TECHNICAL SUPPORT DOCUMENT
FOR NON-ROAD MOBILE SOURCES:
PM2.5 EMISSIONS INVENTORIES
FOR SERIOUS PM2.5 SIP BASE YEAR 2014
CLEAN DATA APPROACH FOR UTAH COUNTY

April 2018
Utah Division of Air Quality (UDAQ)
Planning Branch/Inventory Section/Mobile

ABSTRACT

This document describes the non-road mobile source emissions inventory modeling procedure and results for the Provo Area "Clean Data" Serious PM2.5 SIP for the base year 2014.

Non-road mobile sources include 1) non-road engines and motorized equipment from MOVES2014a (formerly the EPA NONROAD Model), 2) aircraft, 3) airport ground support equipment and 4) diesel locomotives. The majority of non-road emissions come from miscellaneous non-road engines (MOVES/EPA NONROAD Model).

The domain for this SIP was originally the entire state of Utah and portions of surrounding states. However, the "Clean Data" approach pertains to Utah County only.

In Utah County, for NOx, about 68% of total non-road mobile source emissions come from non-road engines and equipment in MOVES/NONROAD, and another 31% comes from diesel locomotives. For PM2.5 exhaust, about 83% of total non-road mobile source emissions come from non-road engines and equipment in MOVES/NR. For VOC, about 82% of total non-road mobile source emissions come from non-road engines and equipment in MOVES/NR, and another 15% comes from aircraft and ground support.

The original modeling domain for this SIP included the entire state of Utah and portions of surrounding states (Utah Division of Air Quality, UDAQ) did not create inventories for out-of-state areas in the domain. Instead, the NEI 2011 was used to obtain inventories for these areas.)

For the "Clean Data SIP", the domain is Utah County only.

Emissions for the non-road sector in the state of Utah were modeled by UDAQ inventory staff.

Temperatures modeled for the base year and projection years are the average temperatures over the three PM2.5 episodes:

Sat, Jan 1 – Wed, Jan 12, 2011
Sat, Dec 7 – Thu, Dec 19, 2013
Mon, Feb 1 – Wed, Feb 17, 2016

This document includes inventory results for the base year (and projection year 2019). Units were converted to tons per year for easy comparison to other source groups—point, area, and on-road mobile.

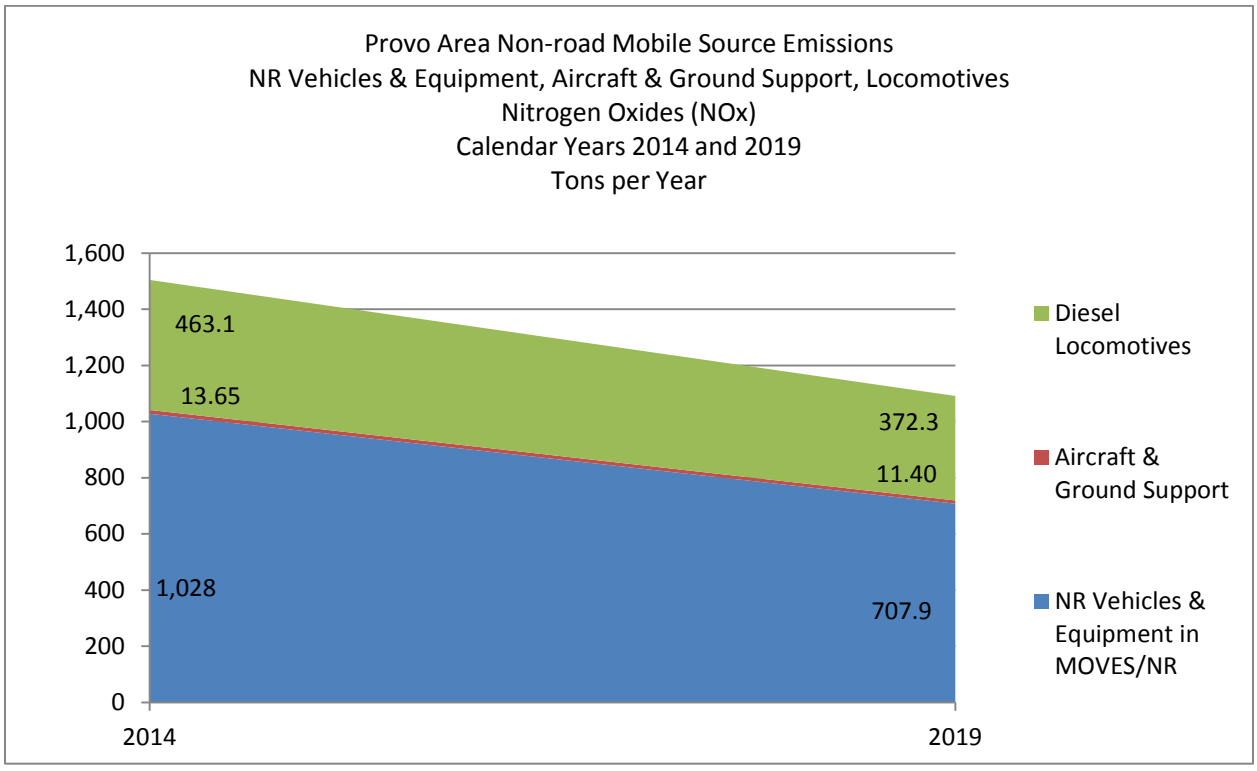
Provo Area Serious PM2.5 SIP "Clean Data" Approach
ii. Summary of Emissions (TPY)

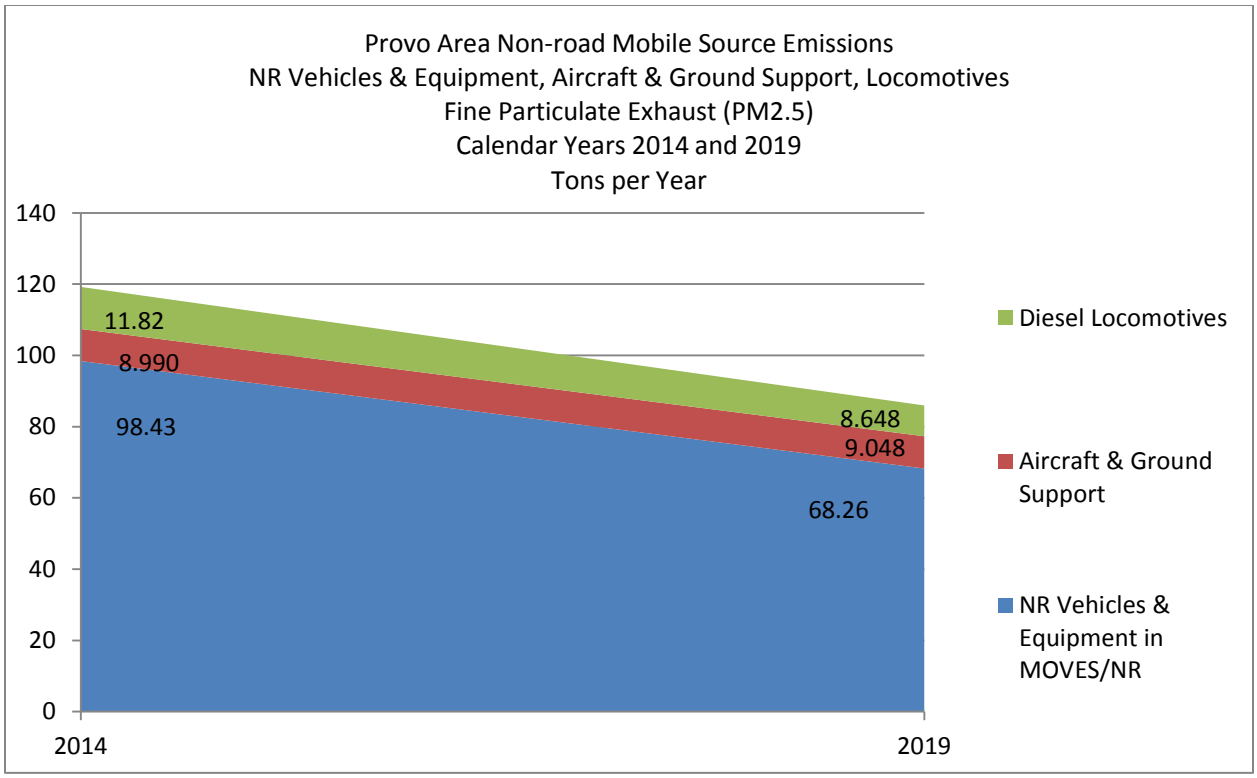
4/13/2018

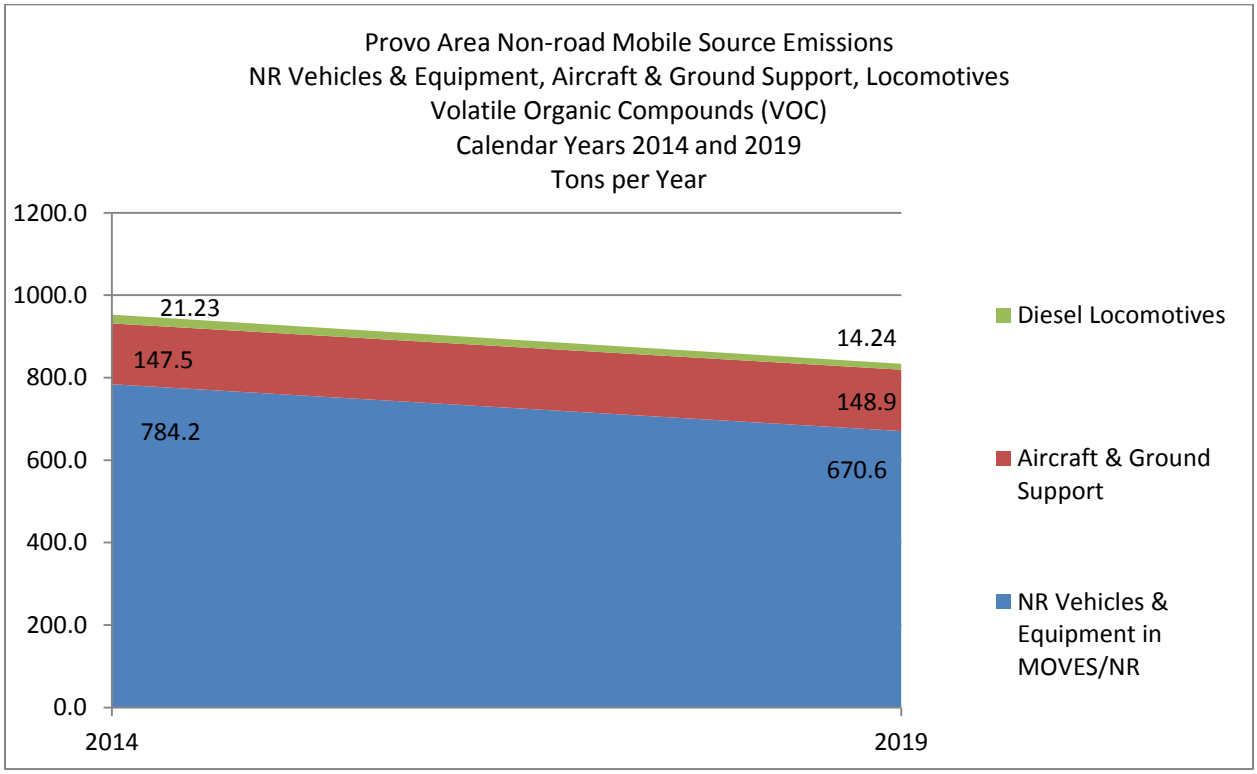
				TONS PER YEAR						
Cal Yr	County	FIPs	Source	CO	NOX	PM10	PM2.5	SO2	VOC	NH3
2014	UT	49049	MOVES/NR	6,715	1,028	102.9	98.43	2.218	784.2	1.566
2014	UT	49049	Aircraft	3,110	11.47	8.954	8.954	5.291	146.8	N/A
2014	UT	49049	Airport GSE	16.82	2.178	0.0405	0.0358	0.0405	0.7213	N/A
2014	UT	49049	Locomotives	89.49	463.1	12.19	11.82	0.1658	21.23	0.2797
2014	UT	49049	**SUM**	**9,931**	**1,505**	**124.1**	**119.2**	**7.715**	**953.0**	**1.846**

Cal Yr	County	FIPs	Source	CO	NOX	PM10	PM2.5	SO2	VOC	NH3
2019	UT	49049	MOVES/NR	6,558	707.9	71.73	68.26	1.497	670.6	1.707
2019	UT	49049	Aircraft	3,139	9.315	9.016	9.016	5.291	148.2	N/A
2019	UT	49049	Airport GSE	15.90	2.087	0.0366	0.0320	0.0405	0.6922	N/A
2019	UT	49049	Locomotives	95.32	372.3	8.916	8.648	0.1933	14.24	0.298
2019	UT	49049	**SUM**	**9,808**	**1,092**	**89.70**	**85.96**	**7.022**	**833.7**	**2.005**

The FAA "Emissions Dispersion and Modeling System", v. 5.1.4.1, does not compute emissions for ammonia (NH3). EDMS reports the same emissions for PM10 and PM2.5 exhaust from aircraft.




