

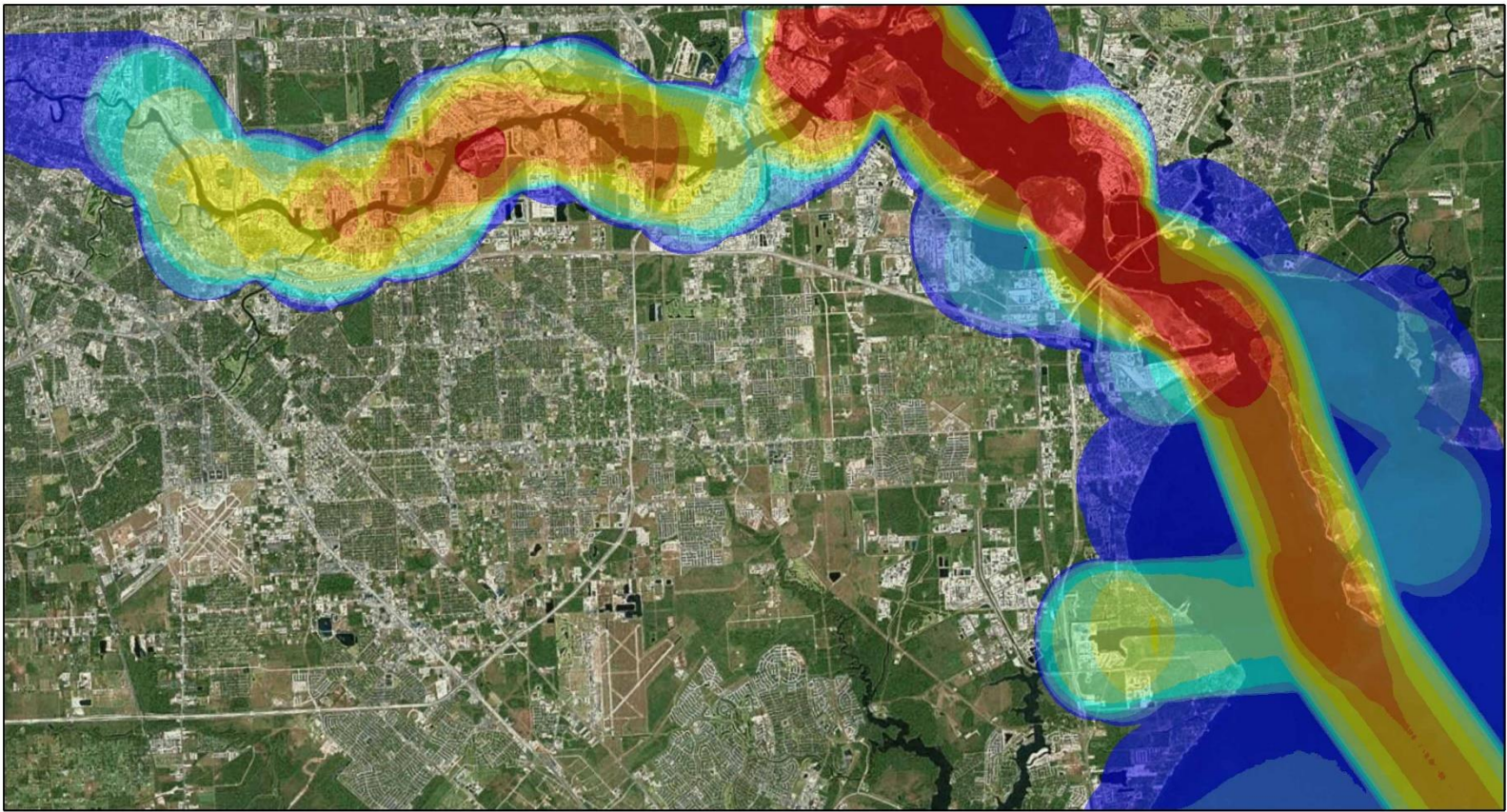


# 2013 Goods Movement Air Emissions Inventory

**PORT HOUSTON**<sup>SM</sup>

March 2017

**Executive Summary**



Prepared by:  
**Eastern Research Group**

**2013 GOODS MOVEMENT AIR EMISSIONS INVENTORY AT THE  
PORT OF HOUSTON**

Prepared for:

