Overview of Texas Non-Road Emissions Inventory Development for Air Quality Modeling

Chris Kite
Air Modeling and Data Analysis Section
Air Quality Division

Non-Road Workgroup Conference Call
March 22, 2018

NONROAD Model Background

- The NONROAD model is executable FORTRAN code.

- Current modeling tools exist to automate the running of NONROAD "under the hood" for multiple counties/scenarios:
  - 2014a of the Motor Vehicle Emission Simulator (MOVES2014a);
  - National Mobile Inventory Model (NMIM); and
  - Texas NONROAD (TexN) model at ftp://amdaftp.tceq.texas.gov/EI/nonroad/TexN/.

- With MOVES2014a and NMIM, runs for multiple states/counties based on NONROAD model defaults are relatively easy to setup and execute.

- When developing non-road air quality modeling inventories for non-Texas U.S. counties, the TCEQ:
  - previously used the NMIM model; and
  - currently uses the MOVES2014a model.

- When developing non-road air quality modeling inventories for Texas, the TCEQ has been using the TexN model:
  - automates the running of NONROAD for all 254 Texas counties;
  - divides the county-level equipment population into 25 sub-sectors;
  - for a given scenario (e.g., 2017 Summer weekday), there are 6,350 NONROAD model runs;
  - each run has a customized population input file with a "...pop" extension; and
  - a single TexN run for all 254 Texas counties usually completes in roughly 24 hours.

TexN Model Diesel Construction Equipment (DCE) Sub-Sectors

DCE Code	Diesel Construction Equipment (DCE) Sub-Sector Description
0	Other - Non-Diesel Construction Equipment
1	DCE - Agricultural Activities
2	DCE - Boring and Drilling Equipment
3	DCE - Brick and Stone Operations
4	DCE - City and 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 - Texas Department of Transportation (TxDOT) Construction Equipment
22	DCE - Utility Construction
23	DCE - Mining and Quarry Operation
25	DCE - Off-Road Tractors, Miscellaneous, and Equipment Under 25 Horsepower