Provo Area Non-road Mobile Source Emissions
NR Vehicles & Equipment, Aircraft & Ground Support, Locomotives
Fine Particulate Exhaust (PM2.5)
Calendar Years 2014 and 2019
Tons per Year
140
120
100
80
60
40
20
0
11.82
8.990
98.43
8.648
9.048
68.26
2014
2019
Diesel Locomotives
Aircraft & Ground Support
NR Vehicles & Equipment in MOVES/NR


Provo Area Non-road Mobile Source Emissions
NR Vehicles & Equipment, Aircraft & Ground Support, Locomotives
Volatile Organic Compounds (VOC)
Calendar Years 2014 and 2019
Tons per Year
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
21.23
147.5
784.2
14.24
148.9
670.6
2014
2019
Diesel Locomotives
Aircraft & Ground Support
NR Vehicles & Equipment in MOVES/NR

iii. ADDENDUM: Revision of Aircraft and Airport Ground Support Equipment SO2/SOx Emissions for Projection Year 2019

The attainment year for the Provo area in this SIP is 2019.

The UDAQ Technical Analysis Section reviewed the SO2/SOx inventories from aircraft and airport ground support equipment (GSE) in the base year 2014 and the "attainment" year 2019. Aircraft were the largest source of SO2/SOx emissions in the non-road mobile source inventory for the Provo area (see Appendix items C - E, "PM2.5 SIP (Serious) NON-ROAD MOBILE SO2 and/or SOx Inventories and Sources").

Aircraft activity for projection years is usually estimated by applying scaling factors for aircraft activity (number of landings and takeoffs) obtained from Federal Aviation Administration. However, historical aircraft activity for calendar years 2013 – 2016 showed that aircraft activity was essentially flat during these years. Therefore, SO2/SOx emissions from aircraft (and airport ground support equipment) were held constant at the 2014 level through calendar year 2019.

As for airport ground support equipment (GSE), the Federal Aviation Administration "Emissions Dispersion and Modeling System" (EDMS v. 5.1.4.1) ties airport GSE activity and emissions to aircraft activity. For example, if one were to enter 1,000 landing/takeoff cycles (LTO) for a given aircraft types, the model automatically calculates emissions from the aircraft and airport GSE.

To summarize: Only SO2/SOx emissions from aircraft and airport GSE were affected by this revision, and only for the attainment year 2019. Other pollutants from aircraft and airport GSE and emissions from other sectors of the non-road inventory will remain as initially modeled as discussed in this document.

The following EXCEL tables have been added to the Appendix:

D. Aircraft (commercial) historical data: number of LTOs statewide and at Salt Lake City International Airport (calendar years 2013 – 2016)

E. Linear Regression Analyses

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iv. Introduction

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

In addition, for the CAMX air dispersion model, the following additional materials and compounds were modeled:

Pollutant No.	Abbreviation	Name
1	TGH	Total Gaseous Hydrocarbons
5	CH4	Methane
20	C6H6	Benzene
45	C6H5-CH3	Toluene
46	C6H4-(CH3)2	Xylenes
79	NMHC	Non-Methane Hydrocarbons
80	NMOG	Non-Methane Organic Gases
86	TOG	Total Organic Gases

Inventories were computed for the base year and the following projection years: 2019.

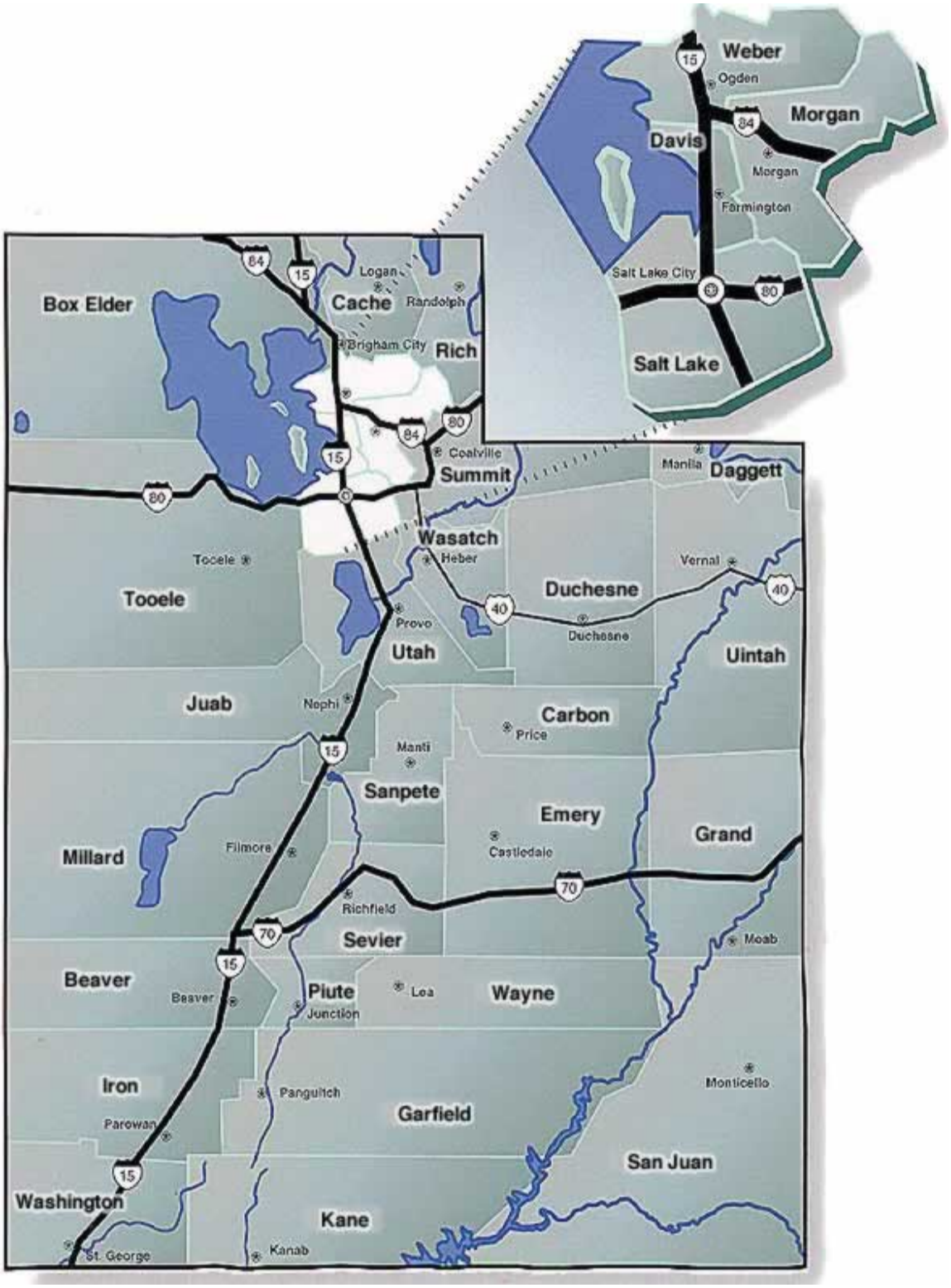
The PM2.5 domain originally consisted of all 29 counties in Utah and portions of Colorado and Wyoming. For the Provo area "Clean Data" SIP, the domain is the Provo area only (Utah County).

UT County Names, FIPs Codes, Abbreviations and Human Population (2010, 2017 and 2020)

No.	County Name	FIPs	Abbrev	Human Populations and Projections (2010)	(2017)	(2020)
1	Beaver	49001	BE	6,629	7,425	7,766
2	Box Elder	49003	BX	49,975	53,231	54,571
3	Cache	49005	CA	112,656	131,441	139,228
4	Carbon	49007	CR	21,403	21,544	21,602
5	Daggett	49009	DG	1,059	1,329	1,444
6	Davis	49011	DA	306,479	342,145	356,968
7	Duchesne	49013	DU	18,607	21,551	22,797
8	Emery	49015	EM	10,976	11,155	11,230
9	Garfield	49017	GA	5,172	5,796	6,063
10	Grand	49019	GR	9,225	9,978	10,300
11	Iron	49021	IR	46,163	53,820	57,055
12	Juab	49023	JU	10,246	12,699	13,750
13	Kane	49025	KA	7,125	7,987	8,357
14	Millard	49027	MI	12,503	12,702	12,787
15	Morgan	49029	MO	9,469	11,202	11,945
16	Piute	49031	PI	1,556	1,611	1,635
17	Rich	49033	RI	2,264	2,452	2,532
18	Salt Lake	49035	SL	1,029,655	1,136,584	1,180,859
19	San Juan	49037	SJ	14,746	15,375	15,644
20	Sanpete	49039	SP	27,822	30,516	31,637

21	Sevier	49041	SE	20,802	21,907	22,380
22	Summit	49043	SU	36,324	42,786	45,491
23	Tooele	49045	TO	58,218	69,939	74,877
24	Uintah	49047	UI	32,588	37,064	38,982
25	**Utah**	**49049**	**UT**	**516,564**	**623,787**	**668,564**
26	Wasatch	49051	WA	23,530	30,019	32,741
27	Washington	49053	WS	138,115	179,358	196,762
28	Wayne	49055	WY	2,778	2,825	2,845
29	Weber	49057	WE	231,236	250,525	258,423
SUM			ALL	2,763,885	3,148,749	3,309,234

UT Governor's Office of Planning and Budget\Demographics\Population Projections\ http://governor.utah.gov/dea/popestimates.html. From the left-hand side menu, choose "Demographics, then "Population Projections"; then page down to "2012 Baseline Projections, then "Population and Households by Area" to see the population data. Data are shown in decades from 1990 to 2060.


Weber
Ogden
Morgan
Davis
Morgan
Farmington
Salt Lake City
Salt Lake
Box Elder
Cache
Logan
Randolph
Brigham City
Rich
Coalville
Summit
Manila
Daggett
Wasatch
Heber
Tooele
Tooele
Vernal
Duchesne
Duchesne
Provo
Utah
Uintah
Juab
Nephi
Carbon
Price
Manti
Sanpete
Emery
Grand
Millard
Fillmore
Castledale
Richfield
Sevier
Moab
Beaver
Beaver
Piute
Junction
Loa
Wayne
Iron
Panguitch
Monticello
Parowan
Garfield
San Juan
Washington
Kane
St. George
Kanab
84
15
80
40
70

v. Overview

The purpose of this document is to explain how the non-road mobile source emission inventories were created for the Provo Area "Clean Data" Serious PM2.5 SIP for the base year (2014).

Non-road mobile sources include a) non-road vehicles, equipment and engines from the EPA NONROAD Model (now obsolete, replaced by MOVES/NR); b) aircraft; c) airport ground support equipment (GSE) and d) diesel locomotives.

The non-road mobile source inventories for this SIP were modeled by Utah Division of Air Quality (UDAQ), Inventory Section (formerly Mobile Sources and Transportation Section).

The baseline inventory covered a January 2014 day based on the average of temperatures recorded during the three $PM_{2.5}$ episodes which took place during the following periods:

Episode #1: Saturday, January 1 through Wednesday, January 12, 2011 inclusive (12 days);
Episode #2: Monday, February 1 through Wednesday, February 17, 2016 inclusive (17 days);
Episode #3: Saturday, December 7 through Thursday, December 19, 2013 inclusive (13 days).

When drafting of this document started, the domain for the SIP included the entire state of Utah and areas of surrounding states.

For the Provo Area "Clean Data" SIP approach, the domain for the inventory is Utah County only.

Projection-year inventories were created using the same method that was used to create the base-year inventory. Emissions units for the baseline and projection-year inventories were tons per year, obtained as follows:

Non-road Sector	Units
Miscellaneous Non-road Engines (MOVES/NR)	(5*Wkdy + 2*Wknd)/7 = Daily Emissions * 365.25 = Tons per Year
Aircraft and Airport Ground Support Equipment	(January emissions) * (365.25/31) = Tons per Year
Diesel Locomotives	2014 Annual Emissions

The CAMX air dispersion model then converts the ton-per-year inventories back to tons per winter weekday and tons per winter weekend day.