Port of Houston Authority

Prepared by:

Eastern Research Group, Inc.  
Morrisville, NC

March 24, 2017

## List of Acronyms

AIS	Automatic Identification System
BMX	By-model-year outputs
BNSF	Burlington Northern Santa Fe Railway
BTS	Bureau of Transportation Statistics
CH <sub>4</sub>	Methane
CHE	Cargo handling equipment
CMV	Commercial marine vessel
CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
DERA	Diesel Emission Reduction Act
DPF	Diesel particulate filters
ECA	Emission control area
GHG	Greenhouse gas
GIS	Geographic Information System
GPS	Global positioning system
GTM	Gross ton miles
GVWR	Gross vehicle weight rating
HDDV	Heavy-duty diesel vehicles
HGB	Houston-Galveston-Brazoria
hp	Horsepower
HSC	Houston Ship Channel
HV	Harbor vessel
IHS	Information Handling Services
IMO	International Maritime Organization
ISO	International Organization for Standardization
KCS	Kansas City Southern Railway
kW	Kilowatt
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LPR	License plate recognition
MMSI	Maritime Mobile Service Identity
MOVES	Motor Vehicle Emissions Simulator

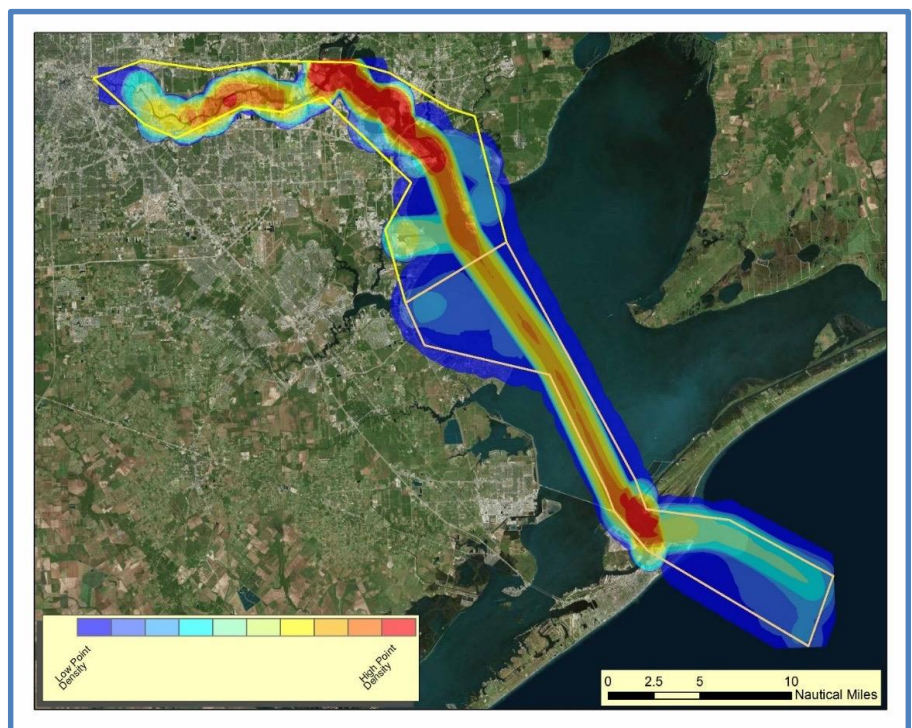
MSD	Medium speed diesel
NO <sub>x</sub>	Nitrogen oxide
NO <sub>2</sub>	Nitrous oxide
OGV	Ocean-going vessel
PHA	Port of Houston Authority
PM	Particulate matter
PM <sub>10</sub>	Particulate matter 10 microns or smaller
PM <sub>2.5</sub>	Particulate matter 2.5 microns or smaller
PTRA	Port Terminal Railroad Association
QA	Quality assurance
RSZ	Reduced speed zones
RTG	Rubber tire gantry
SCR	Selective catalytic reduction
SIP	State Implementation Plan
SO <sub>2</sub>	Sulfur dioxide
SQL	Standard Query Language
SSD	Slow speed diesel
TexN	Texas-specific NONROAD model
TCEQ	Texas Commission on Environmental Quality
tpy	Tons per year
TERP	Texas Emissions Reduction Plan
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
TxDMV	Texas Department of Motor Vehicles
TxLED	Texas Low Emission Diesel Program
UP	Union Pacific Railroad
VOC	Volatile organic compounds
VSP	Vehicle specific power
WBC	Waterborne commerce