Air Quality Modeling Non-Road Inventories Developed with TexN

- Recent non-road inventories associated with attainment demonstration State Implementation Plan (SIP) modeling for the eight-county Houston-Galveston-Brazoria area are available at:
  - ftp://amdaftp.tceq.texas.gov/EI/2012_episodes/hgb_sip/base_2012/nonroad/tex/texn/ for the 2012 base case; and
  - ftp://amdaftp.tceq.texas.gov/EI/2012_episodes/hgb_sip/future_2017/nonroad/tex/texn/ for the 2017 future year.
- For each Texas county, there are 25 directories:
  - 2017_SUM_WKD_48001_00, which is for a 2017 Summer weekday in Anderson County for the DCE sub-sector coded "0"; and
  - there are 24 other directories labeled 2017_SUM_WKD_48001_01 through 2017_SUM_WKD_48001_25 for the remaining DCE sub-sectors.
- Within each sub-directory are the following NONROAD input and output files:
  - **act.dat**: contains the load factor and hours per year activity data by source classification code (SCC) for the run, mostly based on NONROAD model defaults;
  - **nonroad.opt**: NONROAD model input file specifying the period, options, region, SCCs, population files, etc. for the run;
  - **nr.bmv**: evaporative emissions by SCC, horsepower (HP) bin, technology type, and model year;
  - **nr.bmx**: exhaust emissions by SCC, HP bin, technology type, and model year;
  - **nr.msg**: message file for the NONROAD run;
  - **nr.out**: exhaust and evaporative emissions by SCC and HP bin (no technology type or model year detail); and
  - **tx.pop**: equipment population estimates by SCC and HP bin for the year of the scenario (not the default base year).
- The TCEQ has developed in-house LINUX and SAS scripts to aggregate and summarize the various output files for reporting and subsequent emissions processing.
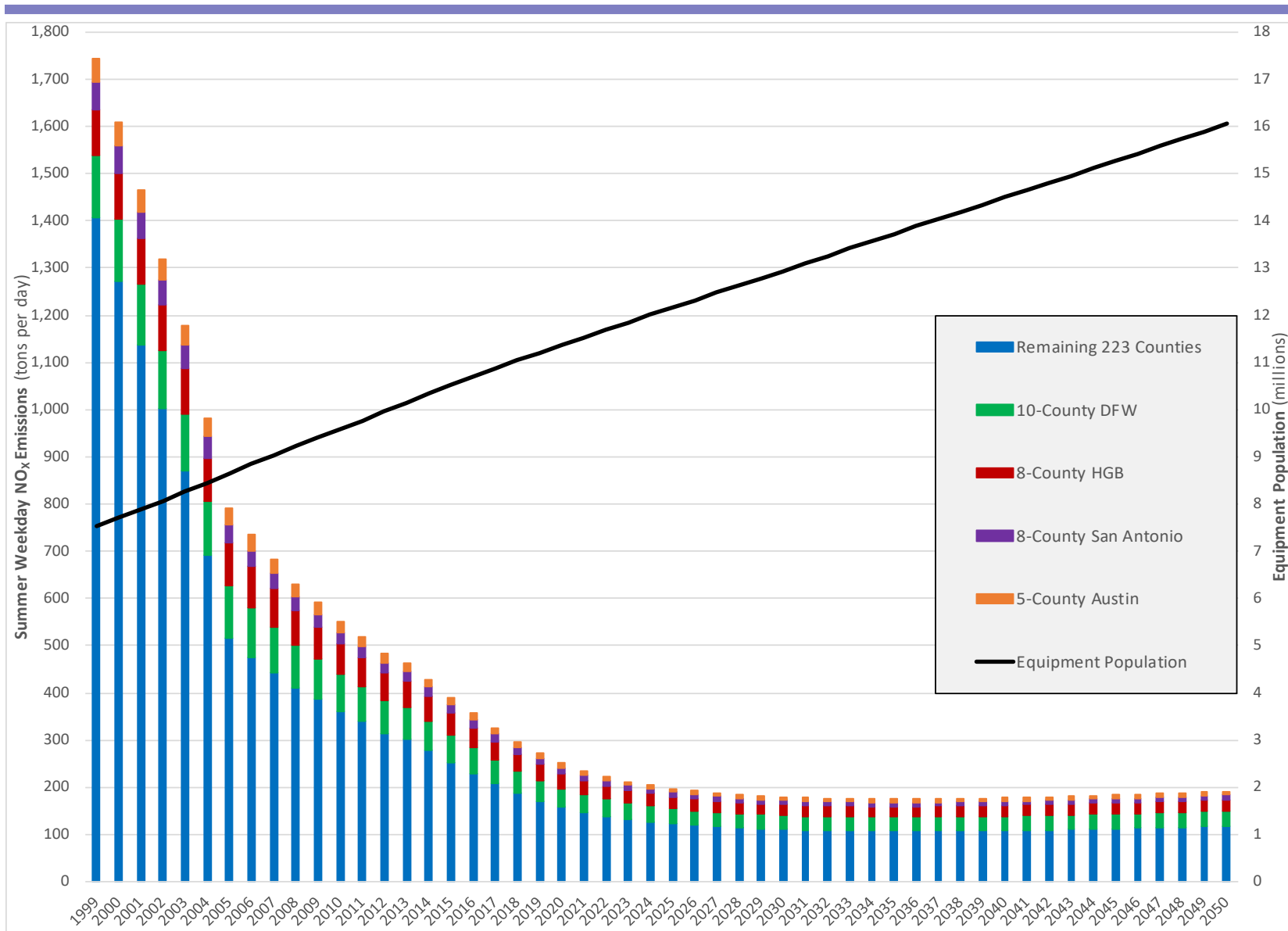
Incorporation of Various Non-Road Equipment Population Studies into TexN

- The TCEQ has funded numerous studies over the past several years to develop local equipment population estimates for significant non-road NO_x emission sources, such as diesel construction and agricultural equipment.

- Some of these studies are available on the TCEQ Air Quality Research and Contract Reports Web page: https://www.tceq.texas.gov/airquality/airmod/project/pj_report_ei.html

  - *Statewide Diesel Construction Equipment Inventory*, August 2005, Eastern Research Group
  - *Update of Diesel Construction Equipment Emission Estimates for the State of Texas – Phase I and II*, July 2009, Eastern Research Group
  - *Development of Emissions Inventory of Agricultural Equipment in All Texas Counties*, August 2009, E.H. Pechan & Associates

- The equipment population estimates from these studies have been incorporated into MySQL database tables for the TexN model broken out by:

  - 214 source classification codes (SCCs);
  - 18 horsepower (HP) bins;
  - 25 DCE sub-sectors; and
  - 254 Texas counties.