EPA guidance requires that states create inventories that use the most recent available data for fleet or equipment characterization, fuel parameters and meteorological data.

Agencies involved in discussions or supplying data include:

Bureau of Transportation Statistics/Transtats/Aviation Databases—commercial aircraft

EPA Office of Transportation and Air Quality: Mobile Team (OTAQ)—general questions

Federal Aviation Administration (FAA)—Emissions and Dispersion Modeling System

FAA Airport Master Record—Airport IQ 5010—aircraft activity for small airports-air taxi and general aviation.

Railroad companies operating in Utah—reports of locomotive fuel consumption by county

Utah Department of Transportation, Division of Aeronautics—aircraft activity for small airports-air taxi and general aviation

Utah Division of Motor Vehicles (UDMV)—snowmobile inventory for Utah

Utah Transit Authority—commuter rail "Front Runner" activity

Emissions from MOVES/NONROAD (Non-road Vehicles, Equipment and Engines)

Features of MOVES versus EPA NONROAD Model

MOVES2014a was used to obtain emission inventories for non-road mobile vehicles and equipment that operate on unpaved roads or other areas but not on paved roads (miscellaneous non-road equipment and vehicles).

MOVES/NR was run for a January weekday and January weekend day. Emissions were converted to tons per year as shown above.

MOVES models the same non-road categories as the EPA NONROAD model. For exactly identical inputs, MOVES gives the same results as NONROAD.

However, MOVES models additional compounds that NONROAD does not, including:

CH4, CO2, NH3, major mobile HAPs (1,3–butadiene, acetaldehyde, acrolein, benzene, formaldehyde), polycylic aromatic hydrocarbons (PAH), various toxic metals, dioxins and furans.

MOVES Inputs for Non-road Mobile Sources

Using MOVES, inputs of fuel (diesel, gasoline, CNG and LPG) and their properties such as ethanol (E-10) volume percent, E-10 market share, E-10 oxygen weight percent, gasoline RVP and fuel sulfur content are supplied from the main MOVES database, movesdb20161117.

Sulfur Content of Fuels

The sulfur content of fuels varies with calendar year and month. In the Provo area, the MOVES default sulfur contents were as follows:

Area	Month and Year	Fuel	Sulfur Content (ppmw)	Fuel Formulation ID
Provo	Jan 2014	Gasoline	30	3135
"	Jan 2017	Gasoline	10	3522
"	Jan 2019	Gasoline	10	3780
"	Jan 2014	NR Diesel	20	20007
"	Jan 2017 – on	NR Diesel	11	20008
"	Jan 2014	Marine Diesel	52	26011
"	Jan 2017	Marine Diesel	56	26012
"	Jan 2018 – on	Marine Diesel	55	26013
"	Jan 2014 - on	CNG	7.6	28001
"	Jan 2014 – on	LPG	7.6	29001

Gasoline in Utah is obtained mostly from local refineries. Two of the major refineries, TESORO (recently renamed Andeavor) and Chevron, have committed to produce ultra-low sulfur gasoline with a sulfur content of 10 ppm sometime in 2019. In addition, Sinclair Oil in Wyoming owns the Pioneer Pipeline, which delivers gasoline to Utah. Sinclair has a petroleum refining capacity of over 75,000 bbls/day, so it was required to produce 10-ppm sulfur gasoline by 2017.

Other inputs include temperature and relative humidity data.

The user must use caution to insure that the MOVES default values for such inputs as fuels and temperatures are appropriate. For example, MOVES default temperatures are generally too low for Utah compared to actual temperatures recorded during the past 20 years (1997 – 2016). Utah obtained meteorological data from one of several reputable websites generally run by colleges and universities in Utah, or from national meteorological websites such as MESOWEST or Western Regional Climate Center.

Meteorological data for this inventory came from MESOWEST operated by the University of Utah Department of Atmospheric Sciences (http://mesowest.utah.edu/). (1)

Aircraft Emissions

Commercial aircraft activity (mostly at Salt Lake City International Airport, but also at other major airports in Utah, including Ogden, **Provo**, St. George, Cedar City and Wendover), was obtained from Transtats/Bureau of Transportation Statistics (https://www.transtats.bts.gov/). Activity data is available for any given historical month, but not for specific days. (2)

The aircraft portion of the inventory includes aircraft and helicopter emissions from all the major and minor airports operating in Utah. The Federal Aviation Administration (FAA) Emissions

and Dispersion Modeling System software (EDMS 5.1.4.1) was used to obtain emission factors for aircraft.

In addition to commercial aircraft, the aircraft inventory includes air taxi (mostly privately owned or operated small aircraft) and general aviation (small aircraft based at small municipal airports in Utah) and military aircraft. Activity for these comes from FAA Master Records. (3)

Aircraft produce significant amounts of CO and SOx. In fact, the majority of SOx in the non-road inventory comes from aircraft.

Airport Ground Support Equipment

Airport Ground Support Equipment (GSE) emissions are included in output from EDMS. UDAQ believes the emission factors from EDMS are more accurate than those from the MOVES/NR model.

Locomotive Emissions

There are six railroad companies operating in Utah. The vast majority of emissions come from Union Pacific Railroad, which operates in seventeen of the 29 counties in Utah.

Locomotives produce significant amounts of NOx, and minor amounts of other pollutants.

Diesel locomotive fuel consumption was reported by the railroads operating in Utah. These reports show annual fuel consumption. Some railroads also report ton-miles by county (Union Pacific Railroad) or miles of track for a round trip, such as reported by AMTRAK and the Utah Transit Authority "Front Runner" commuter rail. Emissions are calculated based on annual diesel fuel consumption.

Federal regulations (Tier IV Non-road Final Rule) require that diesel locomotives operate on ULSD (15 ppm) by 2012. All railroads operating in Utah during 2014 used 15-ppm sulfur diesel except that Salt Lake, Garfield & Western Railway did not return our calls (the latter is an extremely small railroad).

See Federal Register and rule text at https://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf .

Final Comments

PM10 and PM2.5 shown above do not include fugitive dust from unpaved roads, which is an Area Source category.

vi. Nonroad Emissions Sources and Models

A. Miscellaneous Non-road Engines & Equipment	EPA MOVES2014a Model (November 2016) (movesdb20161117)
B. Aircraft (emissions per landing/ takeoff cycle or LTO)	Federal Aviation Administration "Emissions and Dispersion Modeling System" (EDMS), version 5.1.4.1
1. Air Carriers (Commercial)	Bureau of Transportation Statistics (BTS) Transtats" website (2): http://www.transtats.bts.gov/ Number of commercial landings and takeoffs
2. Air Taxi, General Aviation	FAA "Airport Master Records" by Airport (3) http://www.grc1.com/5010web Number of air taxi and general aviation LTOs
3. Military Aircraft	U.S. Dugway Proving Ground (annual report) U.S. Hill Air Force Base (annual report) FAA "Airport Master Records" and consultation with UT Div. of Aeronautics: number of military aircraft takeoffs and landings (LTOs)
C. Airport Ground Support Equip-ment (GSE)	FAA EDMS 5.1.4.1 Model
D. Diesel Locomotives	Railroad Companies (reports from): AMTRAK Salt Lake, Garfield and Western Railway Union Pacific Railroad (includes activity from Burlington Northern Santa Fe) Utah Railway Company Utah Transit Authority (commuter rail): diesel fuel consumption by county and locomotive type: line-haul, yard and commuter

A. Non-road Miscellaneous Engines and Equipment (MOVES2014a)

The EPA MOVES2014a Model (November 2016) was used to compute non-road emissions. "MOVES" calculates emissions for twelve non-road categories:

Agricultural Equipment
Airport Ground Support Equipment
Commercial Equipment
Construction Equipment
Industrial Equipment
Lawn & Garden Equipment

Logging Equipment
Oil Field Miscellaneous Equipment
Pleasure Craft
Railroad Miscellaneous Equipment
Recreational Equipment
Underground Mining Equipment

Commercial marine equipment, locomotives and aircraft are not modeled by MOVES2014a (small personal watercraft are included).

MOVES output includes the usual pollutants of carbon monoxide (CO), nitrogen oxides (NOx), PM10 and PM2.5 exhaust, sulfur dioxide (SO2), volatile organic compounds (VOC) and ammonia (NH3).

In addition, for the CAMX air dispersion model, additional materials and compounds were modeled: benzene, CH4, NMHC, NMOG, TOG, TGH, toluene and xylenes. If the output includes SCC code, then fuel type does not need to be output.

For the base year and each projection year, emissions were computed for a January weekday and a January weekend day. Output units were grams per winter weekday or grams per winter weekend day.

Next, emissions units were converted to January daily and then ton-per-year emissions using the following equation:

$$(5*Wkdy + 2*Wknd)/7 = Daily\ Emissions * 365.25 = Tons\ per\ Year$$

Output was organized into "SMOKE" format and transferred to the CAMX air dispersion model for analysis of pollutant concentrations.

Unlike the EPA NONROAD Model, it is not necessary to manually input fuel parameters such as RVP, ethanol content, sulfur content, etc. Instead, the GUI selections automatically choose the correct fuel parameters from the default database based on the county, years, months and days modeled.

Nonetheless, UDAQ carefully reviewed the MOVES default database tables of fuel supply and fuel formulation to insure that the correct fuel properties were modeled.

1. Sulfur Content of Fuels

For non-road diesel, marine diesel, CNG and LPG, we used MOVES default sulfur content. The sulfur content of these fuels varies slightly with calendar year as follows:

Fuel Region ID	Month & Calendar Year	Fuel	Fuel Formulation	Sulfur Content (ppmw)
500,000,000 and 578,000,000*	Jan 2014	NR Diesel	20007	20

500,000,000 and 578,000,000*	Jan 2014	Marine Diesel	26011	52
"	"	CNG	28001	8
"	"	LPG	29001	8
"	Jan 2015 - on	NR Diesel	20008	11
"	Jan 2019	Marine Diesel	26013	55
"	Jan 2026	CNG	28001	8
"	Jan 2026	LPG	29001	8

*Fuel regions 500 million and 578 million include the following counties:

500	27 counties excluding Salt Lake and Davis Counties
578	2 counties: Salt Lake and Davis Counties

Gasoline sulfur content was set at 30 ppmw for 2014 and 2019. Commitments from local refiners show that only about 1/3 of the gasoline used in Utah will be Tier III by January 2019. In the non-road module of MOVES2014a, UDAQ ran sensitivity tests which showed that only SO2 emissions are affected by gasoline sulfur content.

2. Meteorological Data

For SIP meteorological data, Utah obtained data from MESOWEST, a meteorological website designed by the University of Utah Department of Atmospheric Sciences. MOVES default values for meteorological data are only approximate, so these were not used.

a. Temperature and Relative Humidity Data

Hourly temperature and relative humidity data used for the base year and projection years are the average values from the three PM2.5 episodes as shown below:

Sat, Jan 1 – Wed, Jan 12, 2011
Sat, Dec 7 – Thu, Dec 19, 2013
Mon, Feb 1 – Wed, Feb 17, 2016

b. Hourly Temperatures by Episode Day

January 1 - 12, 2011 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	010411	-4.6	12.7	010811	6.5	21.7
49005	Cache	010401	-4.6	12.7	010811	6.5	21.7
49011	Davis	011211	11.9	17.1	010811	20.0	26.5
49035	Salt Lake	010111	6.7	19.9	010811	19.0	25.0
49045	Tooele	010111	1.4	19.4	010311	15.8	24.8
49049	**Utah**	**010111**	**1.4**	**17.6**	**010911**	**14.6**	**24.8**
49057	Weber	010111	6.8	19.3	010811	18.3	25.0

For the 22 PM2.5 attainment counties, temperatures from Salt Lake County were modeled.
Data for Box Elder County was not available, so Cache County data was used.

