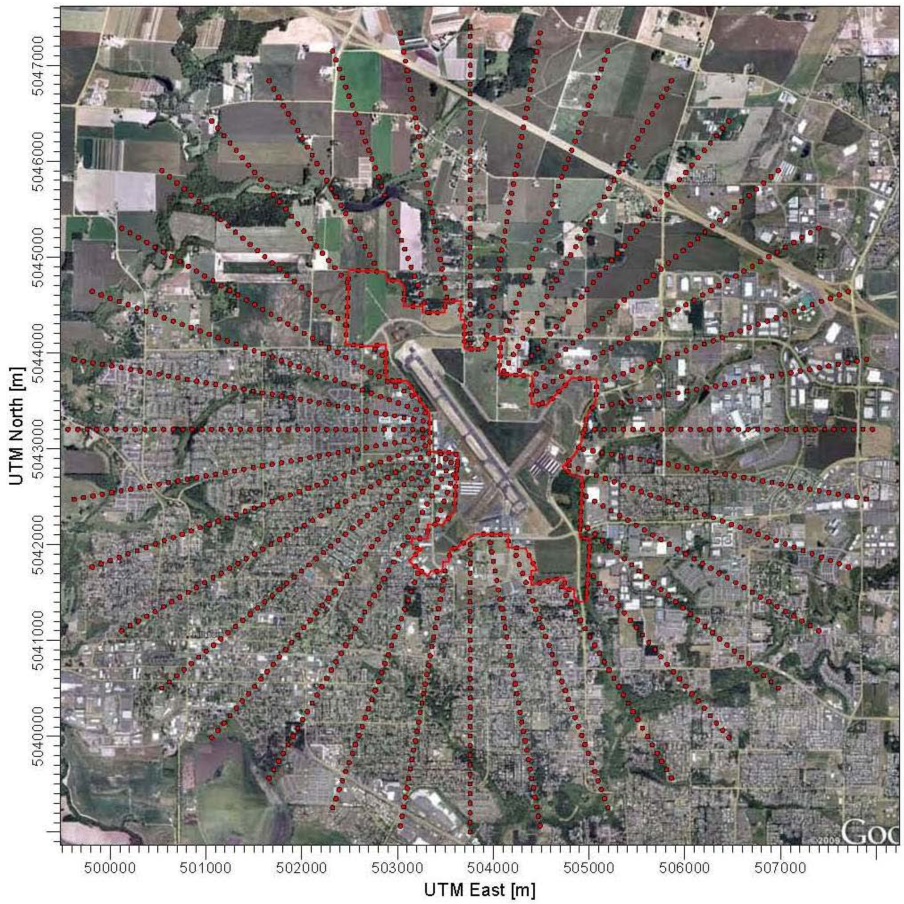


Figure 2-2
Uniform Polar Grid and Cartesian Plant Boundary Receptors Used in Modeling

A review of the 7.5-minute series Hillsboro Quadrangle from the United States Geological Survey (USGS) indicates that the area surrounding the airport is relatively flat. Although there are hills to the northeast of the airport, they are not within the modeled flight path and receptors for the airport and would not affect the modeling. The terrain was therefore modeled as flat and elevation data was not imported into the model.

2.5 Meteorological Data

Representative meteorological data is required to complete the necessary air dispersion modeling. Portland International Airport (ID No. 24229) was determined to be the closest representative surface weather station to HIO and was selected for use in the model. Salem McNary Field (ID No. 24232) was identified as the closest upper air weather station to HIO. Data was downloaded from the WebMET website (http://www.webmet.com), a source of free meteorological data. The most recent year of data available, 1990, was used in the analysis.

2.6 Emission Sources

EDMS models aircraft activity that occurs during six modes of operation. The following modes in an LTO cycle are identified as follows:

- Approach – Airborne segment of an aircraft's arrival extending from the start of the flight profile to touchdown on the runway.
- Taxi-in – The landing roll segment of an arriving aircraft and the taxiing from the runway exit to a gate.
- Startup – Aircraft main engine startup at the gate. Since this mode is only applicable to International Civil Aviation Organization (ICAO) engines, emissions at the gate were not modeled because piston engines are not ICAO certified.
- Taxi-out – Taxiing from the gate to a runway end.
- Takeoff – Segment that extends from the start of the ground roll on the runway through the airborne portion of the ascent during which the aircraft operates at maximum thrust.
- Climb Out – Segment from engine cutback at maximum thrust to the end of the flight profile or mixing height (whichever is lower)

2.6.1 EDMS Sources

EDMS generated over 1,100 sources to represent aircraft activity at the airport. In addition, it creates an hourly emission rate (HRE) that specifies emissions for every source and hour of the day. For the HIO modeling, the HRE file contained over 10 million lines of data and was approximately 500 megabytes.

EDMS creates a series of area sources to represent aircraft emissions. Ground-based emission sources, such as taxiing, have a release height of 12 meters, which is the approximate height of an engine. Airborne sources, such as approach and takeoff operations, are shown as a series of elevated area sources that rise from approximately 22 meters to 619 meters, or the maximum height of the flight profile.

2.6.2 Simplified Sources

To evaluate how to consolidate the EDMS-generated sources to a simplified AERMOD dispersion run, the distance of each source from the runway end was plotted against its height above ground. Release heights of 100 meters, 300 meters, and 500 meters were selected to represent the airborne emissions associated with the airport. The plots of the arrival and departure sources indicated that the airborne sources generally overlap at the same distance from the runway end at these elevations. As a result, the arrival and departure operations were consolidated into a single area source for each release height. The length of each area source was taken as the distance from the runway end for all of the EDMS sources at each of the release heights. The width of the emission source was taken as the distance between Runway 12/30 and Charlie Helipad.