- Within each calendar year:

  - there are 1,410,445 equipment population combinations of SCC, HP bin, DCE sub-sector, and county; and
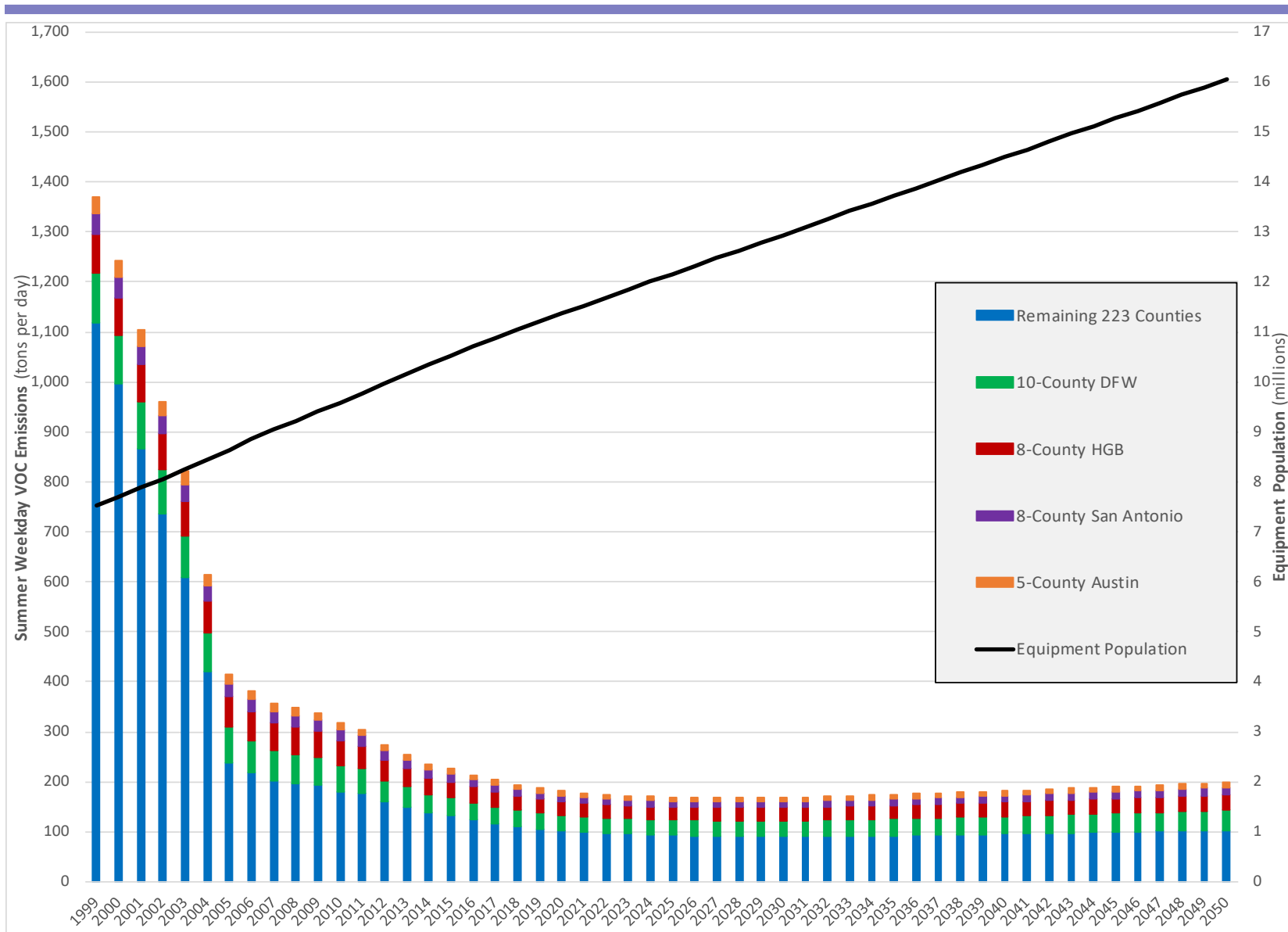 - 300,465 equipment population combinations of SCC, HP bin, and county.