February 1 - 17, 2016 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	020216	-4.8	17.8	021616	33.4	48.4
49005	Cache	020216	-4.8	17.8	021616	33.4	48.4
49011	Davis	020216	15.1	29.8	021716	35.1	58.2
49035	Salt Lake	020216	15.3	27.9	021716	37.4	59.9
49045	Tooele	020316	8.4	25.7	021716	33.6	55.9
49049	**Utah**	**020316**	**11.3**	**27.1**	**021716**	**29.3**	**58.7**
49057	Weber	020216	9.0	24.7	021716	36.6	52.9

December 7 - 19, 2013 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	120913	-10.4	8.1	121913	19.0	30.4
49005	Cache	120913	-10.4	8.1	121913	19.0	30.4
49011	Davis	120913	-0.8	17.1	121913	26.8	33.0
49035	Salt Lake	120913	3.9	18.4	121913	28.0	33.7
49045	Tooele	120913	-0.4	18.4	121913	26.6	30.2
49049	**Utah**	**121013**	**-2.2**	**12.2**	**121913**	**29.6**	**39.2**
49057	Weber	120913	3.9	18.4	121913	26.1	33.1

B. Snowmobile Adjustments (MOVES2014a)

The discussion below sometimes refers to the EPA NONROAD Model because this model was in use when the underlying database for snowmobiles was adjusted to match local survey data. MOVES2014a was used to model the NONROAD vehicles and equipment in these inventories. The main db in MOVES2014a was adjusted the same way as in the EPA NONROAD Model.

UDAQ reviewed the PM2.5 SIP inventories from the EPA NONROAD model for the 2008 base year and projection years 2014, 2017 and 2019. Theses showed that, in several counties, a large majority of VOC emissions from equipment in the NONROAD model were emitted by snowmobiles, as shown below:

Calendar Year	County	FIPs	VOC from Snowmobiles (Tons per Jan Day)	VOC from NR Model (Tons per Jan Day)	Percent from Snowmobiles (%)
2014	Cache	49005	2.788	3.340	83.5
2014	Duchesne	49013	0.1977	0.4188	47.2
2014	Rich	49033	2.792	3.018	92.5
2014	Summit	49043	4.077	4.431	92.0
2014	Utah	49049	0.2150	2.147	10.0
2014	Wasatch	49051	4.311	4.399	98.0
2014	Weber	49057	2.791	3.858	72.3

At the same time, other counties in the domain showed zero VOC emissions from snowmobiles in the EPA NONROAD model.

Questioning the accuracy of the output, UDAQ obtained recent survey data on snowmobile activity from two agencies. The survey data showed that the true number of snowmobiles by county were very different from the allocation in the MOVES2014a default database. (4, 5)

The survey report on snowmobile activity in Utah also showed that activity was spread over the months of December through April inclusive instead of the default months of December through February that are shown in the MOVES default database.

In addition, UDAQ obtained counts of registered snowmobiles by county from the Utah Tax Commission (Division of Motor Vehicle registration data) for calendar years 2008 through 2014. (6)

In summary, reports and databases for Utah showed that actual snowmobile activity differed from data stored in the MOVES2014a database. Therefore, UDAQ created input tables to use in place of defaults stored in the MOVES2014a database as follows:

1. Reallocation of Snowmobile Counts in MOVES Database (File "nrstatesurrogate")

Relative numbers of snowmobiles were reallocated among the counties based on survey data. This was done by modifying the file "nrstatesurrogate" found in the database "movesdb20161117".

For details of changes to the file "nrstatesurrogate", see the Appendix.

2. Utah Snowmobile Population Changed in MOVES2014a Database (File "nrbaseyearequippopulation")

The MOVES file "nrbaseyearequippopulation" shows the default number of snowmobiles in Utah as of calendar year 1999.

From the data supplied by DMV, the Utah snowmobile population for calendar year 1999 was estimated by performing a linear regression on DMV snowmobile counts over calendar years 2008 through 2014. It was found that Utah had about 36,100 snowmobiles in 1999. The default value in the MOVES default database "nrbaseyearequippopulation" showed only 25,729 snowmobiles in Utah.

Therefore, the counts of snowmobiles in the "nrbaseyearequippopulation" file were changed. Details of changes to this file are shown in the Appendix.

3. Utah Snowmobile Counts in Future Years Changed in MOVES2014a Database (File "nrgrowthindex")

The MOVES file "nrgrowthindex" determines counts of equipment in future years.

Because the snowmobile count in the base year (1999) was changed in MOVES, and because data from DMV showed a different annual growth rate of snowmobiles, it was necessary to adjust snowmobile counts in future years. This was done by changing the growth numbers in the "nrgrowthindex" file.

Details of changes to the "nrgrowthindex" file are shown in the appendix.

4. Snowmobile Seasonality Changed in MOVES2014a Database (File "nrmonthallocation)

The MOVES default file "nrmonthallocation" shows that snowmobile activity occurs evenly over the months of January, February and December, as denoted by the values (0.333, 0.333, 0.333).

Snowmobile surveys showed that actual activity in Utah is spread evenly over the months from December through April.

Therefore, the "nrmonthallocation" values were changed to (0.200, 0.200, 0.200, 0.200 and 0.200) for the respective months of December through April.

In MOVES2014a, a folder named "nrjan2014_2" was added to the MySQL data folder to store changes made to the default snowmobile tables. When the MOVES GUI is opened, the user

must go to the menu item “Manage Input Data Series” and choose, using the drop-down list, the name of the data folder that contains the modified snowmobile data (“nrjan2014_2”).
In summary, MOVES default values in the following files were changed for snowmobiles:

File Name	Description
nrstatesurrogateyear	Relative number of snowmobiles by county in calendar year 2002
nrbaseyearequippopulation	Snowmobile counts by county and source type ID: source type IDs for snowmobiles include: 1002 – 1010
nrgrowthindex	Snowmobile annual growth rate. Snowmobiles have growth pattern ID = 98.
nrmonthallocation	Relative snowmobile activity by month

5. Additional MOVES2014a Files Related to Snowmobiles

In addition to changing the default values in the above tables affecting snowmobiles, the following files contain information relevant to snowmobiles, but default values need not be changed. These files help identify source type, growth pattern, and surrogate IDs for snowmobiles.

File Name	Description
nrsourceusetype	Source type IDs by SCC and HP range: snowmobiles are identified as source type IDs 1002 – 1010.
nrgrowthpattern	Growth pattern ID = 98 identifies snowmobiles
nrsurrogate	Surrogate ID = 14 identifies residential snowmobiles

6. No Additional Changes to the MOVES2014a Database

No other changes were made to the MOVES2014a default database.

vii. Aircraft

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

A. 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 smaller municipal airports.	EDMS 5.1.4.1	2275000000
Air Taxi	Small privately-owned commuter planes	EDMS 5.1.4.1	2275000000
General Aviation	Small municipal airport operations (aircraft are "based" in small cities and towns)	EDMS 5.1.4.1	2275000000
Military Aircraft	Military operations	Reports from Military Bases	2275000000

B. Aircraft Activity (Landings and Takeoffs, or LTOs)

For each type of aircraft operation shown above, the first step is to gather the numbers of landings and takeoffs during the relevant time period.

One common error is to count each landing or takeoff as a complete LTO. This is *incorrect*. Instead, one LTO cycle consists of one landing and one takeoff, so care must be taken to observe how aircraft activity is reported. In short, activity from the U.S. DOT BTS "Transtats" website reports commercial activity as separate landings and takeoffs, so the total number of these must be divided by two to obtain LTOs. FAA also reports activity as separate landings and takeoffs. The EDMS emission model assumes that the input is in LTO units. (7)

Air taxi, general aviation and military aircraft operations are treated the same way: one LTO cycle consists of one landing and one takeoff.

For air taxis, general aviation, and military aircraft, only annual activity data are available. Annual activity is reported by the FAA on its "Airport Master Records". These records are updated periodically. Some of the airport records have not been updated since 2010, while others are current to December 31, 2015. For those records that are not up-to-date, FAA scaling factors were used to adjust the number of LTOs to the calendar years being modeled (2014 and projection years). (8)

C. Aircraft Types

1. Commercial

Commercial activity from the U.S. DOT "Transtats" website reports landings and takeoffs by aircraft type using a unique 3-digit code for each aircraft type.

Commercial aircraft landings and takeoffs can be downloaded from the Bureau of Transportation Statistics (BTS) "Transtats" website at http://www.transtats.bts.gov/.

Under "Aviation", one chooses "Air Carrier Statistics - Form 41 Traffic - All Carriers", and then "T-100 Domestic Segment—All Carriers". Next, choose "T-100 Domestic Segment (U.S. Carriers)". In the lower right-hand corner of the box, click on "Download". At the top of the screen, under "Download Instructions", choose the state, calendar year and month. For this SIP, calendar years and months were January 2014.

At the time this document was drafted (February 14, 2017), January 2017 commercial activity had not been posted on the Transtats website. Therefore, January 2014 commercial activity was downloaded, and scaling factors obtained from FAA websites were used to estimate activity during the base year and projection years. (8)

Aircraft Type
Origin City Name
Destination City Name
Departures Performed

Each "departure performed" is either an arrival or a departure. One landing-takeoff cycle (LTO) consists of one departure and one arrival pair. There were 9,594 LTO cycles that took place in January 2014 where the origin or destination was in Utah.

The vast majority of commercial aircraft activity in Utah takes place at Salt Lake City International Airport. There are about 50 additional smaller municipal airports in the state, but only about ten municipal airports handle commercial aircraft. Based on January 2014 activity, the annualized number of commercial LTOs in Utah were about 9,594 * (365.25/31) = 113,039.

2. Air Taxi and General Aviation

The Utah Department of Transportation, Division of Aeronautics, no longer reports aircraft activity for air taxi and general aviation operations. Instead, activity is reported on FAA "Airport Master Records" for each separate airport in Utah at: http://www.gcr1.com/5010web/.

As with commercial aircraft, these records report separate landings and takeoffs, so the total must be divided by two to obtain the number of LTOs.

For General Aviation, the Airport Master Record shows, for each airport, the number of based aircraft of each general type: single-engine, multi-engine, and jets. Single- and multi-engine aircraft operate on aviation fuel, which is similar to gasoline, while jets operate on jet fuel.

The Utah Division of Aeronautics was consulted to determine the specific aircraft types used under each general aircraft type—single- and multi-engine and jets.

For Air Taxi, the Airport Master Record for each airport shows the number of landings and takeoffs. The Utah Division of Aeronautics was consulted to determine the specific aircraft types used for air taxis.

3. Military

There are only two major military airports in Utah, each of which sends annual reports of aircraft activity and the inventory to UDAQ:

Hill Air Force Base (Davis County)
Dugway Proving Ground (Tooele County)
In addition, the Airport Master Records show that about seven small municipal airports have military aircraft activity.

Statewide Aircraft LTOs by Calendar Year and Operational Type

Commercial aircraft LTOs were reported for the month of January 2014. The January number of LTOs was multiplied by (365.25/31) to convert the LTOs to an annual count. Air taxi, general aviation and military LTOs were reported in annual units as shown below:

Calendar Year and Month	Commercial	Air Taxi	General Aviation	Military
Jan 2014	(9,594)(365.25/31) = 113,039	62,298	397,116	24,742

D. Emissions and Dispersion Modeling System (EDMS) Software

The EDMS model (v. 5.1.4.1) was used to obtain emissions from the numerous aircraft types in the inventory.

The user enters the calendar year and name of airport. A list of all the aircraft and engine types opens, and the user selects the specific aircraft type (and engine type if known—otherwise, the default engine type for the aircraft type is chosen). Then, the number of LTOs (separate landings and takeoffs divided by two) is entered. The entire list of aircraft and engine types operating at a particular airport is entered. The user then merely chooses “Update”, and the inventory is generated in the units chosen by the user.

Sensitivity tests showed that the location of the airport has almost no effect on emissions, so Salt Lake City International Airport was selected as the default location.

Emissions reported include CO, NOx, PM10 and PM2.5 exhaust, SO2 and VOC, but not NH3.

A report (2013) from the Journal of Atmospheric Chemistry and Physics states that more research and modeling are needed to determine whether NH3 emissions from aircraft make any meaningful contribution to PM2.5 concentrations. (9)

Aircraft Inventory and Activity Scaling Factors to Calendar Year 2019

EDMS 5.1.4.1 was run for calendar year 2014 for all 29 counties. Sensitivity tests showed that the emission factors did not change for a given aircraft and engine type when the calendar year was changed.

Therefore, to obtain emissions for the projection years, UDAQ initially used FAA scaling factors to adjust the aircraft activity to the calendar year needed. Scaling factors are shown in the FAA Appendix item "Total Combined Aircraft Operations at Airports", Table 32 (shows activity for historical years 2008 – 2015, and projected activity for calendar years 2016 – 2036). (8)

As discussed already, these scaling factors were not applied to SO2/SOx emissions from aircraft and airport ground support equipment.

E. Airport Ground Support Equipment (GSE)

Aircraft ground support emissions (GSE) are generated from the EDMS 5.1.41 model at the same time that aircraft tailpipe emissions are generated.

