SMOKE Technical Support Documentation for NWF SIP Attainment Demonstration

Introduction

Emissions inventories are collected and processed through the Sparse Matrix Operating Kernel Emissions Model (SMOKE).[1] SMOKE modeling spatially allocates, temporalizes, and chemically speciates annual emissions estimations from the emissions inventories. Emissions inventories contain annual estimates of the amount of pollutant emitted from a given emission source, typically represented in tons of that pollutant per year. SMOKE takes that annual emission rate and some other inputs to determine 1) where the emissions are coming from geographically, 2) when those emissions are emitted throughout the year, week, and day, and 3) what chemical species are included in the emission of pollutants. From SMOKE, air quality scientists get emissions data in tons of pollutant per day (tons/day or TPD) for a given emissions source.

Emissions sources are identified by a Source Classification Code (SCC). Each SCC represents a unique source category-specific process or function that emits air pollutants.

SCC's and their emissions are classified into broader source sectors. Emissions sectors relevant to this attainment demonstration include the following:

- **Point**: Any non-EGU, non-oil & gas, or non-airport point sources, including large industrial facilities. Point sources only include sources with annual emission greater than 100 tons per year of NOx or VOC.
- **EGU's**: Electric generating units (EGUs) include emissions from our power plants. These point sources are located at a fixed, stationary location.
- **Nonpoint**: Nonpoint sources include emissions that individually are too small in magnitude to report as point sources. Examples include residential heating and residential charcoal grilling. Nonpoint sources also include any point sources with annual emissions of less than 100 tons per year of NOx or VOC.
- **Solvents**: This sector includes emissions from asphalt paving, and commercial and consumer solvent use such as Hairspray and household cleaning products.
- **Livestock**: Emissions from the agricultural production of livestock, including emissions from manure.
- **Fertilizer**: Nonpoint fertilizer application emissions including only ammonia
- **Onroad**: Includes emissions from onroad vehicles that use gasoline, diesel, and other fuels. Onroad vehicles include light-duty and heavy-duty vehicles operating on roads, highway ramps, and during idling.
- **Nonroad**: Includes emissions from off-road mobile sources that use gasoline, diesel, and other fuels. These source types include construction equipment and lawn and garden equipment.
- **Airports**: Emissions from all aircraft and ground support equipment. These are treated as point sources located at a fixed, stationary location.
- **Rail**: Emissions from railroads. Examples include emissions from FrontRunner trains and some rail yard emissions.

[1] https://www.cmascenter.org/smoke/

- **Oil & Gas Nonpoint Sources**: Emissions from primarily upstream and midstream oil and gas operations from the UDAQ/EPA/Ute Tribe's 2017 oil and gas emissions inventory, with gap-filling and improvements from recent regional scientific studies.
- **Oil & Gas Point Sources**: Any oil and gas source with NOx or VOC emissions greater than 100 tons per year, primarily including midstream and downstream operations.
- **Area Fugitive Dust**: PM10 and PM2.5 fugitive dust sources, including building construction, road construction, agricultural dust, and road dust
- **Biogenics**: hour-specific, grid cell-specific emissions generated from the BEIS 3.6.5 model within SMOKE using BELD4.1 land use data
- **Wildfires & Prescribed Fires**: Point source day-specific wildfires and prescribed fires.
- **Agricultural Fires**: Point source daily agricultural burning emissions
- **Lightning NOx & Oceanic Emissions**: Emissions generated from lightning and the ocean (12km domain only), *modeled in CAMx*

Residential wood combustion emissions were not calculated for this demonstration because the entire modeling episode occurs during the summertime, when residential wood combustion emissions are expected to be zero. Emissions from commercial marine vessels and international emissions were modeled for the 12km domain only (See SMOKE Configuration).

SMOKE Configuration

SMOKE was used to model emissions within Utah's modeling domains for the Northern Wasatch Front (NWF) SIP attainment demonstration modeling exercise. Emissions were modeled using SMOKE version 4.8.1, which was the latest available SMOKE version for public use at the time of modeling. SMOKE modeling for the NWF attainment demonstration is based on scripts and data from EPA's 2016v2 modeling platform,[2] with Utah-specific modifications discussed in this document.

Modeling Domains

Emissions were prepared for 3 modeling domains (Figure 1). The largest domain, 12UDAQ (orange), has a 12 km resolution. 12UDAQ is keyed to the EPA modeling domain 12US1[3] and matches the north-south extent of the EPA domain. All emissions for the 12UDAQ domain were processed using inputs and ancillary files from EPA's 2016v2 Emissions Modeling Platform (see Emissions Inventories & Processing for 12km Domain). No Utah-specific inventory adjustments were made to emissions for the 12UDAQ domain. 12UDAQ emissions are run separately in CAMx (one-way nesting).

[2] EPA 2016v2 Emissions Modeling Platform TSD
https://www.epa.gov/system/files/documents/2021-09/2016v2_emismod_tsd_september2021.pdf
[3] EPA 2016v2 Emissions Modeling Platform TSD, Figure 3-1, page 100

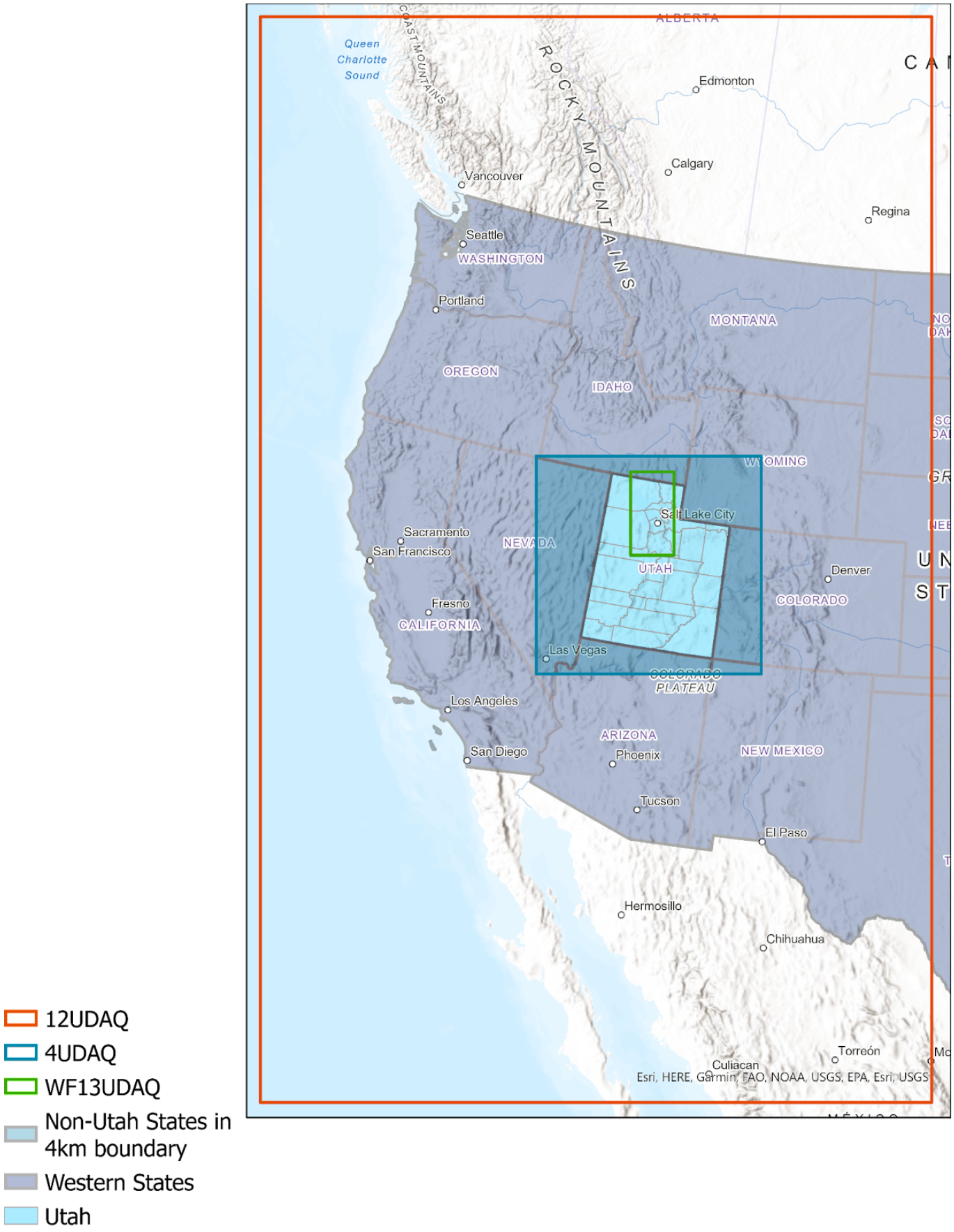


Figure 1 *SMOKE modeling domains*

The two smaller domains, 4UDAQ (blue) and WF13UDAQ (green), have 4 km and 1.33333 km resolution respectively. 4UDAQ is centered over the state of Utah and includes some counties and partial counties from surrounding non-Utah states. WF13UDAQ is centered over the Northern Wasatch Front O3 nonattainment area, which includes Salt Lake and Davis counties, and parts of Weber and Tooele counties. WFUDAQ is keyed to 4UDAQ. WF13UDAQ and 4UDAQ are run with two-way nesting in CAMx.

Table 1: Modeling Domain Specifications. No buffer cells are included.

Specification	12UDAQ	4UDAQ	WF13UDAQ
dx x dy (m)	12,000	4,000	1,333.33333
Southwest Corner X Coordinate (m)	-2,556,000	-1,644,000	-1,332,000
Southwest Corner Y Coordinate (m)	-1,728,000	-312,000	80,000
# Columns	185	186	108
# Rows	299	180	207

Within the 4UDAQ and WF13UDAQ domains, emissions for non-Utah counties are sourced from EPA's 2016v2 platform. For the 4UDAQ, non-Utah emissions come from Arizona, Colorado, Idaho, New Mexico, Nevada, Oregon, and Wyoming. For the WF13UDAQ, non-Utah emissions only come from Idaho. Emissions for counties within the state of Utah are generally sourced directly from UDAQ's inventory, with some exceptions in the sectors described later in this report.

Modeling Episode

Emissions are modeled for the period of June 15 - August 1 in 2017 (UTC), which also includes spin-up days. To account for the complete month of July in local time (MST), August 1, 2017 (UTC) is included in the episode.

Emissions Cases & Data Sources

Emissions inventories were used from various data sources for various modeling cases and spatial extents. Table 2 describes the UDAQ-developed modeling cases used in the Northern Wasatch Front SIP demonstration, as well as the EPA platforms leveraged to develop those cases. Table 3 and its key show the data source for each sector's emissions inventory. Generally, emissions for states bordering the state of Utah within any modeling domain come from the EPA 2016v2 platform. Because the modeling episode is in 2017, some sectors include emissions from the EPA 2017 platform. Emissions inventories were projected to 2023 for future year emissions modeling. Ozone controls implemented as a part of this Northern Wasatch Front Ozone SIP *are not* included in the 2023fy_17nc case; however, ozone controls *are* included in the 2023fy_17c case.

Table 2: Modeling scenarios for the Northern Wasatch Front SIP demonstration

Model Scenario	Description	Source
2017by_17v2	• 2017 NWF summer base year run using 2016v2 platform for surrounding states and ancillary data	UDAQ
2016fj_16j	• 2016v2 platform base year (2016) inventory scripts and inputs	EPA
2023fy_17nc	• 2023 NWF summer projection year run (2017 base year) using 2016v2 platform for surrounding states and ancillary data with NO ozone SIP controls	UDAQ
2023fj_16j	• 2016v2 platform projection year (2023) scripts and inputs	EPA
2023fy_17c	• 2023 NWF summer projection year run (2017 base year) using 2016v2 platform for surrounding states and ancillary data with ozone SIP controls INCLUDED	UDAQ

Table 3 Key	
Color	**Emissions Case**
	EPA 2017 platform (2017gb_17j)
	Biogenics
	EPA 2016v2 platform (2016fj_16j)
	EPA 2016v2 platform (2016fj_16j) projected to 2017
	Utah-specific 2017 inventory
	2017 emissions held static in 2023
	EPA 2016v2 platform (2023fj_16j)
	Utah-specific 2023 inventory

Table 3: Emissions data sources for all sectors, cases, and spatial extents.