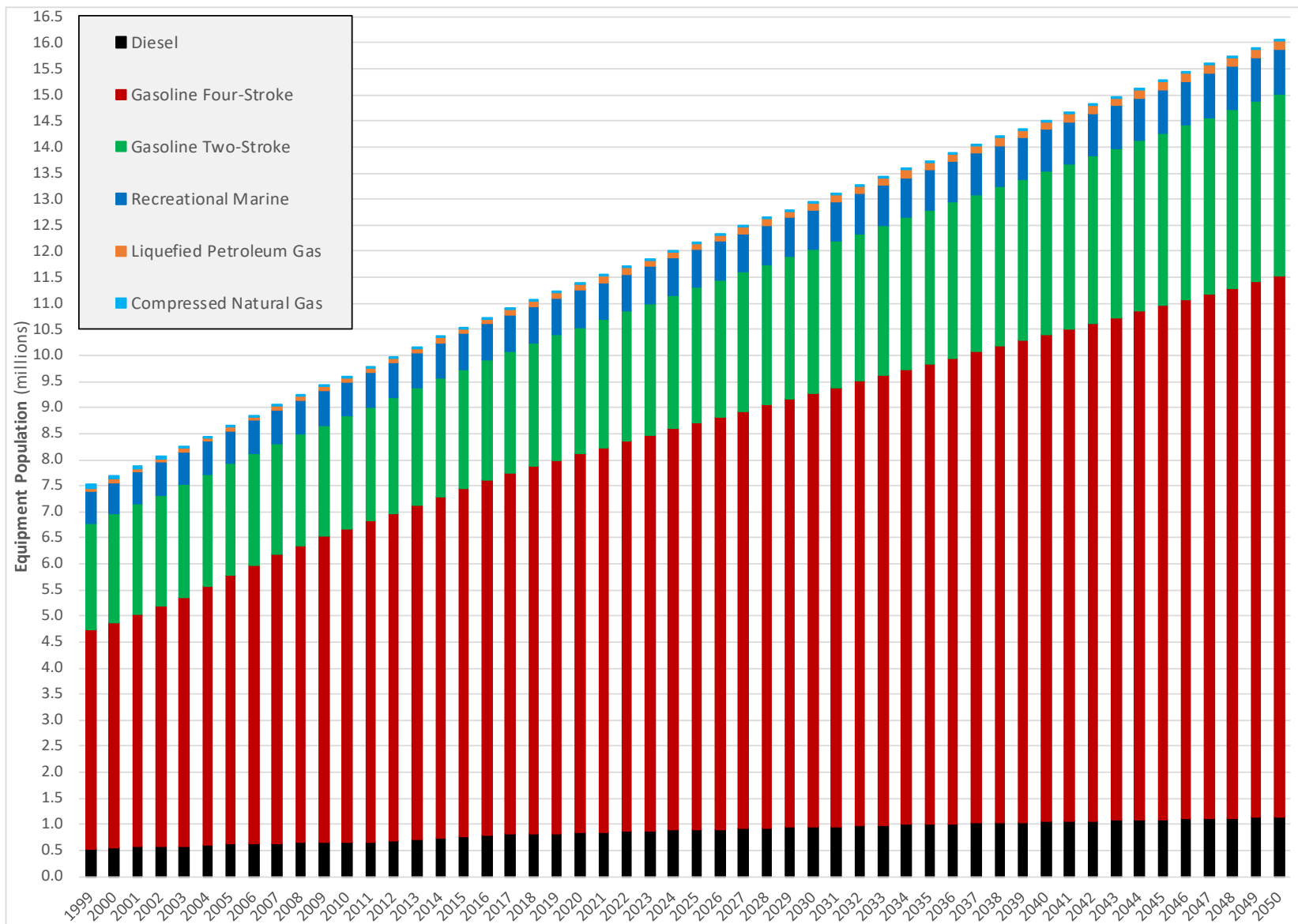# Texas Non-Road NO$_X$ Emission Trends from 1999 through 2050

Legend:
- Remaining 223 Counties
- 10-County DFW
- 8-County HGB
- 8-County San Antonio
- 5-County Austin
- Equipment Population