## Executive Summary

The Port of Houston Authority (PHA) commissioned development of the 2013 Goods Movement Emission Inventory to use the latest emission inventory tools and methodologies to quantify emissions of mobile source criteria pollutants and greenhouse gases that are associated with PHA operations. For this project, the mobile source categories include ocean-going vessel (OGV), harbor vessels (HV), cargo handling equipment (CHE), locomotives, and heavy-duty diesel vehicles (HDDV). The focus of this inventory is on emissions from PHA cargo movements that transited the Houston-Galveston-Brazoria (HGB) nonattainment area. PHA had implemented a previous project to quantify PHA mobile source emissions for year 2007 (Starcrest, 2009).

For this 2013 emission inventory, enhancements to the previous methodology were made to reflect the latest emission estimating tools, many of which were not available in 2009 when the previous inventory was completed. For example, in this 2013 inventory, commercial marine vessel (CMV) activity is based on Automatic Identification System (AIS) data to map individual vessel movements. AIS was developed as an important tool to enhance safety and navigation because it provides real-time information on vessel location, direction, and speed.

AIS vessel data were linked to individual vessel characteristics such as propulsion and auxiliary engine power, maximum vessel speed, and detailed information about the propulsion engines (allowing for cylinder displacement calculations to ensure the correct EPA emission factors were used to estimate emissions). Geographic Information System (GIS) tools were used to map activity and emissions showing where peak activities and emission occur (Figure E-1).



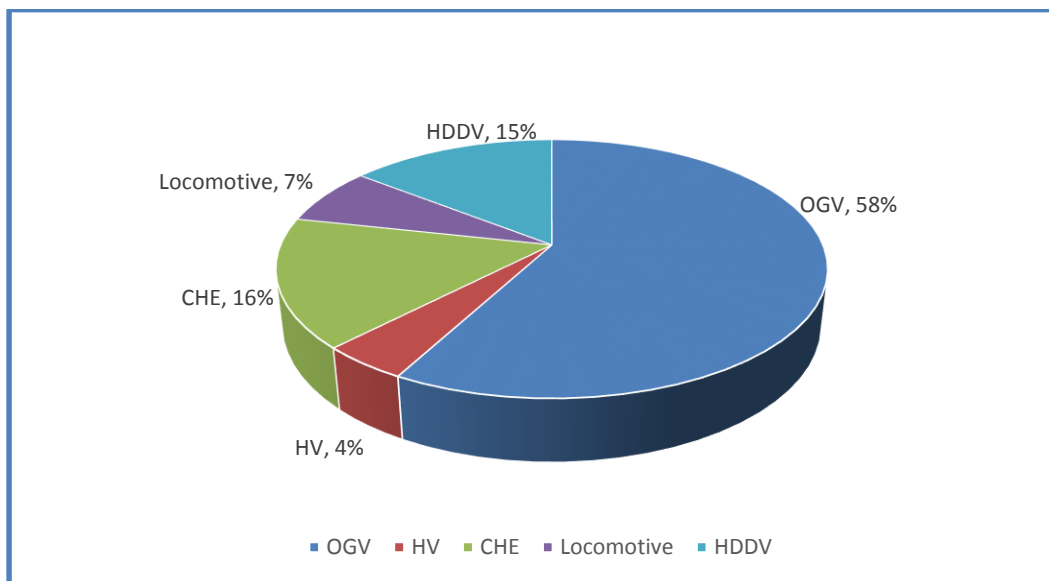
**Figure E-1. Density of 2013 PHA Vessel Traffic Based on AIS Data Points**

For CHE, the Texas Commission on Environmental Quality's (TCEQ) Texas-specific NONROAD (TexN) model was used. This model was developed to reflect equipment and state control programs specific for the state of Texas. This 2013 inventory

includes data that document the EPA regulatory tier groupings of the rail company's locomotives that allow emissions to be adjusted for compliance with federal standards.