	2017			2023		
	4 & 1.33km domains		12km domain	4 & 1.33km domains		12km domain
SECTOR	within Utah	outside Utah	12km all	within Utah	outside Utah	12km all
ptfire	2017gb_17j	2017gb_17j	2017gb_17j	static	static	static
ptagfire	2017gb_17j	2017gb_17j	2017gb_17j	static	static	static
beis	BEIS 3.6.1 with BELD 4	BEIS 3.6.1 with BELD 4	BEIS 3.6.1 with BELD 4	static	static	static
afdust	2016fj_16j	2016fj_16j	2016fj_16j	2023fj_16j	2023fj_16j	2023fj_16j
solvents	2016fj_16j projected to 2017	2016fj_16j projected to 2017	2016fj_16j	2023fj_16j	2023fj_16j	2023fj_16j
airports	2017gb_17j	2017gb_17j	2016fj_16j	2023fj_16j	2023fj_16j	2023fj_16j
livestock	Utah nonpoint inventory	2016fj_16j	2016fj_16j	Utah projected nonpoint inventory	2023fj_16j	2023fj_16j
fertilizer	Utah nonpoint inventory	2016fj_16j	2016fj_16j	static	static	static
nonpt	Utah nonpoint inventory	2016fj_16j	2016fj_16j	Utah projected nonpoint inventory	2023fj_16j	2023fj_16j
nonroad	Utah nonroad (MOVES3)	2016fj_16j	2016fj_16j	Utah projected nonroad	2023fj_16j	2023fj_16j

	2017			2023		
	4 & 1.33km domains		12km domain	4 & 1.33km domains		12km domain
SECTOR	within Utah	outside Utah	12km all	within Utah	outside Utah	12km all
				(MOVES3)		
np_oilgas	Utah nonpoint inventory	2016fj_16j	2016fj_16j	Utah projected nonpoint inventory	2023fj_16j	2023fj_16j
onroad	**Utah onroad (MOVES3)***	2016fj_16j	2016fj_16j	Utah projected onroad (MOVES3)	2023fj_16j	2023fj_16j
rail	Utah nonpoint inventory	2016fj_16j	2016fj_16j	Utah projected nonpoint inventory	2023fj_16j	2023fj_16j
EGUs	Utah point inventory	2016fj_16j	2016fj_16j	Utah projected point inventory	2023fj_16j	2023fj_16j
point oil & gas	Utah point inventory	2016fj_16j	2016fj_16j	Utah projected point inventory	2023fj_16j	2023fj_16j
other point (nonipm)	Utah point inventory	2016fj_16j	2016fj_16j	Utah projected point inventory	2023fj_16j	2023fj_16j
othafdust	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
othar	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
onroad_can	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
onroad_mex	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
cmv_c1c2	*NA*	*NA*	2017gb_17j	*NA*	*NA*	2023fj_16j
cmv_c3	*NA*	*NA*	2017gb_17j	*NA*	*NA*	2023fj_16j
canada_ag	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
canada_og	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
othpt	*NA*	*NA*	2016fj_16j	*NA*	*NA*	2023fj_16j
othptdust	*NA*	*NA*	2016fj_16j	*NA*	*NA*	static

***Utah onroad emissions** for the 2017 base year include MOVES3 output from several Metropolitan Planning Organizations (MPOs) along the Wasatch Front. Utah onroad emissions for the model performance evaluation (also modeled in 2017) only include MOVES3 output from UDAQ's in-house MOVES modeler.

Chemical Mechanism

Emissions are prepared for CMAQ in SMOKE and then converted to CAMx format. Both CMAQ and CAMx use the CB6 chemical mechanism, though some species differ between the versions of CB6 in use at the time of modeling. Table 4 crosswalks the chemical species from the inventory stage through SMOKE to the CMAQ format, and finally to CAMx format. Bromine (BR2) was added specifically to accommodate photochemical modeling of halogen emissions.

Table 4: Chemical species crosswalk[4]

Inventory Pollutant	CMAQ Model Species	CAMx Model Species
Cl2	CL2	CL2
HCl	HCL	HCL
BR2	--	BR2

[4] EPA 2016v2 platform TSD, Table 3-27, page 160

Inventory Pollutant	CMAQ Model Species	CAMx Model Species
BRCL	--	BRCL
CO	CO	CO
NOX	NO	NO
	NO2	NO2
	HONO	HONO
SO2	SO2	SO2
	SULF	SULF
NH3	NH3	NH3
	NH3_FERT	n/a (not used in CAMx)
VOC	AACD	AACD
	ACET	ACET
	ALD2	ALD2
	ALDX	ALDX
	BENZ	BENZ and BNZA (duplicate species)
	CH4	CH4
	ETH	ETH
	ETHA	ETHA
	ETHY	ETHY
	ETOH	ETOH
	FACD	FACD
	FORM	FORM
	IOLE	IOLE
	ISOP	ISOP and ISP (duplicate species)
	IVOC	IVOA
	KET	KET
	MEOH	MEOH
	NAPH + XYLMN (sum)	XYL and XYLA (duplicate species)
	NVOL	n/a (not used in CAMx)
	OLE	OLE
	PAR	PAR
	PRPA	PRPA
	SESQ	SQT
	SOAALK	n/a (not used in CAMx)
	TERP + APIN (sum)	TERP and TRP (duplicate species)
	TOL	TOL and TOLA (duplicate species)
	UNR + NR (sum)	NR
PM10	PMC	CPRM
PM2.5	PEC	PEC
	PNO3	PNO3
	POC	POC
	PSO4	PSO4
	PAL	PAL
	PCA	PCA
	PCL	PCL
	PFE	PFE

Inventory Pollutant	CMAQ Model Species	CAMx Model Species
	PK	PK
	PH2O	PH2O
	PMG	PMG
	PMN	PMN
	PMOTHR	FPRM
	PNA	NA
	PNCOM	PNCOM
	PNH4	PNH4
	PSI	PSI
	PTI	PTI
	POC + PNCOM (sum)	POA

Treatment of HAPs

Some emissions inventories include Hazardous Air Pollutants (HAPs) in addition to the Criteria Air Pollutants (CAPs). In some scenarios, HAPs inventories yield more accurate results than SMOKE would produce by applying speciation profiles to VOCs (volatile organic compounds). To take advantage of higher accuracy, SMOKE may integrate HAPs into the emissions modeling directly, rather than applying chemical speciation profiles, without double counting VOCs. Most sectors modeled in this demonstration did not integrate HAPs, with the exceptions of emissions from the solvents sector and fire sectors. Solvent emissions include partially integrated HAPs. The following four emissions source categories do not contain any naphthalene, benzene, acetaldehyde, formaldehyde, or methanol (NBAFM), so their HAPs are not integrated (HAPs excluded): dry cleaning, industrial maintenance coatings, hair care products, and miscellaneous personal care products. HAPs integration in the solvents sector follows EPA's method for VOC speciation in the 2016v2 platform.[5] Agricultural fires have "full" HAPs integration, meaning that all VOC species from the inventory are maintained through SMOKE. Wildfires and prescribed burns have "partial" integration, meaning that only NABFM species are integrated in SMOKE, while the remaining VOC species are speciated in the typical method via speciation profile.

Emissions Inventories & Processing for 4 & 1.33km Domains

Emissions in SMOKE are processed separately as sectors. All emissions sectors are described in Table 5, as well as their data source, domain extent, .

Table 5: Spatial and temporal resolution for SMOKE platform sectors, and plume rise calculations.

Sector	*Sector description*	*Data Source*	*HAPs integration*	*Spatial*	*Inventory resolution*	*Plume rise*
afdust_adj	Met.-adjusted area fugitive dust emissions	NEI	none	Surrogates	annual	
livestock	Emissions from livestock (emissions from livestock equipment are in the nonroad sector)	UTEI + NEI	none	Surrogates	annual	
fertilizer	Fertilizer emissions (only ammonia)	UTEI +	none	Surrogates	annual	

[5] EPA 2016v2 platform TSD, page 104

Sector	Sector description	Data Source	HAPs integration	Spatial	Inventory resolution	Plume rise
		NEI				
airports	Emissions from airport areas	NEI	none	Area-to-point	annual	
biogenics	Biogenic emissions based on the BEIS model	BEIS	none	Pre-gridded land use	computed hourly	
nonpt	Nonpoint sources not in other nonpoint sectors	UTEI + NEI	none	Surrogates & area-to-point	annual	
nonroad	Mobile sources that do not travel on roads or railroads, including recreational pleasurecraft	UTEI + NEI	none	Surrogates	monthly	
np_oilgas	Nonpoint oil and gas production-related sources	UTEI + NEI	none	Surrogates	annual	
onroad	Onroad mobile source gasoline and diesel vehicles from parking lots and moving vehicles	UTEI + NEI	none	Surrogates	monthly	
pt_oilgas	Point sources related to oil and gas production	UTEI + NEI	none	Point*	annual	in-line**
ptegu	Point sources that are Electric generating units (EGUs)	UTEI + NEI	none	Point*	daily & hourly	in-line**
ptnonipm	Point sources that are not EGUs nor related to oil and gas	UTEI + NEI	none	Point*	annual	in-line**
ptfire	Point source day-specific wild and prescribed fires	SMART FIRE	partial	Point*	daily	3D***
ptagfire	Point source day-specific agricultural fires	SMART FIRE	full	Point*	daily	3D***
rail	Locomotive sources on railroads	UTEI + NEI	none	Surrogates	annual	
solvents	Emissions from solvents (VOCs)	VCPy	partial	Surrogates	annual	

**Point source sectors are not gridded. Point source sectors are applicable to all nested modeling domains regardless of grid resolution.*
***The term "in-line" means that the plume rise calculations are done inside of the air quality model (CAMx) instead of being computed by SMOKE.*
****Plume rise is calculated in SMOKE, resulting in 3D fire emissions. See Fires for more information.*

Emissions inventories developed specifically for Utah (UTEI) are checked for quality and formatted into FF10 prior to SMOKE processing. The following sections describe preparations and modeling of emissions within the state of Utah. Non-Utah emissions modeling is described in the EPA 2016v2 platform TSD.

Point Sources

For the NWF attainment demonstration, point sources include any individual source with VOC or NOx emissions greater than 100 tons per year (TPY). VOC and NOx are precursors to ozone. Any sources in UDAQ's point source inventory which emit less than 100 TPY of VOC or NOx are considered "area" sources and appear in the Nonpoint sector. Point sources are spatially allocated by their specific coordinates, so spatial surrogates are *not* relevant to these sectors.

Point source operators provide a monthly percentage of annual emissions from January to December as part of their emissions inventory submission, which are used to generate source-specific monthly temporal profiles in SMOKE for point sources in Utah's emissions inventory.

Electric Generating Units (EGUs)

Electric Generating Units (EGUs) are modeled in the ptegu sector. Emissions sources include those with North American Industry Classification System (NAICS) codes in the 221 series: Utilities. This classification is consistent with EPA's EGUs sector in the 2016v2 platform. Emissions sources in Utah in the ptegu sector are listed in Table 6:

Table 6: Point sources in the 2017 and 2023 ptegu sectors.

Source Name	2017	2023	Within the NWF NAA?
Intermountain Power Service Corporation- Intermountain Generation Station	Y	Y	N
Pacificorp Energy- Gadsby Power Plant	Y	Y	Y
PacifiCorp Energy: Currant Creek Power Plant	Y	Y	N
PacifiCorp Energy: Lake Side Power Plant	Y	Y	N
PacifiCorp- Hunter Power Plant	Y	Y	N
PacifiCorp- Huntington Power Plant	Y	Y	N
St. George City Power: Red Rock Power Generation Station	Y	Y	N
Sunnyside Cogeneration Associates- Sunnyside Cogeneration Facility	Y	Y	N
Utah Municipal Power Agency: West Valley Power Plant	Y	Y	Y

CEMs data were not used to develop NOx or SO2 profiles or emissions. NOx and SO2 emissions are sourced from Utah's emissions inventory, and monthly temporal profiles are sourced from operator workbooks. All EGUs in Utah were assigned a 24-hour, 7 day week temporal profile.

Oil and Gas Point Sources

Oil and gas point sources include those point sources with NAICS codes as listed in Table 7. Individual oil and gas point sources are listed in Table 8.

Table 7: Oil and gas NAICS codes in the oil and gas point source sector.

NAICS	*Description*
2111	Oil and Gas Extraction
21111	Crude Petroleum and Natural Gas Extraction
211111	Natural Gas Liquid Extraction
211112	Crude Petroleum Extraction
211120	
211130	Natural Gas Extraction
213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations
2212	Natural Gas Distribution
22121	
221210	
4862	Pipeline Transportation of Natural Gas
48621	

486210	
48611	Pipeline Transportation of Crude Oil
486110	

Table 8: Point sources in the 2017 and 2023 pt_oilgas sectors.