For example, when a particular aircraft type is modeled in EDMS, the number of landing and takeoff (LTO) cycles is input. The model automatically generates, in addition to aircraft emissions, ground support equipment emissions from this activity.

GSE emissions from two point sources—Hill Air Force Base and Dugway Proving Ground—are reported in the point source inventories from these sources. GSE emissions from these sources will not be modeled by UDAQ using EDMS. Care will be taken that these emissions are not double-counted.

viii. Diesel Locomotives

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 NOx emissions

All of the criteria pollutants, VOC, CO, NO_x, SO_x, PM10, PM2.5 and NH3 are included in the

locomotive inventory. Emissions were estimated by applying emission factors to the total amount of diesel fuel used by locomotives. Emission factors for the criteria pollutants were obtained from the EPA guidance document "Emission Factors for Locomotives" (April 2009). (10)

For NH3, the EPA document "Documentation for Locomotive Component of the National Emissions Inventory Methodology" (May 2011) was used because the document "Emission Factors for Locomotives" does not include EFs for NH3. (11)

About 90% of locomotive emissions come from Union Pacific Railroad. The second-highest source of locomotive emissions is the Utah Transit Authority commuter rail, the "Front Runner". Commuter rail currently runs from Ogden in the north (Weber County) to Provo in the south (Utah County).

The sulfur content of locomotive diesel fuel affects emissions. UDAQ requested railroad companies to report the sulfur content of diesel fuel along with the volume of fuel used.

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 2014, these companies include: Amtrak, Burlington Northern Santa Fe Railway (BNSF), Union Pacific Railroad Company (UPRR), Utah Railway and Utah Transit Authority (UTA)--commuter rail operations.

To estimate diesel fuel consumption for the projection years, scaling factors were applied.

For projections of commuter/passenger diesel fuel consumption, scaling factors were obtained from an AMTRAK report, "AMTRAK Fleet Strategy, v. 3.1". Passenger growth was projected at 2% per year. Thus diesel fuel consumption for passenger locomotives was projected to increase 2% per year as well. (12)

For projections of freight diesel fuel consumption, scaling factors were obtained by searching for documents from reputable sources that projected growth of freight ton-miles from as early as calendar year 2000 through at least calendar year 2026. These documents include the following:

National Petroleum Council, "Rail Transportation Demand, Topic Paper #2", Aug 1, 2012. (13)

U.S. DOE, Energy Efficiency & Renewable Energy (EERE), "Freight Transportation Demand: Energy-Efficient Scenarios for a Low-Carbon Future", March 2013. (14)

U.S. DOT, "National Freight Strategic Plan", 2015. (15)

Each of the above three reports includes charts that show the growth in freight miles or ton-miles to some distant year:

Milestone Years	Cumulative Percent Growth in Freight Ton-Miles		
	National Petroleum Association (Medium Growth)	U.S. DOE EERE (High Growth)	U.S. DOT: Nat'l Freight Strategic Plan (Low Growth)
2014 – 2017	**3.06%**	5.91%	3.66%
2014 – 2019	5**.10%**	9.85%	4.88%
2014 – 2020	6**.12%**	11.8%	6.10%
2014 – 2023	9.1**9%**	17.7%	7.32%
2014 – 2024	**10.2%**	19.7%	8.54%
2014 – 2026	**12.2%**	23.6%	9.76%

Since we do not know which projection is the most accurate, the "medium-growth" scenario was used, i.e., data from the National Petroleum Association..

ix. Output

A. MOVES2014a

MOVES was run for each of the 29 counties in Utah for a January weekday and January weekend day in 2014, and in the same way for each projection year. Hourly temperature and relative humidity (RH) data were obtained by taking the average hourly temperature and RH values from all the PM2.5 episode days in January 2011, December 2013 and February 2016.

The resulting output in units of grams per January weekday or weekend day were converted to January daily emissions using the equation:

$$(5*Wkdy + 2*Wknd)/7 = \text{Daily Emissions} * 365.25 = \text{Tons per Year}$$

B. Aircraft (EDMS v. 5.1.4.1)

Commercial aircraft activity (landings and takeoffs, or LTOs) were downloaded for January 2014. Daily LTO activity for commercial aircraft is not available on the U.S. DOT Bureau of Transportation Statistics (BTS) "Transtats" website, so monthly activity was captured.

For air taxi, general aviation and military aircraft LTOs, only annual data is available from FAA.

Thus the aircraft portion of the inventory is reported in units of tons per year, where the January inventory for commercial aircraft use the conversion factor of (365.25/31) to obtain TPY from January tons.

The final aircraft inventory is reported in tons per year.

Aircraft GSE emissions will also be reported in tons per year.

C. Diesel Locomotives

Reports submitted by railroads included diesel fuel consumed by locomotives by county. Emissions were computed by applying EPA emission factors in units of grams per gallon consumed.

Locomotive diesel fuel consumption was reported on an annual scale only, so the units of locomotive emissions are tons per year.

D. SMOKE Formats for Air Dispersion Model

For the "Comprehensive Air Quality Model with Extensions" (CAMx), emissions were formatted into EXCEL tables. Data in SMOKE formats include calendar year, county name, FIPs code, pollutant id (from MOVES and applied to all non-road sources), SCC and TPY.

x. APPENDIX ITEMS

A. Base Year Emissions Summaries by County and Pollutant

Jan 2014 Emissions from MOVES/NR (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	103.41	18.98	1.821	1.748	0.0360	9.386	0.0257
Box Elder	49003	BX	2,010.98	270.43	20.16	19.15	0.5852	409.90	0.3618
Cache	49005	CA	3,077.59	338.05	45.49	43.00	0.8966	812.48	0.6429
Carbon	49007	CR	1,043.94	122.86	18.95	17.99	0.2860	304.57	0.2082
Daggett	49009	DG	387.71	11.50	4.818	4.447	0.0714	165.11	0.0566
Davis	49011	DA	4,422.85	700.28	65.53	62.79	1.496	467.42	1.048
Duchesne	49013	DU	589.59	50.55	6.791	6.402	0.1287	124.08	0.0946
Emery	49015	EM	473.54	90.23	12.86	12.26	0.1852	171.75	0.1343
Garfield	49017	GA	695.73	46.96	9.929	9.275	0.1463	231.03	0.1122
Grand	49019	GR	938.12	43.14	10.56	9.821	0.1435	260.66	0.1106
Iron	49021	IR	964.11	118.63	15.10	14.31	0.2978	240.82	0.2169
Juab	49023	JU	402.54	36.50	5.357	5.043	0.0996	108.10	0.0736
Kane	49025	KA	597.19	37.09	6.661	6.203	0.1091	173.84	0.0794
Millard	49027	MI	503.88	73.38	5.918	5.632	0.1515	104.58	0.1004
Morgan	49029	MO	142.47	21.19	1.757	1.694	0.0434	8.450	0.0305
Piute	49031	PI	120.98	6.541	1.709	1.588	0.0280	52.16	0.0218
Rich	49033	RI	1,623.27	50.01	21.06	19.46	0.3112	694.55	0.2478
Salt Lake	49035	SL	23,013.74	2,311.81	228.94	218.53	5.205	1,860.72	3.596
San Juan	49037	SJ	495.01	36.84	5.178	4.842	0.0954	124.52	0.0675
Sanpete	49039	SP	892.41	55.42	12.10	11.30	0.2024	322.56	0.1543
Sevier	49041	SE	765.68	136.73	17.87	17.06	0.2601	176.53	0.1857
Summit	49043	SU	2,846.59	186.37	40.70	38.04	0.6861	1,022.78	0.5306
Tooele	49045	TO	800.74	130.17	10.80	10.31	0.2780	151.90	0.1873
Uintah	49047	UI	1,236.94	114.69	12.15	11.49	0.2924	208.63	0.2117
Utah	49049	UT	6,714.56	1,027.71	102.90	98.43	2.218	784.25	1.566
Wasatch	49051	WA	2,242.83	113.01	32.77	30.47	0.5321	976.85	0.4193
Washington	49053	WS	3,041.71	448.54	51.03	48.65	0.9916	445.64	0.7234
Wayne	49055	WY	210.01	13.30	2.803	2.618	0.0380	60.05	0.0290
Weber	49057	WE	5,011.80	474.04	61.12	57.80	1.237	1,001.49	0.8815
SUM	**All**	**ALL**	**65,369.89**	**7,084.97**	**832.82**	**790.32**	**17.05**	**11,474.83**	**12.12**

Jan 2014 Aircraft Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	40.10	0.0322	0.1100	0.1100	0.0492	0.5179	N/A
Box Elder	49003	BX	229.59	0.2405	0.6284	0.6284	0.2961	4.581	N/A
Cache	49005	CA	862.82	2.139	2.866	2.866	1.515	51.66	N/A
Carbon	49007	CR	58.02	0.2392	0.1654	0.1654	0.1270	2.911	N/A
Daggett	49009	DG	20.61	0.0172	0.0566	0.0566	0.0255	0.2711	N/A
Davis	49011	DA	525.11	46.11	11.62	9.127	4.152	20.58	N/A
Duchesne	49013	DU	69.58	0.0450	0.1835	0.1835	0.0798	0.9118	N/A
Emery	49015	EM	55.21	0.2152	0.1801	0.1801	0.1248	3.022	N/A
Garfield	49017	GA	82.44	0.0706	0.2197	0.2197	0.1001	1.194	N/A
Grand	49019	GR	103.09	0.6633	0.3289	0.3289	0.3029	6.550	N/A
Iron	49021	IR	506.67	5.652	2.069	2.069	2.150	63.18	N/A
Juab	49023	JU	40.38	0.0687	0.1150	0.1150	0.0607	1.415	N/A
Kane	49025	KA	39.86	0.0308	0.1030	0.1030	0.0464	0.5948	N/A
Millard	49027	MI	44.27	0.0399	0.1217	0.1217	0.0557	0.6052	N/A
Morgan	49029	MO	48.79	0.0361	0.1326	0.1326	0.0585	0.7508	N/A
Piute	49031	PI	9.807	0.0049	0.0267	0.0267	0.0111	0.1038	N/A
Rich	49033	RI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	SL	3,717.87	788.81	22.60	22.60	98.55	382.58	N/A
San Juan	49037	SJ	111.53	0.0815	0.2771	0.2771	0.1245	1.747	N/A
Sanpete	49039	SP	28.03	0.0509	0.0924	0.0924	0.0440	1.274	N/A
Sevier	49041	SE	111.06	0.0806	0.3042	0.3042	0.1337	1.368	N/A
Summit	49043	SU	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	TO	985.11	42.64	3.735	3.735	7.083	44.49	N/A
Uintah	49047	UI	115.70	0.2691	0.3108	0.3108	0.1899	3.272	N/A
Utah	49049	UT	3,109.71	11.47	8.954	8.954	5.291	146.76	N/A
Wasatch	49051	WA	217.17	0.8049	0.7989	0.7989	0.4686	17.18	N/A
Washington	49053	WS	710.95	5.796	2.212	2.212	1.825	27.26	N/A
Wayne	49055	WY	29.66	0.0244	0.0814	0.0814	0.0366	0.3874	N/A
Weber	49057	WE	1,119.19	3.763	3.492	3.492	2.038	55.11	N/A
SUM	**All**	**ALL**	**12,992.34**	**909.39**	**61.78**	**59.29**	**124.94**	**840.28**	**N/A**

NOTES

The following counties do not have airports: Rich and Summit.

VOC emissions on this worksheet DO NOT include aircraft VOC refueling emissions. Aircraft VOC

refueling emissions are reported in the Area Source inventory.

The FAA Emissions and Dispersion Modeling System (EDMS) model (v 5.1.4.1) does not report ammonia (NH3) emissions.

An extensive on-line search failed to find any emission factors for NH3 from aircraft.