Texas Non-Road VOC Emission Trends from 1999 through 2050

Texas Non-Road Equipment Population by Fuel/Engine Type

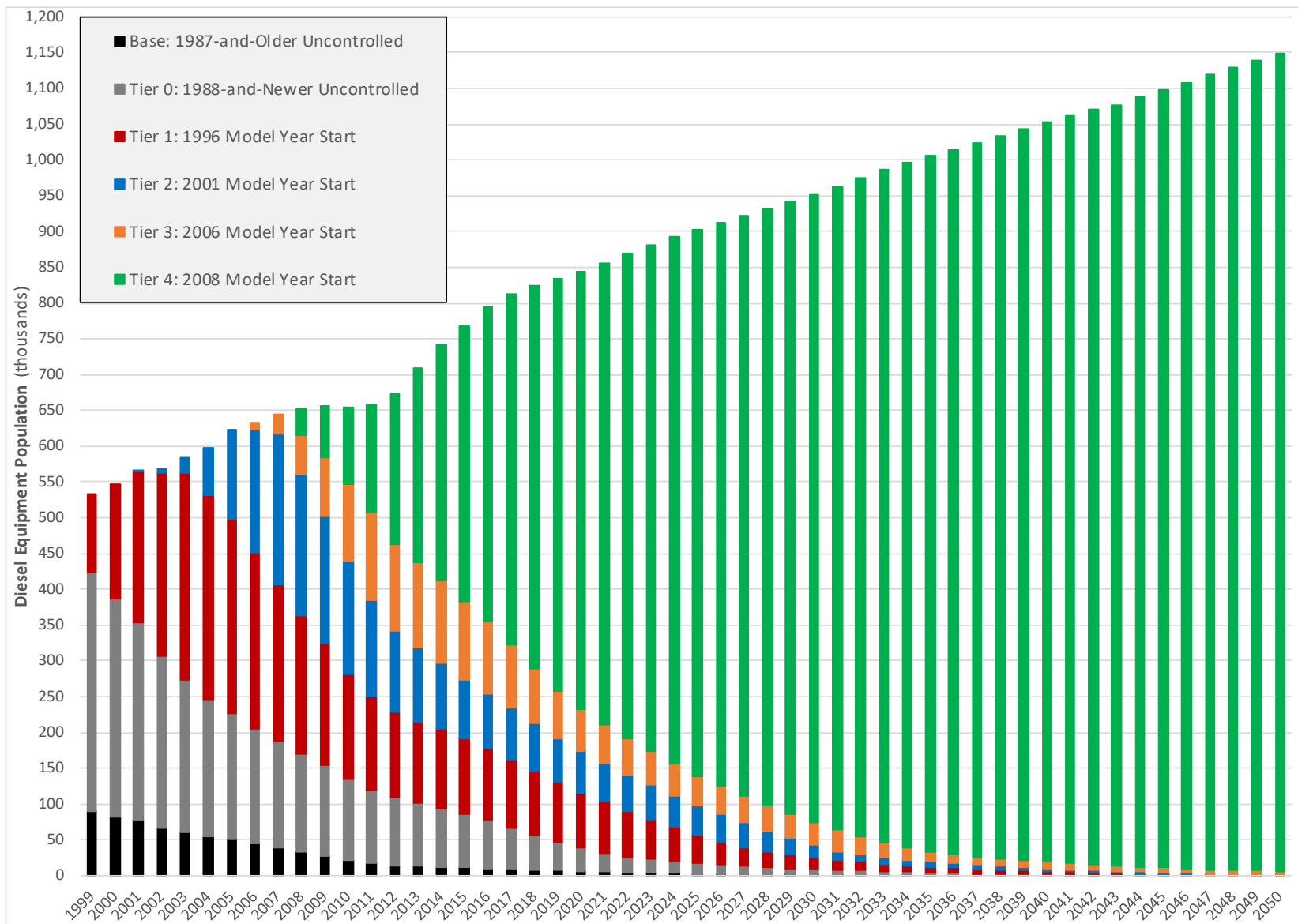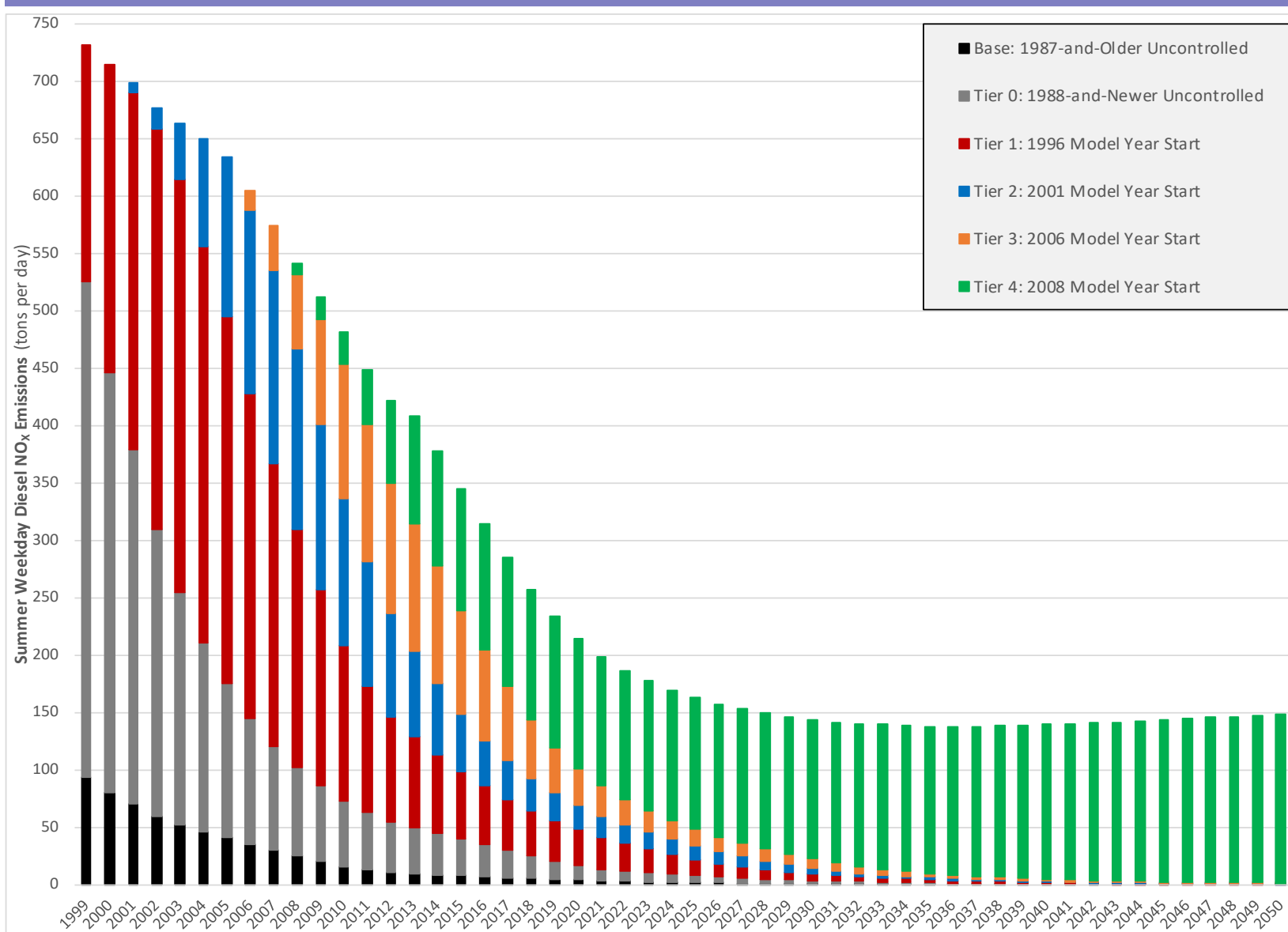# Texas Non-Road NO$_X$ Emissions by Fuel/Engine Type

Summer Weekday NO$_X$ Emissions (tons per day)

Legend:
- Diesel
- Gasoline Four-Stroke
- Gasoline Two-Stroke
- Recreational Marine
- Liquefied Petroleum Gas
- Compressed Natural Gas
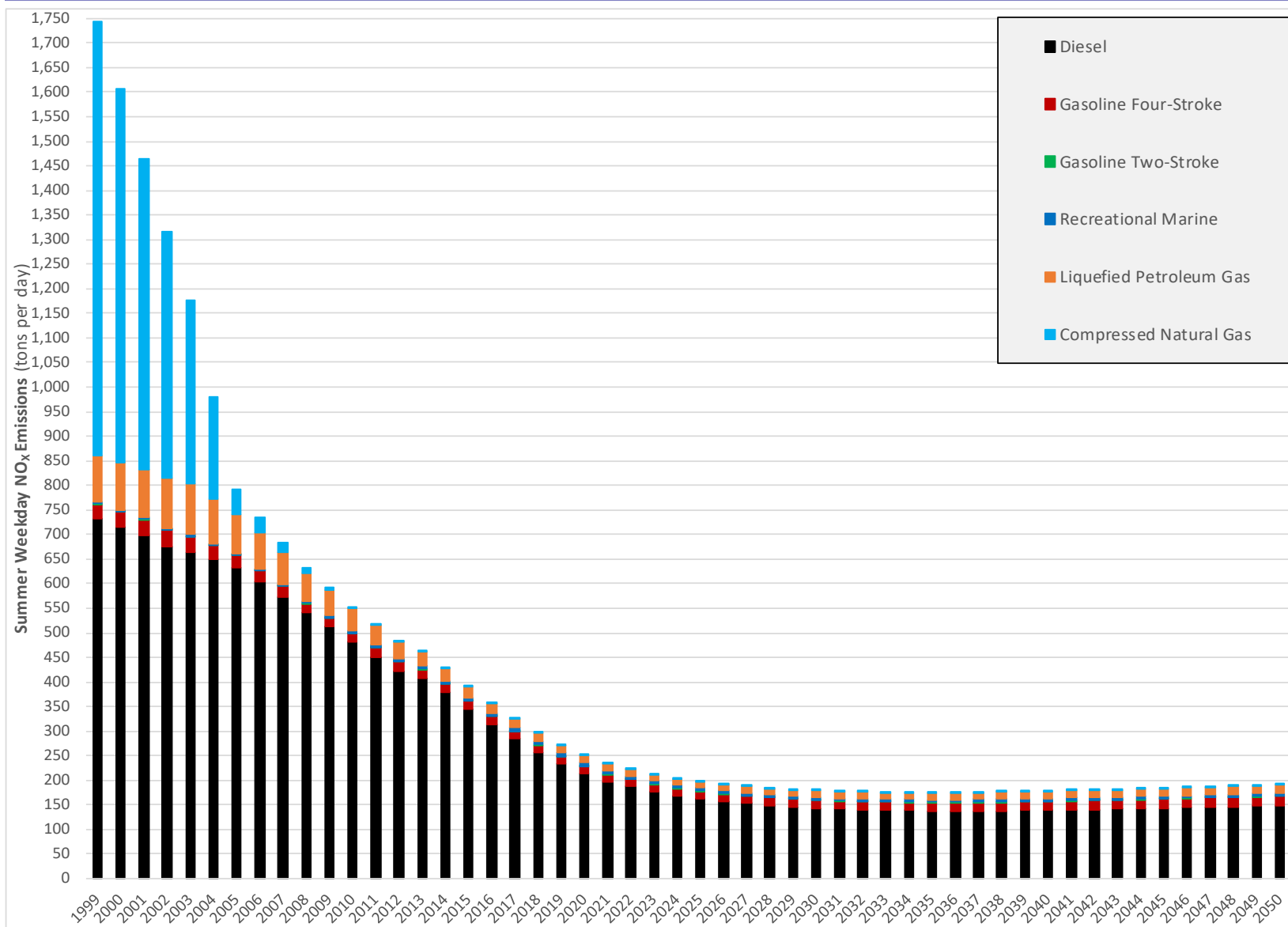
Texas Non-Road Diesel Equipment Population by Certification Standard

Legend:
- Base: 1987-and-Older Uncontrolled
- Tier 0: 1988-and-Newer Uncontrolled
- Tier 1: 1996 Model Year Start
- Tier 2: 2001 Model Year Start
- Tier 3: 2006 Model Year Start
- Tier 4: 2008 Model Year Start

Y-axis: Diesel Equipment Population (thousands)

Texas Non-Road Diesel NOₓ Emissions by Certification Standard

MOVES2014a Non-Road Tables Relevant to Equipment Population

MOVES2014a Table Name	Table Fields			
nrbaseyearequippopulation	sourceTypeID	stateID	population	NRBaseYearID	
nrequipmenttype	NREquipTypeID	description	sectorID	useDefaultScrappage	surrogateID
nrgrowthindex	growthPatternID	yearID	growthIndex		
nrgrowthpattern	growthPatternID	description			
nrgrowthpatternfinder	SCC	stateID	growthPatternID		
nrscc	SCC	NREquipTypeID	description	fuelTypeID	
nrstatesurrogate	surrogateID	stateID	countyID	surrogatequant	surrogateYearID
nrsurrogate	surrogateID	description	surrogateAbbr		

Current MOVES Structure to Project and Allocate State-Level Population

- Under the current structure of MOVES2014a, it is straightforward to develop non-road emissions inventories using the default inputs for equipment population that take a "top-down" allocation approach:

  - The base year population per equipment type at the state level is adjusted to the specified modeling year using growth indices.
  - The state-level population is allocated to counties based on surrogates.

- For example, diesel cranes for four horsepower bins in Texas with 2000 base year:

  - State ID, Base Year, Source Type ID, and Equipment Population from MOVES *nrbaseyearequippopulation* table.
  - The MOVES *nrsourceusetype* table maps unique Source Type IDs to combinations of SCC and HP Bin.
  - The population figures for these categories of diesel cranes in Texas match those reported in the default TX.POP table that comes with NONROAD.

State ID	Base Year	SCC	Source Type ID	HP Bin ID	Equipment Population
48	2000	2270002045	1696	100	245.3
48	2000	2270002045	1697	175	923.7
48	2000	2270002045	1698	300	944.7
48	2000	2270002045	1699	600	581.9

Direct Input of Non-Default County-Level Equipment Population

- There does not appear to be a direct way to incorporate non-default equipment population estimates for various years, counties, SCCs, etc. using a "bottom-up" approach.

- For example, diesel cranes for four horsepower bins in Harris County for 2017:
  - ftp://amdaftp.tceq.texas.gov/EI/2012_episodes/hgb_sip/future_2017/nonroad/tex/texn/
  - The /2017_SUM_WKD_48201_08/ sub-directory is for diesel cranes in Harris County for a 2017 Summer weekday inventory.
  - The tx.pop file contains the equipment population figures for diesel cranes listed below.
  - The current structure of the *nrbaseyearequippopulation* table only allows for state-level population figures by base year.
  - Perhaps a future version of MOVES would have a *nrcountyyearpopulation* table that would allow for direct inputs of equipment population by county FIPS and Source Type ID?

County FIPS Code	Modeling Year	SCC	Source Type ID	HP Bin ID	Equipment Population
48201	2017	2270002045	1696	100	20.9
48201	2017	2270002045	1697	175	1096.6
48201	2017	2270002045	1698	300	660.5
48201	2017	2270002045	1699	600	624.0

Texas Meteorological Inputs for MOVES

- 2016 and 2017 meteorological inputs for Texas are available at
  - ftp://amdaftp.tceq.texas.gov/EI/onroad/met/2016/; and
  - ftp://amdaftp.tceq.texas.gov/EI/onroad/met/2017/.
- Monthly and seasonal (Spring, Summer, Fall, and Winter) inputs are available for:
  - the MOVES *zonemonthhour* database table that has hourly temperature and relative humidity inputs by county; and
  - the MOVES *county* database table that has daily average barometric pressure by county.
- The raw meteorological station data used for developing these inputs were obtained from:
  - National Climatic Data Center (NCDC) files at https://www.ncdc.noaa.gov/orders/qclcd/; and
  - queries of the Texas Air Monitoring Information System (TAMIS) at http://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome.
- Excel spreadsheets are provided showing how the NCDC and TAMIS data sets are used:
  - station data is aggregated and averaged to obtain county-level inputs;
  - inputs are also developed for the 25 multi-county Texas Department of Transportation (TxDOT) districts; and
  - for counties without a meteorological measurement station, the district-level inputs are used instead.

Texas Fuel Formulation Inputs for MOVES

- The TCEQ typically funds statewide fuel sampling studies on three-year intervals to coincide with National Emissions Inventory (NEI) years associated with Air Emissions Reporting Requirements (AERR).

- The most recent studies for 2008, 2011, 2014, and 2017 are available at https://www.tceq.texas.gov/airquality/airmod/project/pj_report_mob.html.

- The 2014 sampling study results were used to develop the fuel formulation inputs for the 2014 AERR on-road inventories available at ftp://amdaftp.tceq.texas.gov/EI/onroad/aerr/2014/.

- The 2017 sampling study are being used to develop the fuel formulation inputs for the 2017 AERR on-road inventories and will be posted when available to ftp://amdaftp.tceq.texas.gov/EI/onroad/aerr/2017/.

- For development of 2016 fuel formulation inputs, the 2014 sampling study is more representative than the 2017 study:
    - EPA's Tier 3 rule requires gasoline sulfur levels to start phasing from 30 parts per million (ppm) down to 10 ppm beginning in January 2017.
    - The 2014 fuel formulation inputs are available MOVES format in the county databases available at ftp://amdaftp.tceq.texas.gov/EI/onroad/aerr/2014/mvs14_inputs/cdb/.

Future Non-Road Emissions Inventory Development

- The TCEQ currently has a project with Eastern Research Group (ERG) to develop a utility that will run MOVES2014a to develop non-road inventories in production mode for multiple counties and DCE sub-sectors (similar to TexN). This work is scheduled for completion in late 2018. Until then, the TCEQ:
  - will continue to use TexN for all non-road modeling inventories within Texas; and
  - will use MOVES2014a in default mode for all non-Texas non-road inventories within the modeling domain.
- Non-road modeling resources that the TCEQ can provide to EPA and others:
  - equipment population summaries by Texas county, SCC, HP bin, etc. for any year in any desired format; and
  - results of non-road inventory development for 254 Texas counties in any desired format, containing fields such as FIPS code, SCC, pollutant code, emissions, etc.
- Discussion questions about 2016 modeling platform needs:
  - Are monthly non-road inventory runs required? Or are seasonal ones acceptable instead? The temporal allocation of non-road activity is typically uniform for months within the same season. For example, the Spring months of March, April, and May have similar activity.
  - For each month/season modeled, are day type inventories needed for both weekday and weekend? The TCEQ typically develops weekday inventories only, and then applies separate temporal profiles during emissions processing to obtain weekend inventories.
  - Is there a time estimate on the release of MOVES2014b? On a recent MOVES workgroup call, it was stated that the MOVES2014b release would have different non-road equipment population estimates.

Questions? Discussion?

Chris Kite

Chris.Kite@tceq.texas.gov

512-239-1959