Source Name	2017	2023	Within the NWF NAA?
EnerVest Operating - Sage Brush Flat Compressor Station	Y	Y	N
EnerVest Operating L.L.C.: Dry Canyon Compressor Station	Y	Y	N
EnerVest Operating L.L.C.: Interplanetary Compressor Station	Y	Y	N
Kern River Gas Transmission Company- Veyo Compressor Station	Y	Y	N
Kinder Morgan Altamont LLC- Altamont East Compressor Station	Y	Y	N
Kinder Morgan Altamont LLC- Altamont West Compressor Station	Y	Y	N
Kinder Morgan Altamont LLC Bluebell Facility	N	Y	N
Kinder Morgan Altamont LLC: Altamont Main Gas Processing Plant	N	Y	N
Kinder Morgan Altamont LLC: Altamont South Compressor Station	Y	Y	N
Northwest Pipeline GP: Cisco Compressor Station	Y	Y	N
Northwest Pipeline GP: Moab Compressor Station	Y	Y	N
Paradox Midstream, LLC- Lisbon Natural Gas Processing Plant	N	Y	N
Questar Pipeline LLC: Kastler Marushack Compressor Station	Y	Y	N

Weekly and daily temporal and chemical speciation profiles for sources in this sector are borrowed from EPA's 2017 platform. Emissions from oil and gas point sources are not expected to contribute to ozone formation along the Wasatch Front because all of the emissions sources in this sector are located in rural areas far from the nonattainment area boundary. EPA Region 8's Office of Air and Radiation provided UDAQ with an oil and gas point source inventory for 15 facilities contributing to a different Uinta Basin-specific modeling demonstration; however, these sources and their emissions were not available in EPA's National Emissions Inventory in 2017. Due to conflicting timelines, these 15 oil and gas point sources located in Indian Country and the reservation under EPA's jurisdiction are not included in the oil and gas point source inventory for this SIP modeling demonstration.

Other Point Sources

Any point source that is not an EGU or a designated oil and gas point source falls into this sector. Throughout EPA's documentation and in the modeling platform scripts, the Other sector is labeled as "ptnonipm," indicating the point sources are not from EPA's Integrated Planning Model (IPM) for EGUs, nor are they considered oil and gas point sources. Weekly and daily temporal and chemical speciation profiles for sources in this sector are borrowed from EPA's 2017 platform. Table 9 lists the point sources in the ptnonipm sector and facilities within the Northern Wasatch Front ozone NAA are noted.

Table 9: Point sources in the 2017 and 2023 ptnonipm sectors.

Source Name	2017	2023	Within the NWF NAA?
Ash Grove Cement Company- Leamington Cement Plant	Y	Y	N

Source Name	2017	2023	Within the NWF NAA?
ATK Launch Systems - Promontory	Y	Y	N
Big West Oil, LLC- Big West Oil Refinery	Y	Y	Y
Brigham Young University- Main Campus	Y	N	N
Chevron Products Co - Salt Lake Refinery	Y	Y	Y
Chevron Products Co - SLC Terminal- Salt Lake City Marketing Terminal	Y	Y	Y
Clean Harbors Aragonite LLC: Hazardous Waste Storage Incineration	Y	Y	N
Dugway Proving Ground- U.S. Army-Dugway Proving Ground	Y	Y	N
ECDC Environmental LC: East Carbon Landfill	Y	Y	N
Genpak Corporation: Polystyrene Foam Production Facility	Y	Y	N
Graymont Western US Incorporated- Cricket Mountain Plant	Y	Y	N
Hexcel Corporation: Salt Lake Operations	Y	Y	Y
Hill Air Force Base- Main Base	Y	Y	Y
Hill Air Force Base- Utah Test and Training Range	Y	Y	N
Holcim (US) Inc.- Devil's Slide Plant	Y	Y	N
Holly Corp- HRMC and HEP Woods Cross Operations	Y	Y	Y
Kennecott Utah Copper LLC- Power Plant Lab Tailings Impoundment	Y	N	Y
Kennecott Utah Copper LLC- Smelter & Refinery	Y	Y	Y
Kennecott Utah Copper LLC: Mine & Copperton Concentrator	Y	Y	Y
Lhoist North America - Grantsville Plant	Y	Y	Y
Materion Natural Resources- Delta Mill	Y	Y	N
McWane Ductile - Utah	Y	Y	N
Nucor Steel- Nucor Steel	Y	Y	N
Procter and Gamble-Paper Manufacturing Plant	Y	Y	N
Tesoro Refining & Marketing Company LLC - Salt Lake City Refinery	Y	Y	Y
University of Utah- University of Utah facilities	Y	Y	Y
US Magnesium LLC- Rowley Plant	Y	Y	N
Utelite Corporation: Shale Processing	Y	Y	N
Vulcraft - Division of Nucor Corporation- Steel Products Manufacturing	Y	Y	N
Wasatch Integrated Waste Mgt District- County Landfill & Energy Recovery Facility (DCERF)	Y	N	Y

Addition of Brominated Compounds to a Large Industrial Point Source

Emissions inventories for US Magnesium LLC- Rowley Plant ("US Mag") were adjusted to include brominated compounds according to flyover measurements from a National Atmospheric and Oceanic Administration (NOAA) campaign during the winter of 2017.[6] Brominated compounds are not currently required to be submitted as part of US Mag's triennial emissions inventory. UDAQ is in the process of acquiring testing of brominated compounds from US Magnesium, however the timeframe for those results are beyond the scope of this SIP. Therefore, UDAQ has determined the most appropriate course of action is to rely on emission flux

[6] "Mid-latitude ozone depletion and air quality impacts from industrial halogen emissions: aircraft measurements in the Great Salt Lake Basin" https://insidecires.colorado.edu/rendezvous/uploads/Rendezvous_2022_7429_1651101137.pdf

measurements for brominated compounds from the NOAA flyover study. These emissions support modeling of halogen chemistry in the photochemical model. The measured 2017 emissions flux was projected to 2023 using the same projection factor (x1.061886296) as all other US Mag emissions projected from 2017 to 2023 in their inventory (Table 10). Brominated compound emissions are associated with the tallest stack in SMOKE, noting that all other US Mag stacks have similar height and identical latitude/longitude coordinates.

Table 10: Measured emissions fluxes for US Mag in winter 2017, converted to tons per year and projected to 2023.

Species	2017 Average emission flux (g/sec)	2017 tons per year (TPY)	2023 Average emission flux (g/sec) PROJECTED	2023 tons per year (TPY)
Br_2	5.51	191.5655572	5.850993491	203.42084
BrCl	30.09	1046.135683	31.95215865	1110.877146

Nonpoint Sources

Nonpoint sources, also sometimes called Area sources, are those emissions sources which cannot reasonably be located by a latitude-longitude coordinate due to the multitude and/or uncertainty in the emissions sources themselves. Area sources are spatially allocated according to spatial surrogates, that include 12km and 4km spatial surrogates that are sourced from EPA[7] and windowed to UDAQ's modeling domains. Surrogates for the 1.3km domain were developed by UDAQ using EPA's SurrogateToolDB. Spatial surrogates used in the 4km and 1.3km nonpoint SMOKE runs are listed in Table 11. Some spatial surrogates relevant to oil and gas were not developed for the 1.3km domain because oil and gas production is nearly zero along the Wasatch Front. Any remaining oil and gas SCCs located in the 1.3km domain were mapped to available oil and gas surrogates (see "Domain Applicability" column in Table 11).

Table 11: List of spatial surrogates applied in 4km and 1.3km SMOKE runs.

Surrogate Code	Description	Domain Applicability
100	Population	4km, 1.3km
150	Residential Heating - Natural Gas	4km, 1.3km
170	Residential Heating - Distillate Oil	4km, 1.3km
190	Residential Heating - LP Gas	4km, 1.3km
239	Total Road AADT	4km, 1.3km
244	All Unrestricted AADT	4km, 1.3km
261	NTAD Total Railroad Density	4km, 1.3km
300	NLCD Low Intensity Development	4km, 1.3km
304	NLCD Open + Low	4km, 1.3km
305	NLCD Low + Med	4km, 1.3km
306	NLCD Med + High	4km, 1.3km

[7] EPA Platform Spatial Surrogates: https://drive.google.com/drive/u/1/folders/1idGoi6I3GvKFCcf87O_8zMirM7Gtd0_E

Surrogate Code	Description	Domain Applicability
307	NLCD All Development	4km, 1.3km
308	NLCD Low + Med + High	4km, 1.3km
309	NLCD Open + Low + Med	4km, 1.3km
310	NLCD Total Agriculture	4km, 1.3km
320	NLCD Forest Land	4km, 1.3km
321	NLCD Recreational Land	4km, 1.3km
350	NLCD Water	4km, 1.3km
650	Refineries and Tank Farms	4km, 1.3km
672	Gas production - oil wells	4km only
676	Well count - all producing	4km only
678	Completions at Gas Wells	4km only
681	Spud Count - Oil Wells	4km only
685	Completions at Oil Wells	4km only
693	Well Count - All Wells	4km, 1.3km
694	Oil Production at Oil Wells	4km, 1.3km
695	Well Count - Oil Wells	4km, 1.3km
696	Gas Production at Gas Wells	4km, 1.3km
698	Well Count - Gas Wells	4km, 1.3km
850	Golf Courses	4km, 1.3km
860	Mines	4km only
6832	Produced water at gas wells	4km only
6833	Produced water at oil wells	4km only

Solvents

The solvents sector includes VOC emissions from everyday items such as cleaners, personal care products, adhesives, architectural and aerosol coatings, printing inks, asphalt, and pesticides. Emissions are sourced from EPA's 2016v2 platform, which were generated with the VCPy framework.[8] Solvents modeled in this platform make use of several new VCP speciation profiles (specifically, vcpy0003, vcpy0004, vcpy0009, vcpy0013). While the 2016v2 platform includes projected emissions inventories for 2023 that align with UDAQ's future year, EPA's base year of 2016 is not aligned with UDAQ's 2017 base year. For this year, the 2016 VCPy solvents inventory from EPA is projected to 2017. EPA describes the basis of the VCPy framework as "... the principle that the magnitude and speciation of organic emissions from this sector are directly related to (1) the mass of chemical products used, (2) the composition of these products, (3) the physiochemical properties of their constituents that govern volatilization, and (4) the timescale available for these constituents

[8] Seltzer, K. M., Pennington, E., Rao, V., Murphy, B. N., Strum, M., Isaacs, K. K., and Pye, H. O. T.: Reactive organic carbon emissions from volatile chemical products, Atmos. Chem. Phys., 21, 5079–5100, https://doi.org/10.5194/acp-21-5079-2021, 2021.

to evaporate."[9] The only relation expected to change between 2016 and 2017 base years is the mass of chemical products used. To determine a change in product used, UDAQ evaluated the average Producer Price Index (PPI)[10] across the summer months represented during our modeling episode: June, July, and August. The PPI measures the average change over time in the selling prices received by domestic producers for their output. EPA cites this metric as one economic statistic used to determine VCP usage in the VCPy framework. In 2016, the average summer PPI for all commodities was 187.3. In 2017 the PPI was 193.6. This shows a 3% increase in PPI from 2016 to 2017, so all solvents emissions from the 2016v2 platform VCPy inventory were increased by 3% to produce the 2017 base year VCPy inventory used in this modeling demonstration. SCCs included in the solvents sector are listed in Table 12.

Table 12: Solvents sector SCCs

SCC	SCC Description
2401001000	Solvent Utilization;Surface Coating;Architectural Coatings;Total: All Solvent Types
2401100000	Solvent Utilization;Surface Coating;Industrial Maintenance Coatings;Total: All Solvent Types
2402000000	Solvent Utilization;Paint Strippers;Chemical Strippers;Application, Degradation, and Coating Removal Steps: Other Not Listed
2420000000	Solvent Utilization;Dry Cleaning;All Processes;Total: All Solvent Types
2425000000	Solvent Utilization;Graphic Arts;All Processes;Total: All Solvent Types
2460100000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Personal Care Products;Total: All Solvent Types
2460110000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Personal Care Products: Hair Care Products;Total: All Solvent Types
2460190000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Personal Care Products: Miscellaneous Personal Care Products;Total: All Solvent Types
2460200000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Household Products;Total: All Solvent Types
2460290000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Household Products: Miscellaneous Household Products;Total: All Solvent Types
2460500000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Coatings and Related Products;Total: All Solvent Types
2460600000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Adhesives and Sealants;Total: All Solvent Types
2460900000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Miscellaneous Products (Not Otherwise Covered);Total: All Solvent Types
2461800000	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Pesticide Application: All Processes;Total: All Solvent Types
2461850000	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Pesticide Application: Agricultural;All Processes
2477777777	Placeholder SCC for oil and gas solvents;Placeholder SCC for oil and gas solvents;Placeholder SCC for oil and gas solvents;Placeholder SCC for oil and gas solvents

Emissions from hot mix asphalt (HMA) plants are submitted as point source inventories, however, all HMA plants in the nonattainment area have 2017 NOx and/or VOC emissions less than 100 TPY. Point sources with NOx and/or VOC emissions less than 100 TPY are assumed to be represented in nonpoint sectors, but emissions from asphalt plants are technically *not* represented in the solvents or nonpoint sectors. In order to

[9] EPA 2016v2 platform TSD, page 45
[10] https://fred.stlouisfed.org/series/PPIACO

accommodate planned rulemaking, UDAQ added emissions from HMA plants to the solvents sector (SCC 2306010100). HMA emissions include all criteria air pollutants, and they are spatially allocated using ARTOPNT, where emissions are allocated only to the grid cell in which the HMA plant is located. HMA plants generate some NOx, therefore 2306010100 is the only NOx source present in Utah's solvents sector.

Oil & Gas Nonpoint Sources

Oil and gas sources within Utah come from a high-resolution joint oil and gas emissions inventory developed by UDAQ, EPA, and the Ute Tribe. Though the inventory is facility-specific, UDAQ treats oil and gas emissions sources as nonpoint for this modeling demonstration, operating under the assumption that oil and gas production will likely not have a significant impact on ozone formation along the Northern Wasatch Front. This platform leverages version V1.89 of the 2017 oil and gas emissions inventory, which includes updates to emissions based on the Uinta Basin Composition Study[11] and new produced water disposal facility emission factors.[12] Updates from ongoing pumpjack engine studies are not included in this modeling platform. Uinta Basin Composition Study speciation profiles are included in the EPA 2016v2 platform, therefore those composition profiles are also employed in UDAQ's platform.

Livestock & Fertilizer

Emissions from livestock include all pollutant emissions from agricultural production of livestock, except PM2.5 emissions from livestock, which are included in the area fugitive dust sector. Any emissions from vehicles associated with livestock production are included in the nonroad sector. All livestock emissions are spatially allocated by the NLCD total agriculture surrogate. SCCs included in Utah's livestock sector are listed in Table 13.

Table 13: SCCs represented in the livestock sector within Utah

SCC	SCC Brief Description
2805025000	Swine production composite
2805018000	Dairy cattle composite
2805002000	Beef cattle production composite
2805010100	Poultry production - turkeys; Confinement
2805007100	Poultry production - layers with dry manure management systems; Confinement
2805040000	Sheep and Lambs Waste Emissions
2805035000	Horses and Ponies Waste Emissions
2805045000	Goats Waste Emissions
2805009100	Poultry production - broilers; Confinement
2805001000	Beef cattle - finishing operations on feedlots (drylots); Dust Kicked-up by Hooves

The fertilizer sector includes ammonia (NH3) emissions from agricultural soils. Fertilizer emissions are not projected to 2023 and are expected to remain constant from 2017 to 2023.

[11] "Uintah Basin VOC Composition Study Impacts on the 2017 Oil and Gas Emissions Inventory" https://documents.deq.utah.gov/air-quality/technical-analysis/DAQ-2021-004302.pdf
[12] "Produced Water Disposal Facility Emission Factors and their Impact on the 2017 Oil and Gas Emissions Inventory" https://documents.deq.utah.gov/air-quality/planning/technical-analysis/DAQ-2020-016022.pdf

Area Fugitive Dust

Emissions included in the area fugitive dust sector are sourced from EPA's 2017 platform.[13] Sources include paved roads, unpaved roads and airstrips, construction (residential, industrial, road, and total), agriculture production, and mining and quarrying. Dust associated with point sources are *not* included in this sector and point source dust emissions remain in their respective point source sectors.

Dust emissions are adjusted twice in SMOKE. First, dust emissions estimates are reduced according to the area of dust that is able to be transported, calculated with land-use based gridded transportable fractions.[14] Gridded land use in the area fugitive dust sector is the same as the Biogenics sector. Second, dust is zeroed out for days and grid cells over which at least 0.01 inches of precipitation occurred, according to the WRF modeling for this episode.

Other Nonpoint

Any remaining stationary area sources are included in the nonpoint sector. Some emissions sources in the nonpoint sector include gas stations, landfills, residential home heating, and other emissions from residences. The nonpoint sector also includes any emissions sources in UDAQ's point source inventory with total NOx or VOC emissions *less* than 100 tons per year, i.e. any point source which is not a major ozone point source.

UDAQ's modeling platform includes a new SCC specifically for emissions from residential home water heaters. Emissions associated with the residential home heating SCC 2104006000 are split into home heating (2104006000) and water heating (2104006005). UDAQ scientists used data from EIA to determine residential natural gas consumption per customer in Utah in 2018, roughly 735 therms per year. We assumed the average resident in Utah has a 230 therms per year water heater, such that 31.3% of total residential natural gas combustion in Utah is associated with water heater usage. 31.3% of emissions from SCC 2104006000 are represented by SCC 2104006005, and the remaining 68.7% of emissions stay with SCC 2104006000. Water heater emissions are assigned a flat monthly temporal profile, assuming emissions from water heaters do not fluctuate throughout the year. Water heater emissions are spatially allocated by the housing surrogate.

Emissions Reduction Credit Bank

Emissions in the Emissions Reduction Credit (ERC) Bank are run in SMOKE. Emissions are equivalent for the 2017 base year and the 2023 future year. All emissions credits for each county (Salt Lake and Davis counties only) are summed and spatially allocated according to the "Industrial Land" (code 505). All banked emissions are assigned the dummy SCC 3888888888.

Onroad Sources

The onroad sector includes emissions from motorized vehicles operating on public roadways. Onroad emissions are modeled outside of SMOKE with MOVES3.

[13] Area Fugitive Dust Sector (afdust), page 26, EPA 2017 Platform
https://www.epa.gov/sites/default/files/2020-11/documents/2017_emissionschapter.pdf
[14] Pouliot, et al., 2010
https://www3.epa.gov/ttn/chief/conference/ei19/session9/pouliot_pres.pdf

MOVES3 output for the onroad sector includes emissions rates for a typical Saturday, Sunday, and Weekday. To prepare the MOVES output for SMOKE, we created a weighted average weekday emission rate to which weekly temporal profiles could be applied in SMOKE.

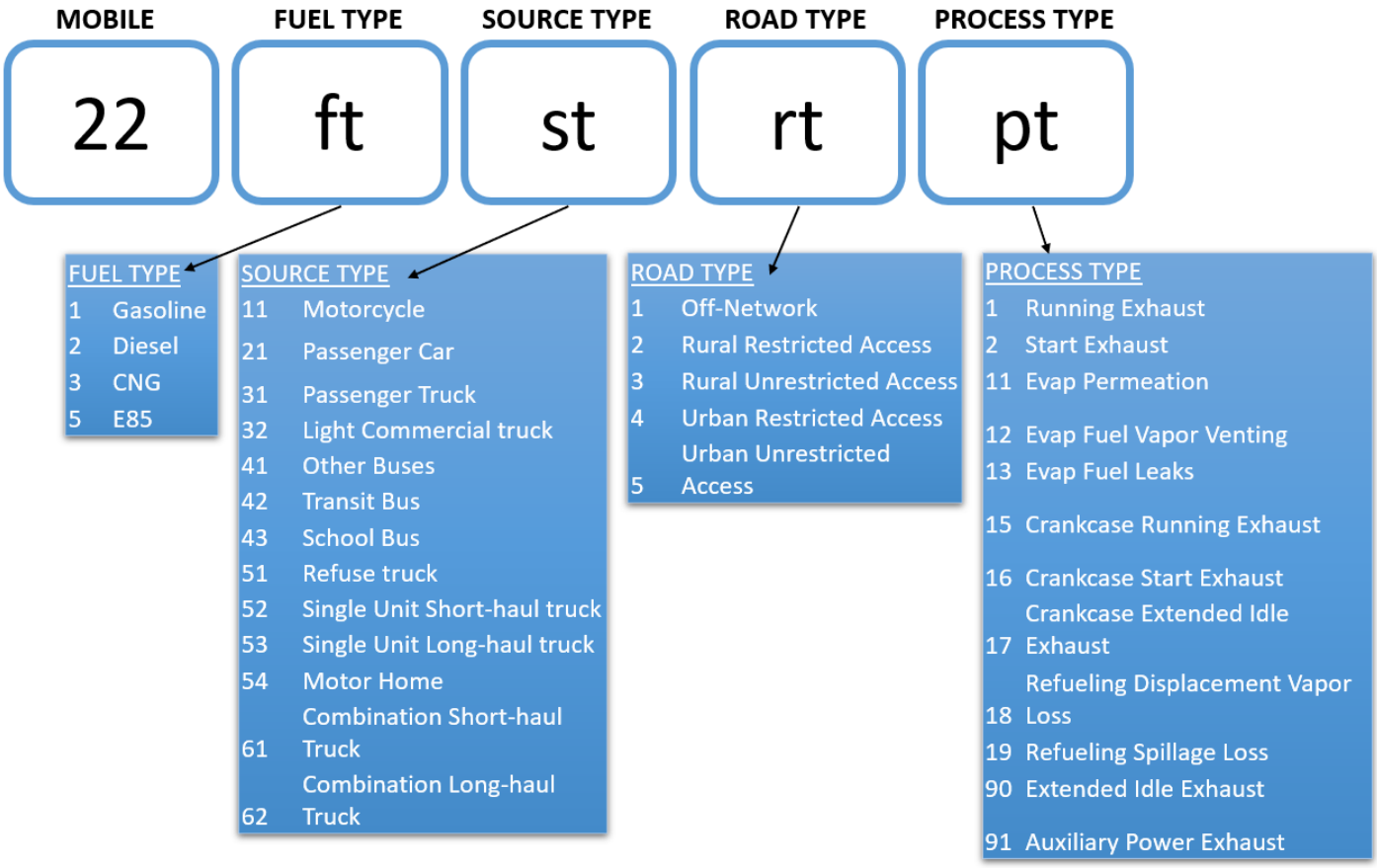
$$Weekly = (Weekday * 5/7) + (Saturday * 1/7) + (Sunday * 1/7)$$

Emissions from MOVES3 for the month of July are input to SMOKE, and since these emissions are already temporalized, monthly temporal profiles for the onroad sector are set to flat distributions. The result of these pre-SMOKE processing calculations is an onroad inventory with July emissions in tons per year.

The 2017 model performance evaluation (MPE) SMOKE model leverages MOVES3 output from a UDAQ run. The 2017 base year SMOKE model uses MOVES3 from a UDAQ for rural counties and from Metropolitan Planning Organizations (MPOs) for Salt Lake, Davis, Weber, and Utah counties.

UDAQ onroad inventories include SCCs of the following type:

Figure 2: Onroad mobile SCC structure



Temporalization of onroad emissions in SMOKE is constructed to match EPA's onroad temporalization in SMOKE-MOVES in the 2016v2 platform.[15] Temporal profiles developed for MOVES defaults in CRC Report

[15] Section 3.3.7 Onroad mobile temporal allocation (onroad), pages 143-145
www.epa.gov/system/files/documents/2021-09/2016v2_emismod_tsd_september2021.pdf

No. A-100[16] are associated with different groupings of counties (i.e. Metropolitan Statistical Area (MSA) core counties, MSA non-core counties, individual counties, etc.). Table 14 shows the type of temporal profile applied in each county in Utah by road type. UDAQ applied temporal profiles in concordance with guidance from the 2016v2 platform TSD, page 143:

> "CRC A-100 data includes profiles by region or county, road type, and broad vehicle category. There are three vehicle categories: passenger vehicles (11/21/31), commercial trucks (32/52), and combination trucks (53/61/62). CRC A-100 does not cover buses, refuse trucks, or motor homes, so those vehicle types were mapped to other vehicle types for which CRC A-100 did provide profiles as follows: 1) Intercity/transit buses were mapped to commercial trucks; 2) Motor homes were mapped to passenger vehicles for day-of-week and commercial trucks for hour-of-day; 3) School buses and refuse trucks were mapped to commercial trucks for hour-of-day and use a new custom day-of-week profile called LOWSATSUN that has a very low weekend allocation, since school buses and refuse trucks operate primarily on business days."

Table 14: Temporal profile types assigned to counties in Utah

FIPS	County Name	Road Type 2	Road Type 4	Road Type 3	Road Type 5
49001	Beaver	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49003	Box Elder	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties
49005	Cache	Region average of non-MSA counties	Region average of non-MSA counties	Region average of MSA Core counties	Region average of MSA Core counties
49007	Carbon	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49009	Daggett	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49011	Davis	Region average of MSA non-Core counties	Individual	Region average of MSA non-Core counties	Individual
49013	Duchesne	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49015	Emery	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49017	Garfield	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49019	Grand	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49021	Iron	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49023	Juab	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties
49025	Kane	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49027	Millard	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49029	Morgan	Region average of MSA non-Core counties	MSA average of non-Core counties	Region average of MSA non-Core counties	MSA average of non-Core counties
49031	Piute	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49033	Rich	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties

[16] Coordinating Research Council (CRC). Report A-100. Improvement of Default Inputs for MOVES and SMOKE-MOVES. Final Report. February 2017. http://crcsite.wpengine.com/wp-content/uploads/2019/05/ERG_FinalReport_CRCA100_28Feb2017.pdf

FIPS	County Name	Road Type 2	Road Type 4	Road Type 3	Road Type 5
49035	Salt Lake	Individual	Individual	Individual	Individual
49037	San Juan	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49039	Sanpete	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49041	Sevier	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49043	Summit	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49045	Tooele	Region average of MSA non-Core counties	Region average of MSA non-Core counties	Region average of MSA non-Core counties	Region average of MSA non-Core counties
49047	Uintah	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49049	Utah	Region average of MSA non-Core counties	Individual	Individual	Individual
49051	Wasatch	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49053	Washington	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties	Region average of MSA Core counties
49055	Wayne	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties	Region average of non-MSA counties
49057	Weber	Region average of MSA non-Core counties	MSA average of non-Core counties	Region average of MSA non-Core counties	MSA average of non-Core counties

Chemical speciation profiles are applied to onroad mobile SCCs in SMOKE, mirroring the way in which speciation is performed in MOVES3.[17] Speciation profiles included in Utah's onroad sector for VOC and PM 2.5 are listed in Table 15. Other pollutants in the onroad sector use default speciation profiles. UDAQ used SMOKE's combination speciation profile utility for some diesel vehicle emissions processes, which combines two or more speciation profiles with a weight for each profile to support a mixture of fuel profiles. Vehicle population data from MOVES3 was analyzed to determine the fraction of pre-2007, 2007-2009, and 2010+ diesel vehicles in Salt Lake County, assuming that Salt Lake County's vehicle population represents a reasonable majority of diesel vehicles in Utah.

Table 15: Speciation profiles applied to onroad mobile SCCs in Utah.

Speciation Profile ID	Pollutant	Description	Fraction of the speciation profile to be used in combination	Fuel Type	Emissions Process
8992	PM 2.5	Light-duty Gasoline Vehicles Exhaust - Start		E85, Gasoline	Crankcase Start Exhaust, Start Exhaust
8993	PM 2.5	Light-duty Gasoline Vehicles Exhaust - Hot Stabilized Running		E85, Gasoline	Crankcase Running Exhaust, Running Exhaust
8994	PM 2.5	Conventional Diesel Exhaust - Idle Cycle		Diesel	Auxiliary Power Exhaust, Crankcase Extended Idle Exhaust

[17] Speciation of Total Organic Gas and Particulate Matter Emissions from Onroad Vehicles in MOVES3 https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=533416&Lab=OTAQ

Speciation Profile ID	Pollutant	Description	Fraction of the speciation profile to be used in combination	Fuel Type	Emissions Process
95220	PM 2.5	CNG transit bus exhaust from a lean-burn engine – oxidation catalyst		CNG	Crankcase Start Exhaust, Start Exhaust, Crankcase Running Exhaust, Running Exhaust
COMBO	PM 2.5	8996: Diesel Exhaust - Heavy-heavy duty truck - 2007 model year with NCOM	57%	Diesel	Crankcase Start Exhaust, Start Exhaust, Crankcase Running Exhaust, Running Exhaust, Extended Idle Exhaust
		8995: Conventional HDD hot stabilized running exhaust	43%		
1001	VOC	Internal Combustion Engine - Natural Gas		CNG	Crankcase Running Exhaust, Crankcase Start Exhaust, Running Exhaust, Start Exhaust
8754	VOC	Gasoline evap -Tier 2 LD vehicles using 10% ethanol		Gasoline	Evap Fuel Leaks, Evap Fuel Vapor Venting, Refueling Spillage Loss
8757	VOC	Gasoline Exhaust -Tier 2 E10 ethanol gasoline composite 2001 +		Gasoline	Crankcase Running Exhaust, Crankcase Start Exhaust, Running Exhaust, Start Exhaust
8769	VOC	Diurnal Permeation Evaporative Emissions from Gasoline Vehicles using 10% Ethanol - Combined - Composite Profile		Gasoline	Evap Permeation
8774	VOC	Diesel Exhaust Emissions from Pre-2007 Model Year Heavy-Duty Diesel Trucks		Diesel	Auxiliary Power Exhaust
8855	VOC	Gasoline Exhaust - Tier 2 light-duty vehicles using 85% Ethanol - Composite Profile		E85	Crankcase Running Exhaust, Crankcase Start Exhaust, Running Exhaust, Start Exhaust
8870	VOC	Gasoline Headspace Vapor - 10% Ethanol (E10) Combined - EPAct/V2/E-89 Program		Gasoline	Refueling Displacement Vapor Loss
8934	VOC	Evaporative Emissions from Flexible-Fuel Gasoline Vehicles using 85% Ethanol		E85	Evap Fuel Leaks, Evap Fuel Vapor Venting, Refueling Spillage Loss, Refueling Displacement Vapor Loss, Evap Permeation
95120	VOC	Liquid diesel - CA composite		Diesel	Refueling Spillage Loss
COMBO	VOC	8774: Diesel Exhaust Emissions from Pre-2007 Model Year Heavy-Duty Diesel Trucks	43%	Diesel	Crankcase Start Exhaust, Start Exhaust, Crankcase Running Exhaust, Running Exhaust, Extended Idle Exhaust. Crankcase Extended Idle Exhaust
		8775: Diesel Exhaust Emissions from 2007-2009 Model Year Heavy-Duty Diesel Trucks	16%		
		95335a: Diesel Exhaust - Heavy duty truck - 2011 model year	41%		

Speciation Profile ID	Pollutant	Description	Fraction of the speciation profile to be used in combination	Fuel Type	Emissions Process
		corrected			

Nonroad Sources

Airports & Rail

Emissions in the airports sector include all emissions from aircraft and associated ground support equipment. UDAQ's platform base year airport emissions are sourced from EPA's 2017 platform within Utah, and from EPA's 2016v2 platform outside Utah. All future year 2023 emissions come from EPA's 2016v2 platform project emissions inventories. SMOKE uses the ARTOPNT feature to assign exact airport coordinates (point) to the appropriate grid cell location (area).[18]

Rail emissions within the state of Utah include all locomotives, railway maintenance locomotives, and point source yard locomotives. This deviates from EPA's platform methodology, which includes maintenance and yard locomotives in the point source sectors. Rail spatial surrogates are used to allocate all rail emissions except for emissions from rail yards (SCC 28500201), which are allocated using the ARTOPNT feature in SMOKE. Rail yard coordinates in the ARTOPNT file are copied from EPA's 2017 platform point source FF10. Rail emissions outside the state of Utah are sourced from EPA's 2016v2 platform and *only* include locomotives in the NEI nonpoint data category, and maintenance/yard locomotives are in the ptnonipm sector.

Other Nonroad

Emissions from non-stationary vehicles which do not operate on typical roads are included in the nonroad sector, including sources such as lawn and garden equipment, construction and mining equipment (not associated with a point source), and pleasurecraft.

Nonroad emissions are modeled outside of SMOKE with MOVES3, where temporalization occurs. Emissions from MOVES3 for the month of July are input to SMOKE, and since these emissions are already temporalized, monthly temporal profiles for the nonroad sector are set to flat distributions.

Emissions from snow blowers and snowmobiles (2265004035, 2265004036, 226004035, 2260004036) are removed from the nonroad sector, assuming that these emissions are zero during our summertime modeling episode.

Emissions from pleasure craft (personal watercraft and recreational boats with outboard or inboard/sterndrive motors) are allocated to counties according to the number of watercraft registrations in each county, however, along the Wasatch Front, personal watercraft are not operated in the county of residence. Bodies of water on which pleasure craft may be operated exist in mainly rural counties beyond the urban corridor of the Wasatch

[18] Section 8.10.1 "ARTOPNT: Area-to-point conversions file"
https://www.cmascenter.org/smoke/documentation/4.8.1/manual_smokev481.pdf

Front. Assuming that pleasure craft owners transport their recreational vehicles to use them, UDAQ removes any pleasure craft emissions from Salt Lake, Davis, Weber, and Tooele counties. These four counties do not include any bodies of water on which pleasure craft may be operated. Emissions from SCCs 2282005010, 228201005, 2282020005, 2282005015, and 2282020010 are removed from these counties prior to SMOKE modeling.

Fires

Emissions from fires are treated as point sources in SMOKE with day-specific emissions. Plume modeling for fires is completed in SMOKE, not in the photochemical model. Fire emissions inventories include acres burned and heat flux in addition to pollutant emissions. Stack parameters are also included in the inventory, directing SMOKE to inject emissions from fires into different 3D layers. Fire locations are satellite-derived coordinates.

Wildfires and prescribed burns are processed separately from agricultural and open burning.

Emissions from fires are calculated as 3D plumes in SMOKE using a SMOKE program called Laypoint. Laypoint uses gridded, hourly meteorological data and stack parameters to calculate the plume rise for all point-source emissions. Wildland fires and burns obviously do not have stacks, so “imaginary stacks” are set at each layer in the 3D model. The “imaginary stacks” inject fire emissions into every vertical layer.

To avoid double-counting these layered fire emissions between the 1.33km and 4km domains, which are interacting in a two-way grid nesting mode in CAMx, all fire emissions in the 4km domain that are overlapped by the 1.33km domain are zeroed out using a masking script provided by EPA from their 2016 regional haze addendum platform.[19]

Biogenics

Biogenic emissions are modeled with the Biogenic Emissions Inventory System (BEIS) version 3.6.1. BEIS creates gridded, hourly, model-species emissions from vegetation and soils. BEIS requires the meteorological variables listed in Table 16.

Table 16: Meteorological Variables Needed for BEIS 3.6.1

Variable	***Description***
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation per met TSTEP
RGRND	solar radiation reaching surface
RN	nonconvective precipitation per met TSTEP
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm

[19] Fires masking package: https://gaftp.epa.gov/Air/emismod/2016/beta/2016fg_addendum/2016fg_scripts_addendum_to_2016ff.zip

TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m

Chemical speciation in BEIS differs from other emissions sectors. Table 17 includes an abbreviated list of chemical species modeled with BEIS.

Table 17: Chemical species groups used in BEIS 3.6.1

BEIS species	***Description***
CO	Carbon Monoxide
NO	Nitrogen Oxide
ALD2	Acetaldehyde
ALDX	Higher acetaldehyde
FORM	Formaldehyde
ISOP	Isoprene
TERP	Terpene
SESQ	Sesquiterpene
ETH	Ethene
ETHA	Ethane
IOLE, OLE	Internal and terminal olefins
ETOH	Ethanol
MEOH	Methanol
PAR	Paraffins

BEIS requires several supplemental datasets: land use, transportable fraction, and seasonal variability. For each grid cell in the domain, BEIS looks for a land use type, the fraction of land that can be transported or made airborne, and the season (either winter or summer) over that grid cell during the model episode.

Land use information is sourced from BELD 4.1[20] with an adjustment to water representation in the land use file based on land use in the meteorological files (MCIP GRIDCRO2D), noting that BELD 4.1 was found to have insufficient water coverage for inland rivers and lakes. The GRIDCRO2D land use is based on the National Land Use Cover Dataset (NLCD).

Transportable fraction is developed from meteorological land use files (MCIP GRIDCRO2D). Land use types and their transport capture class in this platform are listed in Table 18 (MODIS).

Table 18: MODIS land use types

GRIDCRO2D Land Use ID	**Land Use Type**	**Transport Capture Class**	**Capture Class Transportable Fraction**
LUFRAC_01	Evergreen Needleleaf Forest	Forest	50%
LUFRAC_02	Evergreen Broadleaf Forest	Forest	50%

[20] BELD 4.1 Land use scripts (EPA)
https://gaftp.epa.gov/Air/emismod/2016/beta/scripts/smoke_2016beta_platform_beld4.1_land_use.zip

GRIDCRO2D Land Use ID	Land Use Type	Transport Capture Class	Capture Class Transportable Fraction
LUFRAC_03	Deciduous Needleleaf Forest	Forest	50%
LUFRAC_04	Deciduous Broadleaf Forest	Forest	50%
LUFRAC_05	Mixed Forest	Forest	50%
LUFRAC_06	Closed Shrublands	Shrubland	80%
LUFRAC_07	Open Shrublands	Shrubland	80%
LUFRAC_08	Woody Savanna	Grasses	75%
LUFRAC_09	Savanna	Grasses	75%
LUFRAC_10	Grasslands	Grasses	75%
LUFRAC_11	Permanent Wetlands	Grasses	75%
LUFRAC_12	Croplands	Agricultural	75%
LUFRAC_13	Urban and Built-up	Urban	40%
LUFRAC_14	Cropland-Natural Vegetation Mosaic	Agricultural	75%
LUFRAC_15	Snow and Ice	Water	100%
LUFRAC_16	Barren or Sparsely Vegetated	Water	100%
LUFRAC_17	Water Bodies	Water	100%
LUFRAC_18	Wooded Tundra	Forest	50%
LUFRAC_19	Mixed Tundra	Shrubland	80%
LUFRAC_20	Bare Ground Tundra	Water	100%
LUFRAC_21	Lakes	Water	100%

Seasonality is set with the BIOSEASON file; however, for Utah's summertime ozone modeling demonstration, seasonality remains constant in summer.

Lightning NOx and Oceanic Emissions

Day-specific lightning NOx (LNOx) and oceanic emissions were generated using CAMx processors and day-specific WRF meteorological outputs for the 2017 modeling episode. These emissions were considered to remain unchanged between the base and future years.

LNOx emissions were estimated for all 3 domains using the LNOx pre-processing tool in CAMx and CAMx input meteorological files. To avoid double-counting lightning emissions between the 4km and 1.33km domains, which are interacting in a two-way grid nesting mode in CAMx, all lightning NOx emissions in the 4km domain that overlap with the 1.33km domain were zeroed out.

Oceanic emissions were only generated for the 12km domain since it is the only domain including an ocean within it. These emissions were estimated using the oceanic pre-processing tool in CAMx. This tool generates aerosol emissions of sodium, chloride and sulfate, gas emissions of halomethane compounds, and gas emissions of dimethyl sulfide (DMS) using CAMx-ready meteorological and landuse files.

Future Year Emissions Inventories with Controls

UDAQ applies emissions controls to the 2023 case for three future rulemakings: A) to reduce NOx emissions from boilers in the ptnonipm and nonpoint sectors, B) to reduce VOC emissions from hot-mix asphalt (HMA) plants in the solvents sector, and C) to reduce VOC emissions from 2-stroke lawn & garden equipment in the nonroad sector. The implementation of these rules will not meet the timeline requirements for this moderate SIP, but is planned to be part of any future SIP planning efforts beyond this Moderate SIP. The process of developing controls for boilers, HMA plants, and lawn and garden equipment reductions is outlined below for recordkeeping purposes only.

Reductions from the boilers and HMA rules are calculated outside of SMOKE, where CONTROLLED = CORE * (1 - %REDUCTION). Reduction percentages are listed in Table 19. All emissions reductions are applied only in the four nonattainment area counties along the Wasatch Front: Salt Lake, Davis, Weber, and Tooele counties.

Table 19: Future year emissions controls

sector	equipment to be controlled	SCC	% reduction	% reduction in the 1st year	notes
point	> 5 MMBTU boilers	10200601, 10200602, 10200603, 10200701, 30600106	72.99%	3.65%	Boiler reductions are applied only to specific point source units identified as boilers.
nonpoint	2-5 MMBTU boilers	2102006000, 2103000000	89.20%	4.46%	Boiler reductions are applied to the entire SCC. This assumes that all combustion sources in these SCCs are boilers - this is likely an overestimation. UDAQ does not have data to support partitioning the combustion SCC to boiler and non-boiler emissions.
solvents	HMA plants	2306010100	70.00%	70.00%	Reductions are applied to VOC emissions only. All CAP emissions from HMAs are added to the solvents sector.

Lawn & Garden 2-stroke Engine Emissions Reduction Development

Reductions from a lawn and garden equipment emission reduction strategy are calculated within SMOKE using the ARDAY method. The strategy identified by UDAQ would only apply on days forecast as “Mandatory Action Days” (ozone ppb projected to be >= 70ppb) by UDAQ scientists. To model the temporal variability of the rule, reductions are applied in 2023 for days in July that were forecasted to be action days in 2017. A compliance rate of 65% for residential lawn and garden SCCs is enforced, based on a previous rule compliance evaluation in Utah.[21] UDAQ scientists predict a slightly higher compliance rate for commercial lawn and garden SCCs of 80% given the visibility of this sector and potential for public complaints to be filed.

July inventory emissions in tons per year (nonroad emissions are already temporalized for July in MOVES3) were divided by 12 to get a tons per month emissions rate. Then weekday and weekend tons per day were calculated by applying the weekly temporal profiles associated with 2-stroke lawn and garden equipment (opposite profiles for commercial and residential use). Emissions for each day in the episode are assigned a

[21] https://documents.deq.utah.gov/air-quality/planning/technical-analysis/research/DAQ-2020-012054.pdf

tons per day emission rate, depending on whether that day in the episode was a weekend or a weekday. Finally, if the day in the episode was a forecasted Mandatory Action Day in that county, the associated emissions control is applied. SMOKE uses this day-of-month inventory in the nonroad sector instead of the typical annual emissions inventory for the 2-stroke lawn and garden SCCs listed in Table 20.

Table 20: 2-stroke engine lawn and garden equipment SCCs

SCC	Description
2260004016	Rotary Tillers < 6 HP (Commercial)
2260004021	Chain Saws < 6 HP (Commercial)
2260004026	Trimmers/Edgers/Brush Cutters (Commercial)
2260004031	Leafblowers/Vacuums (Commercial)
2260004071	Turf Equipment (Commercial)
2260004015	Rotary Tillers < 6 HP (Residential)
2260004020	Chain Saws < 6 HP (Residential)
2260004025	Trimmers/Edgers/Brush Cutters (Residential)
2260004030	Leafblowers/Vacuums (Residential)

Preparation of Emissions Inventories for OSAT

Ozone Source Apportionment Testing (OSAT)[22] is conducted in CAMx for the nested 4 & 1.33km domains. OSAT tracks contributions to ozone from various emissions source groups and regions. In order to run OSAT, specific emissions source groups, or subsectors, of interest are developed in SMOKE. Sub-inventories were developed as new FF10s and rerun in SMOKE. Source group and region tagging occurs in CAMx, not in SMOKE. Table 21 shows the emissions sectors and subsectors tagged for tracking with OSAT.

Table 21: Emissions sectors tagged for tracking in OSAT.

Source Group ID	Source Group	Description	SCC List
1	Solvents: Consumer Products	All personal care and household cleaning products	2460200000, 2460100000, 2460290000, 2460110000, 2460190000
2	Solvents: Other	Any non-personal care or household cleaning product solvents: Surface coatings, dry cleaning, asphalt paving, degreasing, etc.	2306010100, 2401001000, 2401100000, 2402000000, 2420000000, 2425000000, 2460500000, 2460600000, 2460900000, 2461021000, 2461022000, 2461800000, 2461850000, 2477777777

[22] CAMx User's Guide, 7.1 Ozone Source Apportionment, page 189: https://camx-wp.azurewebsites.net/Files/CAMxUsersGuide_v7.20.pdf

Source Group ID	Source Group	Description	SCC List
3	Nonroad: Lawn & Garden	All lawn & garden equipment: 2- & 4-stroke gasoline-powered mowers, trimmers, leafblowers etc.	2260004015, 2260004016, 2260004020, 2260004021, 2260004025, 2260004026, 2260004030, 2260004031, 2260004035, 2260004071, 2265004010, 2265004011, 2265004015, 2265004016, 2265004025, 2265004026, 2265004030, 2265004031, 2265004040, 2265004041, 2265004046, 2265004051, 2265004055, 2265004056, 2265004066, 2265004071, 2265004075, 2265004076, 2267004066, 2270004031, 2270004046, 2270004056, 2270004066, 2270004071, 2270004076
4	Nonroad: Other	Any remaining non-lawn & garden nonroad equipment: construction equipment, aircraft ground support equipment	(all other nonroad SCCs not in Lawn & Garden)
5, 7	Onroad: Light Duty	Passenger vehicles	All onroad mobile SCC with source type codes 11 (motocycle), 21 (passenger car), or 31 (passenger truck)
6, 8	Onroad: Heavy Duty	Commercial trucks, haul trucks, buses, motor homes, etc.	Any onroad mobile SCC with source type code greater than 31
9	Rail		
10	Biogenics		
11	EGUs		
12	Point Oil & Gas		
13	Nonpoint Oil & Gas		
14	Point: Other	All other point sources not specifically tagged	
15	Point: US Magnesium	all emissions associated with US Magnesium Rowley Plant (point source ID = 10716)	
16	Point: Mine Trucks	Mobile Sources;Off-highway Vehicle Diesel;Construction and Mining Equipment;Off-highway Trucks	2270002051
17	Wildfires, Prescribed Fires		
18	Agricultural Fires		
19	Lightning NOx		
20	Airports		
21	ERC Bank		

Source Group ID	Source Group	Description	SCC List
22	Fertilizer		
23	Livestock		
24	Nonpoint		
25	Area Fugitive Dust		
001ICBC	International Anthropogenic	Non-US anthropogenic emissions estimated based on 12 km base case and zero-out modeling simulations that use GEOS-Chem global model outputs	
002ICBC	Global Natural + Non-Utah US Anthropogenic	Global natural emissions plus any US anthropogenic emissions that are transported into the 4km domain (California anthropogenic, etc.). These were estimated based on 12 km base case and zero-out modeling simulations that use GEOS-Chem global model outputs	
TOPBC	Top Boundary Conditions		

Emissions Inventories & Processing for 12km Domain

Emissions for the 12km domain were processed using inputs from the EPA 2016v2 platform. Sectors in Table 22[23] were modeled in SMOKE for the 12UDAQ domain using only inputs from the 2016v2 platform: no Utah-specific or other adjustments were made to the inventories.

Table 22: Emissions sectors processed for the 12UDAQ domain from the EPA 2016v2 platform

[23] Modified version of Table 2-1, page 16
https://www.epa.gov/system/files/documents/2021-09/2016v2_emismod_tsd_september2021.pdf

Platform Sector	Sector name	NEI Data Category	Description and resolution of the data input to SMOKE
EGU units	ptegu	Point	Point source electric generating units (EGUs) for 2016 from the Emissions Inventory System (EIS), based on 2016v1 with minor updates. Includes some adjustments to default stack parameters, additional closures, and a few units that were previously in ptnonipm. The inventory emissions are replaced with hourly 2016 Continuous Emissions Monitoring System (CEMS) values for nitrogen oxides (NOX) and SO2 for any units that are matched to the NEI, and other pollutants for matched units are scaled from the 2016 point inventory using CEMS heat input. Emissions for all sources not matched to CEMS data come from the raw inventory. Annual resolution for sources not matched to CEMS data, hourly for CEMS sources.
Point source oil and gas	pt_oilgas	Point	Point sources for 2016 from 2016v1 including S/L/T updates for oil and gas production and related processes and updated from 2016v1 with the Western Regional Air Partnership (WRAP) 2014 inventory. The sector includes sources from facilities with the following NAICS: 2111, 21111, 211111, 211112 (Oil and Gas Extraction); 213111 (Drilling Oil and Gas Wells); 213112 (Support Activities for Oil and Gas Operations); 2212, 22121, 221210 (Natural Gas Distribution); 48611, 486110 (Pipeline Transportation of Crude Oil); 4862, 48621, 486210 (Pipeline Transportation of Natural Gas). Includes offshore oil and gas platforms in the Gulf of Mexico (FIPS=85). Oil and gas point sources that were not already updated to year 2016 in the baseline inventory were projected from 2014 to 2016. Annual resolution.
Aircraft and ground support equipment	airports	Point	Emissions from aircraft up to 3,000 ft elevation and emissions from ground support equipment based on 2017 NEI data and backcast to 2016. Corrected from the 2016v1 version which had some double counting.
Remaining non- EGU point	ptnonipm	Point	All 2016 point source inventory records not matched to the ptegu, airports, or pt_oilgas sectors, including updates submitted by state and local agencies for 2016v1 and some additional sources that were not operating in 2016 but did operate in later years. Updates from 2016v1 were minor in that a few sources moved to ptegu. NOx control efficiencies were updated where new information was available. Year 2016 rail yard emissions were developed by the 2016v1 rail workgroup. Annual resolution.
Agricultural fertilizer	fertilizer	Nonpoint	Nonpoint fertilizer application emissions updated from 2016v1 and including only ammonia and estimated for 2016 using the FEST-C model and captured from a run of CMAQ for 2016. County and monthly resolution.

Platform Sector	Sector name	NEI Data Category	Description and resolution of the data input to SMOKE
Agricultural Livestock	livestock	Nonpoint	Nonpoint livestock emissions including ammonia and other pollutants (except PM2.5) updated from 2016v1 and backcast from 2017NEI based on animal population data from the U.S. Department of Agriculture (USDA) National Agriculture Statistics Service Quick Stats, where available. County and annual resolution.
Agricultural fires with point resolution	ptagfire	Nonpoint	2016 agricultural fire sources based on EPA-developed data with state updates, represented as point source day-specific emissions. They are in the nonpoint NEI data category, but in the platform, they are treated as point sources. Data are unchanged from 2016v1. Mostly at daily resolution with some state-submitted data at monthly resolution.
Area fugitive dust	afdust	Nonpoint	PM10 and PM2.5 fugitive dust sources updated from 2016v1 and based on the 2017 NEI nonpoint inventory, including building construction, road construction, agricultural dust, and road dust. Agricultural dust, paved road dust, and unpaved road dust were backcast to 2016 levels. The NEI emissions are reduced during modeling according to a transport fraction (computed for the 2016 platform) and a meteorology-based (precipitation and snow/ice cover) zero-out.
Biogenic	beis	Nonpoint	Year 2016, hour-specific, grid cell-specific emissions generated from the BEIS3.7 model within SMOKE, including emissions in Canada and Mexico using BELD5 land use data. Updated from 2016v1 and consistent with 2017NEI methods.
Category 1, 2 CMV	cmv_c1c2	Nonpoint	Category 1 and category 2 (C1C2) commercial marine vessel (CMV) emissions sources backcast to 2016 from the 2017NEI using a multiplier of 0.98. Emissions unchanged from 2016v1 January 2020 version of CMV. Includes C1C2 emissions in U.S. state and Federal waters, and also all non-U.S. C1C2 emissions including those in Canadian waters. Gridded and hourly resolution.
Category 3 CMV	cmv_c3	Nonpoint	Category 3 (C3) CMV emissions converted to point sources based on the center of the grid cells. Includes C3 emissions in U.S. state and Federal waters, and also all non-U.S. C3 emissions including those in Canadian waters. Emissions are consistent with 2016v1 January 2020 version of CMV and are backcast to 2016 from 2017NEI emissions based on factors derived from U.S. Army Corps of Engineers Entrance and Clearance data and information about the ships entering the ports. Gridded and hourly resolution.

Platform Sector	Sector name	NEI Data Category	Description and resolution of the data input to SMOKE
Locomotives	rail	Nonpoint	Line haul rail locomotives emissions developed by the 2016v1 rail workgroup based on 2016 activity and emission factors and are unchanged from 2016v1. Includes freight and commuter rail emissions and incorporates state and local feedback. County and annual resolution.
Solvents	solvents	Nonpoint	VOC emissions from solvents for 2016 derived using the VCPy framework (Seltzer et al., 2020). Includes cleaners, personal care products, adhesives, architectural coatings, and aerosol coatings, industrial coatings, allied paint products, printing inks, dry-cleaning emissions, and agricultural pesticides. County and annual resolution.
Nonpoint source oil and gas	np_oilgas	Nonpoint	2016 nonpoint oil and gas emissions updated from 2016v1. Based on output from the 2017NEI version of the Oil and Gas tool along with the 2014 WRAP oil and gas inventory and Pennsylvania's unconventional well inventory. Specifically, for the seven WRAP states we used the production-related emissions from the 2014 WRAP inventory. For the exploration-related emissions for these seven WRAP states we used the emissions from the 2017NEI version of the Oil and Gas Tool. County and annual resolution.
Remaining nonpoint	nonpt	Nonpoint	Nonpoint sources not included in other platform sectors and updated from 2016v1 with 2017NEI data. County and annual resolution.
Nonroad	nonroad	Nonroad	2016 nonroad equipment emissions developed with the MOVES3 model updated for 2016v1. MOVES was used for all states except California and Texas, which submitted emissions for 2016v1. County and monthly resolution.
Onroad	onroad	Onroad	2016 onroad mobile source gasoline and diesel vehicles from moving and non-moving vehicles that drive on roads, along with vehicle refueling. Includes the following modes: exhaust, extended idle, auxiliary power units, off network idling, starts, evaporative, permeation, refueling, and brake and tire wear. For all states except California, developed using winter and summer MOVES emissions tables produced by MOVES3 (updated from 2016v1) coupled with activity data backcast from 2017NEI to year 2016 or provided for 2016v1 by S/L/T agencies. Gridded SMOKE-MOVES output was used to compute emissions as nonpoint. https://gaftp.epa.gov/Air/emismod/2016/v2/2016emissions/2016fj_onroad_SMOKE-MOVES_emissions_FF10_27may2021.zip

Platform Sector	Sector name	NEI Data Category	Description and resolution of the data input to SMOKE
Point source fires	ptfire & ptagfire	Events	Point source day-specific wildfires and prescribed fires for 2016 computed using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework (Sullivan, 2008 and Raffuse, 2007) for both flaming and smoldering processes (i.e., SCCs 281XXXX002). Smoldering is forced into layer 1 (by adjusting heat flux). Incorporates state inputs and a few corrections from 2016v1. Daily resolution. Includes agricultural burning (ptagfire sector).
Other Area Fugitive dust sources not from the NEI	othafdust	N/A	Fugitive dust sources of particulate matter emissions excluding land tilling from agricultural activities, from Environment and Climate Change Canada (ECCC) 2016 emission inventory updated for 2016v1. A transport fraction adjustment is applied along with a meteorology- based (precipitation and snow/ice cover) zero-out. County and annual resolution.
Other Point Fugitive dust sources not from the NEI	othptdust	N/A	Fugitive dust sources of particulate matter emissions from land tilling from agricultural activities, ECCC 2016 emission inventory updated for 2016v1, but wind erosion emissions were removed. A transport fraction adjustment is applied along with a meteorology-based (precipitation and snow/ice cover) zero-out. Data were originally provided on a rotated 10-km grid for beta, but were smoothed so as to avoid the artifact of grid lines in the processed emissions. Monthly resolution.
Other point sources not from the NEI	othpt	N/A	Point sources from the ECCC 2016 emission inventory updated for 2016v1. Includes Canadian sources other than agricultural ammonia and low-level oil and gas sources, along with emissions from Mexico's 2016 inventory. Monthly resolution for Canada airport emissions, annual resolution for the remainder of Canada and all of Mexico.
Canada ag not from the NEI	canada_ag	N/A	Agricultural point sources from the ECCC 2016 emission inventory updated from 2016v1, including agricultural ammonia. Agricultural data were originally provided on a rotated 10-km grid, but were smoothed so as to avoid the artifact of grid lines in the processed emissions. Data were forced into 2D low-level emissions to reduce the size of othpt. Monthly resolution.
Canada oil and gas 2D not from the NEI	canada_og 2D	N/A	Low-level point oil and gas sources from the ECCC 2016 emission inventory updated from 2016v1. Data were forced into 2D low-level emissions to reduce the size of othpt. Point oil and gas sources which are subject to plume rise are in the othpt sector. Annual resolution.

Platform Sector	Sector name	NEI Data Category	Description and resolution of the data input to SMOKE
Other non-NEI nonpoint and nonroad	othar	N/A	Year 2016 Canada (province or sub-province resolution) emissions from the ECCC inventory updated for 2016v1: monthly for nonroad sources; annual for rail and other nonpoint Canada sectors. Year 2016 Mexico (municipio resolution) emissions from their 2016 inventory: annual nonpoint and nonroad mobile inventories.
Other non-NEI onroad sources	onroad_can	N/A	Year 2016 Canada (province resolution or sub-province resolution, depending on the province) from the ECCC onroad mobile inventory updated for 2016v1. Monthly resolution.
Other non-NEI onroad sources	onroad_mex	N/A	Year 2016 Mexico (municipio resolution) onroad mobile inventory based on MOVES-Mexico runs for 2014 and 2018 then interpolated to 2016 (unchanged from 2016v1). Monthly resolution.

SMOKE Reports & Quality Control

UDAQ developed several interactive reporting tools to quality check SMOKE runs for the Northern Wasatch Front ozone attainment demonstration modeling platform. Interactive reports are generated for all counties in Utah at the 4 km resolution, and for the nonattainment area counties at the 1.33 km resolution (Salt Lake, Davis, Weber, and Tooele). A summary spreadsheet of emissions totals is also included for each modeling scenario. Reports are linked in the directories below.

- 2017 base year emissions QC reports
- 2023 future year emissions, on the books QC reports

Emissions Summary Tables

Emissions summaries are provided for *one representative weekday*, July 5th, 2017, in tons per day. Emissions summaries are generated from SMOKE reports, so all emissions inventories are already spatially, temporally allocated and chemically speciated. Summary tables are developed from a specific kind of SMOKE report which outputs emissions *per grid cell* in the modeling domain. Two types of emissions sector summaries are provided: one summarizing grid cells describing only the NWF nonattainment area extent (Figure 3, left), and one summarizing grid cells for the entire counties intersecting the nonattainment area extent (Figure 3, right).

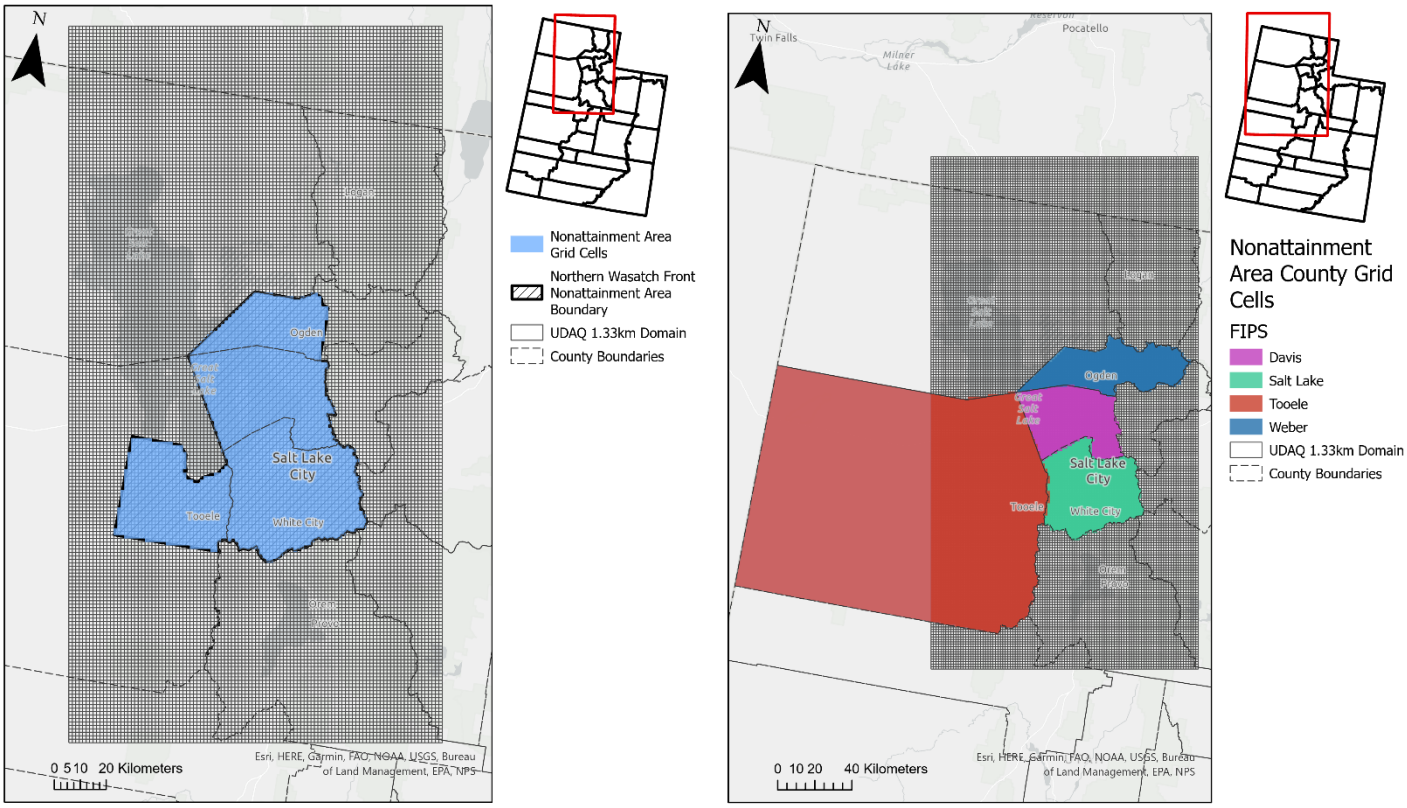


***Figure 3**: 1.3km grid cells comprising the (left) NWF NAA, and (right) counties overlapping the NWF NAA.*

Table 23: Nonattainment area sector summary of emissions (post-SMOKE) in tons per day on a representative weekday.

Sector	2017 NOX TPD	2023 NOX TPD	2017 VOC TPD	2023 VOC TPD
Airports	3.14	3.74	1.25	1.42
EGUs	0.44	0.45	0.03	0.03
ERC Bank	3.09	3.09	0.73	0.73
Livestock			0.69	0.71
Nonpoint	5.36	4.85	8.51	8.26
Nonroad	10.52	8.05	12.53	12.62
Onroad	55.53	35.40	20.47	15.32
Point	20.43	22.00	5.85	6.00
Rail	9.25	8.77	0.47	0.44
Solvents	0.56	0.71	43.20	44.52

Total*	**108.33**	**87.05**	**93.74**	**90.05**

Table 24: Nonattainment area counties sector summary of emissions (post-SMOKE) in tons per day on a representative weekday.

Sector	2017 NOX TPD	2023 NOX TPD	2017 VOC TPD	2023 VOC TPD
Airports	3.14	3.74	1.25	1.42
EGUs	0.44	0.45	0.03	0.03
ERC Bank	3.09	3.09	0.73	0.73
Livestock			0.91	0.93
Nonpoint	5.40	4.88	8.59	8.34
Nonroad	10.63	8.12	13.19	13.22
Onroad	57.41	36.44	20.94	15.64
Point	23.70	25.55	7.73	7.99
Rail	10.01	9.41	0.50	0.47
Solvents	0.56	0.71	43.45	44.76
Total*	**114.39**	**92.39**	**97.32**	**93.54**

**any differences in total TPD emissions in these tables vs. similar summary tables in the SIP narrative are due to rounding.*

Table 24 shows more emissions per sector than Table 23 because of the larger spatial extent of the reporting associated with summarizing emissions from total counties, rather than the exact nonattainment area extent (partial counties). Subsequent emissions summary tables in this TSD are summarized by the nonattainment area extent (Figure 3 (left), Table 23). Detailed county-level post-SMOKE emissions data are available for download at the links below:

Detailed post-SMOKE emissions tables can be downloaded in .csv format here:

- 2017 SMOKE Summary Report, Representative Weekday
- 2023 on the books SMOKE Summary Report, Representative Weekday
- 2023 on the books SMOKE Summary Report, Representative Weekday - Subsectors Prepared for OSAT

Table 25: Post-SMOKE emissions from point sources in the NAA in tons per day (TPD)

Plant ID	Plant Name	2017 NOX	2023 NOX	2017 VOC	2023 VOC
10571	Kennecott Utah Copper LLC: Mine & Copper	13.93	18.38	0.69	0.92

10571	Kennecott Utah Copper LLC: Mine & Copper	0.01	0.01	0.00	0.00
10571	Kennecott Utah Copper LLC: Mine & Copper	0.00	0.00	0.00	0.00
11386	Hexcel Corporation: Salt Lake Operations	0.53	0.52	0.44	0.42
11386	Hexcel Corporation: Salt Lake Operations	0.00	0.01	0.00	0.02
10572	Kennecott Utah Copper LLC- Power Plant	2.62	0.00	0.02	0.00
10346	Kennecott Utah Copper LLC- Smelter & Ref	0.31	0.41	0.02	0.02
10346	Kennecott Utah Copper LLC- Smelter & Ref	0.06	0.04	0.02	0.02
10354	University of Utah- University of Utah f	0.05	0.07	0.02	0.02
10354	University of Utah- University of Utah f	0.06	0.05	0.01	0.00
10707	Lhoist North America - Grantsville Plant	0.00	0.00	0.00	0.00
10335	Tesoro Refining & Marketing Company LLC	0.87	0.90	0.64	0.72
10119	Chevron Products Co - Salt Lake Refinery	0.71	0.49	1.02	0.92
10556	Chevron Products Co - SLC Terminal- Salt	0.00	0.00	0.04	0.04
10122	Big West Oil, LLC- Big West Oil Refinery	0.32	0.32	1.88	1.76
10123	Holly Corp- HRMC and HEP Woods Cross Ope	0.48	0.43	0.61	0.64
10121	Hill Air Force Base- Main Base	0.28	0.37	0.38	0.49
10129	Wasatch Integrated Waste Mgt District- C	0.20	0.00	0.07	0.00
	Total	**20.43**	**22.00**	**5.86**	**6.00**

Table 26: Post-SMOKE emissions from EGU sources in the NAA in tons per day (TPD)

Plant ID	Plant Name	2017 NOX	2023 NOX	2017 VOC	2023 VOC
12495	Utah Municipal Power Agency: West Valley	0.03	0.08	0.00	0.01
10355	Pacificorp Energy- Gadsby Power Plant	0.41	0.37	0.02	0.02
	Total	**0.44**	**0.45**	**0.03**	**0.03**

Table 27: Post-SMOKE emissions from US Magnesium Rowley Plant (outside the NAA but influences O3 production in the NAA)

Pollutant	2017 TPD	2023 TPD

NOX	2.87	3.05
VOC	1.84	1.96
I-HCL	2.81	2.99
CHLORINE	15.43	16.39
BROMINE	0.50	0.57
I-BRCL	2.75	3.10

Table 28: Post-SMOKE emissions from onroad mobile sources within the NAA (in TPD) by vehicle type

Vehicle Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Passenger Truck	23.32	8.97	9.96	5.51
Passenger Car	4.93	2.92	6.18	6.19
Motorcycle	0.07	0.08	0.68	0.88
Light Commercial truck	4.28	1.68	1.61	0.89
Single Unit Short Haul Truck	4.89	3.92	0.89	0.81
Single Unit Long Haul Truck	0.23	0.19	0.04	0.04
Combination Long Haul Truck	12.62	12.61	0.61	0.55
Combination Short Haul Truck	2.97	3.32	0.15	0.16
Motor Home	0.26	0.22	0.16	0.13
Other Buses	1.20	0.93	0.11	0.10
Transit Bus	0.39	0.22	0.04	0.03
School Bus	0.24	0.20	0.03	0.02
Refuse truck	0.13	0.12	0.01	0.01
Total	**55.53**	**35.40**	**20.47**	**15.32**

Table 29: Post-SMOKE emissions from onroad mobile sources within the NAA (in TPD) by fuel type

Fuel Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
CNG	0.09	0.10	0.03	0.06
Diesel	37.29	27.46	3.47	1.77
E85	0.04	0.02	0.04	0.03

Gasoline	18.10	7.82	16.92	13.46
Total	**55.53**	**35.40**	**20.47**	**15.32**

Table 30: Post-SMOKE emissions from onroad mobile sources within the NAA (in TPD) by emissions process type

Process Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Running Exhaust	51.17	31.96	6.02	2.98
Start Exhaust	3.86	2.89	2.53	2.16
Extended Idle Exhaust	0.36	0.30	0.04	0.02
Crankcase Running Exhaust	0.13	0.23	0.18	0.15
Auxiliary Power Exhaust	0.00	0.01	0.00	0.00
Crankcase Extended Idle Exhaust	0.00	0.00	0.00	0.00
Crankcase Start Exhaust	0.00	0.00	0.03	0.03
Evap Fuel Leaks	0.00	0.00	2.28	2.64
Evap Fuel Vapor Venting	0.00	0.00	3.92	3.54
Evap Permeation	0.00	0.00	2.93	2.12
Refueling Displacement Vapor Loss	0.00	0.00	1.91	0.99
Refueling Spillage Loss	0.00	0.00	0.61	0.67
Total	**55.53**	**35.40**	**20.47**	**15.32**

Table 31: Post-SMOKE emissions from nonroad mobile sources within the NAA (in TPD) by equipment type

Equipment Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Lawn and Garden Equipment	1.58	1.58	7.67	8.05
Industrial Equipment	1.87	1.59	0.31	0.28
Construction and Mining Equipment	5.37	3.39	0.84	0.65
Commercial Equipment	1.42	1.29	1.99	2.11
Agricultural Equipment	0.16	0.08	0.02	0.01
Recreational Equipment	0.10	0.10	1.69	1.50

Pleasure Craft: Diesel	0.02	0.01	0.00	0.00
Pleasure Craft: Gasoline 2-Stroke	0.00	0.00	0.01	0.00
Total	**10.52**	**8.05**	**12.53**	**12.62**

Table 32: Post-SMOKE emissions from airports within the NAA (in TPD) by equipment type

Equipment Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Air Taxi	0.11	0.06	0.14	0.08
Aircraft Auxiliary Power Units	0.12	0.15	0.01	0.01
Airport Ground Support Equipment	0.12	0.15	0.04	0.05
Commercial Aircraft	2.32	2.90	0.79	0.98
General Aviation	0.02	0.02	0.05	0.07
Military Aircraft	0.45	0.45	0.22	0.22
Total	**3.14**	**3.74**	**1.25**	**1.42**

Table 33: Post-SMOKE emissions from rail equipment within the NAA (in TPD) by equipment type

Equipment Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Line Haul Locomotives: Class I Operations	2.98	2.45	0.13	0.10
Line Haul Locomotives: Class II / III Operations	0.30	0.30	0.01	0.01
Line Haul Locomotives: Commuter Lines	1.28	1.39	0.06	0.06
Line Haul Locomotives: Passenger Trains (Amtrak)	0.63	0.68	0.03	0.03
Yard Locomotives	4.05	3.95	0.24	0.24
Total	**9.25**	**8.77**	**0.47**	**0.44**

Table 34: Post-SMOKE emissions from solvents (VCPy) within the NAA (in TPD) by source type

Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Dry Cleaning			0.04	0.04
Graphic Arts			5.43	5.58

All Adhesives and Sealants			3.65	3.76
All Coatings and Related Products			1.10	1.13
All Household Products			0.96	0.98
All Personal Care Products			0.11	0.11
Household Products: Miscellaneous Household Products			8.37	8.63
Miscellaneous Products (Not Otherwise Covered)			0.09	0.09
Personal Care Products: Hair Care Products			8.54	8.81
Personal Care Products: Miscellaneous Personal Care Products			0.25	0.26
Paint Strippers			4.20	4.33
Architectural Coatings			3.57	3.68
Industrial Maintenance Coatings			5.00	5.15
Pesticide Application: Agricultural			0.02	0.02
Pesticide Application: All Processes			0.40	0.41
Cutback Asphalt			0.35	0.35
Emulsified Asphalt			1.07	1.07
Asphalt Mixing Plants & Paving/Roofing Materials	0.56	0.71	0.06	0.11
Total	**0.56**	**0.71**	**43.20**	**44.52**

Table 35: Post-SMOKE emissions from livestock within the NAA (in TPD) by source type

Type	2017 VOC	2023 VOC
Beef cattle production composite	0.09	0.09
Dairy cattle composite	0.09	0.10
Goats Waste Emissions	0.01	0.01
Horses and Ponies Waste Emissions	0.09	0.09
Poultry production - broilers	0.00	0.00
Poultry production - layers with dry manure management systems	0.13	0.13
Poultry production - turkeys	0.26	0.27
Sheep and Lambs Waste Emissions	0.01	0.01

Swine production composite	0.00	0.00
Total	**0.69**	**0.71**

Table 36: Post-SMOKE emissions from nonpoint sources within the NAA (in TPD) by source type

Type	2017 NOX	2023 NOX	2017 VOC	2023 VOC
Commercial/Institutional Combustors & Boilers	0.96	0.92	0.05	0.05
100% Green Waste (e.g., residential or municipal yard wastes)	0.00	0.00	0.74	0.81
Bakery Products	0.00	0.00	0.86	0.94
Commercial Cooking - Charbroiling	0.00	0.00	0.18	0.19
Commercial Cooking - Frying	0.00	0.00	0.06	0.06
Industrial Combustors & Boilers	2.45	2.51	0.16	0.16
Municipal Landfills	0.00	0.00	0.35	0.39
Leaking Underground Storage Tanks	0.00	0.00	0.54	0.56
Open Burning	0.00	0.00	0.01	0.01
Aircraft/Rocket Engine Firing and Testing	0.00	0.00	0.00	0.00
Charcoal Grilling - Residential	0.06	0.07	0.17	0.18
Cremation	0.00	0.00	0.00	0.00
Motor Vehicle Fires	0.00	0.00	0.00	0.00
Structure Fires	0.01	0.01	0.07	0.08
Airports : Aviation Gasoline	0.00	0.00	0.09	0.08
Bulk Plants: All Evaporative Losses	0.00	0.00	0.00	0.00
Bulk Terminals: All Evaporative Losses	0.00	0.00	0.35	0.31
Commercial Portable Gas Cans	0.00	0.00	0.40	0.36
Gasoline Service Stations	0.00	0.00	0.99	0.90
Residential Portable Gas Cans	0.00	0.00	0.67	0.60
Petroleum and Petroleum Product Transport	0.00	0.00	2.62	2.37
Residential Distillate Oil Combustors	0.00	0.00	0.00	0.00
Residential Kerosene Heaters	0.00	0.00	0.00	0.00

Residential Liquified Petroleum Gas (LPG) Combustors	0.01	0.01	0.00	0.00
Residential Natural Combustors (All)	0.22	0.15	0.01	0.01
Residential Natural Gas Water Heater Combustor Types	1.65	1.17	0.10	0.08
Wastewater Treatment	0.00	0.00	0.09	0.09
Total	**5.36**	**4.85**	**8.51**	**8.26**

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