A total of seven source groups were consequentially created to represent the aircraft: three elevated sources from Runway 12, three elevated sources from Runway 30, and one ground-level source to represent aircraft movements on the runway and taxiways. To further simplify the model, aircraft and helicopter emissions were also merged into each of the sources; Charlie Helipad was not explicitly included in the model as a source. Table 2-3 summarizes the AERMOD input sources that were used in the modeling. Figure 2-3 shows a two-dimensional plan view of the AERMOD area sources, whereas Figure 2-4 shows the height above ground-level by the distance from the end of Runway 12 for each of the elevated sources included in the model.

2.6.3 Emission Rates

A goal of the simplified modeling was also to avoid the large HRE file that is created by EDMS; rather, an average annual emission rate was used for each of the sources. Emissions from each source type in the HRE file were converted to emissions of tons per year using a Microsoft Access Query. Emissions were found to be slightly less than the emissions inventory developed directly by EDMS; therefore, emissions for the sources were adjusted to equal the EDMS emission inventory. Emissions were then divided by the total area of all of the sources, as determined by EDMS, to create an average emission rate for entry into the models. The aircraft were assumed to be operating continuously at 8,760 hours to per year to develop an average annual emission rate. The emission rates for each main source category are provided in Table 2-4.

Table 2-3
AERMOD Input Sources

Source ID	X Coord. (m)[1]	Y Coord. (m)[1]	Base Elevation (m)	Release Height (m)	Emission Rate g/(s-m^2)	X-Side Length (m)	Y-Side Length (m)	Angle from North (deg)	Initial Vertical Dimension
NW100	503976.19	5042879.84	62	100	2.93E-09	240	2,000	-36	4.1
NW300	503173.96	5043984.92	62	300	2.93E-09	240	4,400	-36	4.1
NW500	502438.44	5044982.70	62	500	2.93E-09	240	7,000	-36	4.1
SE100	504685.22	5041914.16	62	100	2.38E-09	240	2,000	-36	4.1
SE300	506938.65	5038833.70	62	300	2.38E-09	240	4,600	-36	4.1
SE500	509180.78	5035762.25	62	500	2.38E-09	240	7,000	-36	4.1
TAXIQ	504359.18	5042387.29	62	12	4.15E-09	2,000	120	-126	4.1

Notes:
1. Coordinates shown in Universal Transverse Mercator (UTM) coordinate system, North American Datum 1983 (NAD83).

Key:
g/(s-m^2) = grams per second per square meter
m = meters
NW100 = Takeoff (RW 30) and approach (RW 12) – 100 meters
NW300 = Takeoff (RW 30) and approach (RW 12) – 300 meters
NW500 = Takeoff (RW 30) and approach (RW 12) – 500 meters
SE100 = Takeoff (RW 12) and approach (RW 30) – 100 meters
SE300 = Takeoff (RW 12) and approach (RW 30) – 300 meters
SE500 = Takeoff (RW 12) and approach (RW 30) – 500 meters
TAXIQ = Taxi/idle