*A report (2013) from the Journal of Atmospheric Chemistry states that more research and modeling is needed to determine whether NH3 emissions from aircraft make any meaningful contribution to PM 2.5 concentrations.

http://www.atmos-chem-phys.net/13/5505/2013/acp-13-5505-2013.pdf

Jan 2014 Airport Ground Support Equipment Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	0.0841	0.0215	0.000266	0.000235	0.000215	0.0061	N/A
Box Elder	49003	BX	0.3255	0.1018	0.001005	0.000889	0.000812	0.0283	N/A
Cache	49005	CA	6.685	0.8037	0.014149	0.011980	0.018669	0.2780	N/A
Carbon	49007	CR	1.088	0.1113	0.003659	0.003237	0.002956	0.0381	N/A
Daggett	49009	DG	0.0473	0.0114	0.000151	0.000133	0.000122	0.0033	N/A
Davis	49011	DA	0.1870	0.1498	0.000457	0.000405	0.000369	0.0388	N/A
Duchesne	49013	DU	0.0964	0.0307	0.000297	0.000263	0.000240	0.0085	N/A
Emery	49015	EM	0.5573	0.0680	0.001860	0.001646	0.001502	0.0222	N/A
Garfield	49017	GA	0.2218	0.0463	0.000715	0.000633	0.000578	0.0136	N/A
Grand	49019	GR	4.140	0.3937	0.013183	0.011696	0.011305	0.1393	N/A
Iron	49021	IR	17.99	1.747	0.058410	0.051924	0.049754	0.6101	N/A
Juab	49023	JU	0.0044	0.0119	0.000000	0.000000	0.000000	0.0030	N/A
Kane	49025	KA	0.0948	0.0203	0.000305	0.000270	0.000246	0.0059	N/A
Millard	49027	MI	0.1211	0.0262	0.000389	0.000344	0.000314	0.0077	N/A
Morgan	49029	MO	0.0243	0.0183	0.000061	0.000054	0.000049	0.0047	N/A
Piute	49031	PI	0.0013	0.0036	0.000000	0.000000	0.000000	0.0009	N/A
Rich	49033	RI	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	N/A
Salt Lake	49035	SL	566.19	56.99	1.964466	1.868681	1.808689	18.94	N/A
San Juan	49037	SJ	0.2339	0.0547	0.001037	0.000951	0.000604	0.0151	N/A
Sanpete	49039	SP	0.2025	0.0263	0.000417	0.000352	0.000564	0.0089	N/A
Sevier	49041	SE	0.1771	0.0547	0.000548	0.000485	0.000443	0.0152	N/A
Summit	49043	SU	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	N/A
Tooele	49045	TO	27.12	3.634	0.126717	0.120630	0.071870	1.030	N/A
Uintah	49047	UI	1.711	0.1776	0.005018	0.004504	0.004656	0.0621	N/A
Utah	49049	UT	16.82	2.178	0.040474	0.035790	0.047500	0.7213	N/A
Wasatch	49051	WA	3.504	0.3626	0.008685	0.007480	0.009755	0.1292	N/A
Washington	49053	WS	7.397	0.9086	0.022223	0.021085	0.022629	0.2970	N/A
Wayne	49055	WY	0.0660	0.0162	0.000209	0.000185	0.000169	0.0046	N/A
Weber	49057	WE	9.302	1.102	0.023181	0.020262	0.026349	0.3773	N/A
SUM	**All**	**ALL**	**664.39**	**69.07**	**2.288**	**2.164**	**2.080**	**22.81**	**N/A**

Jan 2014 Diesel Locomotive Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	50.36	255.35	6.809271	6.604993	0.050300	11.54	0.1576
Box Elder	49003	BX	127.94	648.76	17.300155	16.781150	0.127800	29.31	0.4003
Cache	49005	CA	5.921	30.02	0.800589	0.776571	0.005900	1.357	0.0185
Carbon	49007	CR	47.46	240.88	6.416784	6.224280	0.102300	10.89	0.1485
Daggett	49009	DG	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Davis	49011	DA	91.81	470.54	12.444165	12.070840	0.156400	21.41	0.2871
Duchesne	49013	DU	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Emery	49015	EM	22.72	115.41	3.071863	2.979707	0.027500	5.219	0.0711
Garfield	49017	GA	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Grand	49019	GR	33.98	172.69	4.594140	4.456316	0.043200	7.812	0.1063
Iron	49021	IR	74.66	378.56	10.095036	9.792185	0.074600	17.11	0.2336
Juab	49023	JU	65.09	330.07	8.801892	8.537835	0.065000	14.91	0.2037
Kane	49025	KA	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Millard	49027	MI	107.43	544.72	14.525816	14.090041	0.107300	24.61	0.3361
Morgan	49029	MO	62.51	316.95	8.451894	8.198337	0.062500	14.32	0.1956
Piute	49031	PI	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Rich	49033	RI	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Salt Lake	49035	SL	128.37	764.45	18.873815	18.307601	0.241200	38.78	0.3964
San Juan	49037	SJ	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Sanpete	49039	SP	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Sevier	49041	SE	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Summit	49043	SU	107.16	543.35	14.489410	14.054728	0.107100	24.55	0.3353
Tooele	49045	TO	145.04	736.02	19.611941	19.023583	0.157800	33.27	0.4538
Uintah	49047	UI	0.000	0.000	0.000000	0.000000	0.000000	0.000	0.000
Utah	49049	UT	89.49	463.08	12.190501	11.824786	0.165800	21.23	0.2797
Wasatch	49051	WA	4.105	20.82	0.555083	0.538431	0.010700	0.9406	0.0128
Washington	49053	WS	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Wayne	49055	WY	0.0000	0.0000	0.000000	0.000000	0.000000	0.0000	0.0000
Weber	49057	WE	88.02	471.69	12.24	11.87	0.1111	22.27	0.2742
SUM	**All**	**ALL**	**1,252.04**	**6,503.35**	**171.27**	**166.13**	**1.617**	**299.54**	**3.910**

Jan 2014 Emissions--All Non-road Mobile Sources (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	193.96	274.38	8.741	8.463	0.136	21.45	0.1833
Box Elder	49003	BX	2,368.83	919.53	38.09	36.56	1.010	443.83	0.7621
Cache	49005	CA	3,953.01	371.02	49.17	46.65	2.436	865.77	0.6614
Carbon	49007	CR	1,150.51	364.09	25.54	24.38	0.518	318.41	0.3567
Daggett	49009	DG	408.37	11.53	4.875	4.503	0.0970	165.39	0.0566
Davis	49011	DA	5,039.95	1,217.07	89.59	83.99	5.805	509.45	1.335
Duchesne	49013	DU	659.27	50.63	6.975	6.586	0.2087	125.00	0.0946
Emery	49015	EM	552.03	205.93	16.11	15.42	0.339	180.01	0.2054
Garfield	49017	GA	778.38	47.08	10.15	9.496	0.2470	232.23	0.1122
Grand	49019	GR	1,079.33	216.89	15.50	14.62	0.501	275.16	0.2169
Iron	49021	IR	1,563.43	504.59	27.32	26.22	2.573	321.72	0.4505
Juab	49023	JU	508.01	366.65	14.27	13.70	0.225	124.44	0.2773
Kane	49025	KA	637.15	37.14	6.765	6.307	0.1557	174.44	0.0794
Millard	49027	MI	655.69	618.17	20.57	19.84	0.315	129.81	0.4365
Morgan	49029	MO	253.78	338.19	10.34	10.02	0.164	23.53	0.2260
Piute	49031	PI	130.79	6.549	1.736	1.615	0.0392	52.26	0.0218
Rich	49033	RI	1,623.27	50.01	21.06	19.46	0.3112	694.55	0.2478
Salt Lake	49035	SL	27,426.18	3,922.06	272.38	261.30	105.80	2,301.03	3.993
San Juan	49037	SJ	606.77	36.98	5.457	5.120	0.2205	126.28	0.0675
Sanpete	49039	SP	920.64	55.49	12.19	11.39	0.2470	323.84	0.1543
Sevier	49041	SE	876.92	136.86	18.17	17.36	0.3943	177.91	0.1857
Summit	49043	SU	2,953.75	729.72	55.19	52.09	0.793	1,047.33	0.8659
Tooele	49045	TO	1,958.02	912.46	34.28	33.19	7.59	230.69	0.6411
Uintah	49047	UI	1,354.35	115.13	12.46	11.81	0.4870	211.97	0.2117
Utah	49049	UT	9,930.58	1,504.43	124.08	119.24	7.72	952.96	1.846
Wasatch	49051	WA	2,467.61	134.99	34.13	31.81	1.021	995.09	0.4322
Washington	49053	WS	3,760.06	455.24	53.26	50.88	2.839	473.20	0.7234
Wayne	49055	WY	239.73	13.35	2.885	2.700	0.0747	60.44	0.0290
Weber	49057	WE	6,228.31	950.60	76.87	73.18	3.412	1,079.25	1.156
SUM	**All**	**ALL**	**80,278.66**	**14,566.77**	**1,068.16**	**1,017.90**	**145.69**	**12,637.46**	**16.03**

B. Projection Year 2019 Emissions Summaries by County and Pollutant

Jan 2019 Emissions from MOVES/NR (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	104.52	13.85	1.328	1.268	0.0236	8.884	0.0281
Box Elder	49003	BX	1,805.84	212.69	13.29	12.62	0.5094	272.30	0.3816
Cache	49005	CA	2,477.09	237.44	29.78	28.10	0.6291	513.59	0.6349
Carbon	49007	CR	840.06	109.88	13.94	13.25	0.2041	188.47	0.1989
Daggett	49009	DG	280.87	10.82	3.087	2.849	0.0589	97.93	0.0469
Davis	49011	DA	4,346.92	486.66	45.36	43.25	1.023	403.89	1.146
Duchesne	49013	DU	560.03	38.08	4.671	4.395	0.0981	86.39	0.0972
Emery	49015	EM	345.73	80.29	9.408	8.987	0.1233	104.08	0.1299
Garfield	49017	GA	647.07	35.15	6.491	6.056	0.1189	155.65	0.1144
Grand	49019	GR	941.32	33.45	7.164	6.654	0.1296	185.85	0.1165
Iron	49021	IR	804.71	84.23	9.94	9.399	0.2039	154.19	0.2178
Juab	49023	JU	347.76	27.25	3.581	3.366	0.0732	69.61	0.0724
Kane	49025	KA	586.24	30.39	4.424	4.117	0.1013	120.41	0.0835
Millard	49027	MI	477.62	59.58	3.954	3.764	0.1273	69.63	0.1067
Morgan	49029	MO	143.71	15.21	1.212	1.164	0.0299	7.649	0.0334
Piute	49031	PI	80.62	5.539	1.095	1.017	0.0210	30.07	0.0183
Rich	49033	RI	1,128.62	46.07	13.76	12.71	0.2465	406.68	0.2024
Salt Lake	49035	SL	23,271.32	1,640.86	172.01	163.19	3.851	1,752.96	3.952
San Juan	49037	SJ	487.70	30.43	3.567	3.331	0.0861	88.01	0.0710
Sanpete	49039	SP	667.11	43.51	7.909	7.377	0.1504	194.61	0.1386
Sevier	49041	SE	722.87	115.19	13.42	12.80	0.1802	127.66	0.1961
Summit	49043	SU	2,128.56	139.89	26.64	24.86	0.4929	615.63	0.4824
Tooele	49045	TO	749.32	98.84	7.083	6.745	0.2157	105.58	0.2008
Uintah	49047	UI	1,142.06	82.52	8.152	7.697	0.2103	139.78	0.2122
Utah	49049	UT	6,557.66	707.92	71.73	68.26	1.497	670.62	1.707
Wasatch	49051	WA	1,469.00	89.69	20.75	19.28	0.3854	562.30	0.3553
Washington	49053	WS	3,049.89	304.83	35.67	33.83	0.6604	376.74	0.7913
Wayne	49055	WY	209.92	10.24	1.931	1.801	0.0324	43.05	0.0309
Weber	49057	WE	4,459.36	339.21	42.29	39.87	0.9006	686.21	0.8962
SUM	**All**	**ALL**	**60,833.51**	**5,129.70**	**583.62**	**552.01**	**12.38**	**8,238.42**	**12.66**

