TECHNICAL SUPPORT DOCUMENT
FOR NON-ROAD MOBILE SOURCES:
PM2.5 EMISSIONS INVENTORIES
FOR PM2.5 SIP BASE YEARS

Four Episodes:
January 11-21, 2007
February 13-19, 2008
January 8-27, 2009
December 7, 2009 to January 23, 2010

(PEAK WINTER EPISODE WEEKDAYS AND WEEKEND DAYS)

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ii. Introduction

This inventory includes emissions of PM10, PM2.5, sulfur dioxide (SO2), nitrogen oxides (NOx), volatile organic compounds (VOC), carbon monoxide (CO) and ammonia (NH3) from miscellaneous non-road engines, locomotives and aircraft.

Inventories were computed for four PM2.5 episodes:

Episode #1: Thursday, January 11, 2007 through Sunday, January 21, 2007 inclusive (11 days);
Episode #2: Wednesday, February 13 through Tuesday, February 19, 2008 inclusive (7 days);
Episode #3: Thursday, January 8 through Tuesday, January 27, 2009 inclusive (20 days);
Episode #4: Monday, December 7, 2009 through Tuesday, January 23, 2010 inclusive (48 days).

Both urban and rural county emission inventories are discussed in this document. The counties in the PM2.5 domain are the following:

Urban: Cache, Davis, Salt Lake, Utah and Weber Counties

Rural:	Box Elder	Emery	Morgan	Summit
	Carbon	Juab	Rich	Tooele
	Duchesne	Millard	Sanpete	Wasatch

Non-road mobile sources are comprised of three main source categories: 1) miscellaneous non-road engines, 2) locomotives and 3) aircraft. Miscellaneous non-road engine emissions were computed by using the EPA NONROAD Model, version 2008.1.0. Locomotive emissions were estimated by applying EPA emission factors to the total amount of fuel used by locomotives. Aircrafts emissions were estimated by applying aircraft specific activity data and *Emissions Dispersion Modeling System (EDMS)*, version 5.1.2.

For most pollutants, the majority of non-road mobile source emissions come from miscellaneous non-road engines. However, emissions of NOx and SOx are higher from diesel locomotives than miscellaneous non-road engines. Emissions from aircraft contribute a relatively small part of total non-road mobile source emissions.

iii. Non-road Emission Source and Models

Non-road Miscellaneous Engines

Mobile source emissions are disaggregated into on-road and non-road emission categories. The EPA NONROAD Model, version 2008.1.0 (December 8, 2008) was used to compute non-road emissions. There are nine categories for non-road emissions which result from the use of fuel in a diverse collection of vehicles and equipment[1]. The nine categories include recreational vehicles, logging equipment, agricultural equipment, construction equipment, industrial equipment, residential and commercial lawn and garden equipment, recreational and commercial marine vessels, locomotive equipment, and aircraft. Commercial marine, locomotive, and aircraft emissions are not predicted in this version of the non-road emissions model. The model includes more than 80 basic and 260 specific types of non-road equipment, and further stratifies equipment types by horsepower rating. Fuel types include gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG).

The NONROAD model estimates emissions for six exhaust pollutants: hydrocarbons (HC), NOx,

carbon monoxide (CO), carbon dioxide (CO2), sulfur oxides (SOX), and particulate matter (PM10 and PM2.5).

Emissions were computed for a winter weekday and a winter weekend day. The NONROAD model is not sensitive to the changes in temperature observed during the PM2.5 episodes. However, NONROAD emissions are sensitive to the choice of weekday versus weekend day. Annual average emissions were calculated by the following equation:

Annual average emission (tons per year) = [(average weekday *5 + average weekend days *2)/7]*365

Input Data

Fuel Reid Vapor Pressure (RVP) of Gasoline
Fuel Reid Vapor Pressure values are obtained from the NONROAD model database C: \non-road\DATA\DAILY\DAYTMPRV.DAT. The following table shows RVP values for State of Utah.

Table 1. RVP Values for the State of Utah

Month	RVP Daily Value
1	12.5
2	11.3
3	11.3
4	9.8
5	8.5
6	8.5
7	7.7
8	7.7
9	8.5
10	8.5
11	9.8
12	11.3

Sulfur Content of Non-road Diesel, Gasoline, LPG and CNG

EPA document assumed the gasoline sulfur limits set under the Tier 2/Sulfur program would apply to gasoline used by non-road equipment. Table 2 shows the scenario specific parameters that were used for NONROAD runs[2]. Table 3 shows the diesel sulfur content[3].

Table 2. Input parameters Used in NONROAD Model

Parameter	Base Case	Tier 2/Sulfur Case
Fuel RVP (psi)	9.0	9.0

Fuel Oxygen Weight %	0.0	0.0
Gasoline Sulfur %	0.034	0.003
LPG/CNG Sulfur %	0.033	0.003

Table 3. Diesel Sulfur Content

Year	Diesel Sulfur ppm
2007	1139
2008	351
2009	351
2010	165

Daily Minimum and Maximum Temperatures by County

The minimum and maximum temperature is the average low and high for the time period selected in each county. Temperature data is from Western Region Climate Center[3] (WRCC). A typical monitor station was selected for each county. Monthly average minimum and maximum temperatures for each county and each episode year were used in NONROAD input files.

Table 4a. January 2007 Average Maximum and Minimum Temperature

		January 2007 Weekday			**January 2007 Weekend**		
County	**FIPS**	Min (F)	Max (F)	Avg (F)	Min (F)	Max (F)	Avg (F)
Box Elder	49003	10.63	26.99	18.81	12.38	25.07	18.73
Cache	49005	2.79	18.83	10.81	3.02	18.82	10.92
Carbon	49007	4.20	23.90	14.05	4.01	23.22	13.62
Davis	49011	9.86	21.70	15.78	9.34	20.63	14.98
Duchesne	49013	4.20	23.90	14.05	4.01	23.22	13.62
Emery	49015	4.20	23.90	14.05	4.01	23.22	13.62
Juab	49023	4.20	23.90	14.05	4.01	23.22	13.62
Millard	49027	4.20	23.90	14.05	4.01	23.22	13.62
Morgan	49029	2.79	18.83	10.81	3.02	18.82	10.92
Rich	49033	4.20	23.90	14.05	4.01	23.22	13.62
Salt Lake	49035	10.21	23.17	16.69	9.99	21.60	15.79
Sanpete	49039	4.20	23.90	14.05	4.01	23.22	13.62
Summit	49043	-4.79	27.07	11.14	-8.70	24.13	7.71
Tooele	49045	10.37	26.57	18.47	10.58	26.02	18.30
Utah	49049	6.61	21.13	13.87	6.23	17.68	11.95
Wasatch	49051	-1.51	24.57	11.53	-4.68	21.50	8.41
Weber	49057	9.16	24.26	16.71	8.48	23.33	15.90

Table 4b. February 2008 Average Maximum and Minimum Temperature

		February 2008 Weekday			**February 2008 Weekend**		
County	**FIPS**	Min (F)	Max (F)	Avg (F)	Min (F)	Max (F)	Avg (F)
Box Elder	49003	21.45	36.61	29.03	20.84	36.77	28.81
Cache	49005	13.68	27.50	20.59	11.75	28.67	20.21

Carbon	49007	15.94	38.19	27.07	10.58	38.03	24.31
Davis	49011	22.89	36.50	29.70	23.63	34.70	29.17
Duchesne	49013	15.94	38.19	27.07	10.58	38.03	24.31
Emery	49015	15.94	38.19	27.07	10.58	38.03	24.31
Juab	49023	15.94	38.19	27.07	10.58	38.03	24.31
Millard	49027	15.94	38.19	27.07	10.58	38.03	24.31
Morgan	49029	13.68	27.50	20.59	11.75	28.67	20.21
Rich	49033	15.94	38.19	27.07	10.58	38.03	24.31
Salt Lake	49035	23.14	39.31	31.23	23.45	36.59	30.02
Sanpete	49039	15.94	38.19	27.07	10.58	38.03	24.31
Summit	49043	2.40	33.80	18.10	3.00	31.50	17.25
Tooele	49045	22.96	41.00	31.98	23.54	40.73	32.14
Utah	49049	19.04	39.81	29.43	16.07	38.21	27.14
Wasatch	49051	-2.80	32.00	14.60	-4.00	30.50	13.25
Weber	49057	21.20	36.82	29.01	20.93	35.96	28.45

Table 4c. January 2009 Average Maximum and Minimum Temperature

		January 2009 Weekday			**January 2009 Weekend**		
County	**FIPS**	Min (F)	Max (F)	Avg (F)	Min (F)	Max (F)	Avg (F)
Box Elder	49003	23.70	39.26	31.48	24.38	39.08	31.73
Cache	49005	17.88	31.54	24.71	19.52	29.60	24.56
Carbon	49007	15.08	36.20	25.64	16.76	35.54	26.15
Davis	49011	25.60	38.70	32.15	26.42	38.24	32.33
Duchesne	49013	15.08	36.20	25.64	16.76	35.54	26.15
Emery	49015	15.08	36.20	25.64	16.76	35.54	26.15
Juab	49023	15.08	36.20	25.64	16.76	35.54	26.15
Millard	49027	15.08	36.20	25.64	16.76	35.54	26.15
Morgan	49029	17.00	37.67	27.33	15.00	37.67	26.33
Rich	49033	13.89	34.22	24.06	12.67	33.00	22.83
Salt Lake	49035	25.78	41.54	33.66	26.36	40.76	33.56
Sanpete	49039	15.08	36.20	25.64	16.76	35.54	26.15
Summit	49043	13.67	38.72	26.19	10.67	36.67	23.67
Tooele	49045	29.28	42.98	36.13	28.52	41.96	35.24
Utah	49049	20.64	39.32	29.98	20.42	38.36	29.39
Wasatch	49051	12.56	36.33	24.44	11.67	33.00	22.33
Weber	49057	24.78	38.66	31.72	25.46	36.86	31.16

Table 4d. December 2009 and January 2010 Average Maximum and Minimum Temperature

		December 2009			**January 2010**		
County	**FIPS**	Min (F)	Max (F)	Avg (F)	Min (F)	Max (F)	Avg (F)
Box Elder	49003	12.55	29.87	21.21	14.13	34.23	24.18
Cache	49005	7.74	27.10	17.42	12.16	29.19	20.68
Carbon	49007	-0.65	27.91	13.63	8.25	34.00	21.13
Davis	49011	16.23	30.84	23.54	22.29	37.35	29.82

Duchesne	49013	-1.26	33.00	15.87	4.26	34.32	19.29
Emery	49015	2.39	26.94	14.67	6.97	28.19	17.58
Juab	49023	11.68	29.71	20.70	19.23	36.84	28.04
Millard	49027	9.87	32.94	21.41	20.13	40.32	30.23
Morgan	49029	5.74	27.19	16.47	12.87	34.06	23.47
Rich	49033	-0.87	26.16	12.65	6.55	30.84	18.70
Salt Lake	49035	16.52	30.61	23.57	21.48	36.61	29.05
Sanpete	49039	-2.10	27.06	12.48	5.03	30.52	17.78
Summit	49043	6.35	29.13	17.74	15.45	37.23	26.34
Tooele	49045	23.48	30.77	27.13	23.58	39.06	31.32
Utah	49049	15.00	30.52	22.76	17.13	37.55	27.34
Wasatch	49051	11.16	31.37	21.27	11.94	34.52	23.23
Weber	49057	15.03	29.94	22.49	22.10	34.73	28.42

Aircraft Emissions

The aircraft source category includes all aircraft types used for public, private, and military purposes. The aircraft emissions inventories are grouped by type of operation rather than aircraft type. Four types of aircraft activity, shown Table 5, are included: commercial, air taxi, general aviation and military aircraft.

Table 5. Four Main Operation Types for Aircraft

Operation Type	Description	Source of Emission Factors	SCC Code Groups
Commercial Flights/Air Carriers	Operations at Salt Lake City International Airport and 8 smaller municipal airports.	EDMS and EPA guidance documents for PM from commercial aircraft	2275000000
Air Taxi	Small privately-owned commuter planes	EDMS and EPA guidance documents for air taxi	2275000000
General Aviation	Small municipal airport operations (aircraft are "based" in small cities and towns)	EDMS and EPA guidance documents for general aviation	2275000000
Military Aircraft	Military operations	Military installations and EPA guidance	2275000000

Criteria pollutant emissions for commercial air carriers were calculated differently than the other three aircraft categories. They were estimated by applying aircraft specific activity data from FAA's *Airport Activity Statistics of Certificated Route Air Carriers* to FAA's *Emissions and Dispersion Modeling System (EDMS)*, version 5.1.2, November 6, 2009[5]. The FAA's T100

Segment data obtained from the Bureau of Transportation Statistics (BTS), which is updated every month, were used in conjunction with the EDMS model. EDMS generates emissions for CO, VOC, NOx, SOx, PM10 and PM2.5 emissions by aircraft type. EDMS does not give emission factors (EF) for PM10 and PM2.5 exhaust for some aircraft types. UDAQ assumed those values were insignificant or too small to count.

Annual aircraft operations data for air taxis, general aviation, and military aircraft are reported by the Utah Department of Transportation, Division of Aeronautics. Criteria pollutant emission estimates were calculated by combining aircraft operations data and EDMS emission factors by aircraft type.

Airport Ground Support Equipment (GSE)

The EPA NONROAD model runs emissions for Airport Ground Support Equipment (GSE). The model produces 3 SCC categories for GSE:

226-500-8005 4-stroke
226-700-8005 LPG
227-000-8005 Diesel

Davis County shows zero emissions for Airport GSE. Tooele County has a small value. This might be for Tooele City airport. Salt Lake County has a bigger value, which indicates that emissions from Salt Lake International Airport are included in the NONROAD model. The NONROAD model covers GSE for other counties and small airports. GSE for Davis County and Tooele County were reported in point sources under Hill Air Force Base and Dugway Proving Ground.

Locomotive (Diesel) Emissions

The locomotive source category includes railroad locomotives powered by diesel-electric engines and does not include locomotives powered by electricity or steam. Locomotive diesel engines are significant contributors to air pollution; they emit especially large amounts of nitrogen oxides (NOx) and particulate matter (PM) which contribute to serious public health problems.

All of the criteria pollutants, VOC, CO, NO_x, SO_x, PM_{10}, and $PM_{2.5}$, are included in the locomotive inventory. The emissions were estimated by applying emission factors to the total amount of distillate fuel oil used by locomotives. Emission factors for the criteria pollutants were obtained from *Emission Factors for Locomotives* (U.S. EPA, 1997)[6]. The estimated average emission rates are shown in Table 6 in grams of pollutant emitted per gallon of fuel consumed (g/gal).

Table 6 - Estimated Baseline In-Use Emission Rates (g/gal)

	HC	CO	NOx	PM
Line-Haul	10	26.6	270	6.7

Switch	21	38.1	362	9.2

Diesel locomotives are grouped by two operations: line haul and yard, or switch.

Emissions from diesel locomotives were reported to UDAQ by the individual railroad companies that operate in Utah. For incomplete data, UDAQ computed missing emissions using EPA guidance. As of 2008 and 2009, these companies include: Amtrak, Burlington Northern Sante Fe Railway (BNSF), Union Pacific Railroad Company (UPRR), Salt Lake Garfield & Western Railway, and Utah Transit Authority (UTA). Commuter rail operated by UTA were also included in the inventory. It started operations on April 26, 2008. Therefore the 2007 inventory did not include commuter rail emissions. About 83% of diesel locomotive emissions come from UPRR.

iv. 2007 – 2010 Episode Year Summary Tables (Appendix)

(7) Non-road Miscellaneous Engines
(8) Aircraft
(9) Locomotives

v. Idaho Non-road Inventory

All the non-road numbers for the Idaho areas found within the modeling domain were provided by the Idaho Department of Environmental Quality.

vi. REFERENCES

The following documents were used as references in creating the non-road mobile source PM2.5 SIP emissions inventories:

1) U.S. Environmental Protection Agency, User's Guide for the Final NONROAD2005 Model, EPA420-R-05-013, December 2005, http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf

2. U.S. Environmental Protection Agency, http://www.epa.gov/otaq/models/tier2/tec2nrsa.pdf

3. U.S. Environmental Protection Agency, *Suggested Nationwide Average Fuel Properties*, Office of Transportation and Air Quality, EPA-420-B-09-018, April 2009, http://www.epa.gov/oms/models/nonrdmdl/nonrdmdl2008/420b09018.pdf.

4. Western Regional Climate Center, http://www.wrcc.dri.edu/Climsum.html (on map, click on "Utah").

5. Federal Aviation Administration, *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01, (Rev. 7 – 11/06/09), November 2009,

http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS%205.0.2%20User%20Manual.pdf

6. U.S. Environmental Protection Agency, *Emission Factors for Locomotives* (U.S. EPA, 1997).