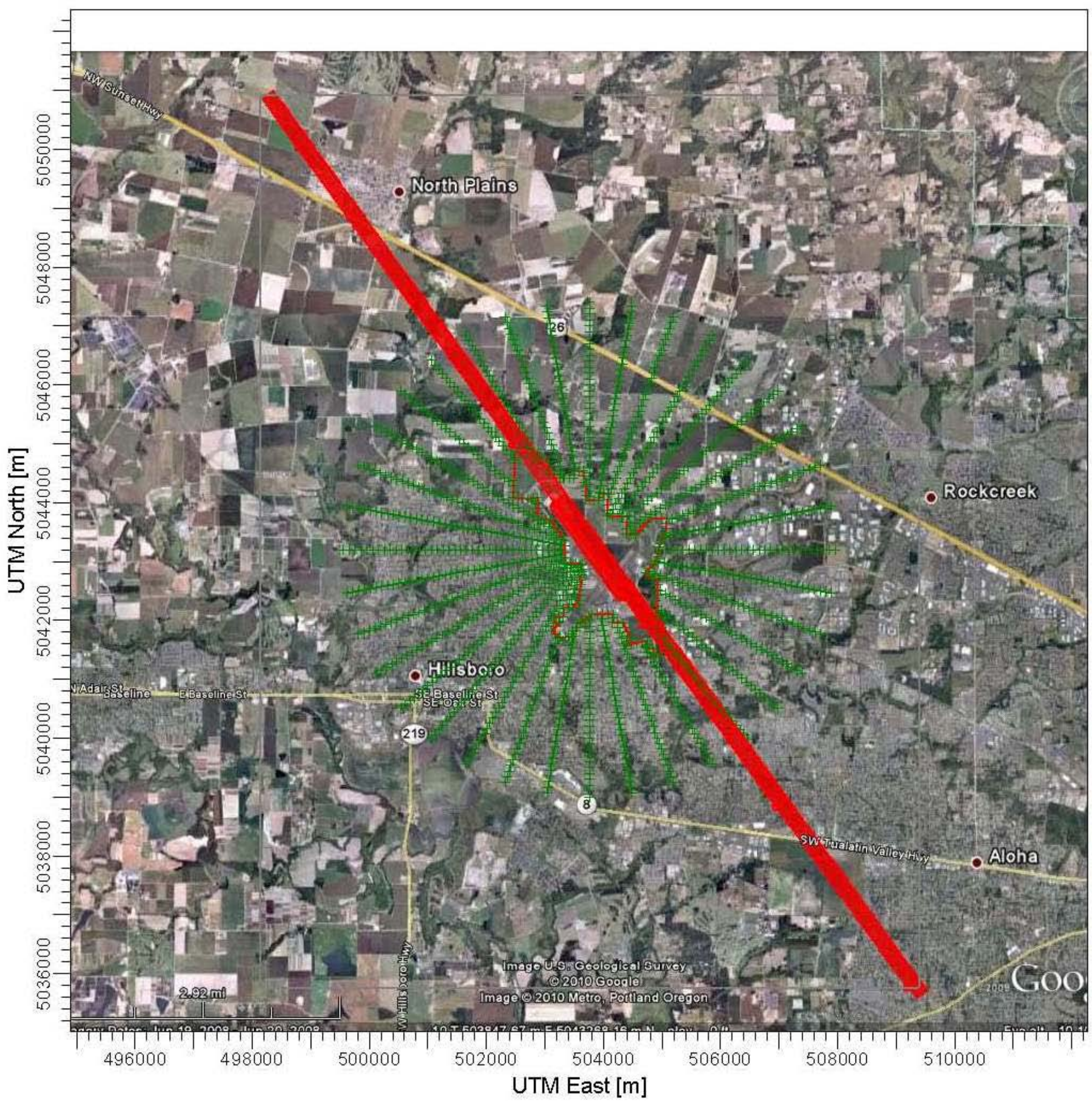


Figure 2-3
Plan View of Simplified Area Sources Used in AERMOD Air Dispersion Modeling

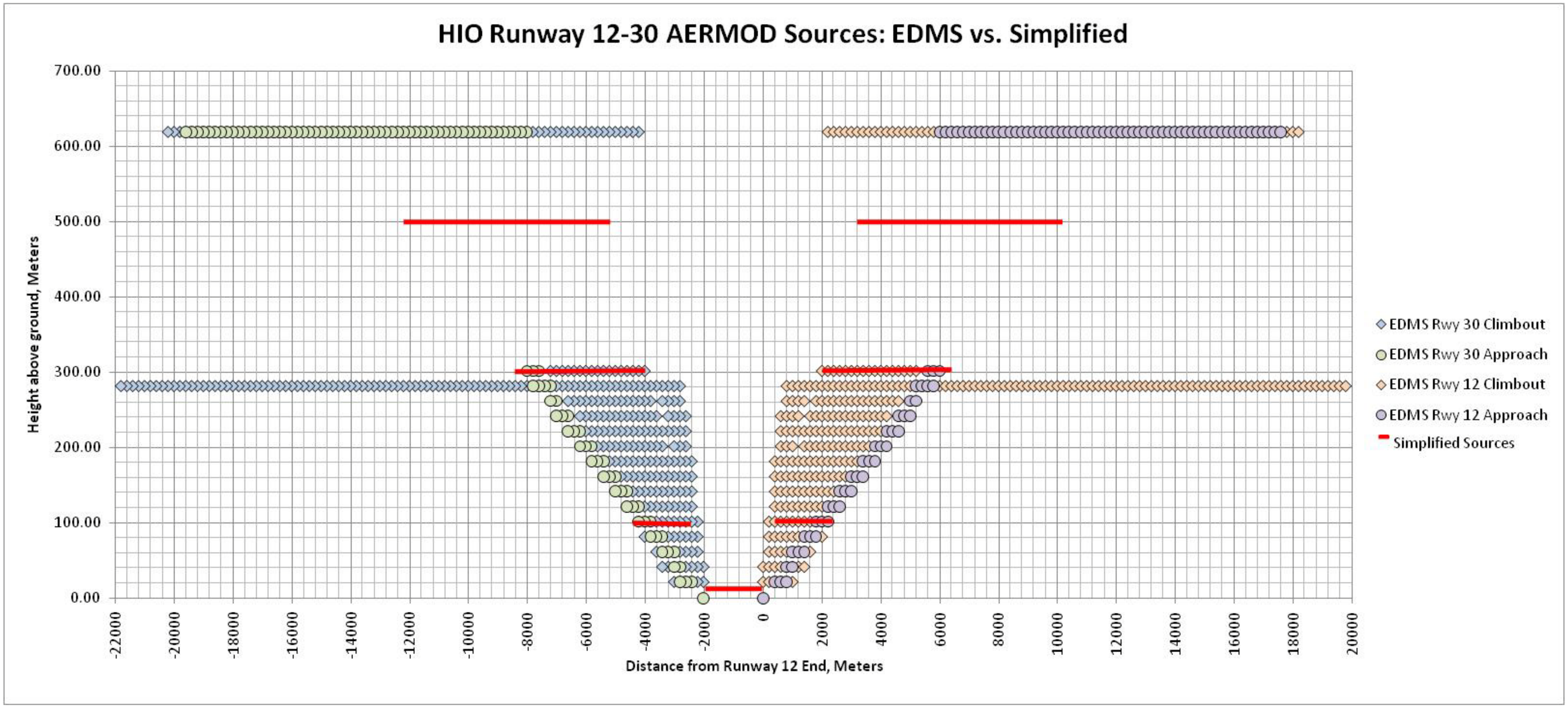


Figure 2-4
Elevation View of Simplified Sources Relative to EDMS Sources Used in AERMOD Air Dispersion Modeling