HDDV emissions were estimated using EPA's latest Motor Vehicle Emissions Simulator (MOVES2014) model, in conjunction with new field measurements of truck counts and activity at multiple terminals. The input files for the MOVES model were tailored specifically for PHA terminals.

The application of these state-of-the-art emission estimating methods provided reasonably accurate estimates for all mobile source categories. With regard to vehicles, vessels, and other equipment related to PHA operations, OGV remains the dominant emissions source accounting for 58% of PHA NO<sub>x</sub> emissions. Cargo handling equipment accounts for 16%, heavy-duty vehicles account for 14%, locomotives account for 7%, and harbor vessels accounts for 5% of PHA NO<sub>x</sub> emissions (Figure E-2)



**Figure E-2. 2013 PHA NO<sub>x</sub> Emission Distribution by Emission Source**

OGV, HV, CHE, locomotive, and heavy-duty diesel onroad activities and corresponding emissions were quantified because they are associated with freight movements related to PHA facilities and terminals. Table E-1 presents 2013 PHA mobile source emissions by pollutant. The table also compares these 2013 PHA mobile source emissions to TCEQ's 2011 State Implementation Plan (SIP) emissions for the Houston-Galveston-Brazoria nonattainment area. Note that TCEQ did not have SIP emission estimates for 2013, so the 2011 data were used in this comparison. This comparison shows that the impact of PHA's activities on local air quality is relatively small, for example PHA represents only 5.13% of the HGB NO<sub>x</sub> total.

**Table E-1. Comparison of PHA 2013 and 2011 HGB Mobile Source Emissions (tons/year)**

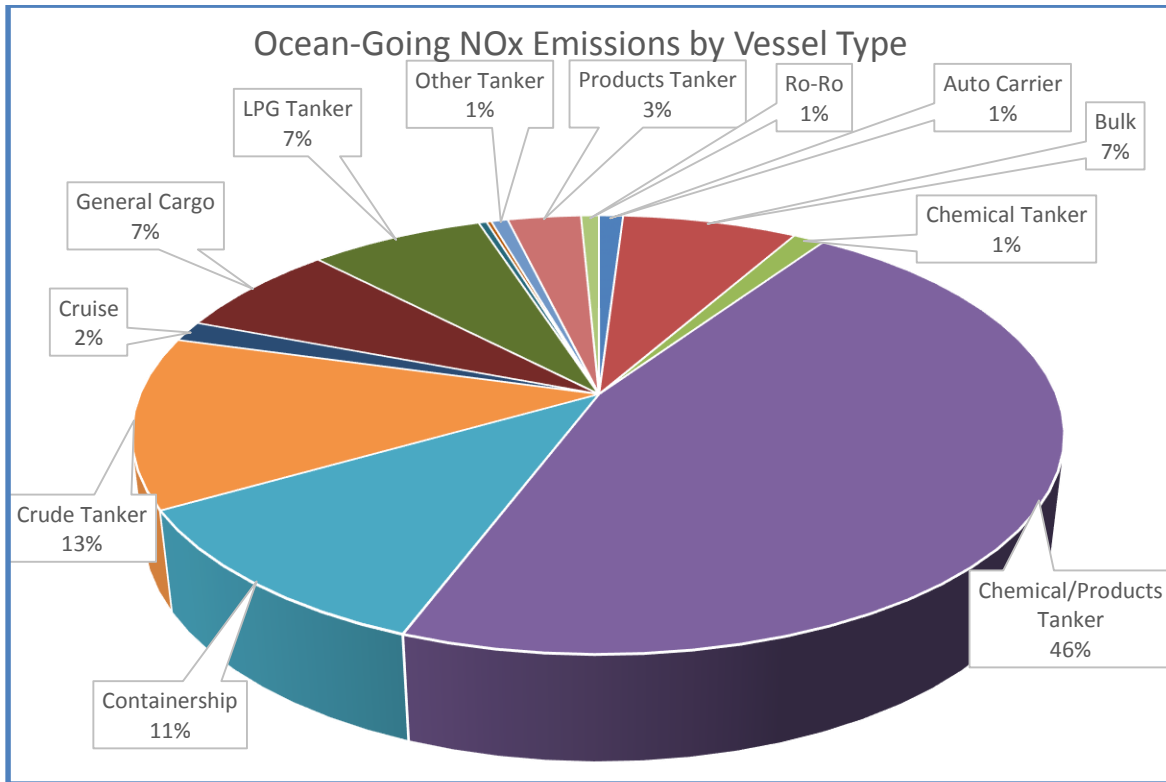
<b>2013 PHA Inventory Component</b>	<b>NO<sub>x</sub></b>	<b>VOC</b>	<b>CO</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>SO<sub>2</sub></b>	<b>CO<sub>2</sub></b>
2013 PHA OGV	4,683	213	488	302	278	2,663	442,085
2013 PHA HV	360	8	103	11	11	0.20	21,376
2013 PHA CHE	1,315	101	437	97	94	1	147,512
2013 PHA Locomotive	583	32	119	20	20	0.42	46,058
2013 PHA HDDV	1,172	110	425	113	82	2	260,499
<b>2013 PHA Total</b>	<b>8,113</b>	<b>463</b>	<b>1,572</b>	<b>544</b>	<b>485</b>	<b>2,667</b>	<b>917,531</b>
2011 TCEQ HGB Total	158,011	182,512	574,154	287,456	46,744	70,310	--
Percent PHA-Related	5.13%	0.25%	0.27%	0.19%	1.04%	3.79%	--

Table E-2 compares the 2013 PHA emissions to the 2007 emissions. The table illustrates that the 2013 PHA mobile source emissions are significantly higher than the 2007 PHA mobile source emissions (Starcrest, 2009). The higher 2013 emissions are primarily associated with marine vessels, although CHE and HDDV emissions are also slightly higher. The elevated SO<sub>x</sub> emissions are also associated with marine vessels despite the significant decline in the fuel sulfur content required by the Emission Control Area (ECA) fuel standards.

**Table E-2. Comparison of 2013 and 2007 PHA Mobile Source Emissions (tons/year)**

<b>Inventory Component</b>	<b>NO<sub>x</sub></b>	<b>VOC</b>	<b>CO</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>SO<sub>2</sub></b>	<b>CO<sub>2</sub></b>
2013 PHA Total	8,113	463	1,572	544	485	2,667	917,531
2007 PHA Total	6,716	346	1,392	450	386	3,340	627,574
Percent Difference	20.80%	33.88%	12.93%	20.84%	25.64%	-20.15%	46.20%

As noted in Figure E-2, OGVs are the largest emission source for PHA. Figure E-3 shows OGV NO<sub>x</sub> emissions by vessel type. As noted in Figure E-3, the three largest emission sources by vessel type are tankers with approximately 70% of the 2013 PHA CMV NO<sub>x</sub> emissions; container ships with 11%, and general cargo ships and bulk carriers with 7% each. Note, vessels that had less than 1% of the NO<sub>x</sub> emissions are not labeled to make the figure more readable.



**Figure E-3. 2013 PHA CMV NO<sub>x</sub> Emission Distribution by Vessel Type**

Tables E-3 through E-13 summarize the 2013 emission estimates and compare them to similar estimates developed for the 2007 inventory (Starcrest, 2009), as well as the TCEQ 2011 HGB nonattainment area (TCEQ, 2015).

The marine vessel emissions summarized in this section include propulsion, auxiliary, and boiler emission estimates for OGV and harbor vessels. For OGVs, Table E-3 compares PHA-related emissions to non-PHA-related emissions. In general, PHA accounts for approximately 50% of the OGV emissions in the port area. Similarly, Table E-4 compares PHA-related and non-PHA-related harbor vessels emissions. PHA-related harbor vessels emissions account for 21 to 24% of harbor vessel port emissions.

**Table E-3. Comparison of 2013 PHA and Non-PHA Ocean-Going Vessels Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 OGV PHA	4,683	213	488	302	278	2,663	442,085
2013 OGV Non-PHA	4,054	172	409	288	264	2,586	428,351
Percent PHA-Related	53.60%	55.23%	54.39%	51.22%	51.24%	50.74%	50.79%



**Table E-4. Comparison of 2013 PHA and Non-PHA Harbor Vessels Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 HV PHA	360	8	103	11	11	0.20	21,376
2013 HV Non-PHA	1,287	25	346	40	39	1	76,627
Percent PHA-Related	21.83%	23.62%	22.99%	22.21%	22.21%	21.83%	21.81%

Table E-5 compares annual OGV emission estimates (combined PHA and non-PHA) for this 2013 inventory to the 2007 inventory. Use of AIS data accounted for actual vessel movements and propulsion operating loads. Coupling the AIS data with Information Handling Services (IHS) Register of Ships characteristics allowed for a more specific assignment of each vessel's engine category, thus allowing for accurate matching of vessel engines to EPA emission factors. Use of AIS is also reflected in Table E-6, which compares 2007 and 2013 harbor vessel annual emissions. In general, ocean-going emissions increased except for SO<sub>2</sub>, which represents the phase-in of the Emission Control Area fuel standards that reduced the fuel sulfur concentration to 10,000 ppm.

Table E-6 compares annual harbor craft emission estimates (combined PHA and non-PHA) for this 2013 inventory to the 2007 inventory. Harbor vessel emissions declined between the two inventories, with the largest decline associated with SO<sub>2</sub> accounting for the phase-in of the ultra-low nonroad diesel fuel standard that reduces fuel sulfur concentration for Category 1 and 2 marine vessels to 15 ppm.

**Table E-5. Comparison of 2013 and 2007 Ocean-Going Vessels Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 OGV	8,737	385	897	590	542	5,249	870,436
2007 OGV	7,442	310	663	1,027	822	13,463	808,210
Percent Difference	17.41%	24.15%	35.32%	-42.55%	-34.01%	-61.01%	7.70%

**Table E-6. Comparison of 2013 and 2007 Harbor Vessels Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 Harbor Craft	1647.05	32.5	448.79	51.35	49.8	0.9	98003.49
2007 Harbor Craft	2,800	105.8	558	128	124.1	61	199,750
Percent Difference	-41.18%	-69.29%	-19.54%	-59.95%	-59.87%	-98.51%	-50.94%

Table E-7 compares annual all PHA CMV (OGV and harbor) emission estimates for this 2013 inventory to the 2011 TCEQ HGB inventory. The 2013 PHA CMV estimates represent about 38% of the HGB nonattainment NO<sub>x</sub> marine vessel emissions. Note that the 2011 TCEQ HGB

inventory does not include vessel boilers, whereas the 2013 PHA estimates do, thus, the 2013 PHA PM and SO<sub>2</sub> emission estimates appear to represent a larger fraction of emissions than the 2011 inventory.

**Table E-7. Comparison of 2013 PHA and 2011 HGB Vessels Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA CMV	5,043	220	591	314	289	2,663	463,462
2011 TCEQ HGB CMV Sources	13,409	485	1,536	507	469	3,216	NA
Percent PHA-Related	37.61%	45.41%	38.48%	61.89%	61.62%	82.82%	NA

Table E-8 compares annual CHE emission estimates for this 2013 inventory to the 2011 TCEQ HGB inventory. CHE accounted for up to 6% of TCEQ's 2011 nonroad equipment emission estimates for the HGB nonattainment area.

Table E-9 compares annual CHE emission estimates for this 2013 inventory to the 2007 inventory. The 2013 CHE emissions tended to be similar to but larger than the 2007 inventory, reflecting an increase of approximately 30% in the number of CHE units in operation in 2013. Conversely, SO<sub>2</sub> emissions declined, accounting for the phase-in of ultra-low nonroad diesel fuel standard that reduces fuel sulfur concentration since 2007.

**Table E-8. Comparison of 2013 PHA CHE and 2011 HGB Nonroad Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA-Related CHE	1,315.2	100.6	436.7	96.88	93.80	1.34	147,512
2011 TCEQ HGB Nonroad Sources	21,738	17,942	183,682	1,852	1,724	340	
Percent PHA-Related	6.1%	0.6%	0.2%	5.2%	5.4%	0.4%	

**Table E-9. Comparison of 2013 and 2007 CHE Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA CHE	1,315.2	100.6	436.7	96.88	93.80	1.34	147,512
2007 PHA CHE	1,020	75	363	63	61	22	112,618
Percent Change	28.4%	34.13%	20.3%	53.8%	53.8%	-93.9%	31.0%

Table E-10 compares annual locomotive emission estimates for this 2013 inventory to the 2011 TCEQ HGB inventory. PHA-related locomotive emissions accounted for 11% or less of the TCEQ 2011 locomotive emission estimates for the HGB nonattainment area.

Table E-11 compares annual locomotive emission estimates for this 2013 inventory to the 2007 inventory. Locomotive emission estimates were smaller in 2013 than in the 2007 inventory. This reduction is due to adjustments made in the inventory to account for BNSF's and UP's use of higher tier locomotives and use of low-sulfur fuels.

**Table E-10. Comparison of 2013 PHA and 2011 HGB Locomotive Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA-Related Locomotive	583	32	119	20	20	0.42	46,058
2011 TCEQ HGB Locomotive	6,172	378	1,044	186	180	65	NA
Percent PHA-Related	9.45%	8.47%	11.40%	10.75%	11.11%	0.65%	

**Table E-11. Comparison of 2013 and 2007 Locomotive Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA Locomotive	583	32	119	20	20	0.42	46,058
2007 PHA Locomotive	885	53	149	33	32	18	56,120
Percent Difference	-34.12%	-39.62%	-20.13%	-39.39%	-37.50%	2.3%	-17.93%

Table E-12 compares annual heavy-duty diesel (HDDV) emission estimates for this 2013 inventory to the 2011 TCEQ HGB inventory. PHA heavy-duty diesel emissions represent relatively small contributions to local air quality. PHA contributions vary by pollutant ranging from 4% for NO<sub>x</sub> to 8.5% for SO<sub>2</sub>. Note the TCEQ did not include CO<sub>2</sub> emission in the 2011 HGB inventory.

Table E-13 compares annual locomotive emission estimates for this 2013 inventory to the 2007 inventory. Table 7-11 shows how the use of the EPA's MOVES2014 model provides different emission estimate than the older MOBILE model used in the 2007 inventory. Specifically, there are lower emissions for NO<sub>x</sub> and CO, higher emissions for PM, and similar emissions for VOC, SO<sub>2</sub> and CO<sub>2</sub>.

**Table E-12. Comparison of 2013 PHA and 2011 HGB Heavy-Duty Diesel Vehicle Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA-Related HDDV	1,172	110	425	113	82	2.2	260,499
2011 TCEQ HGB HDDV	29,574	2,218	10,163	1,587	1,823	26	3,078,625
Percent PHA-Related	4.0%	5.0%	4.2%	5.2%	6.2 %	8.5%	8.5%

**Table E-13. Comparison of 2013 and 2007 Heavy-Duty Diesel Vehicle Emissions (tons/year)**

Inventory	NO <sub>x</sub>	VOC	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	SO <sub>2</sub>	CO <sub>2</sub>
2013 PHA HDDV	1,172	110	425	113	82	2.2	260,499
2007 PHA HDDV	2,357	108	640	56	54	2.2	257,980
Percent Difference	-50.28%	1.85%	-33.59%	101.79%	51.85%	0.0%	0.98%