582-11-11219
Task 3.1 and Task 3.3

Non-Road Emission Inventory Improvements

Technical Report

July 1st, 2012

Prepared by:

Alamo Area Council of Governments

Prepared in Cooperation with the Texas Commission on Environmental Quality

The preparation of this report was financed through grants from the State of Texas through the Texas Commission on Environmental Quality

Title: Non-Road Emission Inventory Improvements	**Report Date:** July 1st, 2012
Authors: AACOG Natural Resources/ Transportation Department	**Type of Report:** Technical Report
Performing Organization Name & Address: Alamo Area Council of Governments 8700 Tesoro Drive, Suite 700 San Antonio, Texas 78217	**Period Covered:** 2006

Sponsoring Agency:
Prepared In Cooperation With The Texas Commission on Environmental Quality.
The preparation of this report was financed through grants from the State of Texas through the Texas Commission on Environmental Quality.

Abstract: This report documents refinements made to the 2006 non-road equipment emissions inventories published by TCEQ. The refinements pertain solely to non-road sources in the AACOG region and were based on the application of local data in the emission calculations for construction equipment, quarry equipment, landfill equipment, and agricultural tractors and combines. When the refined 2006 emission estimates were grouped by county, the majority of construction equipment-generated NO_X emissions were emitted in Bexar County: 8.44 tons of NO_X per ozone season day. Construction equipment emissions estimated for Comal County, 0.78 tons of NO_X per summer weekday, and Guadalupe County, 0.45 tons of NO_X per summer weekday, also accounted for a significant portion of the NO_X emissions from this non-road category. Local departments of transportation, government agencies, utility companies, and private companies were contacted to collect data on locations of construction projects in order to spatially allocate the emissions estimates. Data regarding quarry equipment, landfill equipment, and tractors and combine activity rates; engine characteristics; and equipment populations were collected using local surveys. Ozone season day emissions from quarry equipment were estimated to be 0.266 tons of VOC and 3.782 tons of NO_X in the AACOG region during 2006. As expected, the highest emissions from quarry equipment were estimated for Bexar County followed by Comal County and Medina County. Landfill equipment accounted for 0.029 tons of VOC emissions and 0.328 tons of NO_X emissions in the AACOG region. Refinements made to the tractor calculations resulted in lower emissions than those estimated in either the Nonroad2008a or TexN Models.

Related Reports: 2005 Emission Inventory for the Alamo Area Council of Governments Region	**Distribution Statement:** Alamo Area Council of Governments, Natural Resources/Transportation Department	**Permanent File:** Alamo Area Council of Governments, Natural Resources/Transportation Department

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1. INTRODUCTION

1.1. Background

The Clean Air Act is the comprehensive federal law that regulates airborne emissions across the United States.[1] This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Of the many air pollutants commonly found throughout the country, EPA has recognized six "criteria" pollutants that can injure health, harm the environment, and/or cause property damage. Air quality monitors measure concentrations of these pollutants throughout the country and San Antonio is currently in attainment of the "criteria" pollutants. However, there are concerns over high concentrations of ground level ozone, one of the "criteria" pollutants, which local monitors recorded. Ozone is produced when volatile organic compounds (VOC) and nitrogen compounds (NO_X) react in the presence of sunlight.[2]

According to the EPA, "the health effects associated with ozone exposure include respiratory health problems ranging from decreased lung function and aggravated asthma to increased emergency department visits, hospital admissions and premature death. The environmental effects associated with seasonal exposure to ground-level ozone include adverse effects on sensitive vegetation, forests, and ecosystems."[3] Currently, the ozone primary standard, which is designed to protect human health, is set at 75 parts per billion (ppb). The secondary standard, which is designed to protect the environment, is the same as the primary standard.

To meet air quality standards, local and state air quality planners need an accurate account of emissions and sources in the region. The compilation of the emission inventory (EI) for the AACOG region needs extensive research and analysis. By understanding how these varied sources create ozone precursor pollutants, planners, political leaders, and common citizens can work together to protect heath and the environment. The results are formatted for input into the regional photochemical model.

1.2. Objectives and Approach

The non-road emission inventory provides updates to the emissions published by TCEQ. The non-road emissions inventory produced by the Texas NONROAD (TexN) model was also reviewed and updated. The focus of these improvements are not the end-product generation of emissions estimates in units of tons per day, but rather the raw local inputs such as population figures, local activity profiles, spatial surrogates, temporal profiles, and other input data. All survey work is accompanied by a survey design describing the population, the information collected from the population, a description of how AACOG collected the sample, the type of sample drawn from the population, and the margin of error.

1.3. Inventory Pollutants

Ozone is a secondary pollutant because it forms as the result of chemical reaction between other pollutants, namely:

- Nitrogen Oxides (NO_X)
- Volatile Organic Compounds (VOC)

[1] US Congress, 1990. "Clean Air Act". Available online: http://www.epa.gov/air/caa/. Accessed 07/19/10.
[2] EPA, Sept. 23, 2011, "Ground-level Ozone". Available online: http://www.epa.gov/air/ozonepollution/. Accessed 10/31/11.
[3] EPA, September 16, 2009. "Fact Sheet: EPA to Reconsider Ozone Pollution Standards", p. 1. Available online: http://www.epa.gov/air/ozonepollution/pdfs/O3_Reconsideration_FACT%20SHEET_091609.pdf. Accessed 06/28/10.

The photochemical modeling, that is used to determine a regions ability to comply with the NAAQS, depends on accurately identifying and quantifying emission rates from these pollutants.

1.4. Geographic Area

Updates to the non-road emission inventory include sources in the AACOG region, consisting of twelve counties located in South Central Texas and part of the Hill Country. These counties include: Atascosa, Bandera, Bexar, Comal, Frio, Gillespie, Guadalupe, Karnes, Kendall, Kerr, Medina, and Wilson counties (figure 1-1).

1.5. Modeling Domain Parameters

Development of input files for photochemical model emission processing shall be based on a grid system consistent with EPA's Regional Planning Organizations (RPO) Lambert Conformal Conic map projection with the following parameters:

- First True Latitude (Alpha): 33°N
- Second True Latitude (Beta): 45°N
- Central Longitude (Gamma): 97°W
- Projection Origin: (97°W, 40°N)
- Spheroid: Perfect Sphere, Radius = 6,370 km

All future TCEQ photochemical model emissions processing work shall be based on this grid system.

1.6. Data Sources

Specific non-road emissions were calculated by AACOG based on methodologies provided by EPA and TCEQ. Emission calculations are based on local activity data and the TexN Model. Other data sources included the Texas Department of Transportation (TxDOT)[4], U.S. Census Bureau[5], County Business Patterns[6], Census Building permits[7], Mine Safety and Health Administration[8], Texas Agricultural Statistics reports published by USDA[9], and Texas AgriLife Extension Service's 2011 Texas Crop and Livestock Budgets[10]. All current federal and state regulations are taken into account when calculating emissions.

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[4] Texas Department of Transportation. "TxDOT Letting Schedule". Finance Division. Austin, Texas. Available online: http://www.dot.state.tx.us/business/schedule.htm. Accessed 07/11/11.

[5] U.S. Census Bureau, Population Division. "Population Estimates". Available online: http://www.census.gov/popest/counties/. Accessed 07/13/11.

[6] U.S. Census Bureau. June 30, 2011. "County Business Patterns (CBP)". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 07/12/11.

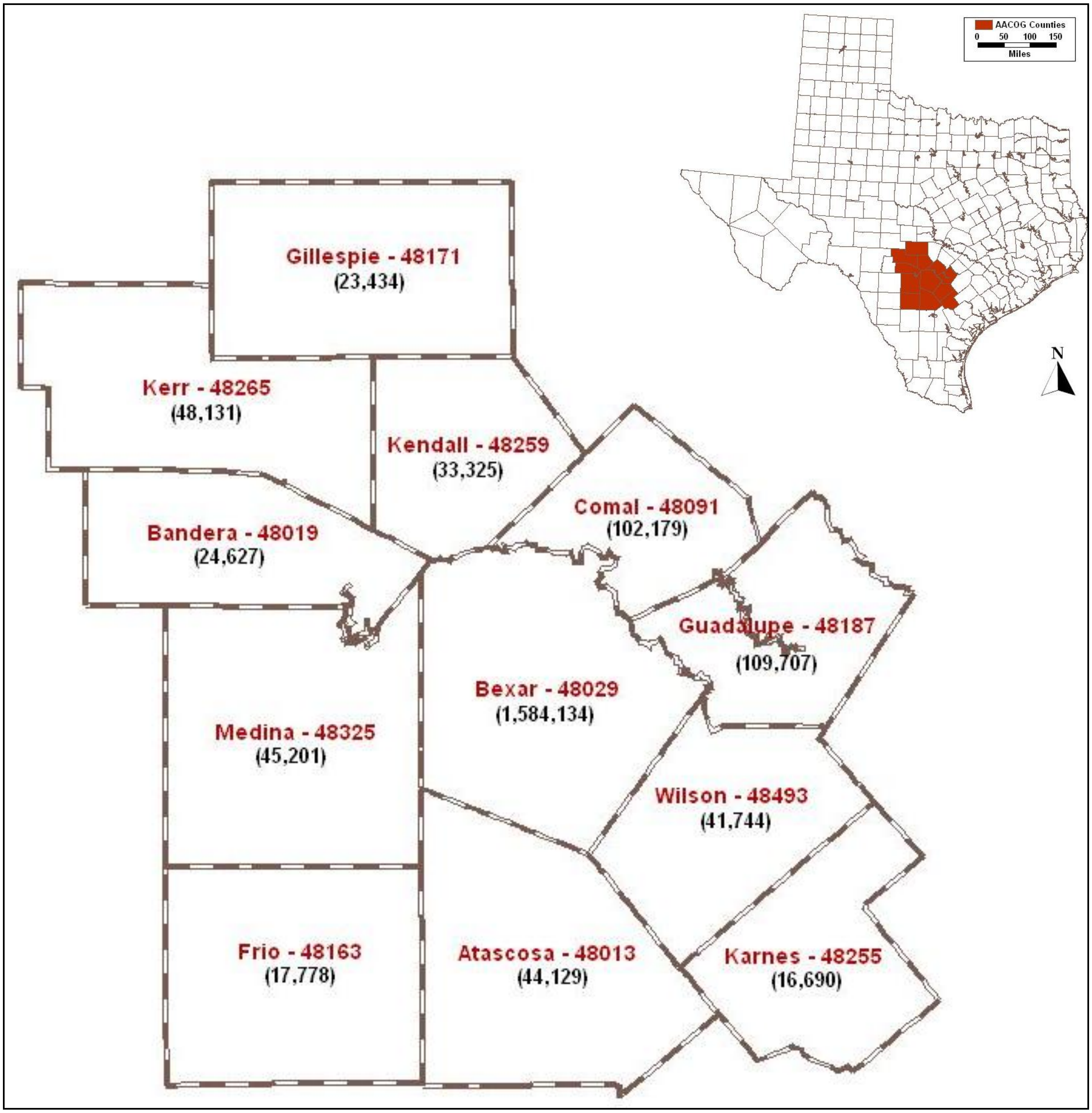
[7] U.S. Census Bureau. "Building Permits". Available online: http://censtats.census.gov/bldg/bldgprmt.shtml. Accessed 07/13/11.

[8] Mine Safety and Health Administration, July 22, 2011. "Mine Data Retrieval System". United States Department of Labor. Available online: http://www.msha.gov/drs/drshome.htm. Accessed 07/27/2011.

[9] United States Department of Agriculture, Updated December 2009. "Texas Agricultural Statistics, 2008". National Agricultural Statistics Service, Texas Field Office". Available online: http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Annual_Statistical_Bulletin/index.asp. Accessed 12/20/2010.

[10] Department of Agricultural Economics: Extension Agricultural Economics, Texas A&M University, 2010. "2011 Texas Crop and Livestock Budgets District 10, Estimated Costs and Returns per Acre". College Station, TX. Available online: http://agecoext.tamu.edu/resources/crop-livestock-budgets/by-district/district-10/2011.html. Accessed 06/10/2011.

Figure 1-1: Map of the AACOG Twelve-County Region with 2008 Population Estimates[11]



Plot Date:	July 27, 2010
Map Compilation:	July 20, 2010
Source:	TransCAD – US Counties Data File

[11] Texas Water Development Board, May 2010. "2011 Regional Water Plan County Population for 2010 – 2060". Austin, TX. Available online: http://www.twdb.state.tx.us/wrpi/data/proj/popwaterdemand/2011Projections/Population/2CountyPopulation.pdf. Accessed 07/20/10.

1.7. Refined Categories

AACOG staff identified sources, prepared a plan to carry out "bottom-up" research, improved emissions inventory inputs, calculated emissions, geo-coded emission sources, and provide model input data files. AACOG updated and expand the following emission inventory categories:

- Construction equipment
- Quarry equipment
- Landfill equipment
- Tractors and Combines

Emission contributions for each category are listed in table 1-1. The results of the emission inventory calculations can be used in the TexN Model, which was developed by TCEQ for calculating non-road emissions.

Table 1-1: Contribution of Emissions for Each Refined Category, 2006.

Emission Inventory Category	NO_X		VOC	
	Tons/Day	Percentage	Tons/Day	Percentage
Construction equipment	11.02	4.6%	1.43	1.0%
Quarry equipment	3.78	1.6%	0.27	0.2%
Landfill equipment	0.30	0.1%	0.03	0.0%
Tractors and Combines	0.94	0.4%	0.10	0.1%
Total Anthropogenic Emissions (mobile, point, non-road, area)	241.54	100.0%	146.93	100.0%

2. DIESEL CONSTRUCTION EQUIPMENT

Construction equipment is used to build roads, highways, buildings, houses, and utility lines in the AACOG region. Concrete operations, landscaping activities, manufacturing facilities, and recycling operations also use construction equipment. Emissions from diesel construction equipment used at landfills and quarries will be calculated in other sections of this report because construction equipment used by these facilities have different engine characteristics, activity rates, and emission calculation methodologies. Emissions are calculated for the following diesel construction equipment:

- Pavers
- Tampers/Rammers
- Plate Compactors
- Rollers
- Scrapers
- Paving Equipment
- Surfacing Equipment
- Signal Boards/Light Plants
- Trenchers
- Bore/Drill Rigs
- Excavators
- Concrete/Industrial Saws
- Cement & Mortar Mixers
- Cranes
- Graders
- Off-highway Trucks
- Crushing/Proc. Equipment
- Rough Terrain Forklifts
- Rubber Tire Loaders
- Tractors/Loaders/Backhoes
- Crawler Tractor/Dozers
- Skid Steer Loaders
- Off-Highway Tractors
- Dumpers/Tenders
- Other Construction Equipment

Construction equipment emissions are calculated using surrogate factors, local data, and existing data from the TexN Model. The five steps used to calculate emissions are:

1. Develop surrogate factors to estimate local diesel equipment population, usage rates, and equipment characteristics.
2. Estimate diesel construction equipment population by subsector for each county in the AACOG region
3. Calculate ozone precursor emissions using local data and outputs from the TexN Model.
4. Spatially allocate diesel construction equipment emissions to the 4km photochemical model grids using local data.
5. Revise equipment population for the diesel construction equipment (DCE) TexN Model subsectors using local data.

Raw local input data such as population size and spatial surrogates were provided to TCEQ.

A summary of DCE categories used for calculating diesel construction equipment emissions in the TexN model is provided in the table below. The single non-DCE category, 0 - other non-diesel construction equipment, is used for all other non-road equipment in the TexN Model.

Table 2-1: Diesel Construction Equipment (DCE) TexN Model Subsectors

Numeric Code	TexN Model Subsector Description (Diesel Construction Equipment for 1-24)
0	Other - Non-Diesel Construction Equipment
1	DCE - Agricultural Activities
2	DCE - Boring & Drilling Equipment
3	DCE - Brick & Stone Operations
4	DEC - City & County Road Construction
5	DCE - Commercial Construction
6	DCE - Concrete Operations
7	DCE - County-Owned Construction Equipment
8	DCE – Cranes
9	DCE - Heavy Highway Construction
10	DCE - Landfill Operations
11	DCE – Landscaping Activities
12	DCE – Manufacturing Operations
13	DCE - Municipal-Owned Construction Equipment
14	DCE - Transportation/Sales/Services
15	DCE - Residential Construction
16	DCE - Rough Terrain Forklifts
17	DCE - Scrap/Recycling Operations
18	DCE - Skid Steer Loaders
19	DCE - Special Trades Construction
20	DCE – Trenchers
21	DCE - TxDOT Construction Equipment
22	DCE - Utility Construction
23	DCE - Mining & Quarry Operation
25	DCE - Off-Road Tractors, Miscellaneous Equipment, & All Equipment Under 25 hp

2.1. Development of Construction Equipment Surrogate Factors

When calculating local construction equipment populations in the AACOG region, surrogate factors were used to adjust TexN equipment populations for each county. To determine surrogate factors for the AACOG region, each DCE subsector was calculated separately based on comparisons of industry trends and other data closely related to diesel construction equipment populations. Data sources for the surrogate factors included employment[12], population[13], TxDOT[14], and Census Building permits[15]. Surrogate factors are listed in table 2-2 and the methodology to calculate the surrogates are detailed on the following page.

[12] U.S. Census Bureau. June 30, 2011. "County Business Patterns (CBP)". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 07/12/11.
[13] U.S. Census Bureau, Population Division. "Population Estimates". Available online: http://www.census.gov/popest/counties/. Accessed 07/13/11.
[14] Texas Department of Transportation. "TxDOT Letting Schedule". Finance Division. Austin, Texas. Available online: http://www.dot.state.tx.us/business/schedule.htm. Accessed 07/11/11.
[15] U.S. Census Bureau. "Building Permits". Available online: http://censtats.census.gov/bldg/bldgprmt.shtml. Accessed 07/13/11.

Table 2-2: Diesel Construction Equipment – Surrogate Factors by Subsector, 2006

DCE Subsector	Numeric code	Allocation Method (NAICS)	Data Source	Year
Agricultural Activities	1	Agriculture support employment (11xxxx)	County Business Patterns	2006
Boring and Drilling Equipment	2	Construction employment (23xxxx)	County Business Patterns	2006
Brick and Stone Operations	3	Brick, stone, and related construction employment (423320)	County Business Patterns	2006
City/County Road Construction	4	County population	US Census	2006
Commercial Construction	5	Construction employment (23xxxx)	County Business Patterns	2006
Concrete Operations	6	Block, brick, pipe, and other concrete (327331, 327332, 327390, 327320)	County Business Patterns	2006
County-Owned Equipment	7	County population	US Census	2006
Cranes	8	Construction employment (23xxxx)	County Business Patterns	2006
Heavy Highway Construction	9	TxDOT highway construction lettings	TxDOT	2006
Landscaping Activities	11	Landscaping services employment (541320, 561730)	County Business Patterns	2006
Manufacturing Operations	12	Manufacturing employment (3xxxxx)	County Business Patterns	2006
Municipal-Owned Equipment	13	County population	US Census	2006
Transportation/Sales/Services	14	County population	US Census	2006
Residential Construction	15	Residential building permits (Single and Multiple Families Units)	Census Building permits	2006
Rough Terrain Forklifts	16	Construction employment (23xxxx)	County Business Patterns	2006
Scrap Recycling Operations	17	Recyclable material merchant and recovery employment (562920, 423930)	County Business Patterns	2006
Skid Steer Loaders	18	Construction employment (23xxxx)	County Business Patterns	2006
Special Trades Construction	19	Specialty trade contractors employment (238xxx)	County Business Patterns	2006
Trenchers	20	Construction employment (23xxxx)	County Business Patterns	2006
TxDOT Equipment	21	County population	US Census	2006
Utility Construction	22	County population	US Census	2006
Tractors, Misc., and < 25 hp	25	Construction employment (23xxxx)	County Business Patterns	2006

To calculate surrogate factors for each subsector, the following formula was used.

Equation 2-1, Allocation of construction equipment by subsector for each county

$EA_{AS} = AMA_{AS} / AMD_{S}$

Where,

EA_{AS} = Equipment allocation for construction equipment subsector S in County A

AMA_{AS} = Allocation value for construction equipment subsector S in County A (from local data)

AMD_{S} = Allocation value for construction equipment subsector S in Texas (from state data)

Sample equation - Allocation of heavy highway construction equipment for Bexar County using TxDOT letting for Texas in 2006 ($5,267,487,852) and TxDOT letting for Bexar County in 2006 ($374,730,310):

$EA_{AS} = (\$374,730,310 / \$5,267,487,852)$

$= 0.0711$

Surrogate factors for each county in the AACOG region by DCE subsector are listed in table 2-3.

2.2. Diesel Construction Equipment Population for Each County

State wide population of construction equipment was multiplied by the surrogate factor for each county to create county level population. The following formula was used to allocate subsector construction equipment population to each county.

Equation 2-2, Allocation of each construction equipment type by subsector and county

$POP_{CAS} = TEQ_{CS} \times EA_{AS}$

Where,

POP_{CAS} = Population of construction equipment type C for construction equipment subsector S in County A

TEQ_{CS} = Population of construction equipment type C for construction equipment subsector S in Texas (from TexN Model)

EA_{AS} = Equipment allocation for construction equipment sector S in County A (from equation 2-1)

Sample calculation - Number of rollers used in Bexar County for heavy highway construction:

POP_{CAS} = 2,311 Rollers in Texas x 0.0711

= 164 Rollers in Bexar County

Diesel construction equipment population for each county is summarized by subsector in table 2-4. Majority of the equipment is operated in Bexar County, but Comal and Guadalupe counties also have significant amounts of construction equipment. Other counties, for example Frio, Karnes, and Bandera, do not have large construction equipment populations.

Table 2-3: Diesel Construction Equipment Surrogate Factors by County and DCE Subsector, 2006

DCE Subsector	Numeric code	48013	48019	48029	48091	48163	48171	48187	48255	48259	48265	48325	48493
Agricultural Activities	1	1.24%	0.24%	1.24%	0.00%	0.24%	0.24%	0.11%	1.06%	0.24%	0.24%	0.25%	0.00%
Boring and Drilling Equipment	2	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
Brick and Stone Operations	3	0.50%	0.50%	3.50%	0.76%	0.00%	0.00%	0.50%	0.00%	0.00%	0.50%	0.00%	0.00%
City/County Road Construction	4	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Commercial Construction	5	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
Concrete Operations	6	0.00%	0.00%	8.03%	0.19%	0.00%	0.10%	0.10%	0.10%	0.10%	0.10%	0.19%	0.10%
County-Owned Equipment	7	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Cranes	8	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
Heavy Highway Construction	9	0.24%	0.66%	7.11%	0.36%	0.12%	0.12%	0.38%	0.05%	0.16%	0.35%	0.44%	0.26%
Landscaping Activities	11	0.04%	0.04%	5.48%	1.00%	0.00%	1.00%	1.00%	0.00%	0.00%	0.22%	0.00%	0.00%
Manufacturing Operations	12	0.02%	0.00%	4.24%	0.45%	0.00%	0.07%	0.66%	0.03%	0.13%	0.06%	0.04%	0.04%
Municipal-Owned Equipment	13	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Transportation/Sales/Services	14	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Residential Construction	15	0.04%	0.00%	6.54%	1.54%	0.00%	0.05%	0.75%	0.00%	0.38%	0.00%	0.01%	0.02%
Rough Terrain Forklifts	16	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
Scrap Recycling Operations	17	0.00%	0.00%	3.80%	1.96%	0.00%	0.00%	0.98%	0.00%	0.00%	0.00%	0.19%	0.00%
Skid Steer Loaders	18	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
Special Trades Construction	19	0.06%	0.04%	7.24%	0.65%	0.02%	0.12%	0.41%	0.07%	0.21%	0.28%	0.13%	0.08%
Trenchers	20	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%
TxDOT Equipment	21	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Utility Construction	22	0.18%	0.08%	6.66%	0.46%	0.07%	0.10%	0.49%	0.06%	0.14%	0.20%	0.18%	0.16%
Tractors, Misc., and < 25 hp	25	0.07%	0.04%	8.86%	0.74%	0.01%	0.12%	0.31%	0.01%	0.19%	0.23%	0.08%	0.08%

Does not include Landfill Operations (DCE #10) and Mining and Quarry Operations (DCE #23)

Table 2-4: Diesel Construction Equipment Population Summary by County and DCE Subsector, 2006

DCE Subsector	Numeric Code	48013	48019	48029	48091	48163	48171	48187	48255	48259	48265	48325	48493
Agricultural Activities	1	50	10	50	0	10	10	5	43	10	10	10	0
Boring and Drilling Equipment*	2	1	0	75	6	0	1	3	0	2	2	1	1
Brick and Stone Operations	3	1	0	10	2	0	0	0	0	0	1	0	0
City/County Road Construction	4	8	4	287	20	3	4	21	3	6	8	8	7
Commercial Construction	5	37	20	4,405	369	7	59	156	7	96	112	38	41
Concrete Operations	6	0	0	36	1	0	0	0	0	0	0	1	0
County-Owned Equipment	7	2	1	81	6	1	1	6	1	2	2	2	2
Cranes*	8	4	2	520	44	1	7	18	1	11	13	5	5
Heavy Highway Construction	9	30	82	888	45	15	15	48	6	20	44	55	33
Landscaping Activities	11	4	4	479	87	0	87	87	0	0	19	0	0
Manufacturing Operations	12	0	0	26	3	0	0	4	0	1	1	0	0
Municipal-Owned Equipment	13	12	6	452	31	4	7	33	4	9	13	12	11
Transportation/Sales/Services	14	11	5	418	29	4	6	31	4	9	12	11	10
Residential Construction	15	2	0	394	93	0	3	45	0	23	0	1	1
Rough Terrain Forklifts	16	13	7	1,575	132	2	21	56	2	34	40	14	15
Scrap Recycling Operations	17	0	0	25	13	0	0	6	0	0	0	1	0
Skid Steer Loaders	18	41	22	4,829	404	7	65	171	8	105	123	42	45
Special Trades Construction	19	4	3	492	44	1	8	28	5	14	19	9	6
Trenchers	20	12	6	1,418	119	2	19	50	2	31	36	12	13
TxDOT Equipment	21	7	3	258	18	3	4	19	2	5	8	7	6
Utility Construction	22	22	10	832	58	8	12	61	8	17	24	23	21
Tractors, Misc., and < 25 hp	25	16	9	1,937	162	3	26	69	3	42	49	17	18
Total		279	193	19,488	1,685	71	356	918	98	436	537	268	234

*Note: Boring and Drilling Equipment (DCE #2) and Cranes (DCE #8) subsectors do not include equipment operated at quarries

2.3. Emissions Calculation Methodology for Construction Equipment.

Once population counts for each county were calculated by subsector, emissions were calculated using existing data in the TexN Model. Population counts were multiplies by horsepower, annual hours, load factor, and emission factor for each equipment type and subsector. To calculate NO_X and VOC emission factors, the TexN Model was run for 2006 summer weekday with typical meteorological conditions supplied by the model, all post processing adjustments, and all rules enabled (Table 2-5). The TexN Model run specifications are:

- Analysis Year = 2006
- Max Tech. Year = 2006
- Met Year = Typical Year
- Period = Annual
- Summation Type = Annual
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = Bexar County
- Sources = Diesel Construction Equipment

The following formula was used to calculate emissions.