Table 2-4
Modeled Source Groups and Emission Rates

EDMS Source Group	***Type [a]***	***Emissions (tpy)***	***Consolidated Group***	***Consolidated Emissions (tpy)***	***Consolidated Emissions (g/sec)***	***Area (m^2)***	***Emission Rate ($g/(s\text{-}m^2)$)***
Airborne Landing – 12	Aircraft	0.032	Takeoff 30/Approach 12	0.328	9.42E-03	3,216,000	2.93E-09
Airborne Landing – 30L	Helicopter	0.046					
Airborne Takeoff – 30	Aircraft	0.250					
Airborne Landing – 30	Aircraft	0.229	Takeoff 12/Approach 30	0.270	7.75E-03	3,264,000	2.38E-09
Airborne Takeoff – 12	Aircraft	0.040					
Runway Landing – 12	Aircraft	0.005	Taxiways	0.035	9.97E-04	240,000	4.15E-09
Runway Landing – 12R	Helicopter	<0.001					
Runway Takeoff – 12	Aircraft	0.009					
TAXIQ	Both	0.020					
Total [b]		**0.632**		**0.632**	**1.82E-02**	**6,720,000**	**2.70E-09**

Notes:
[a] "Type" specifies the type of aircraft that is included in the source group (i.e., helicopters and aircraft represented by two different EDMS models).
[b] Total emission rate identified for "Model Emission Rate ($g/(s\text{-}m^2)$)" is the weighted average of the other modeled emission rates, rather than an additive total.

Key:
EDMS = Emissions and Dispersion Modeling System
$g/(s\text{-}m^2)$ = grams per second per square meter
g/sec = grams per second
m^2 = square meters
TAXIQ = taxi/idle sources
tpy = tons per year

Section 3
Emission Inventory Results

An emissions inventory was completed for lead emissions from aviation gas-fueled aircraft (piston engines) at HIO. The user-created aircraft described in Section 2 were entered into EDMS for the number of LTOs and TGOs identified in the Draft EA for existing conditions. Table 3-1 summarizes the lead emissions and fuel consumption that was estimated by EDMS for piston aircraft operations at HIO.

Table 3-1
Summary of Emissions and Fuel Consumption

Mode	***Lead Emissions***		***Fuel Consumption***	
	(kg/yr)	***(tpy)***	***(kg/yr)***	***(tpy)***
Taxi-Out	3.177	0.004	4,079	4
Takeoff	56.969	0.063	73,149	81
Climb out	212.921	0.235	273,393	301
Approach	278.400	0.307	357,470	394
Taxi-In	21.648	0.024	27,796	31
Total	**573.114**	**0.632**	**735,887**	**811**

Key:
kg/yr = kilograms per year
tpy = short tons per year

To verify the lead emissions inventory that was generated by the model, the fuel consumption estimated by EDMS was multiplied by the lead EI that was entered into the model (0.78 grams lead per kilogram fuel). Annual emissions of lead were estimated to be 0.632 tons per year, which is equal to the lead emissions estimated by EDMS. The method used to estimate lead emissions and dispersion in EDMS was therefore confirmed and no further edits to the model were necessary.

3.1 Source Analysis

As is shown in Table 3-1, total emissions from ground-level sources (e.g., taxi-out and taxi-out) are approximately 0.028 tons per year (tpy). Ground-level source therefore represent less than five percent of the total emissions associated with the airport, as calculated by EDMS. Since the ground-based source represents a small percentage of total emissions at the airport, modeling all of the airports emissions at this level would be overly conservative because emissions would be focused on the ground. By concentrating the emissions at the ground, the ground-level concentrations would be higher than if the emissions were to be dispersed at the higher elevations from the airborne sources.

Section 4
Dispersion Results

The following section describes the results of the air dispersion modeling that was completed for HIO. Results from the full EDMS modeling and the simplified approach are both presented.

4.1 EDMS Dispersion Results

Air dispersion modeling was initially completed using the EDMS-generated sources and HRE files. Due to complications with runway assignments, it was necessary to create two files to model aircraft and helicopter emission sources separately. Modeling was completed using the Lakes Environmental graphical user interface (GUI) to AERMOD. Although sources can be modeled in EDMS directly, EDMS uses a local coordinate system. The files were modeled by Lakes in order to shift the sources to a NAD83 UTM coordinate system. The latest version of AERMOD, Version 09292, was used to complete the modeling.

The ground-level concentrations of lead from aircraft and helicopter emissions were added externally for each receptor. The maximum concentration of lead from aircraft was 0.00396 micrograms per cubic meter ($\mu g/m^3$), while the maximum concentration from helicopters was 0.00022 $\mu g/m^3$; however, these concentrations occurred at different receptors. The maximum combined concentration was 0.00405 $\mu g/m^3$, while the average combined concentration from all receptors was 0.00082 $\mu g/m^3$. Figure 4-1 shows the results of the dispersion modeling.