Jan 2019 Aircraft Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3*
Beaver	49001	BE	40.37	0.0302	0.1106	0.1106	0.0489	0.5038	N/A
Box Elder	49003	BX	231.46	0.2340	0.6330	0.6330	0.2960	4.557	N/A
Cache	49005	CA	869.88	2.129	2.889	2.889	1.519	51.95	N/A
Carbon	49007	CR	56.19	0.2085	0.1586	0.1586	0.1159	2.671	N/A
Daggett	49009	DG	20.74	0.0160	0.0569	0.0569	0.0253	0.2629	N/A
Davis	49011	DA	529.41	46.11	11.63	9.139	4.157	20.66	N/A
Duchesne	49013	DU	81.30	0.0471	0.2142	0.2142	0.0915	1.022	N/A
Emery	49015	EM	54.56	0.2006	0.1777	0.1777	0.1199	2.917	N/A
Garfield	49017	GA	82.87	0.0648	0.2205	0.2205	0.0988	1.154	N/A
Grand	49019	GR	167.76	0.6413	0.5032	0.5032	0.3589	6.878	N/A
Iron	49021	IR	556.75	5.284	2.460	2.460	2.145	76.61	N/A
Juab	49023	JU	40.82	0.0695	0.1163	0.1163	0.0614	1.431	N/A
Kane	49025	KA	40.10	0.0283	0.1035	0.1035	0.0458	0.5787	N/A
Millard	49027	MI	44.49	0.0368	0.1222	0.1222	0.0549	0.5829	N/A
Morgan	49029	MO	49.29	0.0360	0.1340	0.1340	0.0589	0.7546	N/A
Piute	49031	PI	9.916	0.0050	0.0270	0.0270	0.0113	0.1050	N/A
Rich	49033	RI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	SL	3,493.68	938.23	24.15	24.15	114.36	369.57	N/A
San Juan	49037	SJ	112.21	0.0699	0.2780	0.2780	0.1216	1.704	N/A
Sanpete	49039	SP	14.54	0.0438	0.0558	0.0558	0.0286	1.137	N/A
Sevier	49041	SE	98.59	0.0687	0.2699	0.2699	0.1179	1.193	N/A
Summit	49043	SU	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	TO	961.31	10.67	3.256	3.256	2.284	42.41	N/A
Uintah	49047	UI	113.19	0.2139	0.2984	0.2984	0.1692	2.681	N/A
Utah	49049	UT	3,139.33	9.315	9.016	9.016	4.985	148.19	N/A
Wasatch	49051	WA	216.38	0.7708	0.7966	0.7966	0.4576	17.02	N/A
Washington	49053	WS	742.70	5.643	2.314	2.314	1.888	29.81	N/A
Wayne	49055	WY	29.84	0.0228	0.0818	0.0818	0.0363	0.3761	N/A
Weber	49057	WE	788.97	2.797	2.472	2.472	1.470	39.80	N/A
SUM	**All**	**ALL**	**12,586.64**	**1,022.99**	**62.54**	**60.05**	**135.13**	**826.53**	**N/A**

Jan 2019 Airport Ground Support Equipment Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	0.0700	0.0204	0.000218	0.000193	0.000176	0.00570	N/A
Box Elder	49003	BX	0.2721	0.0977	0.000824	0.000729	0.000665	0.02674	N/A
Cache	49005	CA	6.549	0.7932	0.013597	0.011486	0.018303	0.27424	N/A
Carbon	49007	CR	0.8922	0.0934	0.002999	0.002653	0.002422	0.03180	N/A
Daggett	49009	DG	0.0393	0.0108	0.000123	0.000109	0.000100	0.00304	N/A
Davis	49011	DA	0.1631	0.1491	0.000375	0.000332	0.000303	0.03833	N/A
Duchesne	49013	DU	0.0769	0.0327	0.000226	0.000200	0.000182	0.00882	N/A
Emery	49015	EM	0.4579	0.0590	0.001524	0.001348	0.001231	0.01905	N/A
Garfield	49017	GA	0.1836	0.0430	0.000586	0.000518	0.000473	0.01241	N/A
Grand	49019	GR	3.586	0.3727	0.011763	0.010387	0.009761	0.12765	N/A
Iron	49021	IR	7.424	0.8201	0.021565	0.019308	0.021045	0.27907	N/A
Juab	49023	JU	0.0045	0.0120	0.000000	0.000000	0.000000	0.00300	N/A
Kane	49025	KA	0.0785	0.0189	0.000250	0.000221	0.000202	0.00543	N/A
Millard	49027	MI	0.1003	0.0245	0.000319	0.000282	0.000258	0.00702	N/A
Morgan	49029	MO	0.0211	0.0181	0.000050	0.000044	0.000040	0.00467	N/A
Piute	49031	PI	0.0014	0.0036	0.000000	0.000000	0.000000	0.00090	N/A
Rich	49033	RI	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	N/A
Salt Lake	49035	SL	648.48	65.38	2.219530	2.124463	2.113140	21.66659	N/A
San Juan	49037	SJ	0.1929	0.0469	0.000613	0.000542	0.000495	0.01345	N/A
Sanpete	49039	SP	0.1978	0.0212	0.000405	0.000341	0.000557	0.00762	N/A
Sevier	49041	SE	0.1390	0.0469	0.000425	0.000376	0.000343	0.01292	N/A
Summit	49043	SU	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	N/A
Tooele	49045	TO	9.174	1.149	0.025568	0.023342	0.027707	0.37238	N/A
Uintah	49047	UI	1.092	0.1296	0.003648	0.003227	0.002947	0.04267	N/A
Utah	49049	UT	15.90	2.087	0.036625	0.031998	0.044784	0.69220	N/A
Wasatch	49051	WA	3.274	0.3418	0.007875	0.006762	0.009132	0.12188	N/A
Washington	49053	WS	8.829	1.0688	0.028385	0.026599	0.026245	0.34684	N/A
Wayne	49055	WY	0.0548	0.0153	0.000172	0.000152	0.000139	0.00431	N/A
Weber	49057	WE	7.318	0.8690	0.020055	0.017597	0.020264	0.29225	N/A
SUM	**All**	**ALL**	**714.57**	**73.73**	**2.398**	**2.283**	**2.301**	**24.4210**	**N/A**

Jan 2019 Diesel Locomotive Emissions (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	52.93	204.76	4.970	4.821	0.0653	7.753	0.1656
Box Elder	49003	BX	134.47	520.22	12.63	12.25	0.1660	19.70	0.4207
Cache	49005	CA	6.223	24.07	0.5843	0.5668	0.0077	0.9115	0.0195
Carbon	49007	CR	49.99	192.95	4.676	4.536	0.1143	7.287	0.1564
Daggett	49009	DG	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Davis	49011	DA	97.81	376.09	9.033	8.762	0.1854	14.14	0.3059
Duchesne	49013	DU	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Emery	49015	EM	23.98	92.37	2.236	2.169	0.0344	3.481	0.0750
Garfield	49017	GA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Grand	49019	GR	35.90	138.14	3.341	3.241	0.0535	5.199	0.1123
Iron	49021	IR	78.47	303.56	7.368	7.147	0.0968	11.49	0.2455
Juab	49023	JU	68.41	264.68	6.424	6.231	0.0844	10.02	0.2141
Kane	49025	KA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Millard	49027	MI	112.91	436.80	10.60	10.28	0.1394	16.54	0.3533
Morgan	49029	MO	65.69	254.15	6.169	5.984	0.0811	9.623	0.2055
Piute	49031	PI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Rich	49033	RI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Salt Lake	49035	SL	136.38	662.83	15.31	14.85	0.2807	30.67	0.4212
San Juan	49037	SJ	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sanpete	49039	SP	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sevier	49041	SE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Summit	49043	SU	112.62	435.70	10.58	10.26	0.1390	16.50	0.3524
Tooele	49045	TO	152.71	589.73	14.30	13.87	0.2014	22.29	0.4778
Uintah	49047	UI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Utah	49049	UT	95.32	372.27	8.916	8.648	0.1933	14.24	0.298
Wasatch	49051	WA	4.315	16.69	0.4051	0.3930	0.0116	0.6320	0.0135
Washington	49053	WS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wayne	49055	WY	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Weber	49057	WE	92.91	389.22	9.268	8.990	0.1376	15.97	0.2894
SUM	**All**	**ALL**	**1,321.04**	**5,274.22**	**126.80**	**122.99**	**1.992**	**206.44**	**4.126**

Jan 2019 Emissions--All Non-road Mobile Sources (TONS PER YEAR)

County	FIPs	Abbrev	CO	NOx	PM10 Exhaust	PM2.5 Exhaust	SO2	VOC	NH3
Beaver	49001	BE	197.88	218.66	6.409	6.200	0.1380	17.15	0.1936
Box Elder	49003	BX	2,172.04	733.24	26.55	25.50	0.9721	296.59	0.8023
Cache	49005	CA	3,359.74	264.44	33.26	31.57	2.1740	566.73	0.6544
Carbon	49007	CR	947.13	303.13	18.78	17.95	0.4368	198.46	0.3553
Daggett	49009	DG	301.65	10.85	3.144	2.905	0.0842	98.20	0.0469
Davis	49011	DA	4,974.30	909.00	66.02	61.15	5.3655	438.73	1.452
Duchesne	49013	DU	641.41	38.16	4.886	4.609	0.1899	87.42	0.0972
Emery	49015	EM	424.73	172.92	11.82	11.33	0.2787	110.50	0.2049
Garfield	49017	GA	730.12	35.26	6.712	6.277	0.2182	156.82	0.1144
Grand	49019	GR	1,148.57	172.60	11.02	10.41	0.5518	198.05	0.2288
Iron	49021	IR	1,447.35	393.89	19.78	19.03	2.4672	242.57	0.4633
Juab	49023	JU	456.99	292.00	10.12	9.71	0.2190	81.06	0.2864
Kane	49025	KA	626.42	30.44	4.528	4.220	0.1474	121.00	0.0835
Millard	49027	MI	635.12	496.43	14.68	14.17	0.3219	86.76	0.4600
Morgan	49029	MO	258.71	269.42	7.515	7.282	0.1699	18.03	0.2389
Piute	49031	PI	90.54	5.547	1.122	1.044	0.0323	30.18	0.0183
Rich	49033	RI	1,128.62	46.07	13.76	12.71	0.2465	406.68	0.2024
Salt Lake	49035	SL	27,549.86	3,307.32	213.69	204.31	120.61	2,174.87	4.373
San Juan	49037	SJ	600.10	30.54	3.846	3.610	0.2082	89.72	0.0710
Sanpete	49039	SP	681.85	43.57	7.965	7.433	0.1796	195.75	0.1386
Sevier	49041	SE	821.60	115.30	13.69	13.07	0.2984	128.87	0.1961
Summit	49043	SU	2,241.18	575.59	37.21	35.12	0.6319	632.13	0.8348
Tooele	49045	TO	1,872.51	700.39	24.66	23.89	2.7290	170.64	0.6786
Uintah	49047	UI	1,256.34	82.86	8.454	7.999	0.3825	142.51	0.2122
Utah	49049	UT	9,808.22	1,091.59	89.70	85.96	6.7199	833.74	2.005
Wasatch	49051	WA	1,692.96	107.49	21.96	20.47	0.8637	580.07	0.3688
Washington	49053	WS	3,801.43	311.55	38.01	36.17	2.5742	406.90	0.7913
Wayne	49055	WY	239.82	10.28	2.013	1.883	0.0688	43.43	0.0309
Weber	49057	WE	5,348.56	732.10	54.05	51.35	2.5285	742.27	1.186
SUM	**All**	**ALL**	**75,455.75**	**11,500.64**	**775.36**	**737.34**	**151.80**	**9,295.81**	**16.79**

C. PM2.5 SIP (Serious) NON-ROAD MOBILE SO2 and/or SOx Inventories and Sources

10/12/2017

Purpose: A review of the PM2.5 SIP (Serious) NON-ROAD MOBILE SOURCE inventories shows the following statewide emissions of SO2 and/or SOx BEFORE any adjustment of the inventories:

SOURCES OF SO2/SOX IN THE NON-ROAD MOBILE SOURCE PM2.5 SIP INVENTORIES

Cal Yr	Domain	Pollutant	Non-road Vehicles & Engines (MOVES2014a)	Aircraft (Commercial)	Aircraft (Other Types)[1]	Airport Ground Support Equipment	Diesel Locomotives	SUM NON-ROAD
			Tons per January Day x 365.25 = (TPY)					
2014	Entire State	SO2/SOx	17.05	97.49	27.45	2.080	1.617	145.7
2017	Entire State	SO2/SOx	12.42	101.7	25.78	2.179	1.946	144.0
2019	Entire State	SO2/SOx	12.38	109.6	25.52	2.301	1.992	151.8
2020	Entire State	SO2/SOx	12.39	114.1	25.38	2.371	2.015	156.3
2023	Entire State	SO2/SOx	12.46	128.7	24.74	2.591	2.086	170.6
2024	Entire State	SO2/SOx	12.49	131.3	24.78	2.638	2.110	173.3
2026	Entire State	SO2/SOx	12.61	135.9	24.97	2.723	2.158	178.4

[1] Other aircraft activity includes air taxi, general aviation and military.

Projections of SO2/SOx for commercial aircraft are largely driven by FAA scaling factors.