Equation 2-3, Ozone season day diesel construction equipment emissions by equipment type for each county

$$EM_{CAS} = POP_{CAS} \times HP_{CS} \times HRS_{CS} \times LF_C \times EF_C \text{ / 907,184.74 grams per ton / 365 days/year}$$

Where,

EM_{CAS} = Ozone season day NO_X or VOC emissions from construction equipment type C for construction equipment subsector S in County A

POP_{CAS} = Population of construction equipment type C for construction equipment subsector S in County A (from equation 2-2)

HP_{CS} = Construction equipment type C average horsepower for construction equipment subsector S (from TexN Model)

HRS_{CS} = Construction equipment type C average annual hours for construction equipment subsector S (from TexN Model)

LF_C = Construction equipment type C average load factor (from TexN Model)

EF_C = Construction equipment type C NO_X or VOC emission factor (from TexN Model)

Sample equation - NO_X Emissions from rollers used in Bexar County for heavy highway construction:

EM_{CAS} = 164 Rollers in Bexar County x 104 hp x 387 hours x 0.59 load factor x 4.779 grams of NO_X per hp/hour / 907,184.74 grams per ton / 365 days/year

= 0.056 tons of ozone season day NO_X from heavy highway construction rollers in Bexar County

Table 2-5: Bexar County 2006 Construction Equipment Emission Factors from the TexN Model

Equipment Type	SCC	Load Factor*	VOC EF*	NO_X EF*
Pavers	2270002003	0.59	0.556	5.818
Tampers/Rammers	2270002006	0.43	1.274	7.346
Plate Compactors	2270002009	0.43	1.172	6.519
Rollers	2270002015	0.59	0.547	4.779
Scrapers	2270002018	0.59	0.355	4.374
Paving Equipment	2270002021	0.59	0.562	5.614
Surfacing Equipment	2270002024	0.59	0.504	5.851
Single Boards/Light Plants	2270002027	0.43	1.016	5.681
Trenchers	2270002030	0.59	0.507	4.699
Bore/Drill Rigs	2270002033	0.43	0.643	6.678
Excavators	2270002036	0.59	0.405	5.343
Concrete/Industrial Saws	2270002039	0.59	0.700	5.014
Cement & Mortar Mixers	2270002042	0.43	0.770	6.128
Cranes	2270002045	0.43	0.409	5.303
Graders	2270002048	0.59	0.522	4.973
Off Road Trucks	2270002051	0.59	0.285	4.660
Crushing/Proc. Equipment	2270002054	0.43	0.482	5.568
Rough Terrain Forklifts	2270002057	0.59	0.527	4.788
Rubber Tire Loaders	2270002060	0.59	0.409	4.791
Tractors/Loaders/Backhoes	2270002066	0.21	1.519	5.640
Crawler Tractors/Dozers	2270002069	0.59	0.367	4.014
Skid Steer Loaders	2270002072	0.59	2.261	6.878
Off-Highway Tractors	2270002075	0.21	0.462	5.649
Dumpers/Tenders	2270002078	0.59	2.374	7.051
Other Construction Eq.	2270002081	0.21	0.647	7.597

*All Values are from existing data in the TexN Model for Bexar County

While table 2-6 contains total VOC emissions by subsector and county, NO_X emission results are provided in table 2-7. As shown in figure 3-1, the DCE category with the highest emissions was heavy highway construction followed by rough terrain forklifts and skid steer loaders. The equipment types with the highest NO_X emissions were excavators, skid steer loaders, rough terrain forklifts, and crawler tractors/dozers (figure 3-2). The majority of construction equipment NO_X emissions are emitted in Bexar County: 8.44 tons of NO_X per ozone season day (figure 2-3). Comal, 0.78 tons of NO_X per summer weekday, and Guadalupe, 0.45 tons of NO_X per ozone season day, also had significant NO_X emissions.

Table 2-6: Summer Daily Diesel Construction Equipment VOC Emissions by County and DCE Subsector, 2006

DCESubSector	Numeric Code	48013	48019	48029	48091	48163	48171	48187	48255	48259	48265	48325	48493	Total
Agricultural Activities	1	0.01	0.00	0.01	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.02
Boring and Drilling Equipment	2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Brick and Stone Operations	3	0.00	-	0.00	0.00	-	-	-	-	-	0.00	-	-	0.00
City/County Road Construction	4	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Commercial Construction	5	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Concrete Operations	6	-	-	0.01	0.00	-	0.00	0.00	-	0.00	0.00	0.00	-	0.01
County-Owned Equipment	7	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Cranes	8	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Heavy Highway Construction	9	0.00	0.01	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.14
Landscaping Activities	11	0.00	0.00	0.03	0.01	-	0.01	0.01	-	-	0.00	-	-	0.05
Manufacturing Operations	12	0.00	-	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Municipal-Owned Equipment	13	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Transportation/Sales/Services	14	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Residential Construction	15	0.00	0.00	0.04	0.01	0.00	0.00	0.01	0.00	0.00	-	0.00	0.00	0.06
Rough Terrain Forklifts	16	0.00	0.00	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Scrap Recycling Operations	17	-	-	0.00	0.00	-	-	0.00	-	-	-	0.00	-	0.01
Skid Steer Loaders	18	0.00	0.00	0.37	0.03	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.44
Special Trades Construction	19	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Trenchers	20	0.00	0.00	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
TxDOT Equipment	21	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Utility Construction	22	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Tractors, Misc., and < 25 hp	25	0.00	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Total		0.02	0.02	1.12	0.10	0.01	0.02	0.06	0.01	0.03	0.03	0.02	0.01	1.43

Table 2-7: Summer Daily Diesel Construction Equipment NO_X Emissions by County and DCE Subsector, 2006

DCESubSector	Numeric Code	48013	48019	48029	48091	48163	48171	48187	48255	48259	48265	48325	48493	Total
Agricultural Activities	1	0.05	0.01	0.05	-	0.01	0.01	0.00	0.04	0.01	0.01	0.01	-	0.20
Boring and Drilling Equipment	2	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Brick and Stone Operations	3	0.00	-	0.03	0.01	-	-	-	-	-	0.00	-	-	0.04
City/County Road Construction	4	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Commercial Construction	5	0.00	0.00	0.51	0.04	0.00	0.01	0.02	0.00	0.01	0.01	0.00	0.01	0.62
Concrete Operations	6	-	-	0.07	0.00	-	0.00	0.00	-	0.00	0.00	0.00	-	0.08
County-Owned Equipment	7	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Cranes	8	0.01	0.00	0.82	0.07	0.00	0.01	0.03	0.00	0.02	0.02	0.01	0.01	0.99
Heavy Highway Construction	9	0.04	0.10	1.12	0.06	0.02	0.02	0.06	0.01	0.02	0.05	0.07	0.04	1.62
Landscaping Activities	11	0.00	0.00	0.15	0.03	-	0.03	0.03	-	-	0.01	-	-	0.24
Manufacturing Operations	12	0.00	-	0.04	0.00	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.06
Municipal-Owned Equipment	13	0.01	0.00	0.23	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.01	0.31
Transportation/Sales/Services	14	0.02	0.01	0.62	0.04	0.01	0.01	0.04	0.01	0.01	0.02	0.02	0.02	0.81
Residential Construction	15	0.00	0.00	0.51	0.12	0.00	0.00	0.06	0.00	0.03	-	0.00	0.00	0.73
Rough Terrain Forklifts	16	0.01	0.01	1.10	0.09	0.00	0.01	0.04	0.00	0.02	0.03	0.01	0.01	1.34
Scrap Recycling Operations	17	-	-	0.06	0.03	-	-	0.02	-	-	-	0.00	-	0.11
Skid Steer Loaders	18	0.01	0.00	1.11	0.09	0.00	0.01	0.04	0.00	0.02	0.03	0.01	0.01	1.35
Special Trades Construction	19	0.00	0.00	0.17	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.22
Trenchers	20	0.01	0.00	0.80	0.07	0.00	0.01	0.03	0.00	0.02	0.02	0.01	0.01	0.97
TxDOT Equipment	21	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Utility Construction	22	0.00	0.00	0.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.17
Tractors, Misc., and < 25 hp	25	0.01	0.00	0.72	0.06	0.00	0.01	0.03	0.00	0.02	0.02	0.01	0.01	0.88
Total		0.18	0.15	8.44	0.78	0.05	0.15	0.45	0.07	0.20	0.24	0.17	0.12	11.02

Figure 2-1: Construction Equipment Emissions by DCE Subsector, Tons per Ozone Season Day, 2006

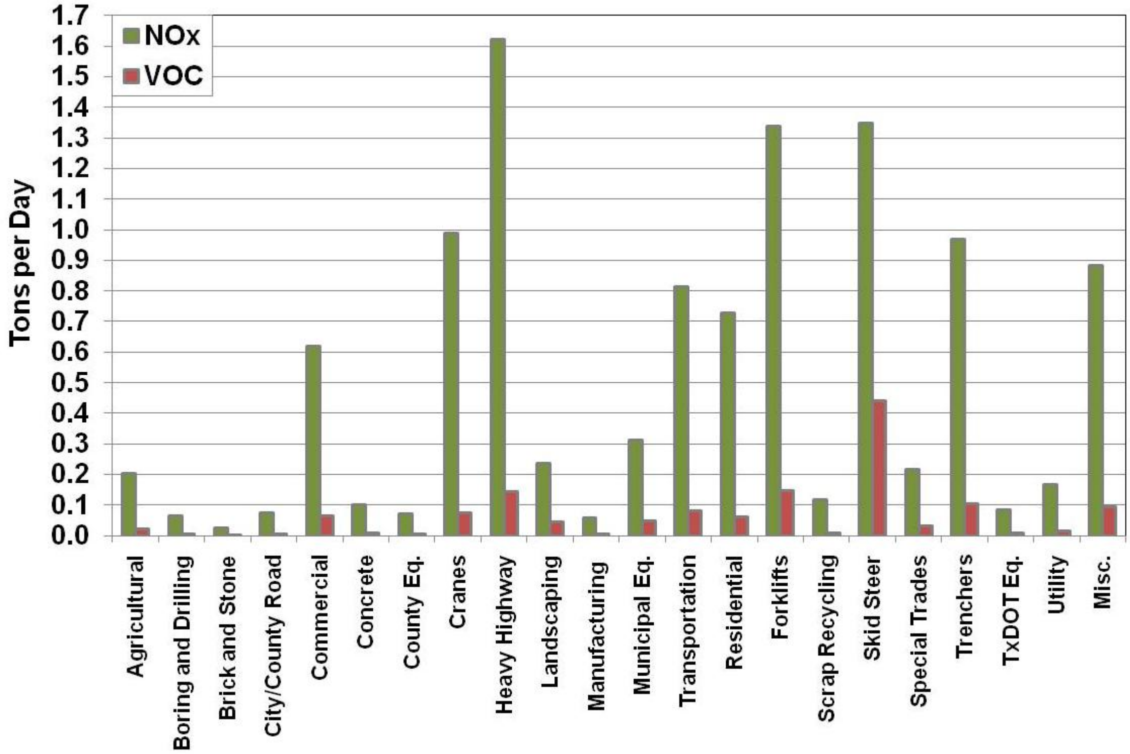


Figure 2-2: Construction Equipment Emissions by Equipment Type, Tons per Ozone Season Day, 2006

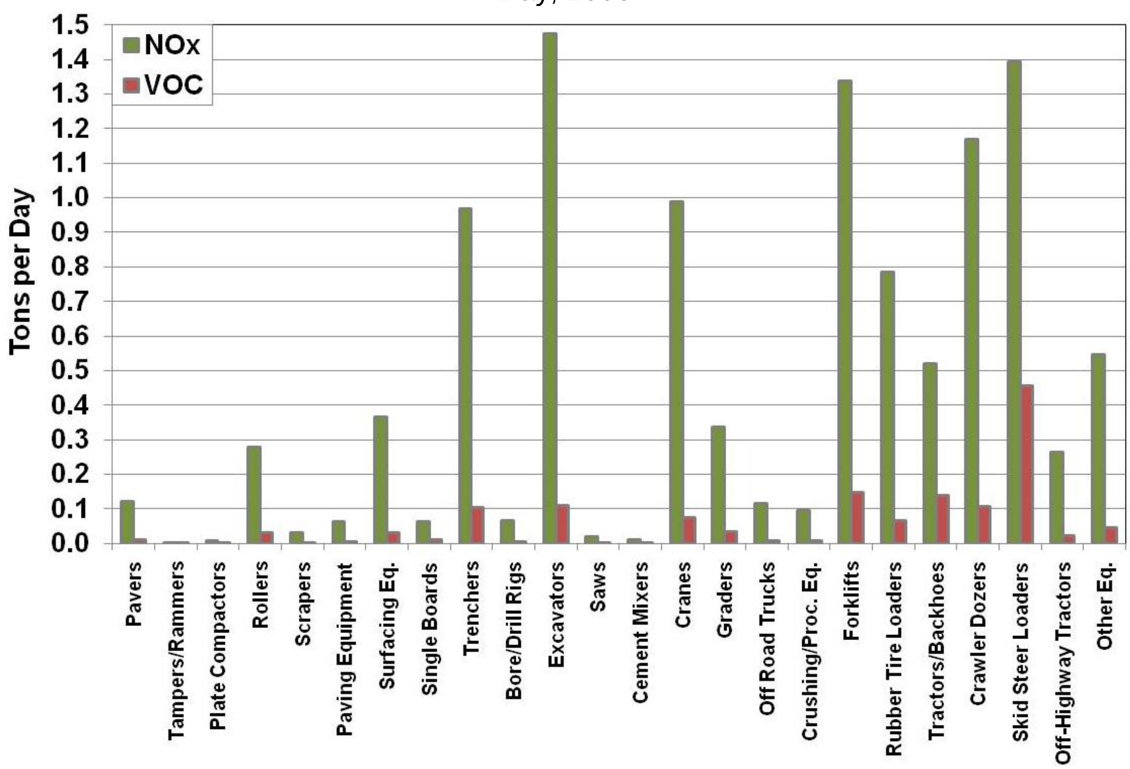
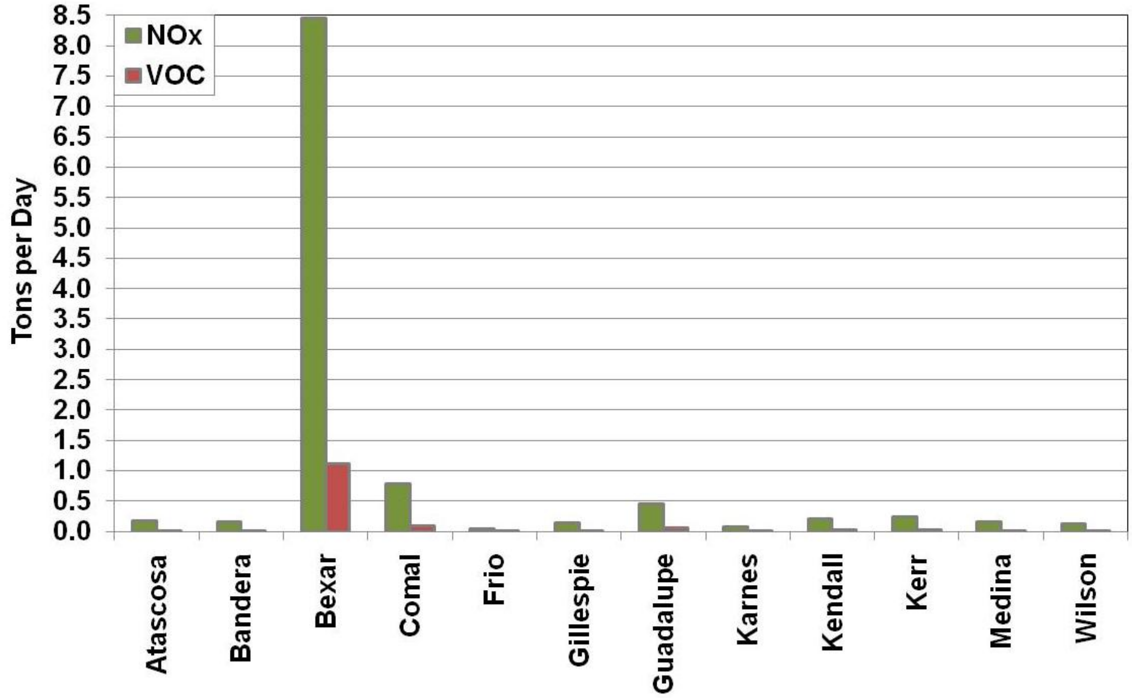


Figure 2-3: Construction Equipment Emissions by County, Tons per Ozone Season Day, 2006



2.4. Spatial Allocation of Construction Equipment Emissions

To allocate construction equipment emissions accurately in the photochemical model, emissions were spatially allocated by subsector based on type and purpose of equipment used. Local departments of transportation, utility companies, government agencies, and private companies were contacted to collect data on size and location of construction projects. Residential building permits, commercial building permits, and demolition permits were also collected to geo-code construction emissions. Diesel construction equipment emissions were allocated to the 4km grid using the spatial surrogates listed in table 2-8.

Previous studies have found that when the updated spatial construction equipment is put into the photochemical model, there was a significant impact on ozone formation. In a previous study using the September 1999 photochemical model, the impacts on the San Antonio ozone monitors were between a maximum increase of 0.44 ppb and a maximum decrease of 0.16 ppb for the peak 8-hour ozone average.[16]

[16] Steven Smeltzer, June, 2008. "Improving Spatial Allocation of Construction Equipment Emissions". Paper presented at EPA's 17th Annual International Emission Inventory Conference: Inventory Evolution - Portal to Improved Air Quality in Portland, Oregon - June 2 - 5, 2008. Available online: http://www.epa.gov/ttnchie1/conference/ei17/session11/smeltzer.pdf. Accessed 12/16/11.

Table 2-8: Spatial Allocation Surrogates for Construction Equipment

DCE Subsector	Numeric Code	Spatial Allocation Methodology	
		Bexar	Surrounding Counties
Agricultural Activities	1	Crop Acres (Corn, Peanuts, Wheat, Sorghum, Cotton, Oats)	Crop Acres (Corn, Peanuts, Wheat, Sorghum, Cotton, Oats)
Boring and Drilling Equipment	2	EPA Default and Quarry Locations	EPA Default and Quarry Locations
Brick and Stone Operations	3	Brick, stone, and related construction employment	Brick, stone, and related construction employment
City/County Road Construction	4	COSA and Bexar County Road Dollar Value	EPA Default
Commercial Construction	5	COSA/Bexar County Building and Demolition Permits	EPA Default
Concrete Operations	6	Block, brick, pipe, and other concrete manufacturing	Block, brick, pipe, and other concrete manufacturing
County-Owned Equipment	7	Bexar County Road Dollar Value	EPA Default
Cranes	8	EPA Default and Quarry Locations	EPA Default and Quarry Locations
Heavy Highway Construction	9	TxDOT and MPO highway construction dollar value	TxDOT highway construction dollar value
Landscaping Activities	11	EPA Default	EPA Default
Manufacturing Operations	12	Manufacturing Employees (only companies > 9 employees)	Manufacturing Employees (only companies > 9 employees)
Municipal-Owned Equipment	13	COSA Road Dollar Value	EPA Default
Transportation/Sales/Services	14	EPA Default	EPA Default
Residential Construction	15	COSA and Bexar County Residential Building Permits	EPA Default
Rough Terrain Forklifts	16	EPA Default	EPA Default
Scrap Recycling Operations	17	Scrap and Waste Materials Employment	Scrap and Waste Materials Employment
Skid Steer Loaders	18	EPA Default	EPA Default
Special Trades Construction	19	EPA Default	EPA Default
Trenchers	20	EPA Default	EPA Default
TxDOT Equipment	21	TxDOT Construction Dollar Value	TxDOT Construction Dollar Value
Utility Construction	22	CPS, Bexar Met, and SAWS Construction Dollar Value	EPA Default
Tractors, Misc., and < 25 hp	25	EPA Default	EPA Default

Construction equipment emissions from brick and stone, concrete, and scrap recycling operations were spatial allocated by employment in each sector, while construction equipment used for manufacturing was allocated to manufacturing facilities with more than 9 employees.[17] Emissions from heavy highway construction and TxDOT equipment subsectors where geo-coded based on dollar amounts for TxDOT[18] and MPO[19] highway projects let between Jan – Aug. 2010. Similarly, city/county road construction, county-owned equipment, and municipal-owned equipment were geo-coded based on 2010 road projects let by Bexar County[20] and City of San Antonio (COSA)[21]. Construction equipment emissions from agricultural activities were allocated to crops acreage in the AACOG region.[22]

Commercial building permits over $30,000 from COSA, Bexar county, and other small cities were used to geo-code commercial construction emissions, while residential permits over $30,000 where used to geo-code residential construction emissions. Commercial and residential construction emissions were also spatial allocated by the location of demolition permits. Utility construction emissions were allocated to the locations of San Antonio Water System (SAWS), CPS Energy, and BexarMet[23] projects over $50,000. Other DCE categories, including landscaping activities, transportation/sales/services, rough terrain forklifts, skid steer loaders, special trades, and trenchers, were spatial allocated based on EPA default methodology using urban area locations from TxDOT GIS files provided by Texas Natural Resources Information System[24].

Locations of the spatial surrogates are shown in the figures 2-4 to 2-13 for each DCE subsector. While Figure 2-14 shows the default EPA spatial allocation of construction equipment emissions, Figure 2-15 shows the updated allocation of construction equipment emissions. These maps also include construction equipment emissions used at quarries and landfills but does not include San Miguel lignite mine in Atascosa County. Construction equipment at the lignite mine was not surveyed and emissions were not calculated.

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[17] InfoUSA, 2010 “Database for Business”. Available online: http://lp.infousa.com/mex_google/mailing-lists-311VE-4484XQ.html. Accessed 12/16/11.

[18] TxDOT, November, 2010. “FY 2011 Statewide Projects by TxDOT District”. Available online: http://www.dot.state.tx.us/business/schedule.htm. Accessed 07/18/11.

[19] San Antonio-Bexar County Metropolitan Planning Organization, December 22, 2010. “San Antonio-Bexar County Metropolitan Area Transportation Improvement Program: Bicycle, Pedestrian, Rideshare and Roadway Projects Let in Year 2010”. San Antonio, Texas. Available online: http://www.sametroplan.org/Plans/TIP/Completed%20Projects%202010.pdf. Accessed 07/18/11.

[20] Bexar County, March 2011. "Road and Bridge Capital Projects”. San Antonio, Texas. Available online: http://inf.bexar.org/infraCitizen.asp?Sect=_CIP. Accessed 03/23/11.

[21] City of San Antonio. “Capital Improvement Plans”. San Antonio, Texas. Available online: http://www.sanantonio.gov/budget/documents/Annual%20Budgets/FY%202010%20Adopted%20Budget/FY%202010%20Adopted%20Document%20-%20Capital%20Budget.pdf. Accessed 07/18/11.

[22] National Agricultural Statistics Service. “CropScape – Cropland Data Layer”. United States Department of Agriculture. Available online: http://nassgeodata.gmu.edu/CropScape/. Accessed 06/06/2011.

[23] Bexar Metropolitan Water District, January 26, 2011. “Fiscal Year 2010-2011 (May 1, 2010 - April 30, 2011) Capital Improvement Program Report”. San Antonio, Texas. Available online http://www.bexarmet.org/Portals/0/Documents/CIP/2011/CIAC_Semi-Annual_Report_02-09-11.pdf. Accessed 07/18/11.

[24] Texas Natural Resources Information System (TNRIS), 2003. “TxDOT Urban Files”. Available online: http://www.tnris.org/get-data?quicktabs_2=1#boundary. Accessed 11/30/11.

Figure 2-4: Brick, Stone, and Related Construction Employment (DCE #3)

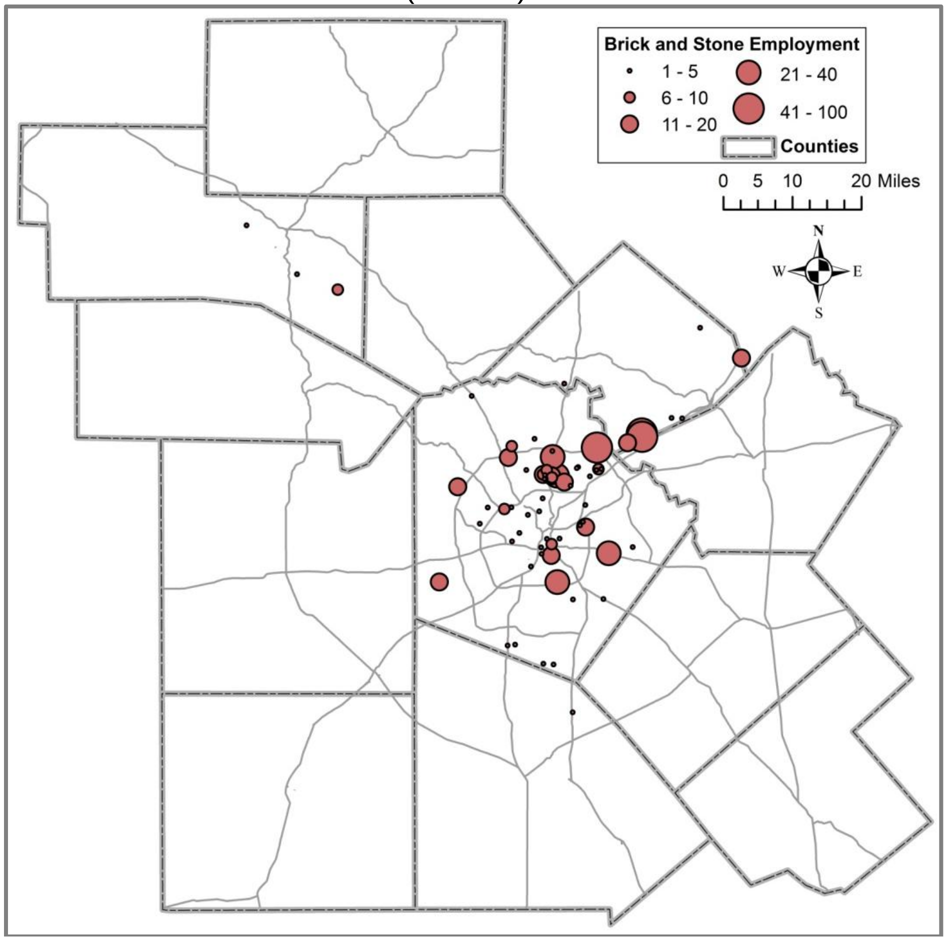


Figure 2-5: Block, Brick, Pipe, and Other Concrete Manufacturing (DCE #6)

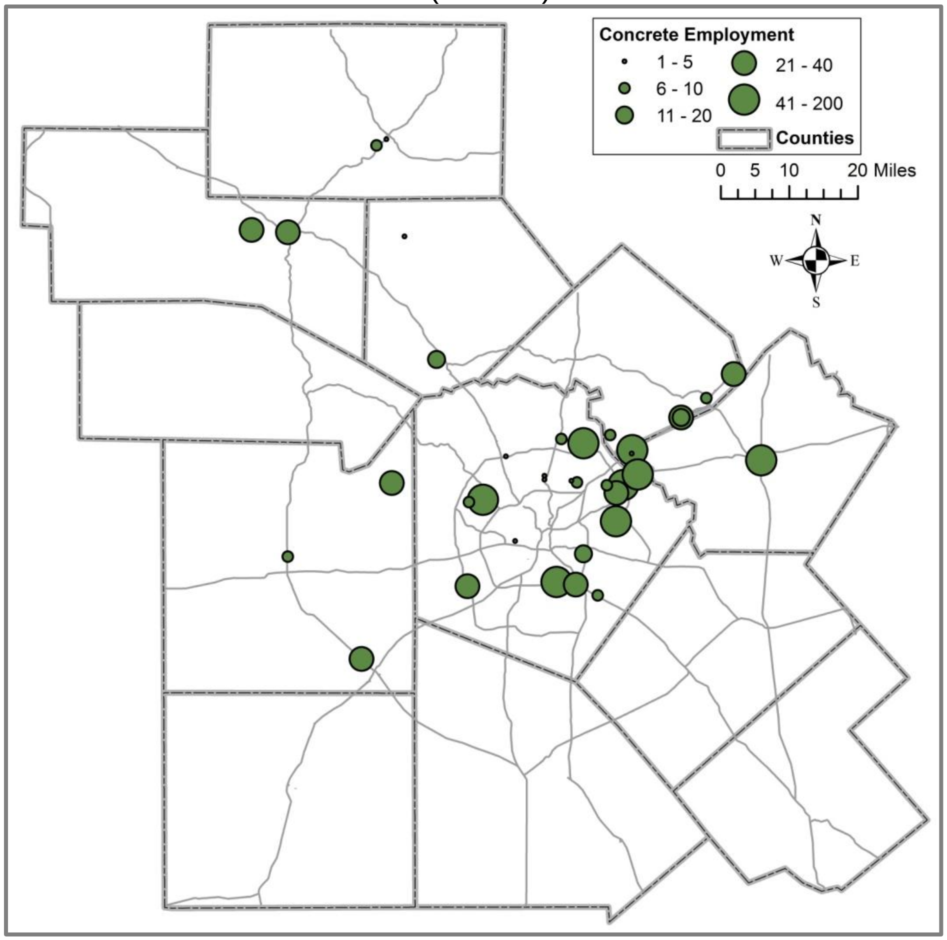


Figure 2-6: Heavy Highway Construction Projects (DCE #9)

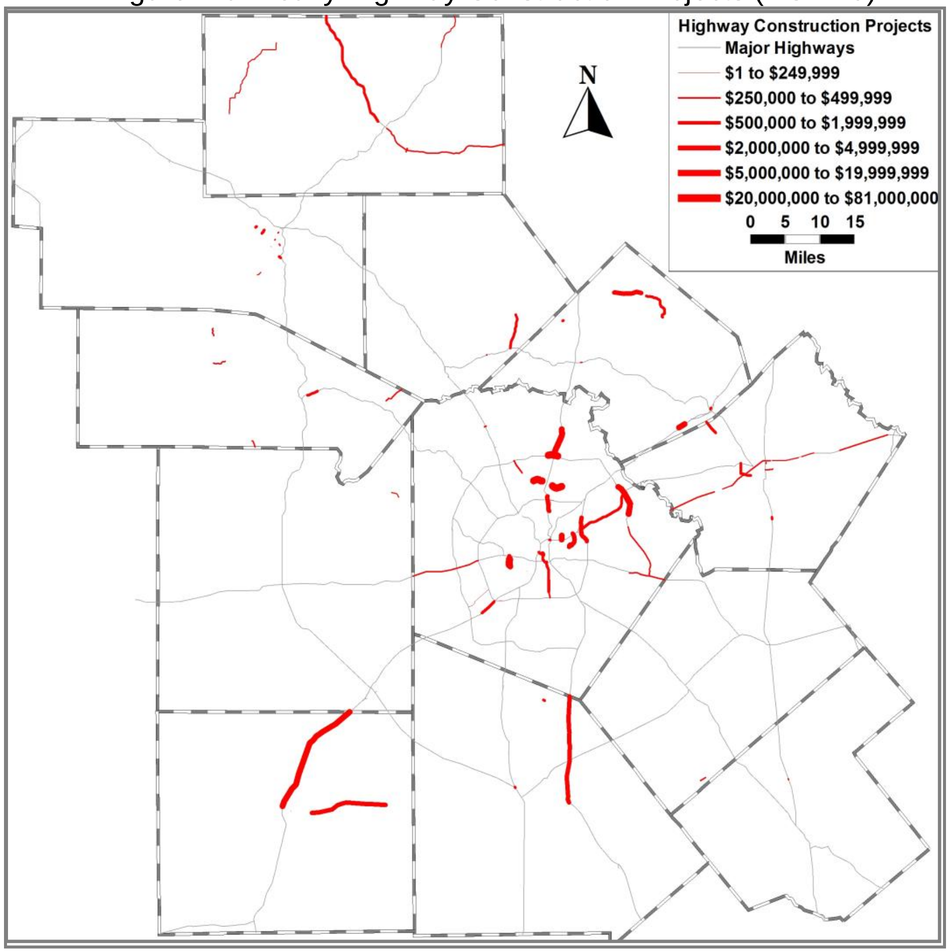


Figure 2-7: Manufacturing Employment (DCE #12)

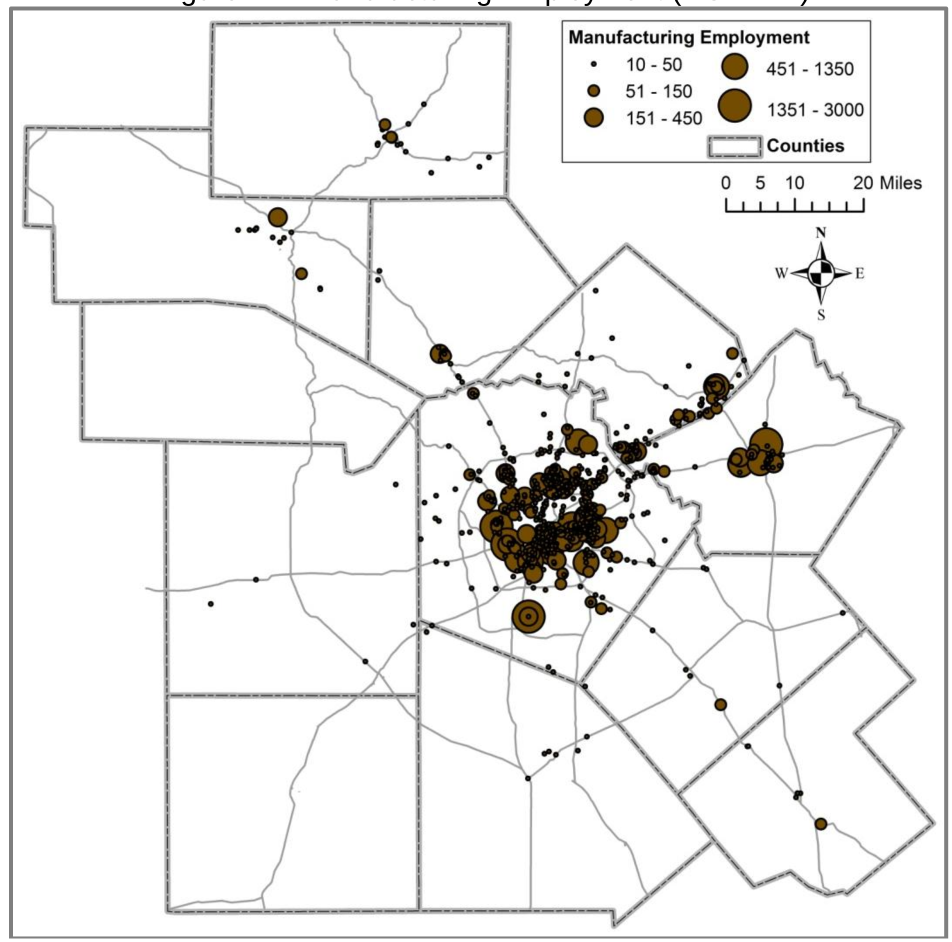


Figure 2-8: Scrap and Waste Materials Employment (DCE #17)

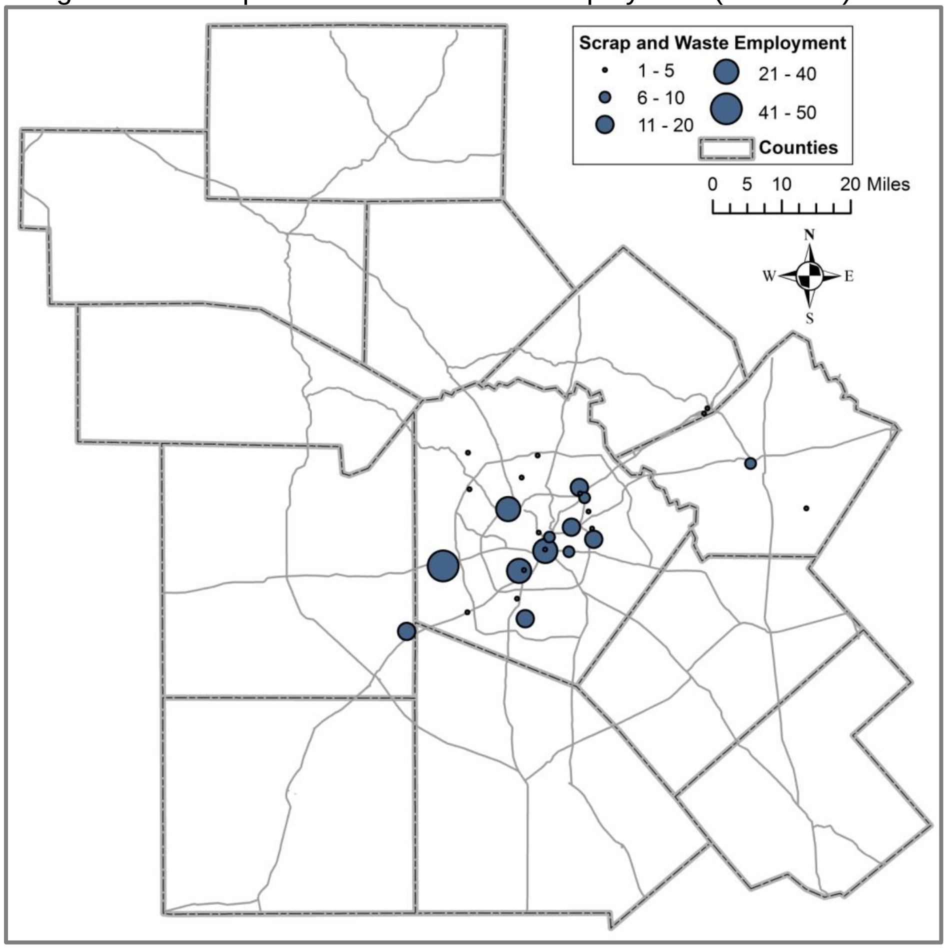


Figure 2-9: TxDOT Construction Dollar Value (DCE #21)

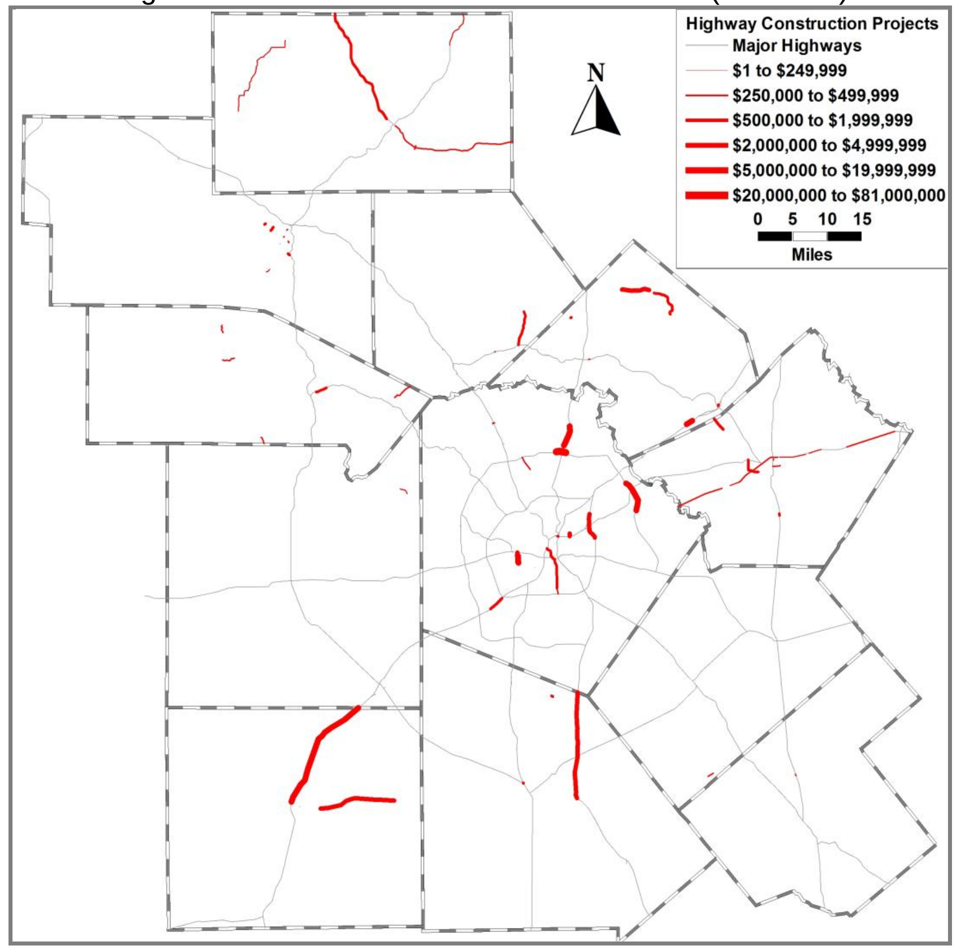


Figure 2-10: City of San Antonio and Bexar County Road Construction (DCE #4)

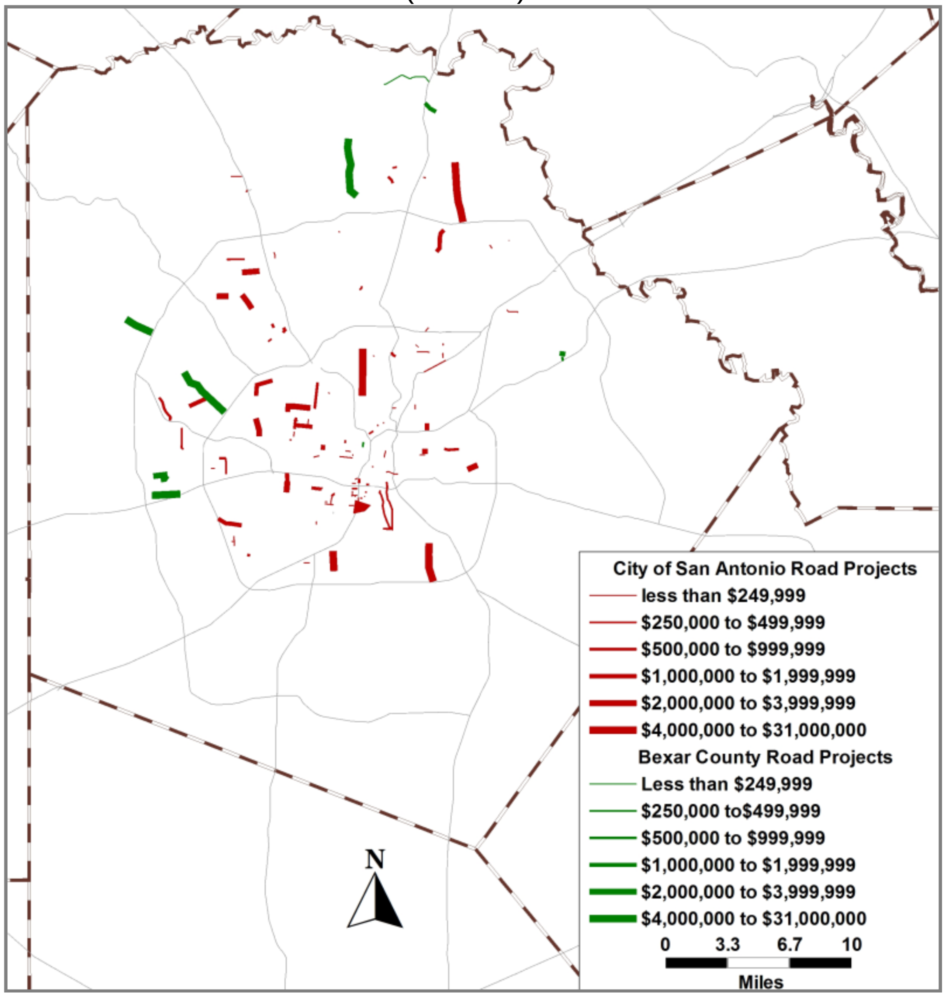


Figure 2-11: Commercial Building Permits (DCE #5)

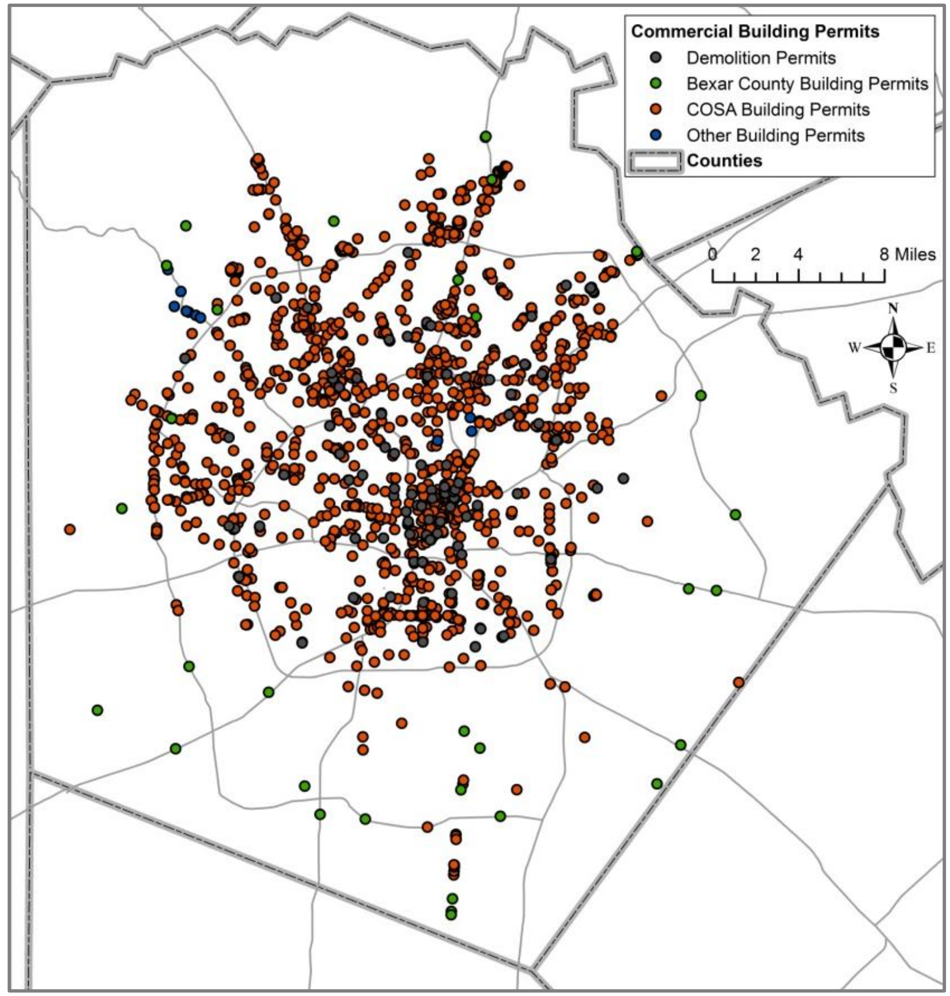


Figure 2-12: Residential Building Permits (DCE #15)

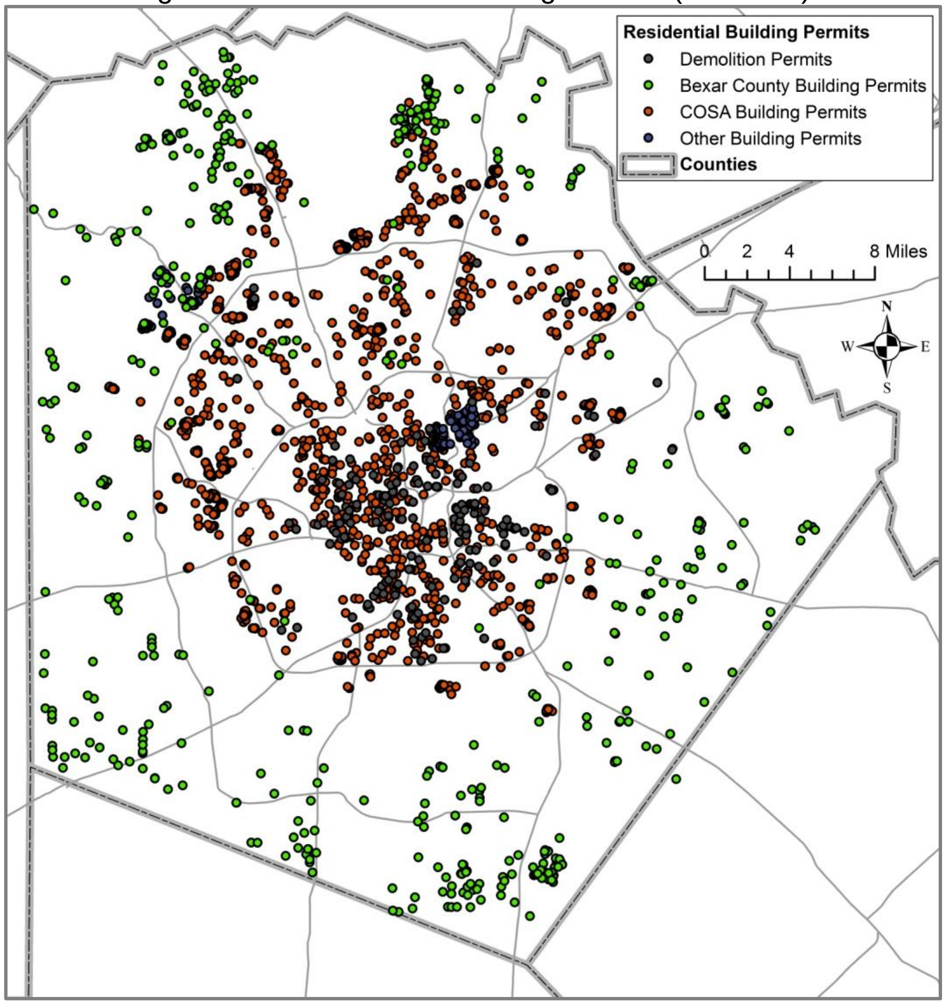


Figure 2-13: Utility Construction Project (DCE #22)

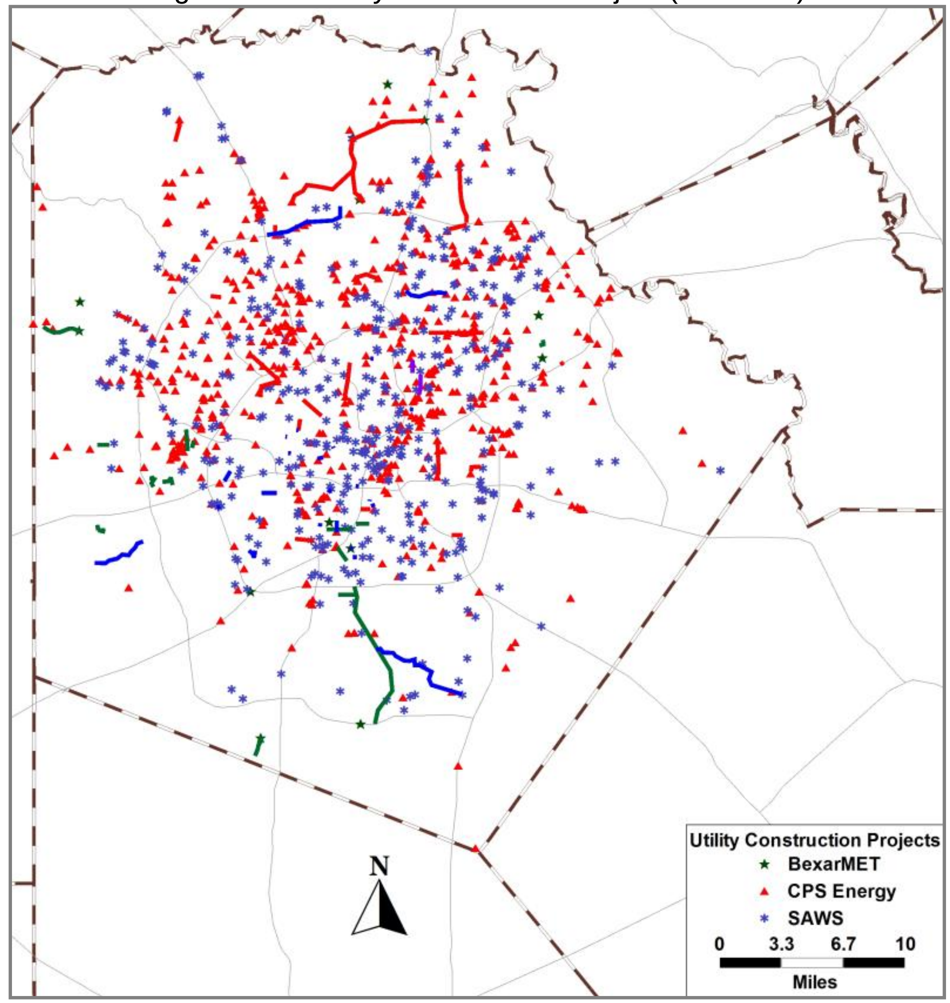


Figure 2-14: Default Construction Equipment Emissions Spatial Allocation (tons of NO_X/day), 2006

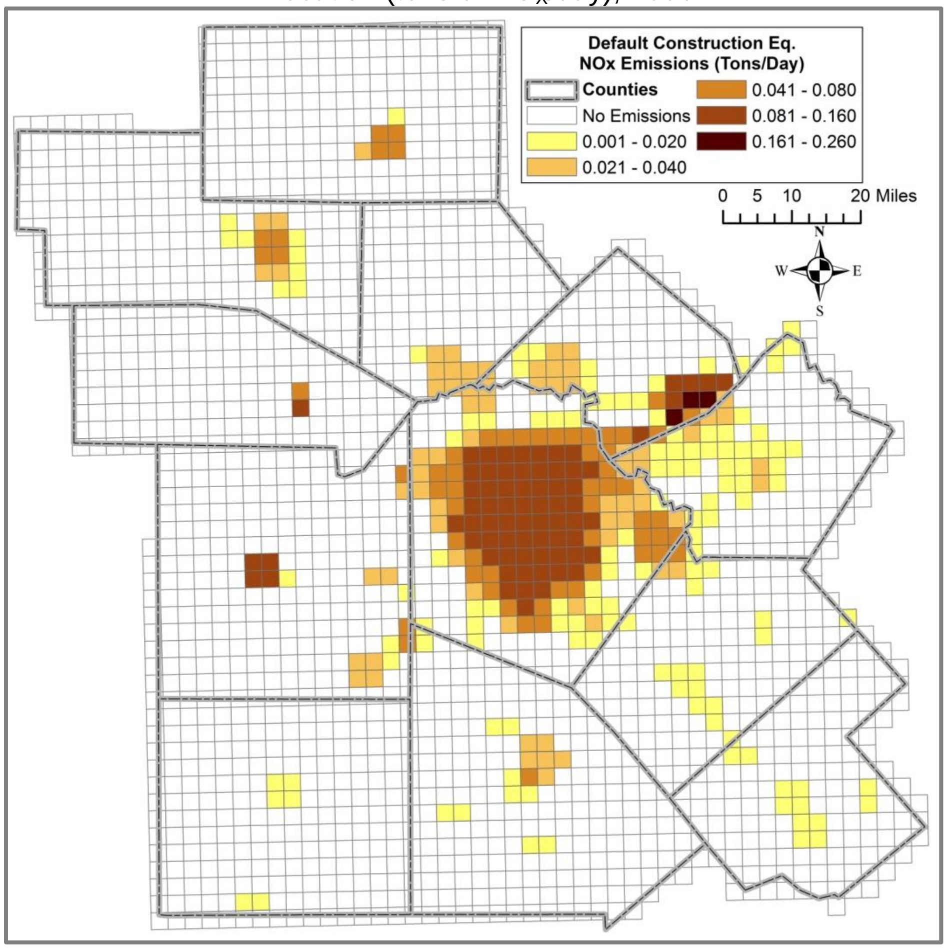
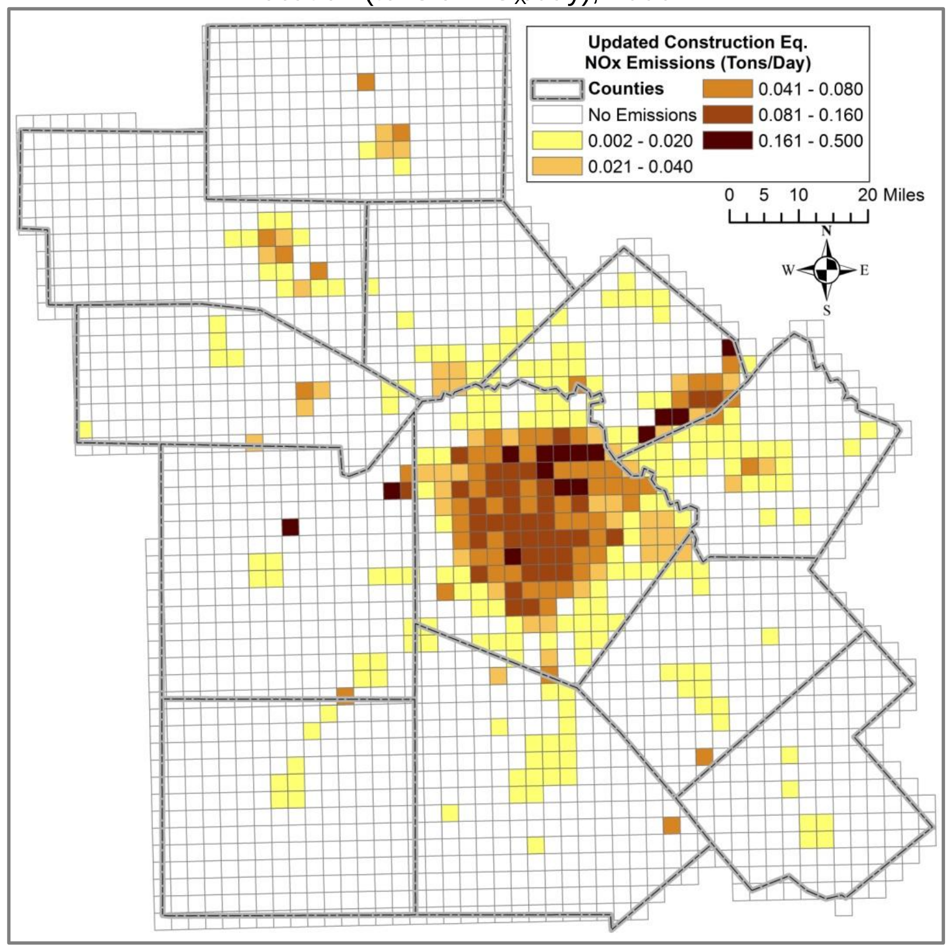


Figure 2-15: Updated Construction Equipment Emissions Spatial Allocation (tons of NO_X/day), 2006



As shown in figure 2-16 and 2-17, there is an increase in NO_X emissions along the northern section of Loop 1604 in Bexar County, and quarry sites in Comal and Medina counties. There is an increase in emissions at other quarry sites in the AACOG region and in south western Bexar County. There was a significant decrease in emissions in southern and near west parts of San Antonio because there is a decrease in new construction activities in these parts of the city. There was a decrease in emissions in rural towns because emissions were spatially allocated to quarry and landfill sites instead.

To improve future construction equipment emissions estimations, emission surrogate factors for construction equipment population can be averaged over multiple years. Also, spatial surrogates can be average over multiple years including residential building permits, commercial building permits, utility projects, heavy highway projects, and county and city road projects.

Figure 2-16: Difference in Construction Equipment Emissions between Default and Updated Spatial Allocation (tons of NO_X/day), 2006

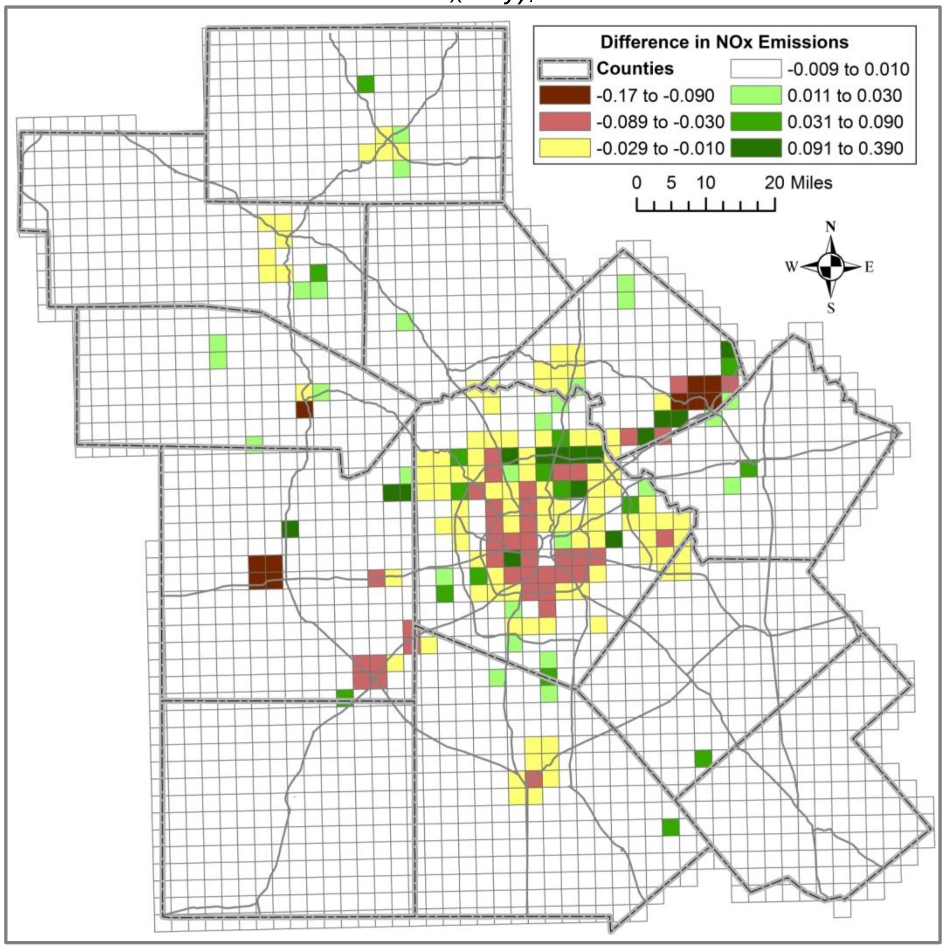
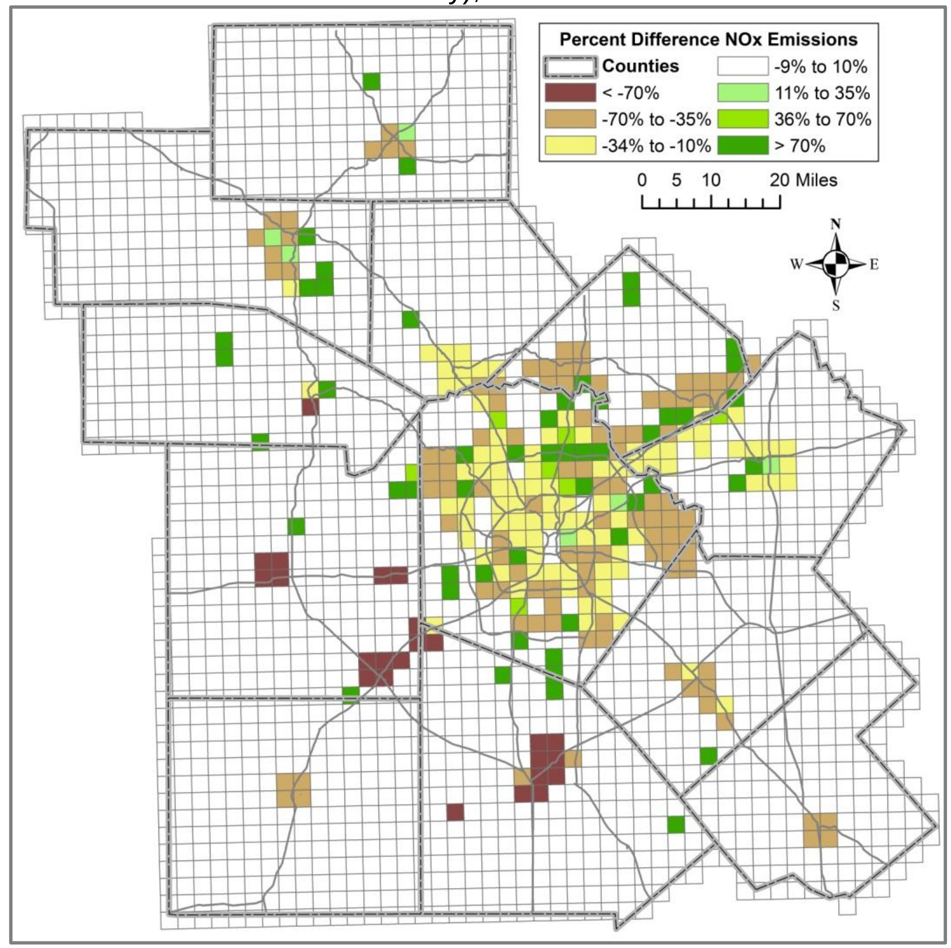


Figure 2-17: Percent Difference in Construction Equipment Emissions between Default and Updated Spatial Allocation (NO_X Emissions > 0.01 tons/day), 2006



3. QUARRY EQUIPMENT

Due to the abundance of rich limestone, aggregate, granite, sand, and gravel deposits, there are numerous quarries in the AACOG Region. Large diesel non-road equipment is used to extract and haul deposits from the quarries. Emissions were calculated for the following diesel quarry equipment:

- Rollers
- Scrapers
- Bore/Drill Rigs
- Excavators
- Cranes
- Graders
- Rock Trucks
- Water Trucks
- Vacuum Trucks
- Rock Crushers
- Rock Separators
- Loaders
- Backhoes
- Dozers
- Aerial Lifts
- Pumps

Local survey data was collected to improve the accuracy of the quarry equipment emissions inventory. The following steps were used to calculate quarry equipment emissions:

1. Perform a survey of local quarry equipment to determine equipment population, usage rates, and characteristics.
2. Identify and count quarry equipment using available aerial imagery of quarries that did not respond to the first survey.
3. Performed a second survey with estimations of local quarry equipment activity at each quarry that did not respond to the first survey. Quarries were asked to make corrections and send back the survey.
4. Perform a focused third survey by phone and e-mail to large quarries that did not respond to the first two surveys.
5. Determining equipment population for quarry sites without local data.
6. Calculate ozone precursor emissions using survey responses and TexN Model data.
7. Calculate weekly adjustment factor for diesel quarry equipment.
8. Allocated diesel quarry equipment emissions to the 4km photochemical model grid system.
9. Provide updated data to TCEQ in electronic format that can be readily included in TexN Model. Raw local input data such as local activity profiles and spatial surrogates will be provided to TCEQ for ease of incorporation in the TexN Model by DCE subsector.

3.1. Conduct a Survey of Local Quarry Equipment Activity

Data on quarry equipment was collected using a “bottom-up” methodology to refine equipment populations, equipment horsepower, activity profiles, and spatial allocations of emissions. A survey questionnaire was sent to local quarries to collect data on:

1. Equipment Population
2. Activity Rates – total annual hours of use by type of equipment
3. Temporal Profiles – equipment use on weekdays and weekend days
4. Engine Characteristics

The following survey questionnaire was used to collect data from quarries in the San Antonio Region.

July 2, 2012

«Company_Name»
«Mine_Name»
«Address»
«Zip»

ATTENTION: OPERATIONS MANAGER

Re: Air Quality Emissions Inventory

The Alamo Area Council of Governments (AACOG) requests your assistance in completing the air quality emissions inventory for San Antonio and the surrounding counties. This inventory is especially significant because the San Antonio region currently risks being declared in non-attainment of federal air quality standards (NAAQS). The purpose of this survey is to provide services to the region. Your response is vital to this process and will serve to produce a true and correct inventory of quarry equipment in the San Antonio region.

AACOG has estimated equipment populations, hour usage, and horsepower quarry equipment based on local data. To greatly increase the accuracy of this information we ask that you review the attached estimates for your quarry, make any additions or corrections necessary, and return it to AACOG in the self-addressed envelope. Please submit your response by September 30th, 2011.

Thank you for your time and participation. If you have any questions or comments please feel free to contact Steven Smeltzer, Environmental Manager at (210) 362-5266.

Regionally yours,

Dean R. Danos
Interim Executive Director
Alamo Area Council of Governments
8700 Tesoro Drive, Suite 700
San Antonio, Texas 78217

Alamo Area Council of Governments (AACOG)
Quarry Equipment Survey

AACOG is conducting a study to assess and quantify air quality within the San Antonio region and surrounding counties by performing an emission inventory. The purpose of this survey is to gather data on diesel quarry equipment in the region.

By filling out this survey, you will be providing valuable data. Thank you for taking the time to provide this information.

Instructions:

1. Please look through the equipment types shown on the following page.
2. List any of the equipment types regularly operated at your business.
3. Fill in the appropriate figures for each equipment type you listed. (Estimates are acceptable)

If you have other quarry equipment that is not shown, please include it as well.

NOTE: If your business has more equipment than will fit in the space provided, please make additional copies of the survey.

Completed surveys can be faxed to (210) 225-5937, or mailed to:
Alamo Area Council of Governments
8700 Tesoro, Suite 700
San Antonio, Texas 78217
Attn: Steven Smeltzer

If you have any questions or comments, please contact us at (210) 362-5266.

THE SURVEY IS CONTAINED ON THE NEXT PAGE

Quarry Survey

Equipment Type	**Fuel Type** Diesel Electricity	Approximate Horse-power Rating (each)	Number of Units	Average Daily Hours for each unit (Mon-Fri)	Average Daily Hours for each unit (Sat-Sun)
Scrapers					
Bore/Drill Rigs					
Excavators					
Cranes					
Graders					
Rock Trucks					
Loaders					
Backhoes					
Dozers					
Lifts					
Rollers					
Water Trucks					
Rock Separators					
Rock Crushers					
Other Large Equipment (specify type)					

There are 77 quarries in the AACOG region; however there are a number of small quarries operated only a few hours during the year. Through the survey process, it was determined that two quarries did not use heavy construction equipment and another quarry ceased operations. There are 53 operating quarries in the region that are large enough to use heavy construction equipment on regular bases.

- Atascosa - 4 quarries
- Bandera - 1 quarry
- Bexar - 22 quarries
- Comal - 10 quarries
- Gillespie - 1 quarry
- Guadalupe - 2 quarries
- Kendall - 1 quarry
- Kerr - 5 quarries
- Medina - 7 quarries

Quarries have many different types of operations on site including asphalt plants, cement kilns, and/or rock crushing facilities. One quarry also operates a landfill at the same site: Nido Incorporated's Schertz Gravel Plant. At this site, emissions from equipment that can be used for both quarry operations and landfill operations were split equally between the landfill and quarry emission inventories.

3.2. Analysis of Aerial Photography

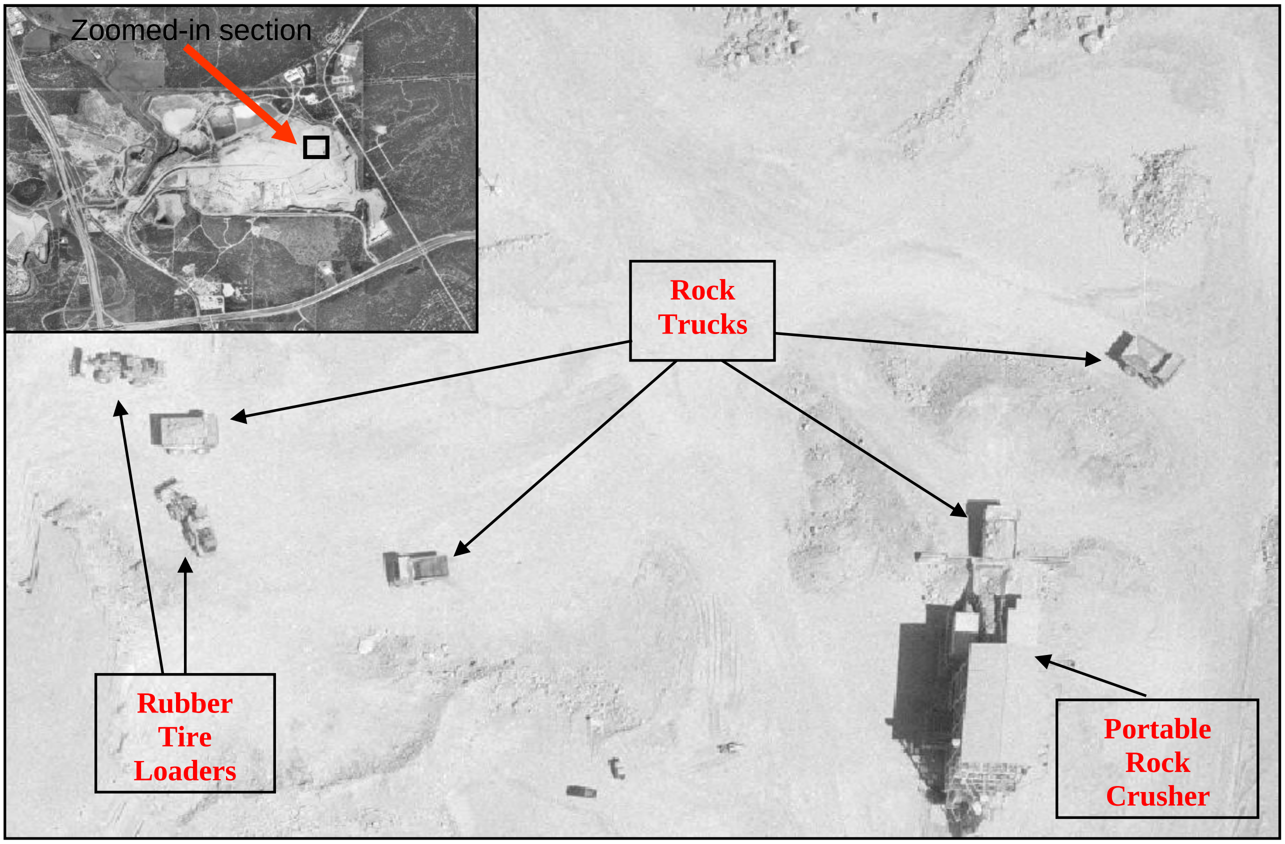
Aerial photographs were studied to provide data on quarries that did not respond to the survey and to confirm the accuracy of data presented in the returned questionnaires. The equipment for each quarry was identified, marked, and counted on the aerial photography. For example, the aerial photography of one of the quarries in Bexar County shows that there were 3 scrapers, 8 excavators, 1 grader, 11 off-highway rock trucks, 18 rubber tire loaders, and 3 tractors/ backhoes working at the quarry. Figure 3-1 shows an example of an aerial photo for a local quarry, which was used to identify specific equipment. In this aerial photograph, 4 rock trucks and 2 rubber-tire loaders active in quarry could be identified.

When comparing survey data with quarries that had only aerial imagery, equipment population was very similar: 3.12 per 10,000 operating hours from survey data and 4.17 per 10,000 operating hours from aerial imagery. The population of water trucks and dozers were lower at quarries with only aerial imagery. However, quarries with only aerial imagery had more scrappers, bore drill rigs, excavators, and cranes.

3.3. Conduct a Second Survey of Local Quarry Equipment Activity

After analyzing aerial photographs and estimating equipment populations, a second survey was sent to local quarries that did not respond to the first survey. These surveys included estimations of equipment population, HP, and activity hours. This survey used the same format as the initial survey and companies were asked to correct the data and to send the surveys back to AACOG.

Figure 3-1: Aerial Photography of a Quarry Showing Rock Trucks and Front-End Loaders



3.4. Conduct a Third Survey of Local Quarry Equipment Activity

After the first two surveys were conducted, some of the large quarries in the region had not responded. A focused third survey was conducted through telephone calls and e-mail to improve survey response rate at large quarries. The three surveys and the aerial imagery provided a detailed count of equipment from quarries in the AACOG region.

In order to make a general conclusion about the targeted population, the number of returned surveys required for an accurate representation is an important concern. Since determining a suitable sample size is not always clear-cut, several major factors must be considered. Due to time and budget constraints, a 95% level of confidence, which is the risk of error the researcher is willing to accept, was chosen. Similarly, the confidence interval, which determines the level of sampling accuracy, was set at +/- 10%. Since the population is finite, the following equation was used to select the sample size.[25]

Equation 3-1, Sampling Size for Quarries

$$RN = [CLV^2 \times 0.25 \times POP] / [CLV^2 \times 0.25 + (POP - 1) CIN^2]$$

Where,

RN = Number of survey responses needed to accurately represent the population
CLV = 95% confidence level (1.96)
POP = Population size (53 quarries)

[25] Rea, L. M. and Parker, R. A., 1992. "Designing and Conducting Survey Research". Jossey-Bass Publishers: San Francisco.

CIN = ± 10% confidence interval (0.1)

For a 10% confidence interval:

$$RN = [(1.96)^2 \times (0.25) \times 53] / [(1.96)^2 \times (0.25) + (53 - 1) \times (0.1)^2]$$
$$= 34.4 \text{ quarries}$$

Thus, local data is needed at 35 quarries in order to meet the 95% level of confidence, and the ±10% confidence interval for equipment population. As shown in table 3-1, 19 quarries responded to the three surveys. Also, previous survey data from 2003 was used for 3 quarries that did not respond to the latest surveys. Aerial imagery was available on additional 22 quarries for a total of 45 quarries with local equipment population counts.

Table 3-1: Survey Response Rate for Quarries

Survey	Number		Employment		Operating Hours	
	n	Percent	n	Percent	n	Percent
First Survey	7	13%	109	15%	244,733	16%
Second Survey	9	17%	224	30%	493,329	32%
Third Survey	3	6%	27	4%	52,718	3%
Quarries no longer operating	1	2%	-	0%	-	0%
Quarries 2003 Survey Data	3	6%	25	3%	54,825	4%
Quarries with Aerial Imagery	22	42%	284	39%	561,693	37%
Quarries with no Local Data	8	15%	67	9%	125,332	8%
Total	53	100%	736	100%	1,532,631	100%

There were 8 quarries that did not have local survey data or aerial imagery, however they only account for 9% of quarry employment in the AACOG region and only 8% of quarry operating hours. Some of the smaller quarries were difficult to survey because they did not have published mailing addresses, phone numbers, or e-mail addresses.

Table 3-2 show that scrapers, bore/drill rigs, and graders operate significant more hours at quarries then what is reported in the TexN Model, while annual operating hours were lower for backhoes. Several equipment types operating at quarries are not included in DCE subsector #23 for Mining and quarries including rollers, rock processing equipment, aerial lifts, and dewatering pumps.

Most quarries have a rock crusher and/or a rock separator located on site, but most rock processing equipment is electric. However, there are several diesel power rock crushers and separators operating at quarries in rural areas. Rock crushers are also considered ‘temporary’ because they might move from quarry to quarry every few years. Most of the rock processing equipment identified through the survey was powered by electric engines. Only two diesel powered rock crushers and one diesel rock separators were recorded, however TCEQ permit database identified 13 more diesel powered rock processing equipment at quarries that did not respond to the survey. The permit database usually had engine type, horsepower, and maximum activity rates for the rock processing equipment. The point source emission inventory was also checked to make sure emissions from rock processing equipment was not double counted.

Table 3-2: Estimated Hours by Equipment Type for Quarries from Previous Studies

Equipment Type	SCC	NONROAD 2008a Model	TexN Model #23 Mining & Quarry	ERG's 2005 Dallas Study[26]	ERG's 2009 Texas Study[27]	AACOG 2005	AACOG 2011
Rollers	2270002015	760	-	-	20	-	2,088
Scrapers	2270002018	914	957	-	957	2,208	1,813
Bore/Drill Rigs	2270002033	466	466	-	-	466	1,715
Excavators	2270002036	1,092	1,593	1,600	1,593	1,092	1,626
Cranes	2270002045	990	990	-	-	990	1,017
Graders	2270002048	962	422	500	422	1.135	762
Rock Trucks	2270002051	1,641	1,551	2,333	1,551	2,051	2,288
Water Trucks	2270002051	1,641	-	-	-	-	1,780
Vacuum Trucks	2270002051	1,641	-	-	-	-	2,192
Rock Proc. Eq.	2270002054	955	-	-	1,102	-	1,193
Loaders	2270002060	761	1,974	3,314	1,974	1,665	2,377
Backhoes	2270002066	1,135	1,566	500	1,566	1,172	814
Bulldozers	2270002069	936	1,897	3,314	1,897	1,467	1,713
Aerial Lifts	2270003010	384	-	-	-	-	1,364
Pumps	2270006010	N/A	-	-	-	-	365

N/A = NONROAD 2008a model data is not applicable for quarry dewater pumps

The following table (3-3) provides reported horsepower for quarry equipment from the survey and previous emission inventories. Findings for bore/drill rigs, rock truck and dozers horsepower were higher than results from previous studies and existing data in the TexN Model, while graders horsepower were lower. Excavator's horsepower from all survey responses for were significantly lower than previous studies except ERG's 2009 results for Texas.

[26] Eastern Research Group Inc., August 31, 2005. "Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region". Austin, Texas. Prepared for: The Houston Advanced Research Center. p. 5-38. Available online: http://files.harc.edu/Projects/AirQuality/Projects/H043.T163/H43.T163FinalReport.pdf. Accessed 11/02/11.

[27] Eastern Research Group Inc., July 31, 2009. "Update of Diesel Construction Equipment Emission Estimates for the State of Texas – Phase I and II". Austin, Texas. Prepared for: The Texas Commission on Environmental Quality. p. 3-7. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/20090731-ergi-DCE_EI_Update.pdf. Accessed 11/02/11.

Table 3-3: Estimated Average HP by Equipment Type for Quarries from Previous Studies

Equipment Type	SCC	NONROAD 2008a Model	TexN Model #23 Mining & Quarry	ERG's 2001 Austin Study[28]	ERG's 2005 Dallas Study[29]	ERG's 2009 Texas Study[30]	AACOG 2005	AACOG 2011
Rollers	2270002015	92	-	-	-	150	-	110
Scrapers	2270002018	409	426	250	-	363	250	315
Bore/Drill Rigs	2270002033	176	176	-	-	-	176	269
Excavators	2270002036	171	500	500	300-600	246	500*	231
Cranes	2270002045	231	230	-	-	-	231	200
Graders	2270002048	204	200	200	100-175	160	200*	142
Rock Trucks	2270002051	783	411	400	454	353	408	529
Water Trucks	2270002051	783	-	-	-	-	-	304
Vacuum Trucks	2270002051	783	-	-	-	-	-	355
Rock Proc. Eq.	2270002054	153	-	-	-	319	-	369
Loaders	2270002060	243	395	500	575	280	394	382
Backhoes	2270002066	93	80	80	50-75	73	80*	97
Dozers	2270002069	260	250	250	-	241	400	483
Aerial Lifts	2270003010	49	-	-	-	-	-	59
Pumps	2270006010	N/A	-	-	-	-	-	288

*Based on ERG's 2001 Austin Study
N/A = NONROAD 2008a model data is not applicable for quarry dewater pumps

The most common equipment types at quarries are front end loaders and rock trucks, followed by excavators and dozers. Only a few vacuum trucks, rollers, and dewater pumps were reported during the survey response. Dewater pumps are used to remove water from quarries. Several pumps may have gone unreported because they were not on the originally survey list of equipment. To determine the error bounds of quarry equipment survey results, an analysis of activity and horsepower responses was conducted. A 95% level of confidence ($p = 0.05$) was reported for equipment types with 5 or more observations in table 3-4. The results assume that the means are normally distributed.

The most common equipment types reported had the lowest percent margin of error for activity rates and horsepower. Loaders and rock trucks had the lowest percent margin of error because they are used at almost all quarries in the region: less than 9% for both activity and horsepower. Other common equipment types, dozers and excavator also had a low percent margin of error. Equipment that had a high margin of error for activity rates, bore drill rigs, cranes, graders, and aerial lifts, are only operated at a few quarries in the region. Equipment horsepower can vary

[28] Eastern Research Group Inc., November 30, 2001. "Diesel Construction Equipment Emissions in the Austin Region, Draft 1.4". Texas. p.15.
[29] Eastern Research Group Inc., August 31, 2005. "Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region". Austin, Texas. Prepared for: The Houston Advanced Research Center. p. 5-38. Available online: http://files.harc.edu/Projects/AirQuality/Projects/H043.T163/H43.T163FinalReport.pdf. Accessed 11/02/11.
[30] Eastern Research Group Inc., July 31, 2009. "Update of Diesel Construction Equipment Emission Estimates for the State of Texas – Phase I and II". Austin, Texas. Prepared for: The Texas Commission on Environmental Quality. p. 3-7. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/20090731-ergi-DCE_EI_Update.pdf. Accessed 11/02/11.

greatly even at the same quarry depending on the need and what equipment is available at the time. For example, at one quarry, front end loaders varied between 135 and 430 hp.

Table 3-4: Confidence Interval at 95% for Quarry Equipment

Equipment Type	SCC	Parameter	n	Mean	Confidence Interval	Percent of Mean
Bore/Drill Rigs	2270002033	Hours/Year	7	1,715	620	36.2%
		HorsePower	7	269	12	4.4%
Excavators	2270002036	Hours/Year	17	1,626	323	19.9%
		HorsePower	16	231	40	17.2%
Cranes	2270002045	Hours/Year	8	1,017	359	35.3%
		HorsePower	8	200	44	21.8%
Graders	2270002048	Hours/Year	11	762	431	56.5%
		HorsePower	10	142	17	12.2%
Rock trucks	2270002051	Hours/Year	71	2,288	171	7.5%
		HorsePower	63	529	46	8.8%
Water Trucks	2270002051	Hours/Year	10	1,780	474	26.6%
		HorsePower	10	304	76	24.8%
Loaders	2270002060	Hours/Year	90	2,377	191	8.0%
		HorsePower	77	382	28	7.2%
Backhoes	2270002066	Hours/Year	18	814	161	19.7%
		HorsePower	12	97	28	29.5%
Dozers	2270002069	Hours/Year	26	1,713	310	18.1%
		HorsePower	23	483	81	16.8%
Aerial Lifts	2270003010	Hours/Year	7	1,364	765	56.0%
		HorsePower	7	59	16	27.6%

3.5. Determining equipment population for quarry sites without local data

As detailed aerial photographs were available for Bexar and Comal County only, equipment populations for quarries with no survey responses or aerial imagery were estimated based on the hours the quarry operated. A quarry operating hours to equipment ratio was calculated by dividing the total pieces of equipment counted in each category by the total number of operation hours at these quarries[31]. The ratio was then used to calculate estimated equipment populations for the remaining quarry sites without local data.

Table 3-5 provides the quarry equipment ratio per 10,000 operating hours for all equipment types except rock processing equipment. The confidence level per 10,000 operating hours was marginal for the equipment types operating at most quarries: rock trucks and loaders. Other equipment types have a significant confidence level because they are not located at all quarries. Equation 3-2 provides the formula used to determine the ratio for equipment per 10,000 hours of operation, while equation 3-3 was used to calculate equipment counts at the quarries without local data. Although there is a large margin of error for some of the equipment that is not used by all quarries, the ratio is only used for 8 quarries that did not respond to the survey and do not have aerial imagery. These quarries only represented 9 percent of total quarry workforce and 8 percent of the operating hours

[31] Mine Safety and Health Administration, July 22, 2011. "Mine Data Retrieval System". United States Department of Labor. Available online: http://www.msha.gov/drs/drshome.htm. Accessed 07/27/2011.

Equation 3-2, Equipment to hours operated ratio for quarries without local data

$HRATIO_A$ = EP_A / Hours x 10,000 hours

Where,

$HRATIO_A$ = Equipment to hours operated ratio for equipment type A

EP_A = Equipment population for equipment type A (from survey data)

Hours = Number of hours quarries with local data operated in 2010, 1,390,273 (from Mine Safety and Health Administration)

Sample Equation – Equipment to hours operated ratio for loaders

$HRATIO_A$ = 148 loaders / 1,348,092 hours x 10,000 hours
= 1.10 loaders per 10,000 hours of operation

Equation 3-3, Equipment population at each quarry without local data

POP_{AB} = EMP_A x $HRATIO_A$ / 10,000 hours

Where,

POP_{AB} = Estimated population of equipment for equipment type A at quarry B

EMP_B = Number of hours operated by quarry B (from Mine Safety and Health Administration)

$HRATIO_A$ = Equipment to hours operated ratio for equipment type A (from equation 3-2)

Sample Equation – Number of loaders operating at quarry B

POP_{AB} = 20,947 hours operated by quarry B x 1.10 Rubber Tire Loaders per 10,000 hours of operation / 10,000 hours
= 2 loaders at quarry B

Table 3-5: Quarry Equipment Ratio per 10,000 Hours of Operation

Equipment Type*	SCC	n (survey)	Standard Deviation	Low	Mean	High	Confidence Level
Rollers	2270002015	2	#	#	0.01	#	#
Scrapers	2270002018	7	0.12	-0.04	0.05	0.14	0.09
Bore/Drill Rigs	2270002033	16	0.22	0.01	0.12	0.23	0.11
Excavators	2270002036	34	0.48	0.09	0.25	0.41	0.16
Cranes	2270002045	19	0.37	-0.02	0.14	0.31	0.16
Graders	2270002048	14	0.23	-0.02	0.10	0.23	0.12
Rock Trucks	2270002051	114	1.09	0.65	0.85	1.05	0.20
Water Trucks	2270002051	11	0.22	-0.05	0.08	0.21	0.13
Vacuum Trucks	2270002051	1	#	#	0.01	#	#
Rock Proc. Eq.	2270002054	N/A					
Loaders	2270002060	148	1.22	0.90	1.10	1.29	0.20
Backhoes	2270002066	14	0.27	-0.04	0.10	0.25	0.14
Dozers	2270002069	31	0.37	0.10	0.23	0.36	0.13
Aerial Lifts	2270003010	12	0.35	-0.11	0.09	0.29	0.20
Pumps	2270006010	3	#	#	0.02	#	#

*Only for Quarries with more than 10,000 quarry hours

#Statistics only calculated for equipment with more than 5 survey responses

N/A - Rock Crushers and separators population counts came only from surveys or TCEQ permit database

Quarry equipment counts for the AACOG region and a comparison to the TexN Model existing data is provided in table 3-6. Almost every equipment type had a higher population counts from the surveys compared to the TexN Model existing data. There were more front end loaders, excavators, and graders operating at quarries in the AACOG region, while there are fewer backhoes. Some of the less common equipment types, bore drill rigs, cranes, and rock processing equipment, are not reported in the mining and quarry DCE subsector or the equipment population was zero.

Table 3-6: Quarry Equipment Counts for the AACOG Region

Equipment Type	SCC	TexN Model DCE #23 Mining & Quarry	AACOG 2011
Rollers	2270002015	*	2
Scrapers	2270002018	11	12
Bore/Drill Rigs	2270002033	*	21
Excavators	2270002036	40	53
Cranes	2270002045	*	22
Graders	2270002048	15	22
Rock Trucks	2270002051	136	146
Water Trucks	2270002051		15
Vacuum Trucks	2270002051		1
Rock Proc. Eq.	2270002054	0	16
Loaders	2270002060	155	200
Backhoes	2270002066	93	24
Dozers	2270002069	44	41
Aerial Lifts	2270003010	*	14
Pumps	2270006010	*	3

*Not included in the DCE #23 Mining & Quarry subsector and the TexN Model does not break down bore/drill rigs and cranes into individual DCE subsectors

As shown in table 3-7, Bexar County had the largest population of quarry equipment followed by Comal County. Quarry equipment also operates in Medina and Atascosa counties, while there were few quarry equipment in other AACOG counties. Overall there was 597 pieces of quarry equipment operating in the AACOG region. There is also one active mine in the AACOG region; San Miguel Lignite mine in Atascosa County. Equipment from this mine was not surveyed and the equipment is not included in the equipment counts.

Table 3-7: Quarry Equipment Counts by County

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Gillespie (48171)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total*
Rollers	2270002015	0	N/A	2	0	N/A	N/A	0	0	0	2
Scrapers	2270002018	0		1	6			0	0	2	12
Bore/Drill Rigs	2270002033	0		7	11			0	0	2	21
Excavators	2270002036	2		30	9			0	3	6	53
Cranes	2270002045	1		12	5			0	0	3	22
Graders	2270002048	1		10	5			0	0	2	22
Rock Trucks	2270002051	5		62	52			0	6	12	146
Water Trucks	2270002051	0		8	5			0	0	1	15
Vacuum Trucks	2270002051	0		1	0			0	0	0	1
Rock Proc. Eq.	2270002054	2		4	1			1	0	7	16
Loaders	2270002060	13		95	57			0	6	25	205
Backhoes	2270002066	0		14	5			0	0	4	24
Dozers	2270002069	2		21	9			0	1	5	41
Aerial Lifts	2270003010	0		8	4			0	0	2	14
Pumps	2270006010	0		3	0			0	0	0	3

N/A= Data is not reported for these counties because the information is proprietary

*Total equipment population includes equipment in Bandera, Gillespie, and Guadalupe Counties

3.6. Calculate Ozone Precursor Emissions

The methodology used to estimation quarry equipment emissions incorporated information on equipment type, equipment population, horsepower, and activity data extracted from returned survey questionnaires and aerial imagery. When specific data such as load or emission factors were not provided in the survey returns, existing data in the TexN Model was used (Table 3-8). The TexN Model run specifications were:

- Analysis Year = 2006
- Max Tech. Year = 2006
- Met Year = Typical Year
- Period = Annual
- Summation Type = Annual
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = Bexar County
- Sources = Diesel Quarry Equipment

Table 3-8: Bexar County 2006 Emission Factors for Diesel Quarry Equipment from the TexN Model

Equipment Type	SCC	Load Factor	VOC EF	NO_X EF
Rollers	2270002015	0.59	0.547	4.779
Scrapers	2270002018	0.59	0.323	3.982
Bore/Drill Rigs	2270002033	0.43	0.643	6.678
Excavators	2270002036	0.59	0.401	5.294
Cranes	2270002045	0.43	0.409	5.303
Graders	2270002048	0.59	0.485	4.619
Rock Trucks	2270002051	0.59	0.281	4.595
Water Trucks	2270002051	0.59	0.281	4.595
Vacuum Trucks	2270002051	0.59	0.281	4.595
Rock Crusher	2270002054	0.43	0.482	5.568
Rock Separators	2270002054	0.43	0.482	5.568
Loaders	2270002060	0.59	0.329	3.861
Backhoes	2270002066	0.21	1.523	5.655
Dozers	2270002069	0.59	0.367	4.012
Aerial Lifts	2270003010	0.21	2.329	7.528
Pumps	2270006010	0.43	0.842	6.044

VOC and NO_X emissions were calculated using the formula provided below.

Equation 3-4, Emission from quarry diesel equipment

QDE_A = (EP_A x HRS_A x HP_A x LF_A x EF_A) / 907,184.74 grams/ton / 365 days/year

Where:

QDE_A = Emissions for equipment type A, tons of NO_X or VOC per ozone season day
EP_A = Equipment population for equipment type A (from survey)
HRS_A = Annual hours for equipment type A (from survey)
HP_A = Average rated horsepower for equipment type A (from survey)
LF_A = Typical load factor for equipment type A (from TexN Model, Table 3-8)
EF_A = NO_X or VOC emission factor for equipment type A (from TexN Model, Table 3-8)

Sample equation – Ozone Season day NO_X emissions for front end loaders operating at quarries in Bexar County in 2006

QDE_A = (95 loaders x 2,433 hours for each loader x 388 hp x 0.59 x 3.861 grams of NO_X per hour) / 907,184.74 grams/ton / 365 days/year
= 0.626 tons of NO_X per Ozone season Day

Table 3-9 list VOC emissions and table 3-10 provides NO_X emissions by equipment type and county. Ozone season day emissions from quarry equipment were 0.266 tons of VOC and 3.782 tons of NO_X in the AACOG region. Emissions are dominated by rock trucks and loaders (Figure 3-2), while rock processing equipment, dozers, and excavators are also significant emission sources. As expected, Bexar County had the highest quarry equipment emissions followed by Comal County and Medina County (Figure 3-3)

3.7. Temporal Allocation

A weekday versus weekend adjustment factor was calculated based on the total hours for each time period from the surveys. Weekend average activity hours are 29.6 percent of weekday average activity hours.

3.8. Spatial Allocation of Emissions

Emissions were spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model (Figure 3-4). Emissions were geo-coded to the location of quarries identified through TCEQ Permits[32], Mineral Locations Database[33], Find the Best directory[34], and aerial photographs. The largest emissions sources are concentrated just north of the IH 35 in Comal County, along northern 1604 in Bexar County, and on the northern border between Bexar and Comal County. These quarries are concentrated along the Balcones Escarpment because the area has easily accessible limestone that is suitable for making Portland cement. Southwest Bexar County also has a small concentration of quarry equipment emissions near the border with Atascosa County because of accessible limestone and sand deposits.

Future emission inventories could improve data collect on rock crushers, separators, and dewatering pumps because they could be a significant source of emissions. There was only 3 rock processing equipment and 3 dewater pumps recorded in the survey. Future local surveys of quarry equipment should include all equipment sources found through this survey process. Improved aerial imagery from rural counties in the AACOG region would also improve equipment county data and emission estimates.

DCE construction equipment subsector #23 for quarries also includes mining equipment. Future data collection should include other operating mines in the AACOG region including San Miguel lignite mine in Atascosa County. There are at least 6 asphalt plants in the AACOG region that are not included in TCEQ point database and may emit significant amounts of VOC emissions. Future studies should locate, identify, and calculate emissions from these plants.

[32] TCEQ. Permit Database". Austin Texas. Available online: https://webmail.tceq.state.tx.us/gw/webpub. Accessed 07/27/11.
[33] MineralMundi. "Mineral Locations Database". United States Geological Survey Mineral Resources Program. Available online: http://www.mineralmundi.com/texas.htm. Accessed 07/27/11.
[34] Find the Best, 2011. "Texas Active Mines". Available online: http://active-mines.findthebest.com/directory/d/Texas. Accessed 07/27/11.

Table 3-9: Ozone Season Daily Diesel Quarry Equipment VOC Emissions by County, 2006

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Gillespie (48171)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Rollers	2270002015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scrapers	2270002018	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.004
Bore/Drill Rigs	2270002033	0.000	0.000	0.003	0.005	0.000	0.000	0.000	0.000	0.001	0.008
Excavators	2270002036	0.000	0.000	0.008	0.002	0.001	0.001	0.000	0.001	0.001	0.014
Cranes	2270002045	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.002
Graders	2270002048	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Rock Trucks	2270002051	0.003	0.002	0.037	0.035	0.001	0.000	0.000	0.002	0.007	0.087
Water Trucks	2270002051	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.004
Vacuum Trucks	2270002051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Rock Proc. Eq.	2270002054	0.001	0.000	0.004	0.001	0.000	0.000	0.000	0.000	0.005	0.011
Loaders	2270002060	0.007	0.001	0.053	0.027	0.001	0.001	0.000	0.003	0.014	0.107
Backhoes	2270002066	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Dozers	2270002069	0.001	0.000	0.016	0.004	0.000	0.000	0.000	0.001	0.002	0.024
Aerial Lifts	2270003010	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Pumps	2270006010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total		0.012	0.003	0.128	0.078	0.003	0.003	0.001	0.008	0.031	0.266

Table 3-10: Ozone Season Daily Diesel Quarry Equipment NO_X Emissions by County, 2006

Equipment Type	SCC	Atascosa (48013)	Bandera (48019)	Bexar (48029)	Comal (48091)	Gillespie (48171)	Guadalupe (48187)	Kendall (48259)	Kerr (48265)	Medina (48325)	Total
Rollers	2270002015	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Scrapers	2270002018	0.001	0.001	0.004	0.024	0.000	0.008	0.000	0.001	0.004	0.044
Bore/Drill Rigs	2270002033	0.001	0.000	0.027	0.047	0.000	0.000	0.000	0.001	0.007	0.084
Excavators	2270002036	0.006	0.000	0.103	0.028	0.009	0.007	0.000	0.014	0.017	0.183
Cranes	2270002045	0.002	0.000	0.017	0.007	0.000	0.000	0.000	0.000	0.004	0.030
Graders	2270002048	0.001	0.000	0.010	0.004	0.000	0.001	0.000	0.000	0.002	0.019
Rock Trucks	2270002051	0.049	0.026	0.598	0.574	0.020	0.003	0.002	0.039	0.108	1.419
Water Trucks	2270002051	0.001	0.000	0.028	0.021	0.004	0.000	0.000	0.001	0.004	0.059
Vacuum Trucks	2270002051	0.000	0.005	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.012
Rock Proc. Eq.	2270002054	0.009	0.000	0.035	0.008	0.000	0.000	0.014	0.000	0.337	0.403
Loaders	2270002060	0.079	0.010	0.626	0.315	0.007	0.014	0.002	0.033	0.166	1.252
Backhoes	2270002066	0.000	0.000	0.004	0.001	0.000	0.000	0.000	0.000	0.001	0.006
Dozers	2270002069	0.009	0.001	0.171	0.043	0.004	0.003	0.000	0.010	0.020	0.262
Aerial Lifts	2270003010	0.000	0.000	0.003	0.002	0.000	0.000	0.000	0.000	0.001	0.006
Pumps	2270006010	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Total		0.157	0.045	1.637	1.074	0.043	0.036	0.020	0.100	0.671	3.782

Figure 3-2: Diesel Quarry Equipment Emissions by Equipment Type, Tons per Ozone Season Day, 2006

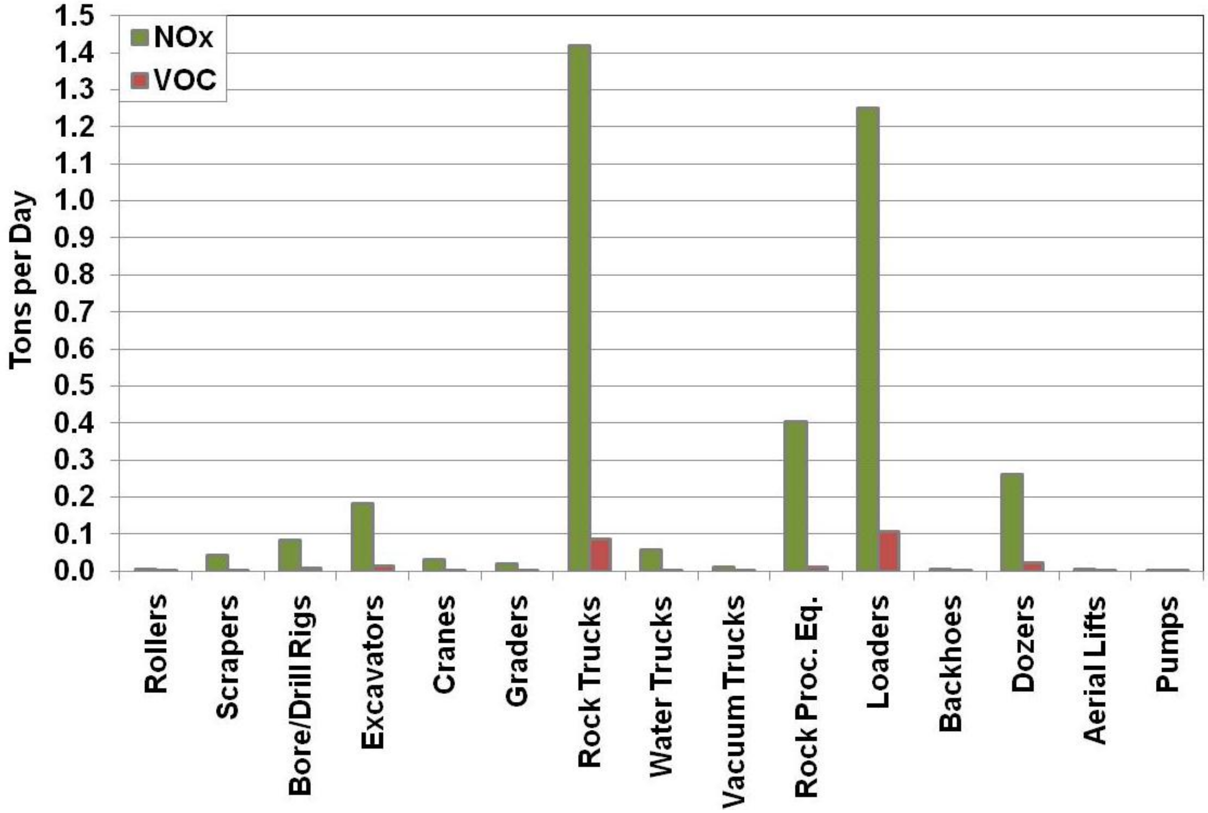


Figure 3-3: Diesel Quarry Equipment Emissions by County, Tons per Ozone Season Day, 2006

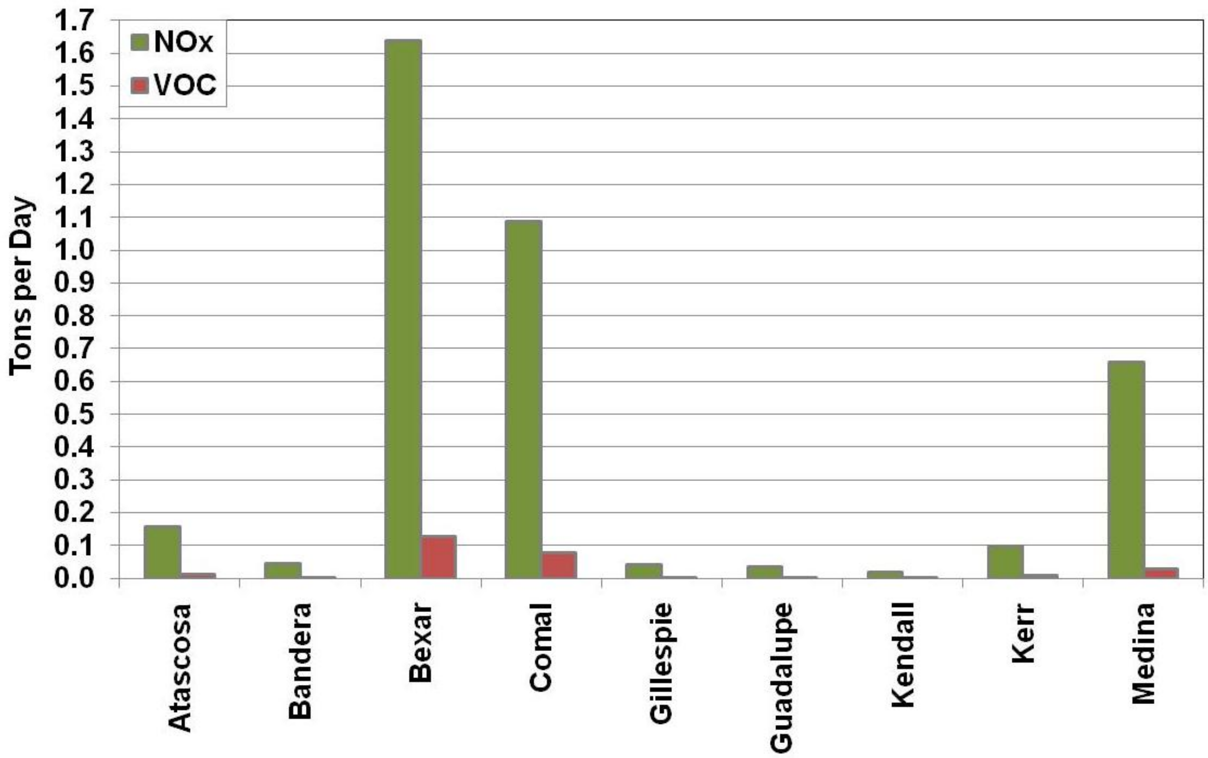
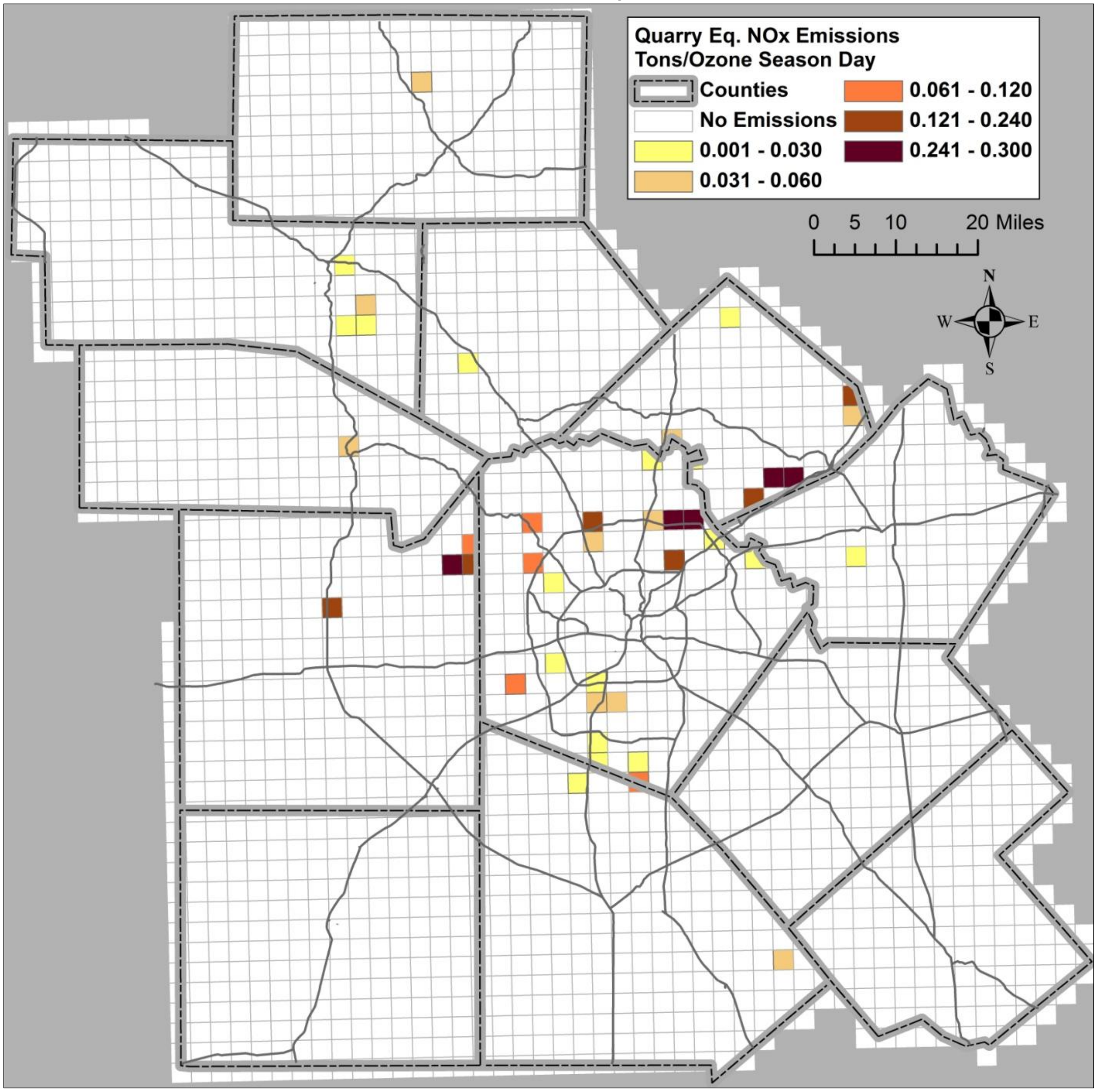


Figure 3-4: Quarry Equipment NO_X Emissions by 4km Photochemical Modeling Grid, Average Ozone Season Day, 2006



Plot Date: Nov. 18, 2011
Map Compilation: Nov. 17, 2011
Source: Survey Data and Aerial Imagery

4. LANDFILL EQUIPMENT

Large diesel equipment used in landfills can be a significant source of ozone precursor emissions. The following equipment types are used at landfills in the AACOG region:

- Compactor
- Excavators
- Graders
- Off Highway Trucks
- Loaders
- Tractors / Bulldozers
- Other landfill equipment

The equipment listed above can be utilized for other purposes, including construction projects and quarry operations. However, emissions from diesel equipment operating at landfills are calculated separately from other construction equipment categories because landfill equipment has different engine characteristics and activity rates. The methodology used to estimate landfill equipment emissions relies on local data produced from surveys and data extracted from the TexN Model. The following steps were used to calculate emissions from landfill equipment:

1. Conduct a survey of local landfill equipment to determine local equipment usage rates and characteristics.
2. Conduct a second survey with estimations of equipment activity at the one landfill that did not respond to the first survey. The landfill was asked to make corrections and send back the survey.
3. Calculate ozone precursor emissions.
4. Spatially allocate diesel landfill equipment emissions to the 4km photochemical model grids.
5. Provide updated data in electronic format that can be readily included in TexN Model DCE subsector #10 for landfill operations.

Raw local input data such as population size, local activity profiles, and spatial surrogates were provided to TCEQ.

There are 6 active landfills in the AACOG region:

- Covel Gardens Landfill — Bexar County
- Tessman Road Landfill — Bexar County
- Waste Management — Comal/Guadalupe County
- City of Fredericksburg Landfill — Gillespie County
- Nido Ltd / Beck Landfill — Guadalupe County
- City of Kerrville Landfill — Kerr County

One landfill also operates a quarry at the same site: Nido Incorporated's Schertz Gravel Plant. At this site, emissions from equipment that can be used for both quarry operations and landfill operations were split equally between the landfill and quarry emission inventories.

4.1. Conduct a Survey of Local Landfill Equipment Activity

Data on landfill equipment was collected using a "bottom-up" methodology to refine equipment populations, equipment horsepower, activity profiles, and spatial allocations of emissions. A survey questionnaire was sent to each landfill to collect data on:

- Equipment Population
- Activity Rates – total annual hours of use by type of equipment
- Temporal Profiles – equipment use on weekdays and weekend days
- Engine Characteristics

On the following page is an example of the survey questionnaire used to collect equipment data from landfills in the San Antonio Region.

July 2, 2012

«Company_Name»
«Mine_Name»
«Address»
«Zip»

ATTENTION: OPERATIONS MANAGER

Re: Air Quality Emissions Inventory

The Alamo Area Council of Governments (AACOG) requests your assistance in completing the air quality emissions inventory for San Antonio and the surrounding counties. This inventory is especially significant because the San Antonio region currently risks being declared in non-attainment of federal air quality standards (NAAQS). The purpose of this survey is to provide services to the region. Your response is vital to this process and will serve to produce a true and correct inventory of landfill equipment in the San Antonio region.

AACOG has estimated equipment populations, hour usage, and horsepower landfill equipment based on local data. To greatly increase the accuracy of this information we ask that you review the attached estimates for your landfill, make any additions or corrections necessary, and return it to AACOG in the self-addressed envelope. The information you provide will remain strictly confidential and unavailable to public information requests. Please submit your response by October 14th, 2011.

Thank you for your time and participation. If you have any questions or comments please feel free to contact Steven Smeltzer, Environmental Manager at (210) 362-5266.

Regionally yours,

Dean R. Danos
Interim Executive Director
Alamo Area Council of Governments
8700 Tesoro Drive, Suite 700
San Antonio, Texas 78217

Alamo Area Council of Governments (AACOG)
Landfill Equipment Survey

AACOG is conducting a study to assess and quantify air quality within the San Antonio region and surrounding counties by performing an emission inventory. The purpose of this survey is to gather data on diesel landfill equipment in the region.

By filling out this confidential survey, you will be providing valuable data. Thank you for taking the time to provide this information.

Instructions:

1. Review the equipment estimates shown on the following page.
2. Make any corrections to the estimates.
3. Return the corrected equipment data to AACOG in the self-addressed envelope.

If you have other landfill equipment that is not shown, please include it as well.

NOTE: If your business has more equipment than will fit in the space provided, please make additional copies of the survey.

Completed surveys can be faxed to (210) 225-5937, or mailed to:
Alamo Area Council of Governments
8700 Tesoro, Suite 700
San Antonio, Texas 78217
Attn: Steven Smeltzer

If you have any questions or comments, please contact us at (210) 362-5266.

THE SURVEY IS CONTAINED ON THE NEXT PAGE

Landfill Equipment Survey

Equipment Type	Fuel Type Diesel Electricity	Approximate Horse-power Rating (each)	Number of Units	Average Daily Hours for each unit (Mon-Fri)	Average Daily Hours for each unit (Sat-Sun)
Scrapers					
Excavators					
Graders					
Off Highway Trucks					
Loaders					
Tractors and Dozers					
Compactors					
Other Large Equipment (specify type)					

4.1. Conduct a Second Survey of Landfill Equipment Activity

There was only one landfill that did not respond to the first survey; a second survey was sent to this landfill. Estimations of equipment population, HP, and activity hours were included in the survey for this landfill. The landfill confirmed the estimations and sent the survey form back to AACOG.

In order to make a general conclusion about the targeted population, the number of returned surveys required for an accurate representation is an important concern. Since determining a suitable sample size is not always clear-cut, several major factors must be considered. Due to time and budget constraints, a 95% level of confidence, which is the risk of error, the researcher is willing to accept, was chosen. Similarly, the confidence interval, which determines the level of sampling accuracy, was set at +/- 5%. Since the population is finite, the following equation was used to select the sample size.[35]

Equation 4-1, Sampling Size for Landfills

$$RN = [CLV^2 \times 0.25 \times POP] / [CLV^2 \times 0.25 + (POP - 1)\ CIN^2]$$

Where,

- RN = Number of survey responses needed to accurately represent the population
- CLV = 95% confidence level (1.96)
- POP = Population size (6 Landfills)
- CIN = ± 5% confidence interval (0.05)

For a 10% confidence interval:

$$RN = [(1.96)^2 \times (0.25) \times 6] / [(1.96)^2 \times (0.25) + (6 - 1) \times (0.05)^2]$$
$$= 5.88 \text{ responses}$$

Thus, all 6 landfills need to be surveyed in order to meet the 95% level of confidence, and the ±5% confidence interval for equipment population. Since all landfills responded to the survey, the level of confidence and confidence interval was met for the survey.

Estimated horsepower from the returned surveys are provided in table 4-1, while the estimated hours are provided in table 4-2. Survey results from ERG's 2005 Dallas study[36], AACOG 2005 survey, and, the survey returns in 2011 were similar for most equipment types. AACOG's 2011 survey had higher horsepower compactors, excavators, and off-road trucks compared to other surveys. Annual hours for front end loaders are higher, while graders had lower usage rates compared to the other results.

[35] Rea, L. M. and Parker, R. A., 1992. "Designing and Conducting Survey Research". Jossey-Bass Publishers: San Francisco.

[36] Eastern Research Group Inc., August 31, 2005. "Ozone Science and Air Modeling Research Project H43T163: Diesel Construction Equipment Activity and Emissions Estimates for the Dallas/Ft. Worth Region". Austin, Texas. Prepared for: The Houston Advanced Research Center. p. 5-36. Available online: http://files.harc.edu/Projects/AirQuality/Projects/H043.T163/H43.T163FinalReport.pdf. Accessed 07/23/10.

Table 4-1: Estimated HP by Equipment Type for Landfills from Previous Studies

Equipment Type	SCC	NONROAD 2008a Model	TexN Model	ERG's 2005 Dallas Study	AACOG 2005	AACOG 2011
Rollers/Compactors	2270002015	92	-	303	345	412
Scrapers	2270002018	409	403	308	341	280
Excavators	2270002036	171	225	238	225	349
Graders	2270002048	204	208	158	222	195
Off-Road Trucks	2270002051	783	-	-	192	317
Loaders	2270002060	243	168	135	166	203
Dozers	2270002069	260	200	225	261	286
Other Construction	2270002081	328	400	-	207	450

*Weighted Average Horsepower

Table 4-2: Estimated Hours by Equipment Type for Landfills from Previous Studies

Equipment Type	SCC	NONROAD 2008a Model	TexN Model	ERG's 2005 Dallas Study	AACOG 2005	AACOG 2011
Rollers/Compactors	2270002015	760	2,951	2,951	3,268	2,546
Scrapers	2270002018	914	663	663	2,100	1,070
Excavators	2270002036	1,092	2,249	2,249	2,088	2,608
Graders	2270002048	962	1,345	1,345	939	874
Off-Road Trucks	2270002051	1,641	-	-	1,270	1,445
Loaders	2270002060	761	1,641	1,641	1,435	2,074
Dozers	2270002069	936	2,588	2,588	3,349	2,747
Other Construction	2270002081	606	1,566	-	3,573	3,026

To determine the error bounds of the landfill equipment survey, an analysis of horsepower and activity responses was conducted. A 95% level of confidence ($p = 0.05$) was reported for equipment types with 5 or more observations (table 4-3). Only scrappers were not included in the calculations because there were only 2 scrappers identified on survey returns. The results assume that the means are normally distributed. Compactors, excavators, and dozers had similar annual hour usage for all the landfills, while the horsepower for was similar for loaders and dozers. The largest variety of equipment usage and size are for excavators' horsepower, off highway trucks' usage, and graders' horsepower.

The results from the survey provided updated data to TexN Model DCE subsector #10 for landfill operations. Landfills use more excavators, off road trucks, and dozers then the default data in the TexN Model.

Table 4-3: Confidence Interval at 95% for Landfill Equipment

Equipment Type	SCC	n	Parameter	Mean	Confidence Interval[#]	Percent of Mean
Compactor	2270002015	6	Hours/Year	2,539	139	5.5%
			Horsepower	412	85	20.8%
Excavators	2270002036	5	Hours/Year	2,608	64	2.5%
			Horsepower	349	129	36.9%
Graders	2270002048	5	Hours/Year	856	216	25.2%
			Horsepower	196	55	28.3%
Off Highway Trucks	2270002051	12	Hours/Year	1,474	462	31.4%
			Horsepower	318	46	14.3%
Loaders	2270002060	5	Hours/Year	2,087	432	20.7%
			Horsepower	203	15	7.4%
Dozers	2270002069	14	Hours/Year	2,765	251	9.1%
			Horsepower	285	21	7.3%
Other equipment*	2270002081	5	Hours/Year	3,026	0	0.0%
			Horsepower	450	0	0.0%

*note: only one landfill had other type of large diesel construction equipment
[#]note: there was a 100% survey response rate

Table 4-4: Landfill Equipment Counts for the AACOG Region

Equipment Type	SCC	TexN Model DCE #10 – Landfills	AACOG 2011
Rollers/Compactors	2270002015	-	6
Scrapers	2270002018	7	2
Excavators	2270002036	1	5
Graders	2270002048	5	5
Off-Road Trucks	2270002051	-	12
Loaders	2270002060	6	5
Dozers	2270002069	10	14
Other Construction	2270002081	*	5

*TexN Model does not break down other construction equipment into individual DCE subsectors

4.2. Calculate Ozone Precursor Emissions

The methodology used to calculate landfill equipment emissions incorporated information on equipment type, equipment population, horsepower, and activity data extracted from returned survey questionnaires. When specific data such as load or emission factors were not provided in the survey returns, existing data in the TexN Model was used (Table 4-5). The TexN Model run specifications are:

- Analysis Year = 2006
- Max Tech. Year = 2006
- Met Year = Typical Year
- Period = Annual
- Summation Type = Annual
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = Bexar County

- Sources = Diesel Landfill Equipment

Table 4-5: TexN Model Load and Emission Factors for Landfill Equipment, Bexar County 2006

Equipment Type	SCC	Load Factor	VOC EF	NO_X EF
Rollers/Compactors	2270002015	0.59	0.547	4.779
Scrapers	2270002018	0.59	0.323	3.982
Excavators	2270002036	0.59	0.401	5.294
Graders	2270002048	0.59	0.485	4.619
Off-Road Trucks	2270002051	0.59	0.281	4.595
Loaders	2270002060	0.59	0.329	3.861
Dozers	2270002069	0.59	0.367	4.012
Other Construction Eq.	2270002081	0.59	0.485	5.691

For each type of equipment, VOC and NO_X emissions were calculated using the following formula:

Equation 4-2, Emissions from landfill diesel equipment

LDE_A = (EP_A x HRS_A x HP_A x LF_A x EF_A) / 907,184.74 grams/ton / 365 days/year

Where:

LDE_A = Emissions for equipment type A, tons of NO_X or VOC per ozone season day
EP_A = Equipment population for equipment type A (from survey)
HRS_A = Annual hours for equipment type A (from survey)
HP_A = Horsepower for equipment type A (from survey)
LF_A = Typical load factor for equipment type A, 0.59 (from TexN mode, Table 4-5)
EF_A = NO_X or VOC Emission factor for equipment type A (from TexN Model, Table 4-5)

Sample equation – Ozone Season weekday NO_X emissions for 3 large diesel dozers operating at a landfill in Bexar County in 2006

LDE_A = (7 loaders x 2,951 hours/year x 302 hp x 0.59 x 3.861 grams of NO_X per hour) / 907,184.74 grams/ton / 365 days/year
= 0.043 tons of NO_X per Day

Table 4-6 provides VOC emissions from landfill equipment, while table 4-6 lists NO_X emissions from landfill equipment. Landfill equipment accounted for 0.029 tons of VOC emissions and 0.328 tons of NO_X emissions in the AACOG region. As shown in figure 4-1, dozers, other construction equipment, compactors, and off-road trucks are the largest sources of NO_X emissions from landfill operations. As expected, Bexar County had the largest amount of emissions from landfill equipment (Figure 4-2). Landfill equipment emissions also occur in Gillespie, Comal, Guadalupe, and Kerr counties.

4.3. Temporal Allocation

Using local survey data, weekend emissions are 50.5% of weekday emissions because landfills operate less on weekends.

4.4. Spatial Allocation of Emissions

Emissions were spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model. Weekday emissions were geo-coded to the location of landfills identified through aerial photographs (figure 4-3).

Table 4-6: Ozone Season Daily Diesel Landfill Equipment VOC Emissions by County, 2006

Equipment Type	SCC	Bexar (48029)	Comal (48091)	Gillespie (48171)	Guadalupe (48187)	Kerr (48265)	Total
Rollers/Compactors	2270002015	0.002	0.001	0.001	0.001	0.000	0.006
Scrapers	2270002018	-	0.000	-	-	0.000	0.000
Excavators	2270002036	0.002	-	0.001	0.001	-	0.003
Graders	2270002048	0.000	0.000	0.000	-	0.000	0.001
Off-Road Trucks	2270002051	0.002	0.000	0.001	0.000	0.000	0.003
Loaders	2270002060	0.000	-	0.000	0.000	0.001	0.001
Dozers	2270002069	0.004	0.001	0.001	0.001	0.001	0.008
Other Construction	2270002081	0.006	-	-	-	-	0.006
Total		0.017	0.003	0.004	0.003	0.002	0.029

Table 4-7: Ozone Season Daily Diesel Landfill Equipment NO_X Emissions by County, 2006

Equipment Type	SCC	Bexar (48029)	Comal (48091)	Gillespie (48171)	Guadalupe (48187)	Kerr (48265)	Total
Rollers/Compactors	2270002015	0.021	0.011	0.011	0.010	0.004	0.056
Scrapers	2270002018	-	0.004	-	-	0.001	0.005
Excavators	2270002036	0.028	-	0.009	0.007	-	0.043
Graders	2270002048	0.004	0.001	0.001	-	0.002	0.007
Off-Road Trucks	2270002051	0.029	0.004	0.009	0.005	0.001	0.049
Loaders	2270002060	0.002	-	0.003	0.003	0.007	0.015
Dozers	2270002069	0.045	0.010	0.016	0.006	0.007	0.084
Other Construction	2270002081	0.069	-	-	-	-	0.069
Total		0.197	0.030	0.049	0.031	0.021	0.328

Figure 4-1: Diesel Landfill Equipment Emissions by Equipment Type, Tons per Ozone Season Day, 2006

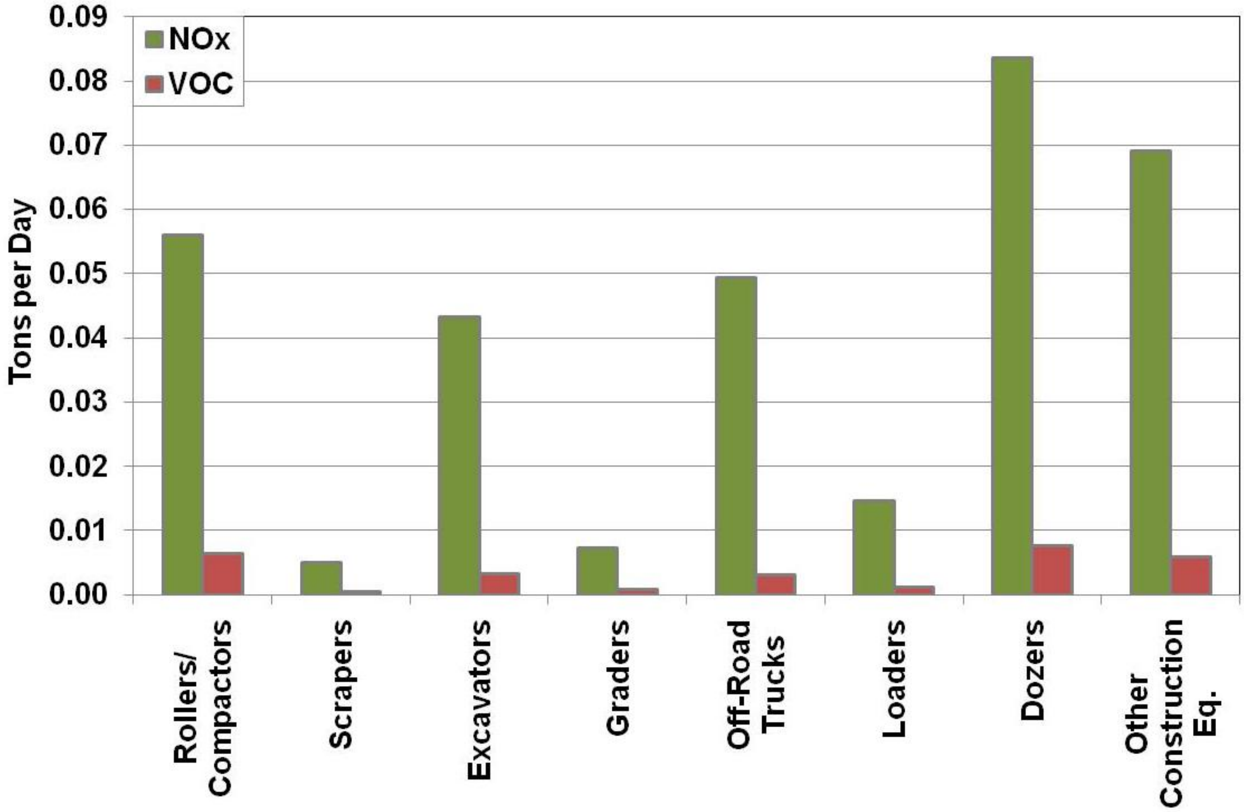


Figure 4-2: Diesel Landfill Equipment Emissions by County, Tons per Ozone Season Day, 2006

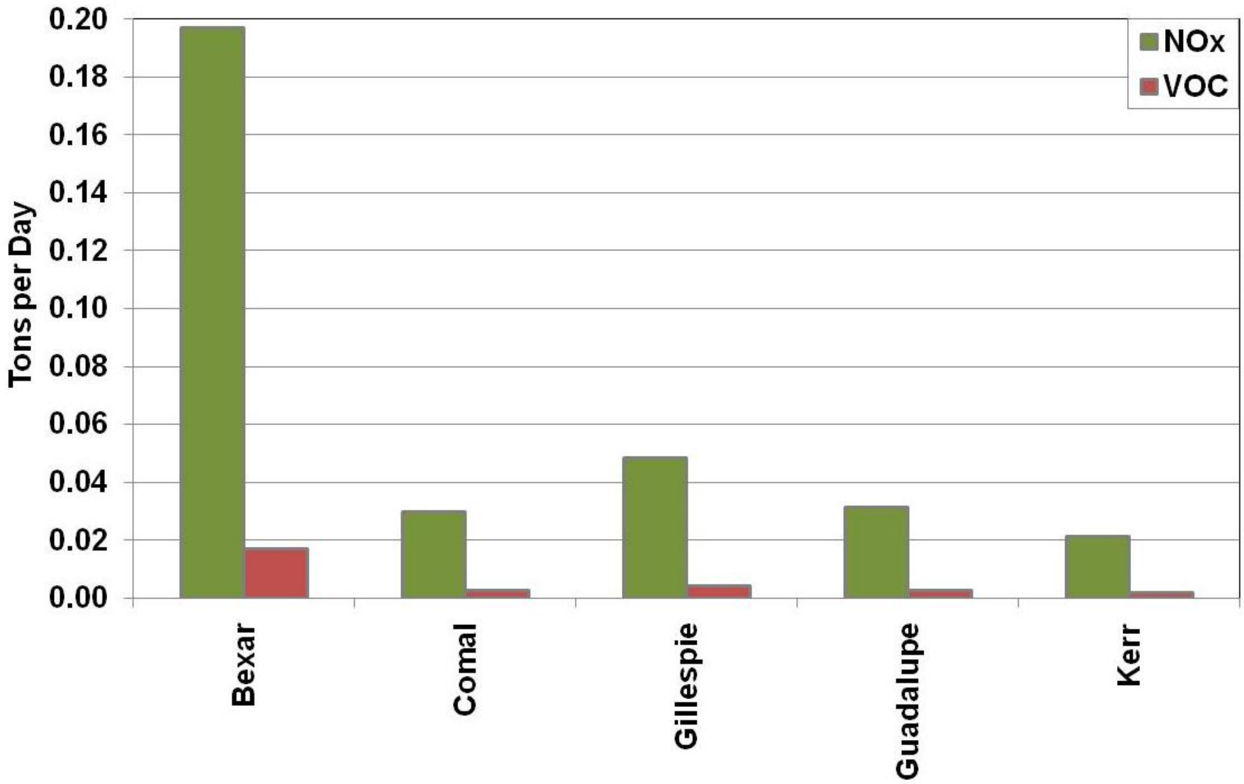
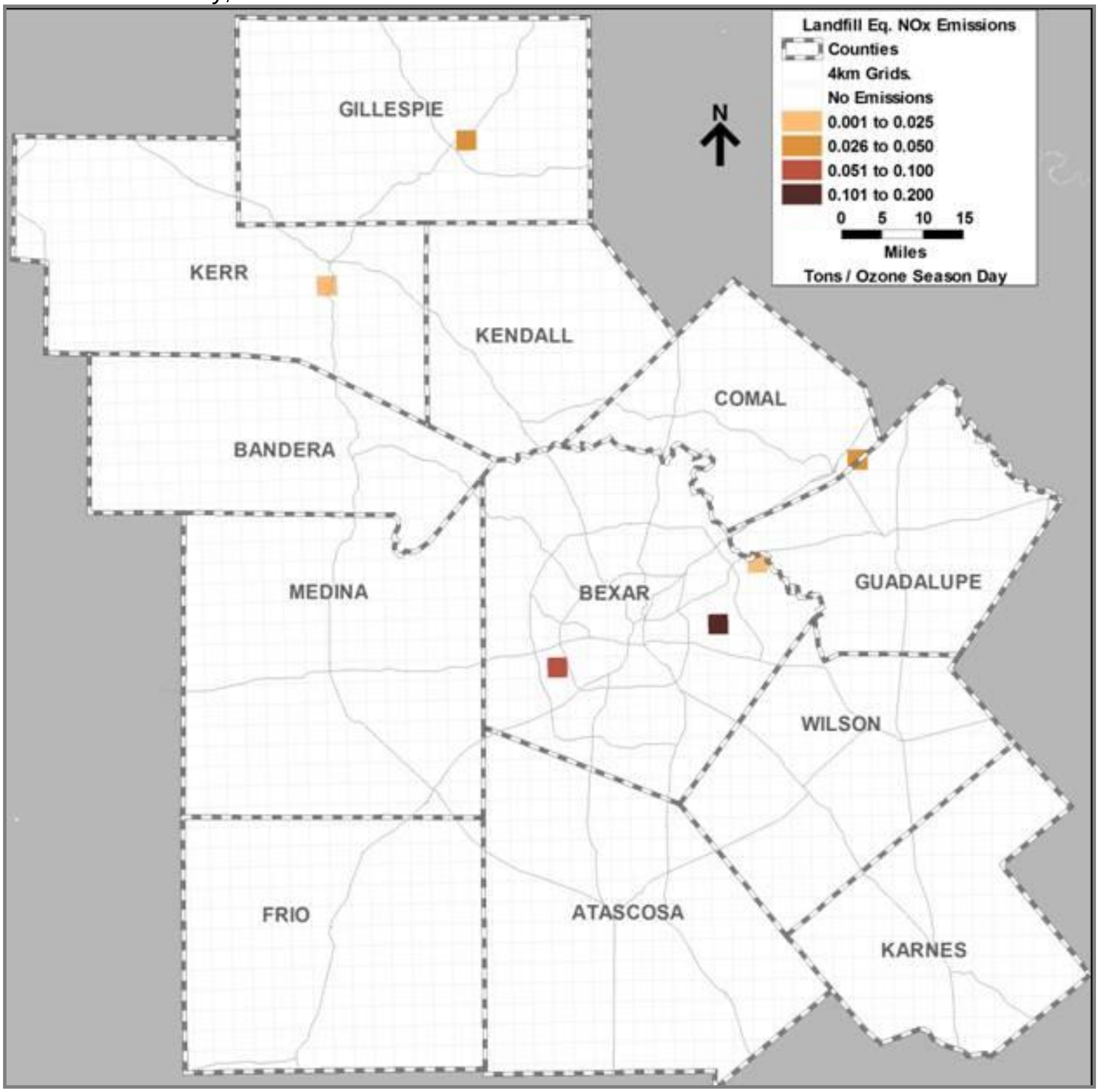


Figure 4-3: Landfill Equipment NO_X Emissions by 4km Photochemical Modeling Grid, Average Ozone Season Day, 2006



Plot Date: Nov. 18, 2011
Map Compilation: Nov. 17, 2011
Source: Survey Data and Aerial Imagery

5. TRACTORS AND COMBINES

Agricultural equipment used to plant and harvest crops contributes to ozone pre-cursor emissions. Despite recent engine and fuel regulations, non-road engines continue to emit large amounts of nitrogen oxides (NO_X). The following steps were used to calculate tractor and combine emissions:

1. The Texas Agricultural Statistics and Census of Agriculture were used to identify types and location of crops in the AACOG region.
2. Activity data for tractors and combines was calculated using survey data from local agricultural extension agents. Also, data from the existing 2009 agricultural emission inventory performed by Pechan under contract to TCEQ was used.
3. Ozone precursor emissions from tractors and combines were calculated using local information and existing data in the TexN model.
4. Tractor and combine emissions were allocated to the 4km June 2006 photochemical model grid.
5. Updated data was provided to TCEQ in electronic format that can be readily included in TexN Model for agricultural activities. Raw local input data such as local activity profiles and spatial surrogates were provided to TCEQ.

5.1. Types and Locations of Crops in the AACOG Region

To calculate tractor and combine emissions, crop acres planted and harvested for every county was collected. Volume I of the 2007 Census of Agriculture, which was made available by the United States Department of Agriculture (USDA), contained acreage of hay by county.[37] Crop acreages for all other crop types were retrieved from the 2008 Texas Agricultural Statistics report published by USDA (Table 5-1).[38] When data on crop acres was not reported in 2008, crop acres from the 2007 Texas Agricultural Statistics report were used.

5.2. Activity Data for Tractors and Combines

5.2.1. Seasonal Adjustment

Agricultural tasks that use tractors include soil preparation, plowing, planting, fertilizing, cultivating, and applying pesticides, while combines are used for harvesting. For each crop type, the climate of south-central Texas influences the time of the year for each agricultural activity. To calculate emissions from agricultural tractors and combines, the time it takes a farmer to plow, plant, fertilize, cultivate, and harvest each crop by month is necessary. Activity data by month were determined via correspondence with local Texas Agricultural Service County Extension agents who have observed farm activity over the past 20 years in AACOG region (table 5-2).

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[37] United States Department of Agriculture, Updated December 2009. "2007 Census of Agriculture". AC-07-A-51. National Agricultural Statistics Service. Available online: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/st48_2_027_027.pdf. Accessed 12/20/2010.

[38] United States Department of Agriculture, Updated December 2009. "Texas Agricultural Statistics, 2008". National Agricultural Statistics Service, Texas Field Office". Available online: http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Annual_Statistical_Bulletin/index.asp. Accessed 12/20/2010.

Table 5-1: Acres Harvested by Crops for Each AACOG County, 2008.

FIPS	County	Corn		Sorghum		Wheat		Cotton		Hay		Peanuts		Oats	
		Planted	Harvest	Planted	Harvest	Planted	Harvest	Planted	Harvest	Planted	Harvest	Planted	Harvest	Planted	Harvest
48013	Atascosa	0	0	0	0	1,700	1,300	3,800	3,600	37,968*	37,968*	4,700	4,500	0	0
48019	Bandera	0	0	0	0	0	0	0	0	5,287*	5,036*	0	0	0	0
48029	Bexar	9,700	8,400	6,100	2,900	5,300	2,200	1,900	1,900	36,979*	36,979*	0	0	2,900	500
48091	Comal	0	0	0	0	0	0	0	0	8,654*	8,654*	0	0	0	0
48163	Frio	0	0	10,100	6,700	12,400	10,500	1,800	1,800	10,581*	10,521*	15,200	15,100	0	0
48171	Gillespie	0	0	0	0	6,200	4,100	0	0	24,594*	23,965*	0	0	6,700	1,300
48187	Guadalupe	21,000	16,600	15,600	13,500	12,400	10,600	0	0	36,007*	36,007*	0	0	2,700	500
48255	Karnes	11,800*	10,900*	6,900*	3,700*	0	0	1,700*	1,700*	35,863*	34,168*	0	0	0	0
48259	Kendall	0	0	0	0	0	0	0	0	9,614*	8,853*	0	0	0	0
48265	Kerr	0	0	0	0	0	0	0	0	6,627*	6,207*	0	0	0	0
48325	Medina	34,700	28,800	16,400	11,100	7,700	2,900	12,200	7,800	28,552*	27,834*	0	0	0	0
48493	Wilson	10,400	6,700	7,000*	5,400*	5,000	2,400	0	0	51,114*	50,204*	0	0	0	0
Total	AACOG	87,600	71,400	62,100	43,300	50,700	34,000	21,400	16,800	291,840	286,396	19,900	19,600	12,300	2,300

*2007 Data

Table 5-2: Typical Agricultural Activity by Month for the AACOG Region

Crop	Months of Agricultural Activity						
	Acres Planted			Acres Harvested			
	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticides (Tractors)	Harvest (Combine)
Corn	**Aug.**	Dec.	Feb.	Feb.**-April**	**April**	March	**July**
Hay	**N/A**	Jan.	March	**April**	**N/A**	**N/A**	**June–Aug.**
Peanuts	March	**Apr.**	**June**	**N/A**	**July-Aug.**	**June-Sept.**	**Sep.**–Nov.
Wheat	**Aug.**	**Sep.**	**Oct.-** Dec.	Jan.	**N/A**	Dec.	**May**
Sorghum	**July-Aug.**	Jan.	**April**	March*****	**May**	March	**July**
Cotton	**Sep.-**Nov.	Feb.	**April**	**May**	**June-Aug.**	**Apr.-May**	**Aug.**
Oats	**Aug.**	**Sep.**	**Oct.**-Dec.	Jan.	**N/A**	Dec.	**May**

N/A = Agricultural activity is not necessary for the indicated crop.
Note: **Bolded** months – occur during the ozone season
*For fertilizing sorghum, acres planted instead of acres harvested were used because fertilizing occurs before planting.

Figures 5-1 and 5-2 compares seasonal use profiles for tractors and combines. The winter season is from December to February and the spring season is from March to May. The summer is between June and August, while the fall season is in September, October, and November. A comparison between default nonroad2008a model, the Pechan report, and AACOG survey data is presented on the graphs.

Figure 5-1: Comparison of Seasonal Use Profiles for Tractor Agricultural Equipment.

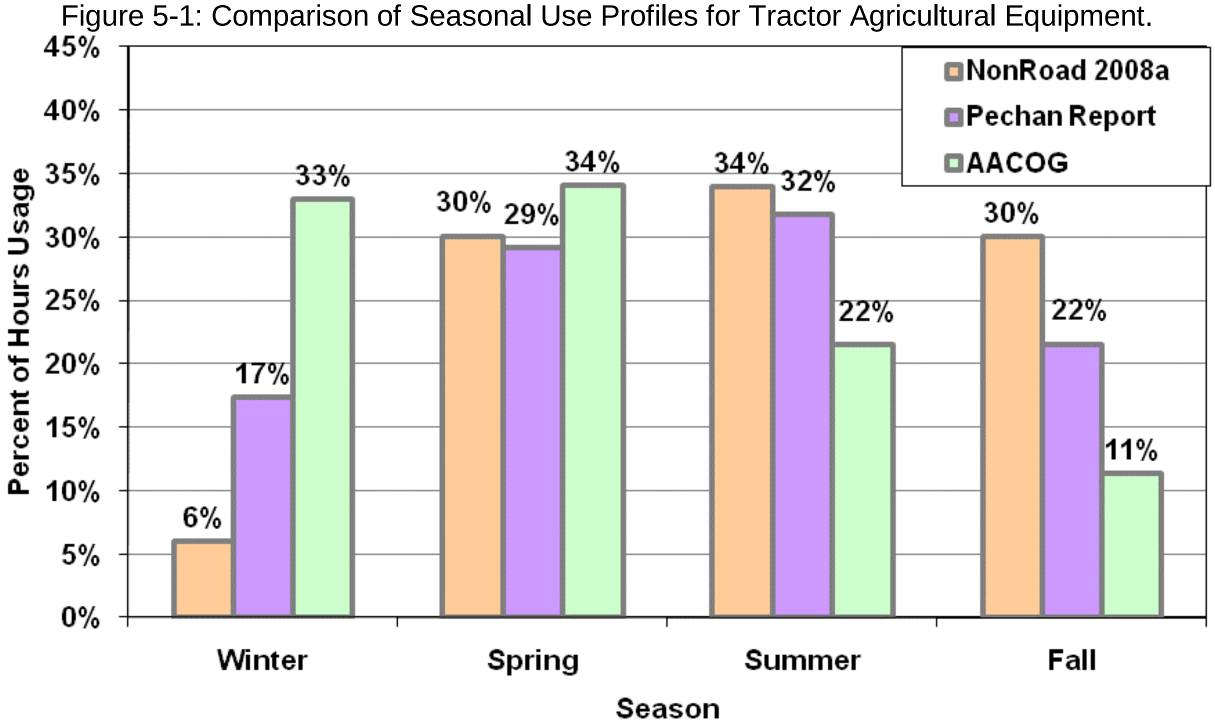
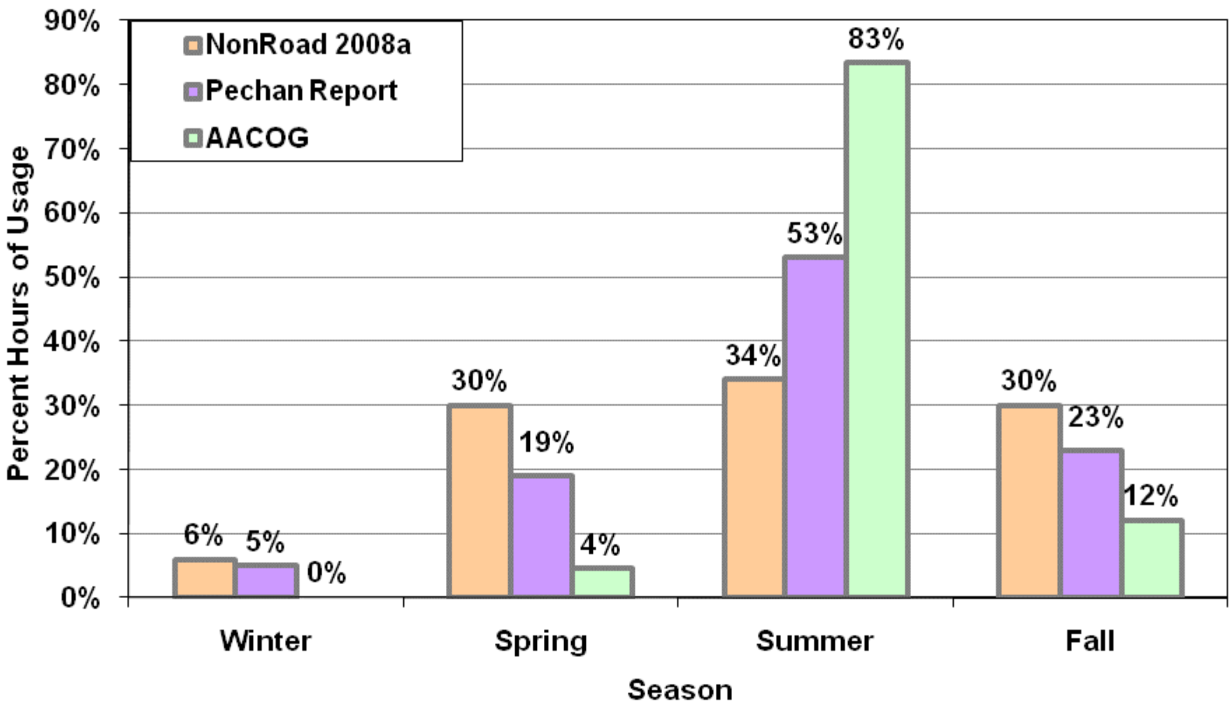


Figure 5-2: Comparison of Seasonal Use Profiles for Combine Agricultural Equipment.



For the tractors, the AACOG region had higher rates of activity than results from the Pechan study and Nonroad2008a model in winter and spring seasons but significantly less activity in the fall and summer seasons. This occurs because local crops like corn, hay, sorghum, and cotton are plowed in the winter season. Planting of local corn and hay takes place during the winter months, while fertilization of wheat and oats also takes place in the winter. Combines, on the other hand, have higher activity in the summer period when most local crops are harvested.

5.2.2. Hourly Rates for Agricultural Activity

The amount of time it takes a tractor or combine to perform an agricultural activity is dependent on crop type. Table 5-3 defines the hours required to complete agricultural activities for one acre of each crop in the AACOG region. Rates are based on data provided by local Texas Agricultural Extension Service County Extension agents and existing TexN idling rates (based on load factor).

The survey did not take into account tractors activity needed for soil preparation and pesticide application. Data from A&M's Texas AgriLife Extension Service's 2011 Texas Crop and Livestock Budgets was used for these categories.[39] Activity rates for the application of pesticides includes: pesticide, fungicide, herbicide, insecticide, and defoliant. Soil preparation involves tillage to remove weeds and crop residue situated in the seedbed. Removal of these weeds eliminates overcrowding or competition for resources such as food and water.

[39] Department of Agricultural Economics: Extension Agricultural Economics, Texas A&M University, 2010. "2011 Texas Crop and Livestock Budgets District 10, Estimated Costs and Returns per Acre". College Station, TX. Available online: http://agecoext.tamu.edu/resources/crop-livestock-budgets/by-district/district-10/2011.html. Accessed 06/10/2011.

Table 5-3: Average Rate to Accomplish Each Agricultural Activity in the AACOG Region, Hour/Acres.

Crop	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticide (Tractors)	Harvest (Combines)
Corn	0.22	0.28	0.28	0.05	0.21	0.15	0.34
Hay	N/A	0.21	0.17	0.05	N/A	N/A	Cut – 0.28 Rake – 0.11 Bale – 0.24
Peanuts	0.39	0.21	0.28	N/A	0.21	0.31	Dig – 0.85 Shake – 0.85
Wheat	0.39	0.21	0.17	0.05	N/A	0.05	0.34
Sorghum	0.63	0.28	0.28	0.05	0.21	0.17	0.34
Cotton	1.03	0.28	0.28	0.05	0.21	0.15	0.42
Oats	0.39	0.21	0.17	0.05	N/A	0.05	0.34

The results of AACOG survey were compared to A&M's Texas AgriLife Extension Service's 2011 Texas Crop and Livestock Budgets. Irrigate spring crops where used from Texas A&M study for the comparison because it matches most of the crops harvested in the AACOG region. Table 5-4 provides seasonal agricultural activities comparisons between AACOG survey results and Texas A&M, while table 5-5 compares acres per hour for each agricultural activity. AACOG's survey did not record agricultural activity for the cultivating of wheat and oats.

The application of fertilizer to cotton crops was the only significant difference between Texas A&M and AACOG's survey results for the monthly allocation of agricultural activities. Texas A&M stated that fertilization operations occurred in November while the results of the agricultural survey indicated that fertilization occurs in May. According to Texas Cooperative Extension, it is better to apply one half to two-thirds of the cotton fertilizer as side dressing between first square and first bloom in the spring.[40] According to Texas A&M, sorghum is also planted earlier in January than the results from AACOG study indicate (April).

The amount of time to perform each agricultural activity is similar between the two studies. AACOG survey found it took longer to plant wheat and oats, while the Texas AgriLife Extension Service reported it took longer to plow peanuts and cotton. Also, the time to fertilize corn, sorghum, and cotton was longer according to Texas AgriLife Extension Service. As shown in table 5-6, although Texas A&M estimates that production hours for corn, peanut and cotton crops were higher than AACOG survey results, the average difference was only 29%. Overall, there was only a small difference between Texas A&M estimations of tractor hours per acre and AACOG survey results. Texas A&M results were 16% higher than the survey results when the weighted average of 1.31 hours per acre from the AACOG survey was compared to 1.51 hours per acre from Texas A&M.

[40] Hons, F. M. *et al.* "Managing Nitrogen Fertilization in Cotton". Texas Cooperative Extension, The Texas A&M University System, L-5458 11-04. p. 3-4. Available Online: http://www.cottoninc.com/Agronomy/ManagingNitrogenFertilizationInCotton/ManagingNitrogenFertilizationInCotton.pdf. Accessed 06/10/11.

Table 5-4: Comparision Between AACOG Survey Results and Texas A&M Agricultural Activity by Month for the AACOG Region

Crop	AACOG							Texas A&M						
	Acres Planted			Acres Harvested				Acres Planted			Acres Harvested			
	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticides (Tractors)	Harvest (Combines)	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticides (Tractors)	Harvest (Combines)
Corn	Aug.	Dec.	Feb.	Feb.-Apr.	April	March	July	Aug.	Oct.	Feb.	Feb.	March	March	Aug.
Hay	N/A	Jan.	Mar.	Apr.	N/A	N/A	Jun.–Aug.	Not provided						
Peanuts	March	April	Jun.	N/A	Jul.- Aug.	June-Sept.	Sep.–Nov.	March	May	May	N/A	June	June-Sept.	Oct.
Wheat	Aug.	Sep.	Oct.- Dec.	Jan.	N/A	Dec.	May	Aug.	Oct.	Dec.	Dec.	Dec.	Dec.	May
Sorghum	July-Aug.	Jan.	April	March	May	March	July	July-Aug.	Dec.	Jan.	Jan.	May	March	July
Cotton	Sep.-Nov.	Feb.	April	May	Jun.- Aug.	Apr.-May	Aug.	Sep.-Nov.	Jan.-Mar.	Mar.	Nov.	June	Apr.-May	Aug.
Oats	Aug.	Sep.	Oct.- Dec.	Jan.	N/A	Dec.	May	Aug.	Oct.	Dec.	Dec.	Dec.	Dec.	May

Table 5-5: Comparision Between AACOG Survey Results and Texas A&M Average Rate to Accomplish Each Agricultural Activity

Crop	AACOG (Acres/Hour)							Texas A&M (Acres/Hour)						
	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticides (Tractors)	Harvest (Combines)	Soil Prep. (Tractors)	Plow (Tractors)	Plant (Tractors)	Fertilize (Tractors)	Cultivate (Tractors)	Pesticides (Tractors)	Harvest (Combines)
Corn	8	6	6	35	8	11	5	8	4	7	7	5	11	Not provided
Hay		8	10	35			Cut - 6 Rake - 15 Bale - 7	Not Provided						
Peanuts	4	8	6		8	5	Dig - 2 Shake - 2	4	3	4		8	5	Dig - 1 Shake - 2
Wheat	4	8	10	35		36	5	4	10	36	36	15	36	Not provided
Sorghum	3	6	6	35	8	10	5	3	8	9	7	10	10	Not provided
Cotton	2	6	6	35	8	11	4	2	3	7	7	10	11	Not provided
Oats	4	8	10	35		36	5	4	10	36	36	15	36	Not provided

Table 5-6: Comparision between AACOG survey Results and Texas A&M Agricultural Activity for Total Tractor Hours per acre by Crop Type

Crop*#	**AACOG Survey**	**Texas A&M**
Corn	**1.20**	**1.61**
Peanuts	**1.41**	**1.82**
Wheat	**0.87**	**0.83**
Sorghum	**1.62**	**1.64**
Cotton	**2.01**	**2.46**
Oats	**0.87**	**0.83**
Weighted Average**	**1.31**	**1.51**

*Not including Hay production because Texas A&M did not provide values for Hay
#Including TexN idling time/load factor for tractors
**Weighted by crop acres in the AACOG region

To calculate annual hours of use for tractors and combines, the number of acres for each crop type is multiplied by the time to complete each agricultural activity. The following formula was used to calculate hours of tractor usage for each county.

Equation 5-1, Annual Hours for Tractors and Combines

$$HRS_A = (PACRES_A \times PREP_A) + (PACRES_A \times PLOW_A) + (PACRES_A \times PLANT_A) + (HACRES_A \times FER_A) + (HACRES_A \times CUL_A) + (HACRES_A \times PEST_A)$$

Where,

HRS_A = Annual tractor hours for crop type A
$PACRE_A$ = Number of acres planted for crop type A (from 2008 Texas Agricultural Statistics Report)
$HACRE_A$= Number of acres harvested for crop type A (from 2008 Texas Agricultural Statistics Report)
$PREP_A$ = Amount of time to prepare one acre of soil for crop type A (from survey)
$PLOW_A$ = Amount of time to plow one acre for crop type A (from survey)
$PLANT_A$ = Amount of time to plant one acre for crop type A (from survey)
FER_A = Amount of time to fertilize one acre for crop type A (from survey)
CUL_A = Amount of time to cultivate one acre for crop type A (from survey)
$PEST_A$ = Amount of time to apply pesticide to one acre for crop type A (from survey)

Sample equation - Hours of tractor usage in Atascosa County, 4,700 acres of peanuts planted and 4,500 acres of peanuts harvested

$$HRS_A = (4{,}700 \times 0.39) + (4{,}700 \times 0.21) + (4{,}700 \times 0.28) + (4{,}500 \times 0.00) + (4{,}500 \times 0.21) + (4{,}500 \times 0.31)$$
$$= 6{,}521 \text{ hours}$$

A comparison of annual hours of use for tractors and combines from Nonroad2008a, TexNR and AACOG data (by county) was performed. Figures 5-3 and 5-4 show that the AACOG region hours were significantly less than the Nonroad2008a and TexNR model for tractors, but combine use in the AACOG region was higher than both models.

Figure 5-3: Comparisons of Nonroad2008a, TexN Model, and AACOG Annual Hours of Usage for Agricultural Tractors.

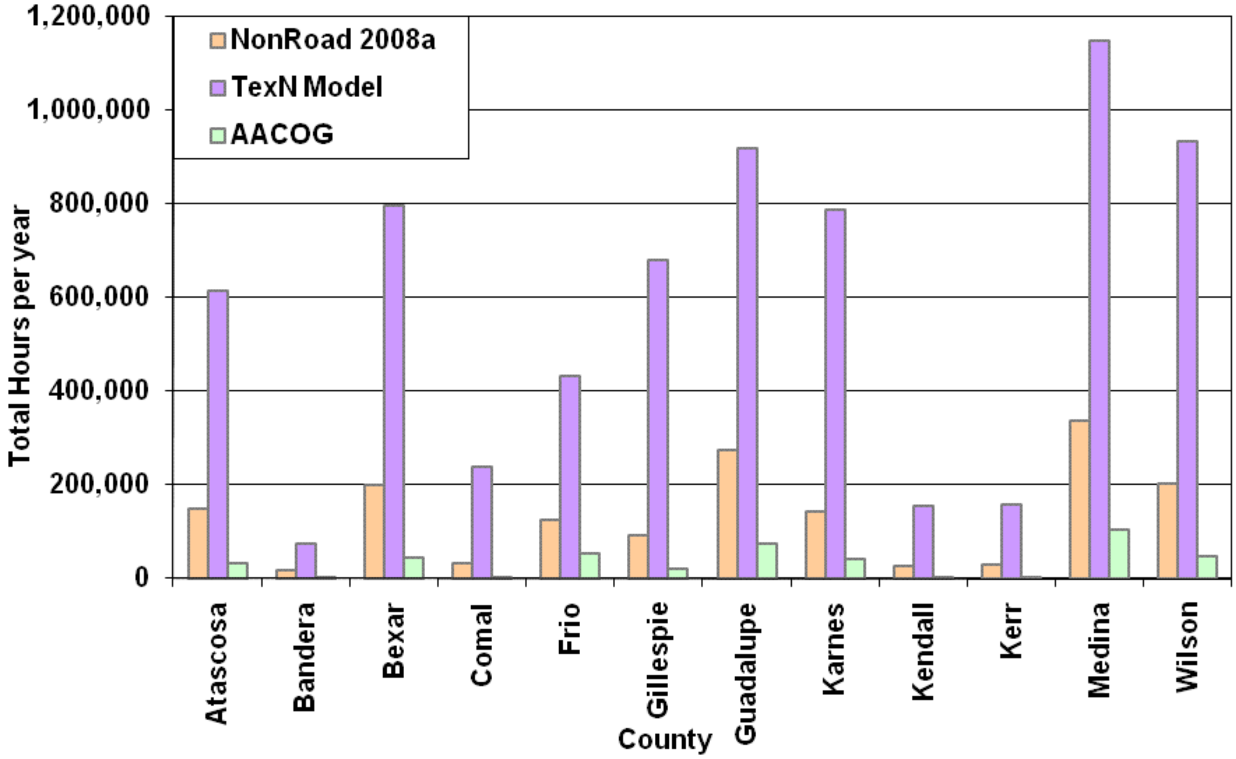
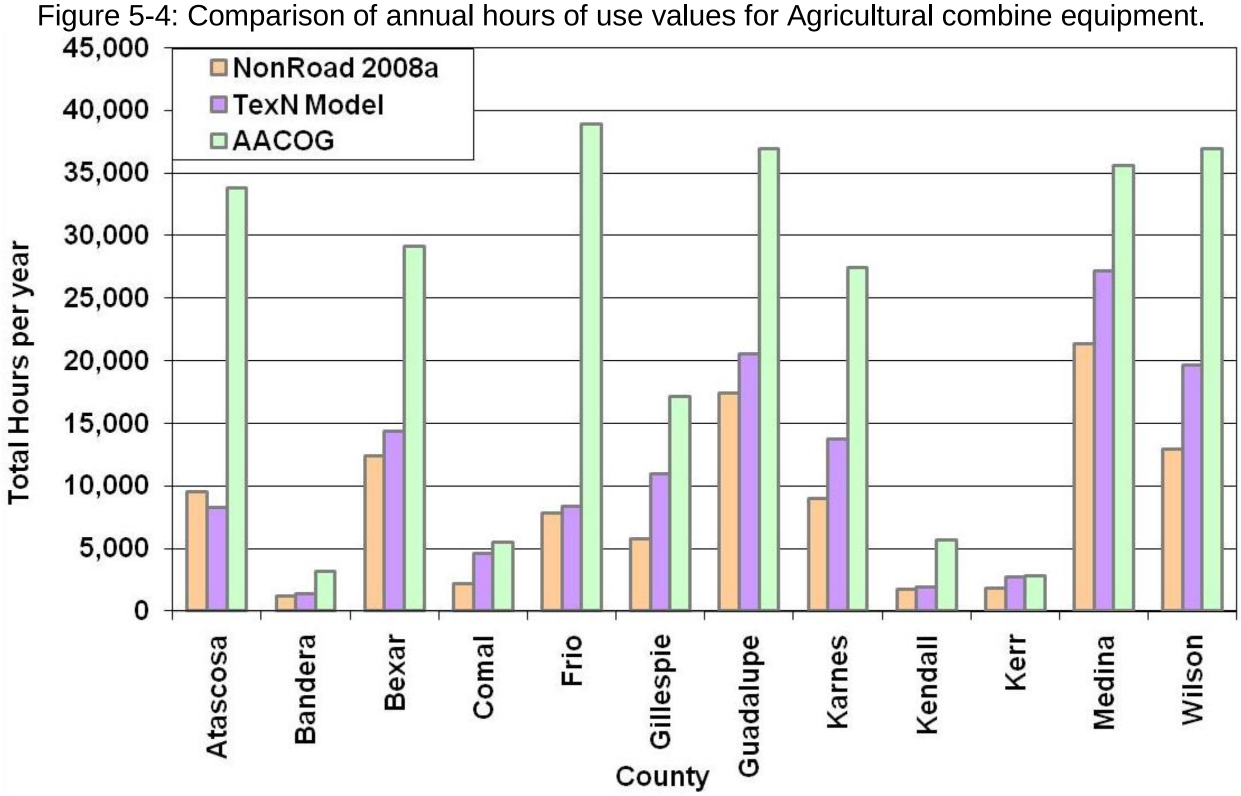


Figure 5-4: Comparison of annual hours of use values for Agricultural combine equipment.



To calculate average daily ozone season tractor and combine usage, the number of acres for each crop is multiplied by the time it takes to complete each agricultural activity and percentage of the activity that occurs during the ozone season.

Equation 5-2, Ozone Season Hours for Tractors and Combines

$$OSD_A = [(PACRES_A \times PREP_A \times PREP\%_A) + (PACRES_A \times PLOW_A \times PLOW\%_A) + (PACRES_A \times PLANT_A \times PLANT\%_A) + (HACRES_A \times FER_A \times FER\%_A) + (HACRES_A \times CUL_A \times CUL\%_A) + (HACRES_A \times PEST_A \times PEST\%_A)] / 214 \text{ days per ozone season}$$

Where,

- OSD_A = Average ozone season daily tractor hours for crop type A
- $PACRE_A$ = Number of acres planted for crop type (from 2008 Texas Agricultural Statistics Report)
- $HACRE_A$ = Number of acres harvested for crop type (from 2008 Texas Agricultural Statistics Report)
- $PREP_A$ = Amount of time to prepare one acre of soil for crop type A (from survey)
- $PREP\%_A$ = Percentage of soil preparation occurs during the ozone season for crop type A (from survey)
- $PLOW_A$ = Amount of time to plow one acre for crop type A (from survey)
- $PLOW\%_A$ = Percentage of plowing occurs during the ozone season for crop type A (from survey)
- $PLANT_A$ = Amount of time to plant one acre for crop type A (from survey)
- $PLANT\%_A$ = Percentage of planting occurs during the ozone season for crop type A (from survey)
- FER_A = Amount of time to fertilize one acre for crop type A (from survey)
- $FER\%_A$ = Percentage of fertilizing occurs during the ozone season for crop type A (from survey)
- CUL_A = Amount of time to cultivate one acre for crop type A (from survey)
- $CUL\%_A$ = Percentage of cultivating occurs during the ozone season for crop type A (from survey)
- $PEST_A$ = Amount of time to apply pesticide to one acre for crop type A (from survey)
- $PEST\%_A$ = Percentage of pesticide application occurs during the ozone season for crop type A (from survey)

Sample equation - Hours of tractor usage in Atascosa County, 4,700 acres of peanuts planted and 4,500 acres of peanuts harvested

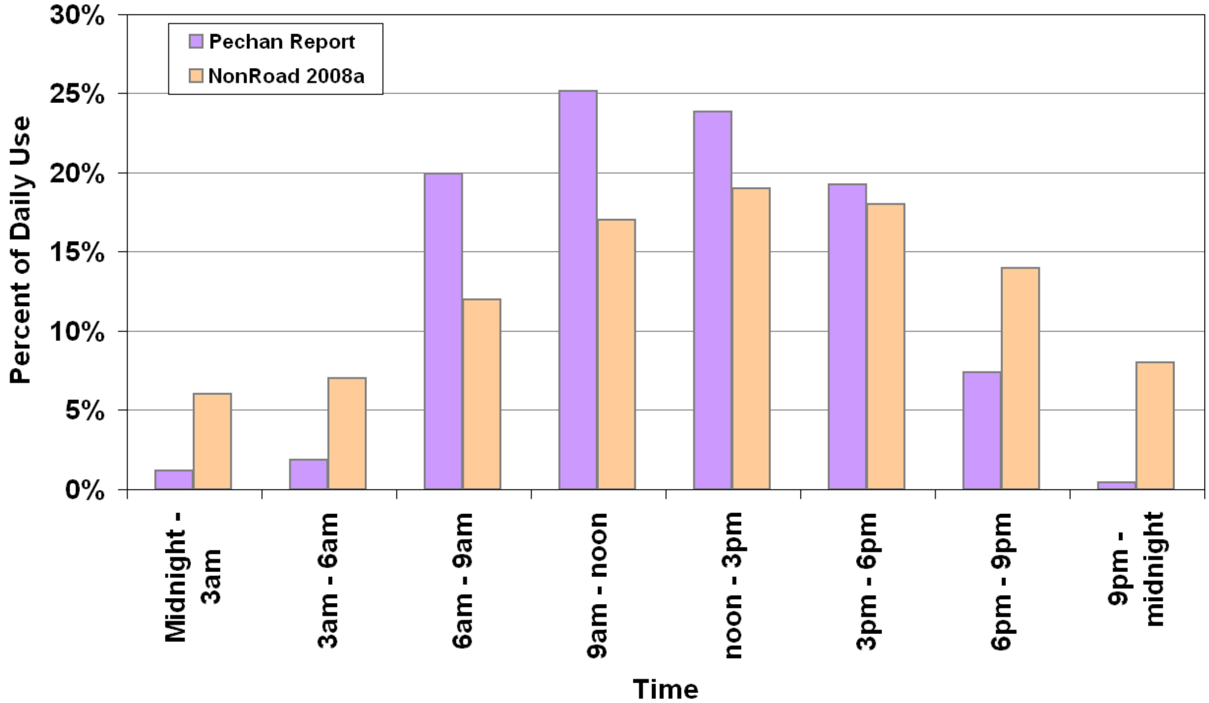
$$OSD_A = [(4{,}700 \times 0.39 \times 0\%) + (4{,}700 \times 0.21 \times 100\%) + (4{,}700 \times 0.28 \times 100\%) + (4{,}500 \times 0.00 \times 0\%) + (4{,}500 \times 0.21 \times 100\%) + (4{,}500 \times 0.31 \times 100\%)] / 214 \text{ days per ozone season}$$

$$= 22 \text{ hours}$$

5.2.3. Agricultural Equipment Diurnal Profiles

A comparison of agricultural equipment diurnal profile from Pechan and EPA's (Nonroad2008a) default data is provided in figure 5-5. Pechan's data showed lower activity rates at nighttime and higher equipment usage between 6 am and 3 pm compared to the Nonroad2008a default data. Since AACOG survey did not record information on diurnal cycles, Pechan's survey data was used to allocate tractor and combine emissions by hour for the June 2006 photochemical model.

Figure 5-5: Comparison of Agricultural Equipment Diurnal Profiles



5.3. Emissions from Tractors and Combines

Local activity data provided above and existing data in the TexN Model were used to calculate tractor and combine emissions by county. Emissions estimates were based on activity data, horsepower, load factor, emission factors, and fuel ratio (Table 5-7). The TexN Model run specifications are:

- Analysis Year = 2006
- Max Tech. Year = 2006
- Met Year = Typical Year
- Period = Annual
- Summation Type = Annual
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = Bexar County
- Sources = Tractors and Combines Agriculture Equipment

The formula used to calculate for VOC and NO_X emissions is provided below.

Equation 5-3, Annual Emissions for Tractors and Combines

AE_{AB} = (HRS_A x HP_B x LF_B x EF_B x $Fuel_B$) / 907,184.74 grams/ton

Where,

AE_{AB} = Annual emissions for crop type A equipment type B (tons/yr)
HRS_A = Annual hours for crop type A (hrs/acre) (from equation 5-1)
HP_B = Average rated horsepower for equipment type B (hp) (from TexN Model, Table 5-7)
LF_B = Typical load factor for equipment type B (from TexN Model, Table 5-7)

EF_B = Average emissions factor per unit of use for equipment type B (g/hp-hr) (from TexN Model, Table 5-7)
$Fuel_B$ = Fuel ratio for equipment type B (percentage of 2-wheel 4-stroke, 4-stroke, 2-wheel diesel, or diesel from TexN Model, Table 5-7)

Table 5-7: Bexar County 2006 Emission Factors for Tractor and Combine Equipment from the TexN Model

Type	Engine/Equipment	SCC	Fuel Ratio	HP	Load Factor	VOC EF	NO_X EF
Tractors	4-stroke 2-Wheel Tractors	2265005010	0.0023	11	0.62	10.361	3.017
	4-stroke Tractors	2265005015	0.0132	57	0.62	7.361	7.038
	Diesel 2-Wheel Tractors	2270005010	0.0710	8	0.59	0.839	4.539
	Diesel Tractors	2270005015	0.9135	132	0.59	0.377	4.45
Combines	4-stroke	2265005020	0.0106	122	0.74	13.408	7.998
	Diesel	2270005020	0.9894	190	0.59	0.543	5.559

Sample equation - Diesel tractors annual emissions for peanuts in Atascosa County
AE_{AB} = (6,205 hours x 132.04 hp x 0.59 x 4.445 grams of NO_X/hp-hr x 0.9135) / 907,184.74 grams/ton
= 2.27 tons/year

Equation 5-4, Ozone Season Daily Emissions from Tractors and Combines
DE_{AB} = OSD_A x HP_B x LF_B x EF_B x $Fuel_B$ / 907,184.74 grams/ton

Where,
DE_{AB} = Ozone Season Day emissions for crop type A and equipment type B (tons/day)
OSD_A = Average ozone season daily hours for crop type A (hrs/acre) (from equation 5-2)
HP_B = Average rated horsepower for equipment type B (hp) (from TexN Model, Table 5-7)
LF_B = Typical load factor for equipment type B (from TexN Model, Table 5-7)
EF_B = Average emissions factor per unit of use for equipment type B (g/hp-hr) (from TexN Model, Table 5-7)
$Fuel_B$ = Fuel ratio for equipment type B (percentage of 2-wheel 4-stroke, 4-stroke, 2-wheel diesel, or diesel from TexN Model, Table 5-7)

Sample equation - Diesel tractors ozone season daily emission for peanuts in Atascosa County
DE_{AB} = (22 hours x 132.04 hp x 0.59 x 4.445 grams of NO_X/hp-hr x 0.9135) / 907,184.74 grams/ton
= 0.00760 tons/day.

Figure 5-6 shows annual NO_X emissions from tractors by county, while figure 5-7 provides annual combine NO_X emissions by county. As expect, emission results for tractors are lower than the Nonroad2008a model estimations and much less then the TexN Model because annual hours from the survey results are much lower than existing data in both models. On average, combine emissions are about 53% higher than the Nonroad2008a and TexN Model. Table 5-8 and 5-9 provides detail data by county and fuel type for annual tractor and combine emissions. The breakdown by fuel type for tractors and combines are based on existing data in the TexN model.

Figure 5-6: Comparison of Annual NO_X Emissions for Tractor Agricultural Equipment

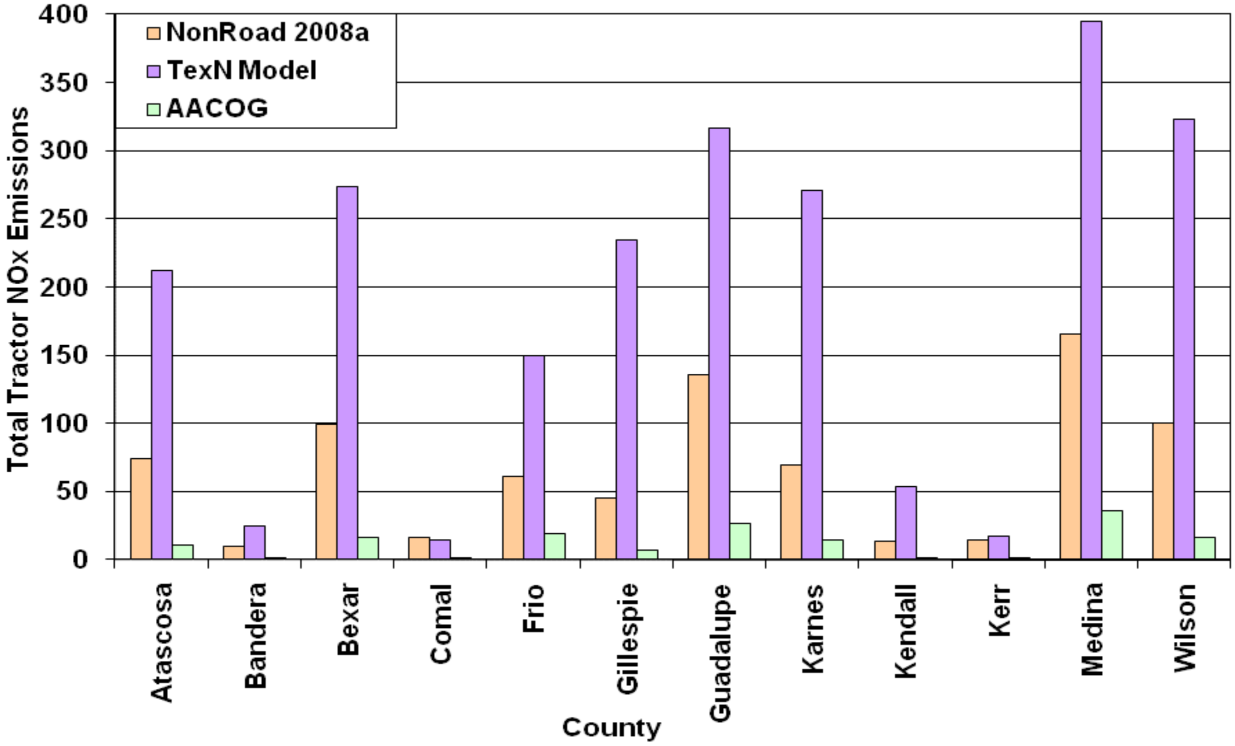


Figure 5-7: Comparison of Annual NO_X Emissions for Combine Agricultural Equipment

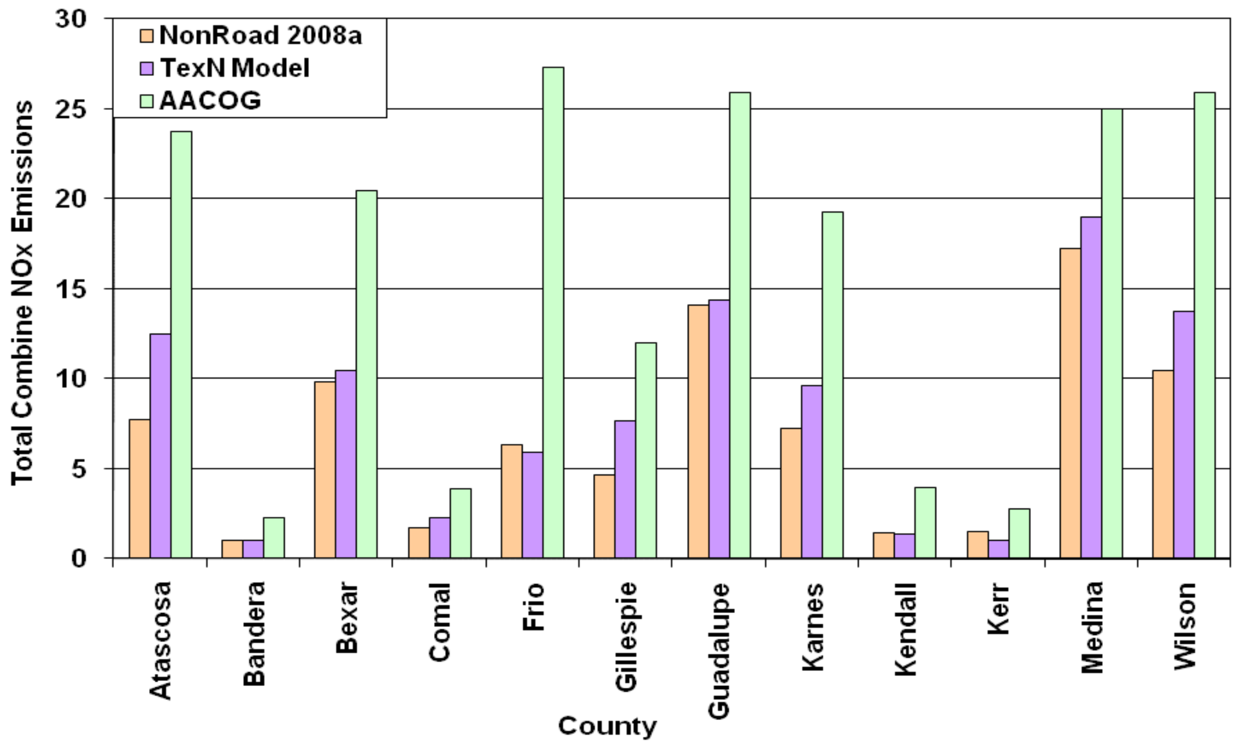


Table 5-8: Annual VOC and NO_X Emissions from Tractors in the AACOG Regions

County	2-wheel 4-Stroke Tractor (tons/year)		4-Stroke Tractor (tons/year)		2-Wheel Diesel Tractor (tons/year)		Diesel Tractor (tons/year)		Total Tractor (tons/year)	
	VOC	NO_X	VOC	NO_X	VOC	NO_X	VOC	NO_X	VOC	NO_X
Atascosa	0.01	0.00	0.12	0.12	0.01	0.05	0.94	11.11	1.08	11.28
Bandera	0.00	0.00	0.01	0.01	0.00	0.00	0.07	0.79	0.08	0.80
Bexar	0.01	0.00	0.17	0.17	0.01	0.08	1.36	16.08	1.56	16.32
Comal	0.00	0.00	0.01	0.01	0.00	0.01	0.11	1.30	0.13	1.32
Frio	0.01	0.00	0.21	0.20	0.02	0.09	1.63	19.27	1.87	19.56
Gillespie	0.00	0.00	0.08	0.08	0.01	0.03	0.62	7.35	0.71	7.46
Guadalupe	0.01	0.00	0.29	0.28	0.02	0.13	2.25	26.54	2.57	26.95
Karnes	0.01	0.00	0.16	0.15	0.01	0.07	1.26	14.82	1.44	15.05
Kendall	0.00	0.00	0.02	0.01	0.00	0.01	0.12	1.43	0.14	1.45
Kerr	0.00	0.00	0.01	0.01	0.00	0.00	0.08	0.99	0.10	1.00
Medina	0.02	0.01	0.40	0.38	0.03	0.17	3.10	36.60	3.55	37.16
Wilson	0.01	0.00	0.18	0.17	0.01	0.08	1.41	16.64	1.61	16.89
Total	0.08	0.02	1.66	1.59	0.13	0.72	12.96	152.90	14.83	155.23

Table 5-9: Annual VOC and NO_X Emissions from Combines in the AACOG Regions, 2008

County	4-stroke Combine (tons/year)		Diesel Combine (tons/year)		Total Combine (tons/year)	
	VOC	NO_X	VOC	NO_X	VOC	NO_X
Atascosa	0.48	0.29	2.24	22.98	2.72	23.27
Bandera	0.05	0.03	0.21	2.18	0.26	2.21
Bexar	0.41	0.25	1.93	19.80	2.35	20.05
Comal	0.08	0.05	0.37	3.75	0.44	3.80
Frio	0.55	0.33	2.58	26.44	3.13	26.77
Gillespie	0.24	0.15	1.14	11.63	1.38	11.78
Guadalupe	0.53	0.31	2.45	25.10	2.98	25.42
Karnes	0.39	0.23	1.82	18.67	2.21	18.90
Kendall	0.08	0.05	0.37	3.84	0.45	3.89
Kerr	0.06	0.03	0.26	2.69	0.32	2.72
Medina	0.51	0.30	2.36	24.18	2.87	24.48
Wilson	0.53	0.31	2.45	25.10	2.98	25.42
Total	3.90	2.33	18.19	186.37	22.09	188.70

5.4. Spatial Allocation of Emissions

Data from the Natural Agricultural Statistics Service was used to geo-code tractor and combine emissions.[41] The following crops were identified and used to estimate acres in each 4km grid square:

- Corn
- Pasture/Hay
- Peanuts

[41] National Agricultural Statistics Service. "CropScape – Cropland Data Layer". United States Department of Agriculture. Available online: http://nassgeodata.gmu.edu/CropScape/. Accessed 06/06/2011.

- Wheat
- Sorghum
- Cotton
- Oats

Maps of crops acres provided in figure 5-8 were check with satellite imagery to make sure location of crops were accurate. While peanut and cotton crops are grown in the southwest part of AACOG's region, oats are commonly grown in the eastern and northern sections of AACOG's region. Corn, wheat, and sorghum are mostly grown in the southern part of the region. There are few crops in Kerr, Kendall, and Bandera because the soils in these counties are not suitable for extensive crop production.

Once crop locations were identified, tractor and combine emissions were spatially allocated to the 4-km photochemical grid system used in the June 2006 photochemical model (figure 5-9). VOC and NO_X average ozone season day emissions from tractors and combines were allocated to the location of each crop type. Monthly allocation of emissions in table 5-10 was used to allocate emissions by day in the June photochemical model. On average, 5.7% of tractor activity occurs during June, while 22.3% of combine activity occurs in June. Combine activity is greater in June compared to tractors because crops in the AACOG region are usually harvested from June to August.

Table 5-10: Monthly Allocation of Emissions

Month	Tractors	Combines
January	18.6%	0.0%
February	6.7%	0.0%
March	17.9%	0.0%
April	11.4%	0.0%
May	2.1%	6.7%
June	5.7%	22.3%
July	4.7%	34.1%
August	13.6%	24.7%
September	6.6%	4.1%
October	2.8%	4.1%
November	2.8%	4.1%
December	6.9%	0.0%
Total	100.0%	100.0%

Updated data was provided to TCEQ in electronic format that can be readily included in TexN Model DCE subsector #1 for agricultural activities. Emission inventory results were converted in EPS3 format for quick inclusion into photochemical models. Several improvements can be implemented to estimating emissions from tractor and combine emissions in future research. If the data will be used for multiple base cases and projections in the photochemical model, crop acreages could be based on a five year averages instead of crop data for one year. Although county total crop acres do not change significant year by year, there are variations in types of crops grown. Another improvement would be to survey local equipment usage for soil preparation and pesticide applications to develop local activity profiles.

Figure 5-8: Acres of Corn, Peanuts, Wheat, Sorghum, Cotton, and Oats for each 4km Photochemical Modeling Grid.

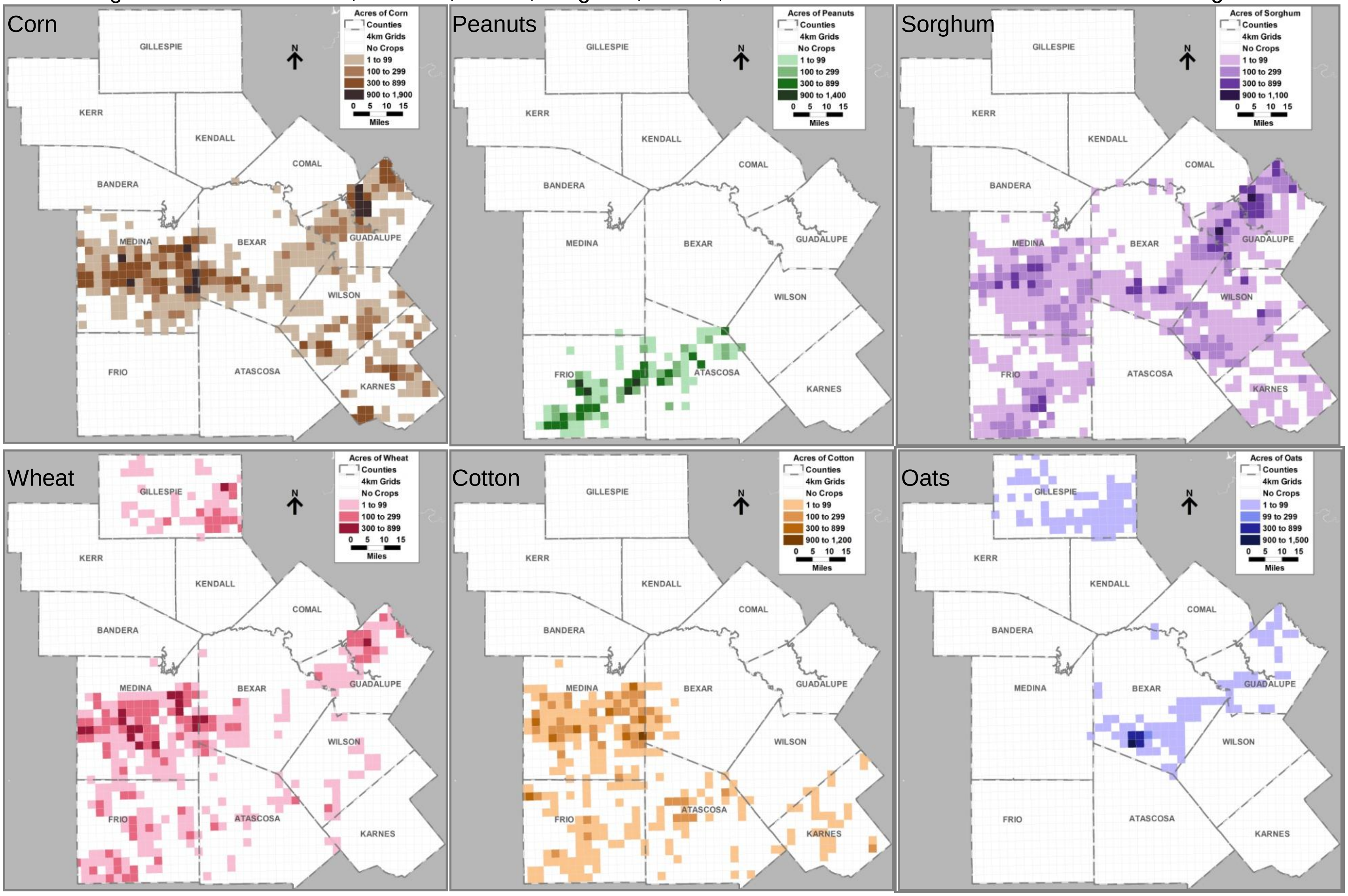


Figure 5-9: Tractor and Combine NO_X Emissions by 4km Photochemical Modeling Grid, Average Ozone Season Day, 2006