4.2 Simplified AERMOD Dispersion Results

Air dispersion modeling was also completed using the seven simplified area sources described in Section 2 and the average annual emission rates. Since aircraft and helicopter sources and emissions were combined for this study, only one model was created for the simplified approach. The maximum ground-level concentration of lead was estimated at 0.000389 $\mu g/m^3$ from this simplified approach. This value is approximately 0.0002 $\mu g/m^3$ less than the combined results of the EDMS modeling. The ground-level concentration is approximately four percent less than the EDMS modeling. The average lead concentration was 0.00068 $\mu g/m^3$, which is 17 percent less than the EDMS modeling. Figure 4-2 shows the results of the simplified AERMOD dispersion modeling.

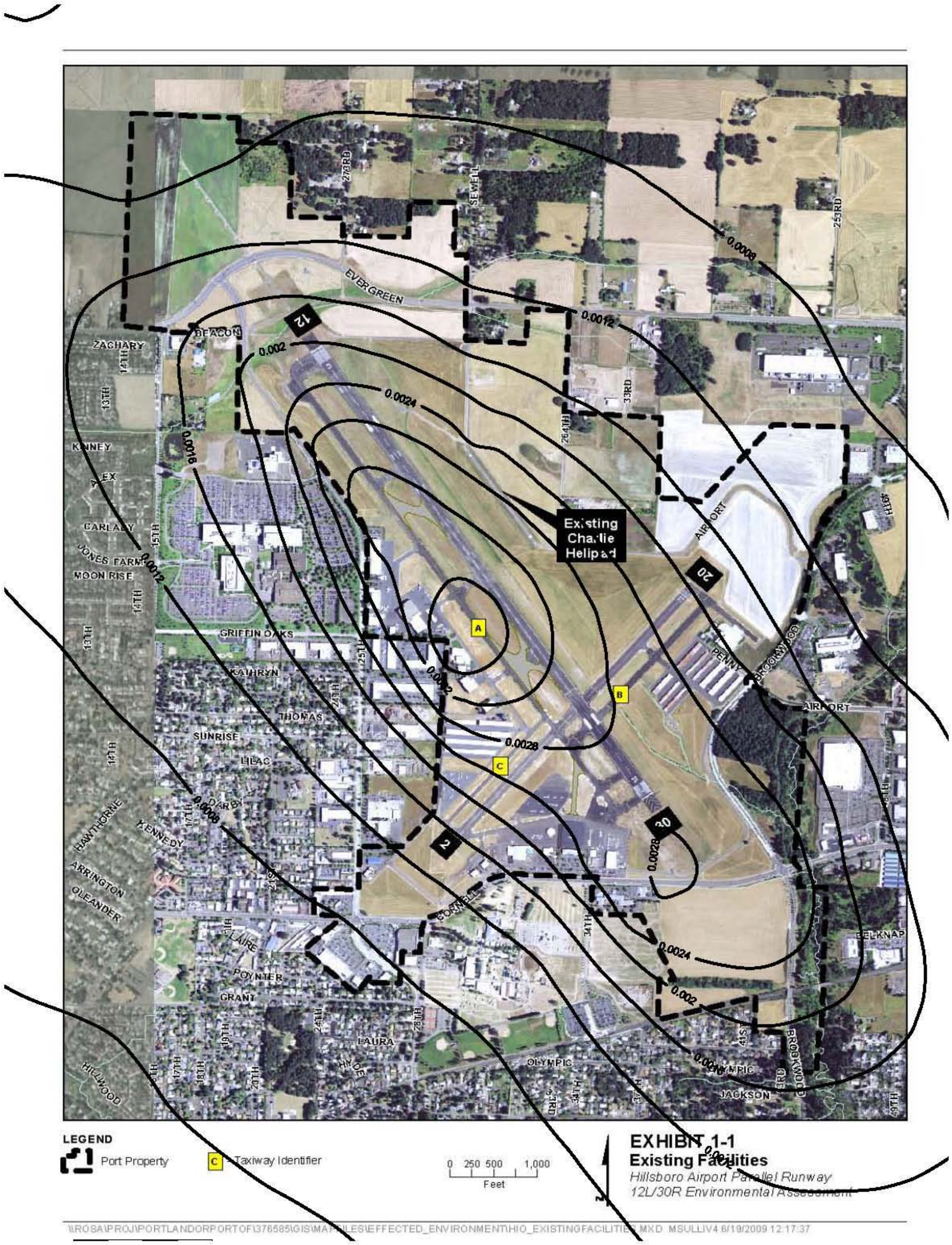


Figure 4-1
Lead Concentrations from Combined (Aircraft + Helicopter) EDMS Modeling

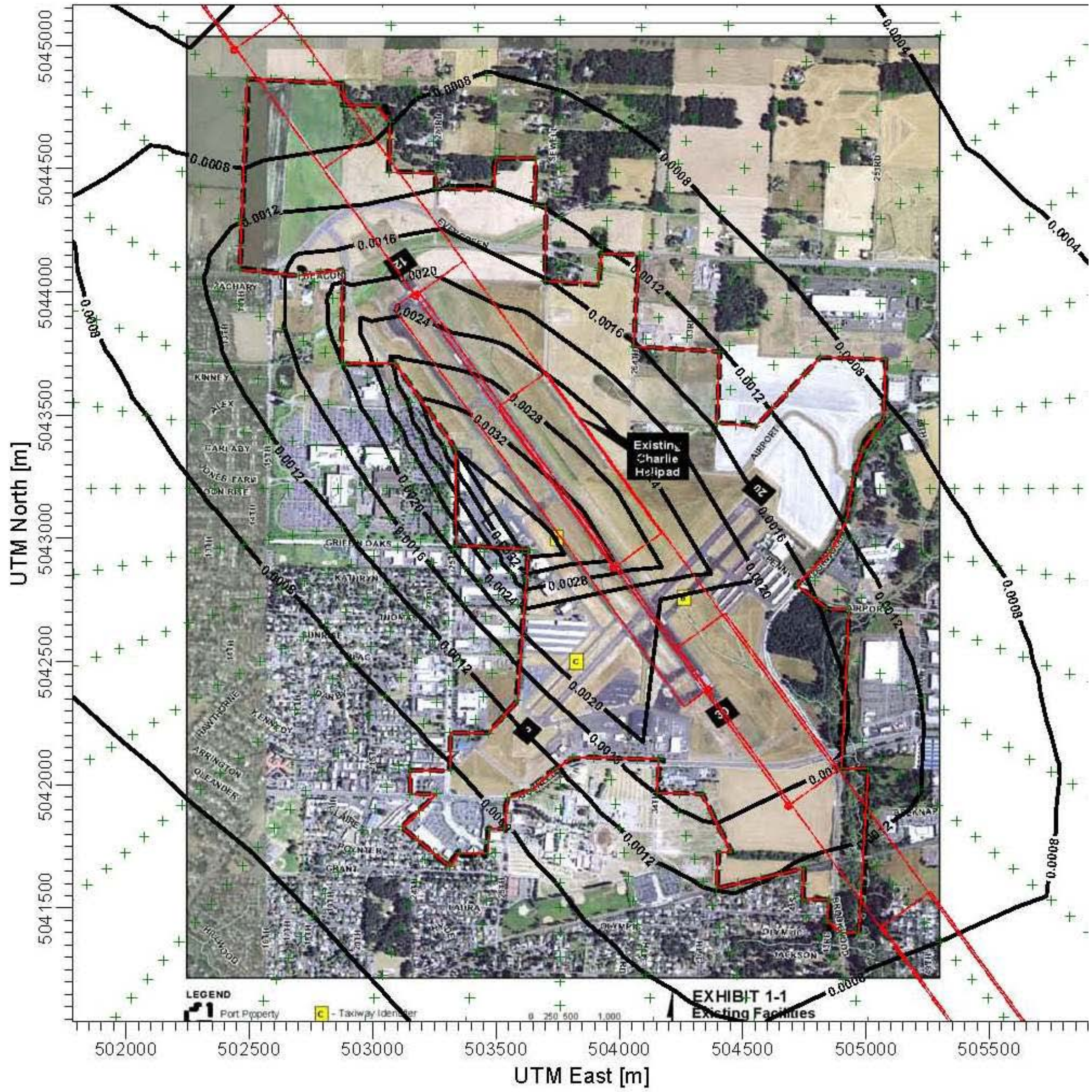


Figure 4-2
Lead Concentrations from Simplified AERMOD Modeling

4.3 Sensitivity Analysis

A sensitivity analysis was completed to evaluate how lead concentrations would be affected by different source scenarios.

4.3.1 Modified Source Release Height

An initial sensitivity analysis was completed by decreasing the height of the airborne release heights by 50 meters from the original simplified model. This resulted in airborne release heights of 50, 250, and 450 meters. The default release height for ground-level aircraft is 12 meters, which most closely represents the engine height of large jet aircraft. Since the only sources included in the modeling are small piston aircraft, the release height was estimated to be approximately half of the default height (6 meters).

The maximum ground-level concentration was estimated at 0.00766 $\mu g/m^3$, while the average concentration was estimated at 0.00104 $\mu g/m^3$. These values were found to be 89 percent and 26 percent higher, respectively, than the EDMS concentrations. Figure 4-3 shows the isopleths created with this model scenario.

4.3.2 Ground-Level Sources

A second sensitivity analysis was completed to evaluate the effect of concentrating all of the emissions associated with the airport (i.e., airborne and ground-level emissions) into the ground-based source for taxiing. This represents a scenario where all of the emissions that occur beyond the airfield are not simply dropped down to the ground-level; rather, as shown in Figure 4-4, the emissions from all of the sources are modeled in the source representing the runways and taxiways. Consistent with the defaults in EDMS, a release height of 12 meters was used for this source. The maximum ground-level concentration was estimated at 0.06567 $\mu g/m^3$, while the average concentration was estimated at 0.01007 $\mu g/m^3$. These values were found to be over 1,500 percent and over 1,100 percent higher, respectively, than the EDMS concentrations. Figure 4-4 shows the isopleths created with this model scenario.

4.4 Source Group Analysis

Source groups were used in the modeling to determining the contribution of an emission source to the overall concentration. The results of the simplified modeling indicate that on average airborne sources contribute 23 percent of the modeled concentration, whereas ground sources contribute the remaining 77 percent. The sensitivity analysis with the reduced release heights indicated that airborne sources represent 32 percent of the modeled concentration, whereas ground sources reflect 68 percent. The distribution of all source groups for the maximum concentration from the AERMOD models is provided in Figure 4-5.

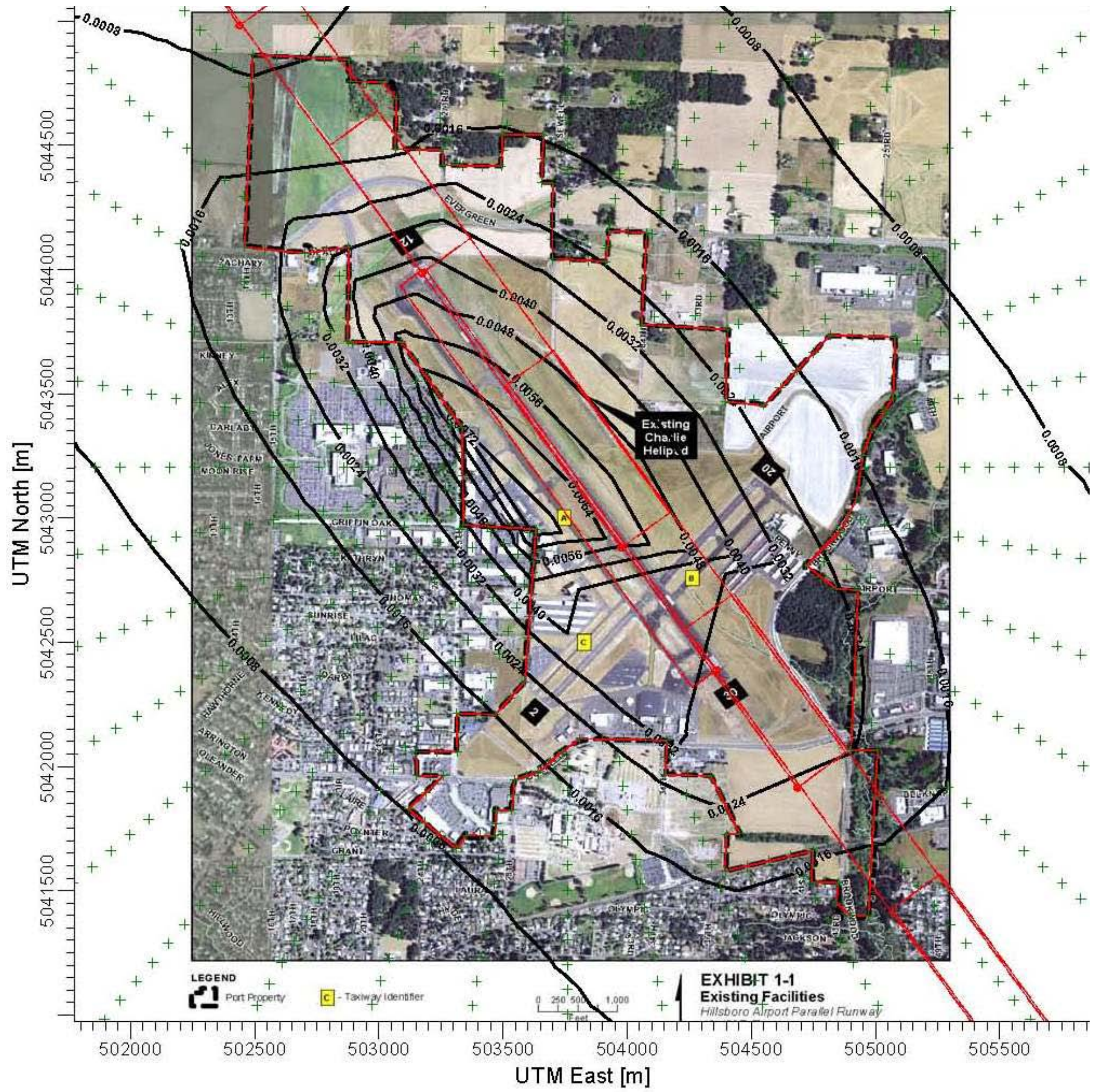


Figure 4-3
Sensitivity Analysis: Release Height Reduced by 50 Meters for Airborne Sources and Ground-Based Source Release Height Reduced to 6 Meters

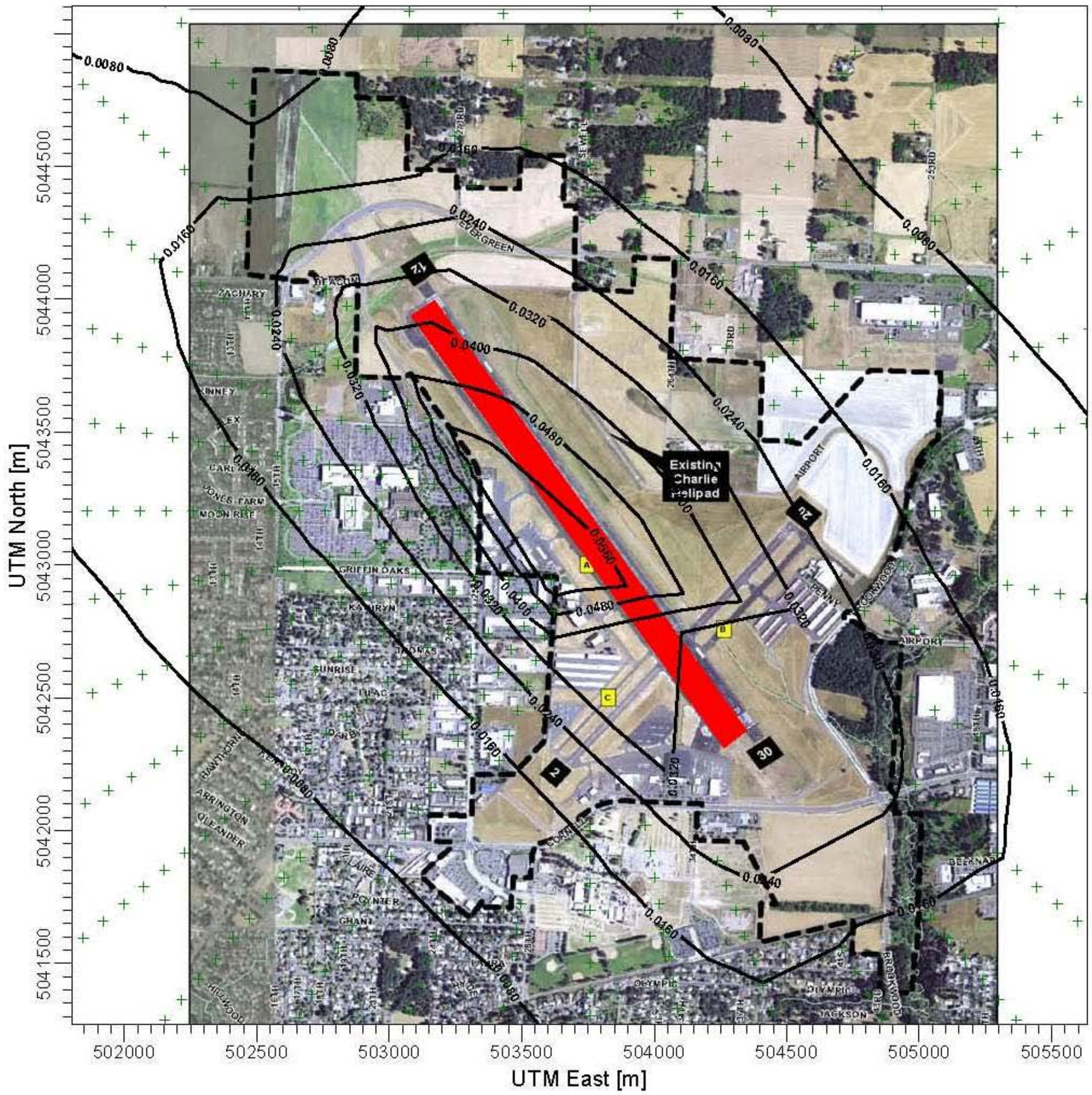
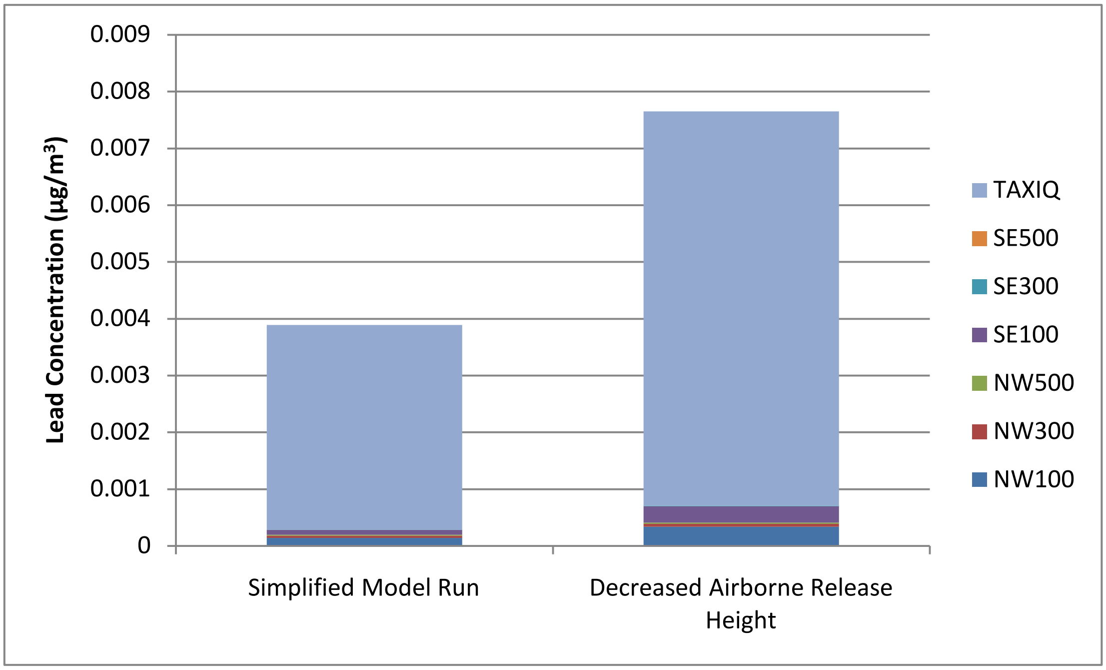


Figure 4-4
Sensitivity Analysis: Emission Rates for All Sources Consolidated into Ground-Level Source Group



Key:
TAXIQ = taxi/idle source group
SE500 = Takeoff (RW12) and Approach (RW 30) – 500/450 meter release height
SE300 = Takeoff (RW12) and Approach (RW 30) – 300/250 meter release height
SE100 = Takeoff (RW12) and Approach (RW 30) – 100/50 meter release height
NW500 = Takeoff (RW30) and Approach (RW 12) – 500/450 meter release height
NW300 = Takeoff (RW30) and Approach (RW 12) – 300/250 meter release height
NW100 = Takeoff (RW30) and Approach (RW 12) – 100/50 meter release height

Figure 4-5
Contribution of each Source Group to Overall Emissions (Based on Maximum Lead Concentration Determined from Modeling)