D. Historical Data: Commercial Aircraft Activity (Landings and Takeoffs), Calendar Years 2013 - 2016

Instead of applying scaling factors for each projection year, examine historical takeoffs and landings of commercial aircraft:

Cal Yr	Domain #1 (Utah)	Aircraft Type	Number of Separate Landings & Takeoffs	Domain #2 SLC Int'l	Number of Separate Landings & Takeoffs	Percent from SLC Int'l
2013	Entire State	Commercial	244,785	SLC Int'l	235,221	96.1%
2014	Entire State	Commercial	241,010	SLC Int'l	233,757	97.0%
2015	Entire State	Commercial	236,242	SLC Int'l	229,058	97.0%
2016	Entire State	Commercial	246,436	SLC Int'l	229,728	93.2%

The above data shows that most of the commercial aircraft activity in the state takes place at SLC Int'l.

E. Historical Data for Linear Regression (to Project Numbers of Landings & Takeoffs)

Cal Yr	Domain	Aircraft Type	Number of Separate Landings & Takeoffs
2013	Entire State	Commercial	244,785
2014	Entire State	Commercial	241,010
2015	Entire State	Commercial	236,242
2016	Entire State	Commercial	246,436

SLOPE	18.5000
Y-INTERCEPT	204,850.0
CORRELATION	0.0053

PROJECTIONS OF COMMERCIAL AIRCRAFT LANDINGS & TAKEOFFS

Cal Yr			N
2017	entire state	comm	242,165
2019	entire state	comm	242,202
2020	entire state	comm	242,220
2023	entire state	comm	242,276
2024	entire state	comm	242,294
2026	entire state	comm	242,331

Result of L.R. shows that commercial aircraft activity (in terms of number of landings and takeoffs) is essentially flat.

LINEAR REGRESSION #2: LTOs at Salt Lake City International Airport

Cal Yr	Domain	Aircraft Type	Number of Separate Landings & Takeoffs
2013	SLC Int'l	Commercial	235,221
2014	SLC Int'l	Commercial	233,757
2015	SLC Int'l	Commercial	229,058
2016	SLC Int'l	Commercial	229,728

SLOPE	-2117.8000
Y-INTERCEPT	4,498,249.1
CORRELATION	-0.9069

PROJECTIONS OF COMMERCIAL AIRCRAFT LANDINGS & TAKEOFFS

Cal Yr			N
2017	SLC Int'l	Comm	226,647
2019	SLC Int'l	Comm	222,411
2020	SLC Int'l	Comm	220,293
2023	SLC Int'l	Comm	213,940
2024	SLC Int'l	Comm	211,822
2026	SLC Int'l	Comm	207,586

F. MOVES2014a Model: Changes to Underlying Database for Snowmobiles

The following files in the MOVES2014a database were changed, as discussed in the body of the report:

1. File Name: “nrstatesurrogate”

Counts show the relative numbers of snowmobiles by county.

Surrogate ID	County ID	Surrogate Year ID	Original Count	Revised Count	
14	49000	2002	1,891	1,891	UT
14	49001	2002	0	0	Beaver
14	49003	2002	0	0	Box Elder
14	49005	2002	10	226	Cache
14	49007	2002	0	96	Carbon
14	49009	2002	0	58	Daggett
14	49011	2002	0	0	Davis
14	49013	2002	67	17	Duchesne
14	49015	2002	0	55	Emery
14	49017	2002	217	19	Garfield
14	49019	2002	0	0	Grand
14	49021	2002	0	64	Iron
14	49023	2002	0	24	Juab
14	49025	2002	0	0	Kane
14	49027	2002	0	0	Millard
14	49029	2002	135	0	Morgan
14	49031	2002	724	18	Piute
14	49033	2002	512	226	Rich
14	49035	2002	0	0	Salt Lake
14	49037	2002	0	0	San Juan
14	49039	2002	43	100	Sanpete
14	49041	2002	52	18	Sevier
14	49043	2002	31	330	Summit
14	49045	2002	0	0	Tooele
14	49047	2002	38	48	Uintah
14	49049	2002	3	29	Utah
14	49051	2002	59	349	Wasatch
14	49053	2002	0	0	Washington
14	49055	2002	0	0	Wayne
14	49057	2002	0	226	Weber

2. File Name: “nrbaseyearequippopulation”

Based on estimated snowmobile counts obtained from the Utah Tax Commission for calendar year 1999, the populations of snowmobiles were adjusted upwards as follows:

FIPS	Year	Source Type ID	Equipment Description	HP Min	HP Max	Original Population	Revised Population
49000	1999	1002	2-Str Snowm	1	3	103.4	145.1
49000	1999	1003	2-Str Snowm	3	6	61.0	85.6
49000	1999	1004	2-Str Snowm	11	16	65.6	91.9
49000	1999	1005	2-Str Snowm	16	25	5,219.0	7,322.7
49000	1999	1006	2-Str Snowm	25	40	5,268.0	7,391.5
49000	1999	1007	2-Str Snowm	40	50	2,364.8	3,318.0
49000	1999	1008	2-Str Snowm	50	75	8,331.3	11,689.6
49000	1999	1009	2-Str Snowm	75	100	3,424.1	4,804.3
49000	1999	1010	2-Str Snowm	100	175	892.0	1,251.6
SUM						25,729.1	36.100.0

3. File Name: nrgrowthindex

The 1999 base year population of snowmobiles in Utah was changed. Therefore, snowmobile growth factors in future years were also changed.

However, data from Utah Tax Commission showed snowmobile counts actually decreased over calendar years 2005 through 2014. Therefore, growth factors also decrease over calendar years as follows:

Snowmobile Indicator Code: 098
SCC: 226001020
Type: 2-Stroke Snowmobile

Calendar Year	Growth Pattern ID	Original Growth Indicator Value	Revised Growth Indicator Value	Utah Actual Snow-mobile Counts
1970	98	500	500	
1990	“	1,000	353	
1996	“	1,000	309	
1997	“	1,063	302	
1998	“	1,121	294	
1999	“	1,172	287	
2000	“	1,213	280	
2001	“	1,256	272	
2002	“	1,307	265	
2003	“	1,364	258	
2004	“	1,427	250	
2005	“	1,496	243	28,248
2006	“	1,567	236	28,222
2007	“	1,635	228	29,241
2008	“	1,696	221	30,782
2009	“	1,749	214	28,768
2010	“	1,800	206	26,294
2011	“	1,852	199	26,167
2012	“	1,908	192	22,144

2013	"	1,967	184	23,184
2014	"	2,026	177	20,993
2015	"	2,083	170	
2016	"	2,135	162	
2017	"	2,184	155	
2018	"	2,229	148	
2019	"	2,271	140	
2020	"	2,310	133	
2021	"	2,345	126	
2022	"	2,377	118	
2023	"	2,406	111	
2024	"	2,431	103	
2025	"	2,454	96	
2026	"	2,473	89	
2027	"	2,490	81	
2028	"	2,505	74	
2029	"	2,517	67	
2030	"	2,526	59	

4. File Name: nrmonthallocation

In the default file, fractions of annual activity by month were changed for snowmobiles (SCC = 2260001020 as follows:

State	SCC	Equipment Description	Jan	Feb	Mar	Apr	Dec
0	2260001020	Snowmobiles	0.200	0.200	0.200	0.200	0.200

(Fractions for all other months are zero.)

xi. Footnotes

1. University of Utah "MESOWEST" website (http://mesowest.utah.edu/)

2. U.S. Department of Transportation "Transtats" website, http://www.transtats.bts.gov/

Under "Aviation", one chooses "Air Carrier Statistics - Form 41 Traffic - All Carriers", and then "T-100 Domestic Segment—All Carriers". In the lower right-hand corner of the box, click on "Download". At the top of the screen, under "Download Instructions", choose the state, calendar year and month. For this SIP, calendar years and months were January 2011, December 2013, and February 2016. In addition to the boxes already checked, put a check mark in front of the following parameters:

Aircraft Type
Origin City Name
Destination City Name
Departures Performed

3. Federal Aviation Administration: “Airport Master Records”, http://www.grc1.com/5010web Website temporarily down

4. McCoy, N., Fujisaki, I., Keith, J., *An Economic and Social Assessment of Snowmobiling in Utah*, January 2001.
http://extension.usu.edu/iort/files/uploads/pdfs/interdisciplinary_cf7.pdf.

5. Utah Snowmobile Association, Utah State Parks OHV Program, *2012 Snowmobile User Survey Results*, February 2012.

6. Utah Tax Commission\Utah Division of Motor Vehicles: Snowmobile Counts by Year and County
http://tax.utah.gov/econstats/mv/registrations-2010#2014

7. Federal Aviation Administration, Office of Environment and Energy, “Aviation Emissions and Air Quality Handbook, v. 3, update 1, January 2015, Glossary, Landing and Takeoff (LTO):

> **“Landing and Takeoff (LTO)** -LTO refers to an aircraft's landing and takeoff cycle. One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff). The standard L TO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as its heads out of the mixing zone and back up to cruising altitude. The five specific operating modes in a standard LTO are: approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle.”

https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/Air_Quality_Handbook_Appendices.pdf

Google search keys: FAA aircraft operations and LTO

Finding: FAA “aviation emissions and air quality handbook”

8. Aircraft Activity Scaling Factors
http://www.faa.gov/data_research/aviation/aerospace_forecasts/
The scaling factors are found in the EXCEL document under the bold heading “FY 2016-2036 Forecast Tables”, (choose OPERATIONS/ Tables 32 – 34).

9. Atmospheric Chemistry and Physics, “Impacts of aircraft emissions on the air quality near the ground”, 2013, http://www.atmos-chem-phys.net/13/5505/2013/acp-13-5505-2013.pdf.

10. U.S. EPA, *Emission Factors for Locomotives* (EPA-420-F-09-025), April 2009, https://www3.epa.gov/nonroad/locomotv/420f09025.pdf

11. Bergin, Michelle S., "Locomotive Emission Inventories for the United States from ERTAC Rail", 2012, http://www.epa.gov/ttnchie1/conference/ei20/session8/mbergin.pdf (emission factor for ammonia from diesel locomotives).

12. AMTRAK, "Amtrak Fleet Strategy: Building a Sustainable Fleet for the Future of America's Intercity and High-Speed Passenger Railroad", March 2012. https://www.amtrak.com/ccurl/36/921/2012-Amtrak-Fleet-Strategy-v3.1-%2003-29-12.pdf

13. National Petroleum Council, "Rail Transportation Demand, Topic Paper #2", Aug 1, 2012. https://www.npc.org/FTF_Topic_papers/2-Rail_Transportation_Demand.pdf
14. U.S. DOE, Energy Efficiency & Renewable Energy, "Freight Transportation Demand: Energy-Efficient Scenarios for a Low-Carbon Future", Rail Freight Ton-Miles 1980 – 2030, pp. 32 – 33, March 2013. http://www.nrel.gov/docs/fy13osti/55641.pdf.

15. U.S. DOT, "National Freight Strategic Plan: DRAFT FOR PUBLIC COMMENT", 2015, https://www.bmwe.org/cms/file/02152016_171655_DOT_NFSP_Public_Comment.pdf

xii. References

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

1. Federal Aviation Administration, *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01, (Rev. 10 – 060713, June 2013), https://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf

2. U.S. EPA, "MEMORANDUM: Development of Nonroad, Stationary, and Area Source Emissions for Tier 2/Sulfur NPRM, March 29, 1999. http://www.epa.gov/otaq/models/tier2/tec2nrsa.pdf

3. U.S. EPA, "MOVES2014a User Guide", EPA-420-B-15-095, November 2015, https://www3.epa.gov/otaq/models/moves/documents/420b15095.pdf

4. U.S. EPA, "MOVES2014 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity", EPA-420-B-15-093, November 2015, https://www3.epa.gov/otaq/models/moves/documents/420b15093.pdf

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

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

Reports from Railroads

7. AMTRAK, 2014 fuel consumption (Utah), Jeffrey White, WhiteJef@amtrak.com.

8. Salt Lake Garfield & Western Railway, 2008 fuel consumption, Donald M. Hogle, 801-322-3429.

9. Union Pacific Railroad Company (UPRR), Jon Germer, Manager Environmental Affairs, July 11, 2012, 2011 fuel consumption (Utah), mjgermer@up.com. The report includes fuel consumption from Burlington Northern & Santa Fe Railroad.

10. Utah Railway, 2014 fuel consumption, Stephen Green, stgreene@gwrr.com.

11. Utah Transit Authority, 2011 and 2014 Front Runner (commuter rail) fuel consumption and miles, Daniel Locke, DLocke@rideuta.com.

12. U.S. EPA, Federal Register, “Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel”, Final Rule, June 29, 2004, https://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf.