Carbon Monoxide (CO) Traffic Air Quality Analysis

North Houston Highway Improvement Project
From US 59/I-69 at Spur 527
To I-45 at Beltway 8 North

Harris County
TxDOT Houston District
CSJ: 0912-00-146

August 2020

The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried-out by TxDOT pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated December 9, 2019, and executed by FHWA and TxDOT.

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1.0 Project Description

The Texas Department of Transportation (TxDOT) proposes to construct improvements to Interstate Highway 45 (I-45) in the northern portion of the City of Houston. The proposed project, referred to as the North Houston Highway Improvement Project (NHHIP), begins at the interchange of I-45 and Beltway 8 North and continues south along I-45 to Downtown Houston where it terminates at the interchange of U.S. Highway (US) 59/I-69 and Spur 527 south of Downtown Houston. The project area also includes portions of I-10 and US 59/I-69 near Downtown Houston. The project area is composed of three study segments, Segments 1 through 3.

This carbon monoxide traffic air quality analysis technical report supports the Final Environmental Impact Statement (Final EIS) that evaluates the social, economic, and environmental impacts potentially resulting from the Preferred Alternative for the proposed project.

Existing Facility

Segment 1: I-45 from Beltway 8 North to north of I-610 (North Loop)

I-45 within this segment consists of eight general purpose lanes (i.e., mainlanes; four lanes in each direction), four to six frontage road lanes (two to three lanes in each direction), and a reversible high occupancy vehicle (HOV) lane in the middle, all within a variable right-of-way (ROW) width of 250 to 300 feet. The existing posted speed limit along the general purpose lanes and reversible HOV lane is 60 miles per hour (mph). The existing posted speed limit for the frontage roads is 45 mph. The length of Segment 1 is approximately 8.8 miles, and the area of the existing ROW is approximately 349 acres.

Segment 2: I-45 from north of I-610 (North Loop) to I-10

I-45 within this segment primarily consists of eight at-grade general purpose lanes (four lanes in each direction), four to six frontage road lanes (two to three lanes in each direction), and a reversible HOV lane in the middle, all within a variable ROW width of 300 to 325 feet. Segment 2 also includes a depressed section that consists of eight general purpose lanes (four lanes in each direction) and a reversible HOV lane in the middle, all below grade, within a 245-foot ROW. The frontage road lanes associated with the depressed section are located at-grade. The existing posted speed limit is 60 mph along the general purpose lanes, 55 mph along the reversible HOV lane, and 40 mph along the frontage road lanes. The I-45 and I-610 frontage roads are discontinuous at the I-45/I-610 interchange. The length of Segment 2 is approximately 4.5 miles, and the area of the existing ROW is approximately 220 acres.

Segment 3: Downtown Loop System (I-45, US 59/I-69, and I-10)

The Downtown Loop System consists of three interstate highways that create a loop around Downtown Houston. I-45 forms the western and southern boundaries of the loop and is known locally as the Pierce Elevated because it partially follows the alignment of Pierce Street. I-10 forms the northern boundary of the loop, and US 59/I-69 forms the eastern boundary of the loop. The loop includes three major interchanges: I-45 and I-10, I-10 and US 59/I-69, and US 59/I-69 and I-45. The interchange of US 59/I-69 and Spur 527 is located southwest of Downtown Houston.

I-45 along the western and southern sides of Downtown consists of six elevated general purpose lanes (three lanes in each direction) within a variable ROW that is typically 205 feet to 320 feet wide. I 10 north of Downtown, between I-45 and US 59/I-69, consists of six general purpose lanes (three lanes in each direction) within an existing ROW width of 420 feet. US 59/I-69 along the east side of Downtown consists of six general purpose lanes (three lanes in each direction) within an existing ROW width of 225 feet. US 59/I-69 south of Downtown from I-45 to Spur 527 has eight general purpose lanes (four in each direction). Generally, local streets serve as one-way frontage roads within Segment 3, except near the I-10 and US 59/I-69 interchange, where the frontage roads are discontinuous. The length of Segment 3, which includes the Downtown Loop System, is approximately 13.1 miles, and the existing ROW is approximately 638 acres.

Proposed Facility

The Preferred Alternative for the proposed project is described below, by study segment. The Preferred Alternative includes changes to the Recommended Alternative (for each segment) presented and evaluated in the Draft Environmental Impact Statement. Section 2.0 of the Final EIS discusses the design changes, including the proposed locations of storm water detention areas.

Segment 1: I-45 from Beltway 8 North to north of I-610 (North Loop)

The Preferred Alternative would widen the existing I-45 primarily on the west side of the roadway to accommodate four managed express (MaX) lanes. The proposed typical section would include eight to ten general purpose lanes (four to five lanes in each direction), four MaX lanes (two lanes in each direction), and four to six frontage road lanes (two to three lanes in each direction). The general purpose lanes and MaX lanes would be at-grade except at major cross streets, where they would be elevated over the intersecting streets. Approximately 200 to 225 feet of new ROW would be required for the roadway widening, mostly to the west of the existing I-45. New ROW would also be required on the west side of I-45 for proposed storm water detention areas. New ROW would be required to the east of the existing I-45 ROW at intersections with major streets and between Crosstimbers Street and I-610. Approximately 246 acres of new ROW would be required in Segment 1.

Segment 2: I-45 from north of I-610 (North Loop) to I-10 (including the interchange with I-610)

The Preferred Alternative would widen the existing I-45 to accommodate four MaX lanes. The proposed typical section would include ten general purpose lanes (five lanes in each direction), four MaX lanes (two lanes in each direction), and four to six frontage road lanes (two to three lanes in each direction). From north of Cottage Street to Norma Street, the general purpose lanes and the Max lanes would be depressed, while the frontage road lanes would be at-grade. The proposed I-45 and I-610 frontage roads would be continuous through the I-45/I-610 interchange. New ROW would be required from both the east and west sides of the existing I-45. The new ROW would include proposed storm water detention areas on the east side of I-45, south of Patton Street. Approximately 44 acres of new ROW would be required in Segment 2.

The Preferred Alternative provides a structural "cap" over a portion of the depressed lanes of I-45 from north of Cottage Street to south of N. Main Street. Future use of the structural cap area for another purpose would require additional development and funding by entities other than TxDOT.

Segment 3: Downtown Loop System (I-45, US 59/I-69, and I-10)

The Preferred Alternative would reconstruct all the existing interchanges in the Downtown Loop System and reroute I-45 to be parallel to I-10 on the north side of Downtown and parallel to US 59/I 69 on the east side of Downtown. Access to the west side of Downtown would be provided via "Downtown Connectors" that would consist of entrance and exit ramps for various Downtown streets. A section of the Downtown Connectors would be below-grade (depressed) between approximately W. Dallas Street to Andrews Street. The existing elevated I-45 roadway along the west and south sides of Downtown would be removed. The portion of I-45 (Pierce Elevated) between Brazos Street and US 59/I-69 could be left in place for future use and redevelopment by others; however, an alternative use for the structure is not proposed by TxDOT and is not evaluated in this Final EIS.

To improve safety and traffic flow in the north and east portions of Segment 3, portions of both I-10 and US 59/I 69 would be realigned (straightened) to eliminate the current roadway curvature. I-45 and US 59/I-69 would be depressed along a portion of the alignment east of Downtown. South of the George R. Brown Convention Center, the rerouted I-45 would begin to elevate to tie to existing I-45 southeast of Downtown, while US 59/I-69 would remain depressed as it continues southwest toward Spur 527. US 59/I-69 would be widened from eight to twelve general purpose lanes between I 45 and SH 288, and would be reconstructed to ten general purpose lanes from SH 288 to Spur 527.

The four proposed I-45 MaX lanes in Segments 1 and 2 would terminate/begin in Segment 3 at Milam Street/Travis Street, respectively. I-10 express lanes (two lanes in each direction) would be located generally in the center of the general purpose lanes within the proposed parallel alignment of I-10 and I-45 on the north side of Downtown. The I-10 express lanes would vary between being elevated and at-grade.

New ROW to the east of the existing US 59/I-69 along the east side of Downtown would be required to accommodate the proposed realigned I-45. A new continuous southbound access road would be provided adjacent to US 59/I-69 and would tie to existing Hamilton Street on the south side of the Convention Center. The existing St. Emanuel Street would serve as a northbound access road. The project ROW would include areas to be developed as storm water detention. Approximately 160 acres of new ROW would be required, the majority of which would be for the I-10 and US 59/I 69 realignments (straightening) and to construct the proposed I-45 lanes adjacent to US 59/I-69 along the east side of Downtown.

The Preferred Alternative provides a structural "cap" over the proposed depressed lanes of I-45 and US 59/I-69 from approximately Commerce Street to Lamar Street. There would also be a structural cap over the depressed lanes of US 59/I-69 between approximately Main Street and Fannin Street, and in the area of the Caroline Street/Wheeler Street intersection. Future use of the structural cap areas for another purpose would require additional development and funding by entities other than TxDOT.

The estimated time of completion (ETC) year and design year for the project are 2035 and 2040, respectively.

2.0 Background Information

A traffic air quality analysis (TAQA) is required for projects that add capacity and have an annual average daily traffic (AADT) of 140,000 vehicles per day (vpd) or higher at the ETC and design year. Since the project would add capacity and the ETC and design year traffic volume is above 140,000 vpd, a TAQA is required to assess whether the project would adversely affect local air quality by contributing to carbon monoxide (CO) levels that exceed the 1-hour or 8-hour CO National Ambient Air Quality Standard (NAAQS). The Environmental Protection Agency (EPA) developed the NAAQS to be protective of public health, including sensitive populations. The Texas Commission on Environmental Quality (TCEQ) has not adopted more stringent standards. The EPA reevaluates the NAAQS on a five year schedule following a process[1] that allows for the public and scientific community to submit relevant information for inclusion in their NAAQS assessment. TxDOT relies on the CAA requirements to scale what analyses are needed for NEPA. Therefore, by comparing modeled CO concentrations to EPA's latest CO NAAQS, actions can be evaluated as to whether they will have a potential CO impact.

A CO analysis was conducted for the NHHIP Alternatives Analysis in January 2016 and finalized in March 2017. Because design changes have occurred since that analysis, and because the analysis was based on traffic data from the Houston-Galveston Area Council's (H-GAC) 2035 Regional Travel Demand Model, an updated CO analysis is required for the Preferred Alternative, based on the updated ETC and design years. Furthermore, since the last analysis, there have been updated CO emission rates published by TxDOT. The same general areas and receptors that were analyzed as part of the Alternatives Analysis were carried forward to this analysis; however, minor adjustments to receiver coordinates were made due to changes in ROW.

See **Figure 1** for the overall project location, segment limits, and the CO analysis areas.

[1] See: https://www.epa.gov/criteria-air-pollutants/process-reviewing-national-ambient-air-quality-standards

Figure 1: Project Segments and CO Analysis Areas

3.0 Analysis Methodology

CO concentrations for the Build Alternative were modeled for the ETC and design years using the steady-state Gaussian dispersion model, CALINE3. The emission rates used in the analysis were based on the MOVES2014[2] [3] model, gathered from the TxDOT Emission Rates Lookup Table (ERLT) for TAQA table (*TxDOT Air Quality Toolkit, June 2016*) and identified in **Table 1** below.

Table 1: Emission Rates and Projected Vehicle Speeds

Facility Type	Emission Rates (grams/mile)		Vehicle Speed
	2035	2040	
Segments 1 and 2 (main lanes and HOV)	0.51	0.45	60 mph
Segments 1 and 2 (frontage roads)	0.54	0.48	45 mph
Segment 3 (main lanes and HOV)	0.51	0.45	50 mph

The traffic data for the NHHIP project were developed in close coordination with the TxDOT Transportation Planning and Programming (TP&P) Division and finalized in October 2017 (see **Appendix A**). The traffic data is based on actual field counts and a projection of the measured volumes to the years of 2017 and 2040, using growth rates derived from the H-GAC Regional Travel Demand Model. The data was further interpolated based on the growth rate to calculate traffic data for the ETC year of 2035 for purposes of this CO analysis. The same traffic data was also used for the traffic noise analysis for the project for consistency of traffic data between the analyses. Traffic for the ETC year (2035) and design year (2040) is shown by segment in **Table 2**. This data represents the traffic volumes of the associated analysis segments, as derived from the traffic data in **Appendix A.**

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[2] On August 28, 2018, EPA released MOVES2014b. However, EPA indicates that MOVES2014b does not significantly change the on road criteria pollutant emissions results of MOVES2014 and is not considered a new model for State Implementation Plan (SIP) and transportation conformity purposes. Therefore, no updates to the project modeling are required by this MOVES update.

[3] EPA has indicated in an April 9, 2018 email: MOVES2014 includes the impact of 2017-2025 Light-Duty GHG standards on direct emissions from vehicles. The emission impacts of any new GHG standards cannot be quantified until they are proposed, and MOVES official releases include new standards only after they have been finalized. Note that because the 2017-2025 GHG standards were projected to have a very small impact on criteria and toxic emissions from vehicles and because the vehicles affected by the 2017-2025 GHG standards would still need to meet applicable criteria pollutant emissions standards (e.g., Tier 3), we expect the impact of changes in GHG standards on direct criteria and toxic pollutant emissions from vehicles to be very small.

Table 2: Projected AADT and Design Hourly Volume (DHV) along NHHIP Segments

Segment/Alternative	*ADT*		*DHV*	
	2035 (ETC)	**2040 (Design)**	**2035 (ETC)**	**2040 (Design)**
Segment 1, Preferred Alternative: Airline to Stokes	363,200	388,900	29,056	31,112
Segment 2, Preferred Alternative: Main St to Quitman Rd	363,200	388,900	29,056	31,112
Segment 3, Preferred Alternative: Downtown Loop	**2035 (ETC)**	**2040 (Design)**	**2035 (ETC)**	**2040 (Design)**
Area 1: IH 45/IH 10 from IH 10/IH 45 split to Downtown Connectors	529,921	558,100	42,394	44,648
Area 2: IH 10 from Downtown Connectors to IH 69/US 59	529,921	558,100	42,394	44,648
Area 3: IH 45/US 59 from IH 10/IH 45 to SH 288	455,840	478,500	46,823	49,115

The following adverse meteorological conditions are the worst-case assumptions and input parameters used in the analysis, in accordance with Appendix D of TxDOT's *Standard Operating Procedure for Complying with CO TAQA Requirements* (September 2015):

- 1-hour average background concentration of 2.5 ppm
- 8-hour average background concentration of 1.9 ppm
- Averaging time of 60 minutes
- Atmospheric Stability Class of 6 (stable)
- Mixing height of 1,000 meters
- Wind speed of 1 meter per second
- Winds blowing parallel to the roadway

The CALINE3 input and output data files have been submitted to TxDOT for inclusion in the project files.

4.0 Receptor Locations

Receptors were modeled on the ROW line along areas with the highest AADT and narrowest ROW for each segment. A standard height of 5.9 feet was given to the receptors for all models to simulate the average height of a person. **Tables 3-5** detail the DHV, speed, and width of ROW at each receptor. Aerial maps depicting the receptor locations along the project ROW are found in **Appendix B**.

Segment 1

The area from Airline Road to Stokes Road was selected as the modeled area for Segment 1 because it has the highest traffic volume along Segment 1. A receptor was placed at the narrowest ROW location, as well as at three additional locations with varying ROW width along the segment for the analysis.

Table 3: Receptor Descriptions (Segment 1)

Segment 1, Preferred Alternative: Airline Rd to Stokes Rd						
	ROW Width	2035 Total DHV	2040 Total DHV	2035 Total AADT	2040 Total AADT	Speed
Receptor 1	490 feet	29,056	31,112	363,200	388,900	60 mph (main and HOV lanes), 45 mph (frontage roads)
Receptor 2	658 feet					
Receptor 3	558 feet					
Receptor 4	575 feet					

Segment 2

The area from Main Street to Quitman Road along Segment 2 was selected as the modeled area for Segment 2 because it has the highest traffic volume along Segment 2. A receptor was placed at the narrowest ROW location, as well as at four additional locations with varying ROW width along the segment for the analysis.

Table 4: Receptor Descriptions (Segment 2)

Segment 2, Preferred Alternative: Main St to Quitman Rd						
	ROW Width	2035 Total DHV	2040 Total DHV	2035 Total AADT	2040 Total AADT	Speed
Receptor 5	432 feet	29,056	31,112	363,200	388,900	60 mph (main and HOV lanes), 45 mph (frontage roads)
Receptor 6	423 feet					
Receptor 7	376 feet					
Receptor 8	323 feet					
Receptor 9	352 feet					

Segment 3

The area from the I-45 and I-10 split to the Downtown Connectors (Area 1), the area from the Downtown Connectors to US 59/I-69 (Area 2), and the area along US 59/I-69 from I-10/I-45 to SH 288 (Area 3) were selected as the modeled areas for Segment 3 because of high traffic volume. For Area 1, receptors were placed at varying ROW widths on the southbound side because of the presence of White Oak Bayou on the ROW boundary on the northbound side. For Areas 2 and 3, receptors were placed at the narrowest ROW location on both sides of the road, as well as at additional locations with varying ROW width for the analysis.

Table 5: Receptor Descriptions (Segment 3)

Segment 3, Preferred Alternative: Area 1, I-45/I-10 to Downtown Connectors						
	ROW Width	**2035 Total DHV**	**2040 Total DHV**	**2035 Total AADT**	**2040 Total AADT**	**Speed**
Receptor 10	612 feet	42,394	44,648	529,921	558,100	50 mph
Receptor 11	650 feet					
Receptor 12	630 feet					
Receptor 13	621 feet					
Segment 3, Preferred Alternative: Area 2, Downtown Connectors to US 59/I-69						
	ROW Width	**2035 Total DHV**	**2040 Total DHV**	**2035 Total AADT**	**2040 Total AADT**	**Speed**
Receptor 14	482 feet	42,394	44,648	529,921	558,100	50 mph
Receptor 15	418 feet					
Receptor 16	430 feet					
Segment 3, Preferred Alternative: Area 3, US 59/I-69 to SH 288						
	ROW Width	**2035 Total DHV**	**2040 Total DHV**	**2035 Total AADT**	**2040 Total AADT**	**Speed**
Receptor 17	411 feet	46,823	49,115	455,840	478,500	50 mph
Receptor 18	373 feet					
Receptor 19	481 feet					

5.0 Analysis Results

The 1-hour CO NAAQS is 35 ppm, while the 8-hour NAAQS is 9 ppm, which are not to be exceeded more than once in a year. The 1-hour and 8-hour CO background concentrations for the project are 2.5 ppm and 1.9 ppm, respectively. These values were obtained from Appendix B of *TxDOT's Standard Operating Procedure for Complying with CO TAQA Requirements* (2015).

Modeling results indicate that local concentrations of CO are not expected to exceed national standards at any time along any segment of the project; furthermore, CO concentrations are expected to remain relatively consistent from the ETC to the design year. Even if the analysis were run at the speeds associated with a worst-case emission rate, it would still not exceed the NAAQS at any time. The highest CO concentration result and percent of the 1-hour and 8-hour NAAQS per segment is recorded in **Tables 6-8**. Segment 3 is projected to have the highest CO concentration along the NHHIP project due to higher traffic volume. Specifically, the portion of Segment 3 along US 59/I-69 from I-45/I-10 to SH 288 (Area 3) has the highest projected CO concentration. This segment and area has the highest traffic volume and is designed as a depressed section of roadway. Overall, there is not an appreciable change in CO emissions from 2035 to 2040 because the emission rates do not substantially change in the 5 year period.

A table detailing the full results of the 1-hour and 8-hour CO concentrations per segment at each receptor can be found in **Appendix C.**

Table 6: Worst-Case 1-Hour and 8-Hour CO Concentrations (Segment 1)

2035: Estimated Time of Completion (ETC)					
1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
2.7	2.5	1.9	**2.0**	8%	22%
2040: Design Year					
1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
2.8	2.5	1.9	**2.1**	8%	23%

Table 7: Worst-Case 1-Hour and 8-Hour CO Concentrations (Segment 2)

2035: Estimated Time of Completion (ETC)					
1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
2.8	2.5	1.9	**2.1**	8%	23%
2040: Design Year					
1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background Concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
2.8	2.5	1.9	**2.1**	8%	23%

Table 8: Worst-Case 1-Hour and 8-Hour CO Concentrations (Segment 3)

	2035: Estimated Time of Completion (ETC)					
	1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background Concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
Area 1	2.9	2.5	1.9	**2.1**	8%	24%
Area 2	2.9	2.5	1.9	**2.1**	8%	24%
Area 3	3.9	2.5	1.9	**2.7**	11%	30%
	2040: Design Year					
	1 Hour CO Concentration (ppm)	1 Hour CO Background Concentration (ppm)	8 Hour CO Background Concentration (ppm)	8 Hour CO Concentration (ppm)	1-Hour % NAAQS	8-Hour % NAAQS
Area 1	2.9	2.5	1.9	**2.1**	8%	24%
Area 2	2.9	2.5	1.9	**2.1**	8%	24%
Area 3	3.7	2.5	1.9	**2.6**	11%	29%

Based upon public comment, TxDOT provided additional information in **Appendix D** of this Technical Report and in Appendix C of the MSAT Technical Report, regarding: 1) overall status of air quality in the greater Houston area, 2) mobile source air emission projections for Harris County, 3) ambient air monitoring for national ambient air quality standards (NAAQS) and air toxics for the greater Houston area, 4) TCEQ toxicology assessment of air toxics monitoring for the greater Houston area, 5) national near-road monitoring data, 6) an EPA Study Assessing Outdoor Air Near Schools. In particular, the EPA school study was conducted to protect children's health. It covered 62 schools including 14 schools abutting major roadways across the U.S. For these 14 schools, EPA found monitored MSAT were less than thresholds for assessing short-term or long-term health risks. Young Scholars' Academy was part of this EPA study and is on the IH45 corridor. With these results, EPA concluded additional studies or controls for MSAT were not warranted. The CO TAQA and MSAT Technical Reports and associated additional information do not identify adverse impacts associated with air quality.

6.0 Additional Information

The transportation related criteria pollutants include CO, ozone, particulate matter (PM), and nitrogen dioxide (NO_2). Ozone is not directly emitted from vehicles but is instead created in the atmosphere from a combination of other vehicle emissions: volatile organic compounds (VOCs) and nitrogen oxides (NO_x), including NO_2. In their conformity rule, EPA defines hot-spot analyses as only applying to areas in nonattainment or maintenance for either CO or PM. Harris County is designated as attainment/unclassifiable for both CO and PM and thus not subject to a hot-spot analysis; however, FHWA identifies CO as a potential project-related concern that needs to be evaluated, hence the above CO analysis which provides a worst-case screening for CO. In addition, the project will be required to meet conformity requirements for ozone prior to the environmental decision.

There are also other sources of data that can help in the evaluation of potential criteria pollutant impacts, including near-road monitors, TCEQ trends modeling, and EPA air quality trends data. A discussion of these is included in **Appendix D**. To summarize, air quality has been and is expected to continue improving over time. This is largely due to federal regulation on vehicle and fuel requirements[4], but also to a myriad of other local, state, and federal regulations, programs, and initiatives.

[4] EPA has not yet incorporated the recently released Corporate Average Fuel Economy (CAFE) standards; however, "it is expected that incremental impacts on criteria and air toxic pollutant emissions would be too small to observe under any of the regulatory alternatives under consideration" (per 85 FR 25061). Therefore, the new CAFE standards are not expected to have a significant effect on this conclusion.

APPENDIX A
Traffic Data

North Houston Highway Improvement Project

Traffic Volume for Noise Analysis

October 18, 2017

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-610 EB MAINLANES	92,200	120,200	0.078	7.6%	3.4%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	92.4%	96.6%			
Medium Duty	3.2%	1.4%			
Heavy Duty	4.4%	2.0%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-610 WB MAINLANES	100,100	131,800	0.078	7.1%	3.2%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	92.9%	96.8%			
Medium Duty	2.6%	1.2%			
Heavy Duty	4.5%	2.0%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-45 SB MAINLANES Segment 1&2	130,300	169,100	0.08	5.9%	2.7%
I-45 SB Frontage Roads Segment 1&2	15,800	20,100	0.08	5.9%	4.4%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes		Frontage Roads		
	% of ADT	% of DHV	% of ADT		% of DHV
Light Duty	94.1%	97.3%	94.1%		95.6%
Medium Duty	2.5%	1.1%	2.5%		1.9%
Heavy Duty	3.4%	1.6%	3.4%		2.5%

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-45 NB MAINLANES Segment 1&2	120,800	161,700	0.08	6.1%	2.7%
I-45 NB Frontage Roads Segment 1&2	18,700	38,000	0.08	6.1%	4.6%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes		Frontage Roads		
	% of ADT	% of DHV	% of ADT		% of DHV
Light Duty	93.9%	97.3%	93.9%		95.4%
Medium Duty	2.6%	1.2%	2.6%		2.0%
Heavy Duty	3.5%	1.5%	3.5%		2.6%

North Houston Highway Improvement Project

Traffic Volume for Noise Analysis

October 18, 2017

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-45 SB MAINLANES Segment 3	105,000	132,400	0.08	4.8%	2.2%
Data for Use in Air & Noise Analysis					
Vehicle Class	**Mainlanes**				
	% of ADT	**% of DHV**			
Light Duty	95.2%	97.8%			
Medium Duty	2.6%	1.2%			
Heavy Duty	2.2%	1.0%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-45 NB MAINLANES Segment 3	101,800	129,400	0.08	4.6%	2.1%
Data for Use in Air & Noise Analysis					
Vehicle Class	**Mainlanes**				
	% of ADT	**% of DHV**			
Light Duty	95.4%	97.9%			
Medium Duty	2.8%	1.3%			
Heavy Duty	1.8%	0.8%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-10 EB MAINLANES	116,300	151,300	0.08	8.0%	3.6%
Data for Use in Air & Noise Analysis					
Vehicle Class	**Mainlanes**				
	% of ADT	**% of DHV**			
Light Duty	92.0%	96.4%			
Medium Duty	2.6%	1.2%			
Heavy Duty	5.4%	2.4%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
I-10 WB MAINLANES	116,700	145,000	0.08	8.5%	3.8%
Data for Use in Air & Noise Analysis					
Vehicle Class	**Mainlanes**				
	% of ADT	**% of DHV**			
Light Duty	91.5%	96.2%			
Medium Duty	2.8%	1.3%			
Heavy Duty	5.7%	2.5%			

North Houston Highway Improvement Project

Traffic Volume for Noise Analysis

October 18, 2017

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
US 59 SB MAINLANES	82,800	108,700	0.13	6.1%	2.7%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	93.9%	97.3%			
Medium Duty	2.9%	1.3%			
Heavy Duty	3.2%	1.4%			

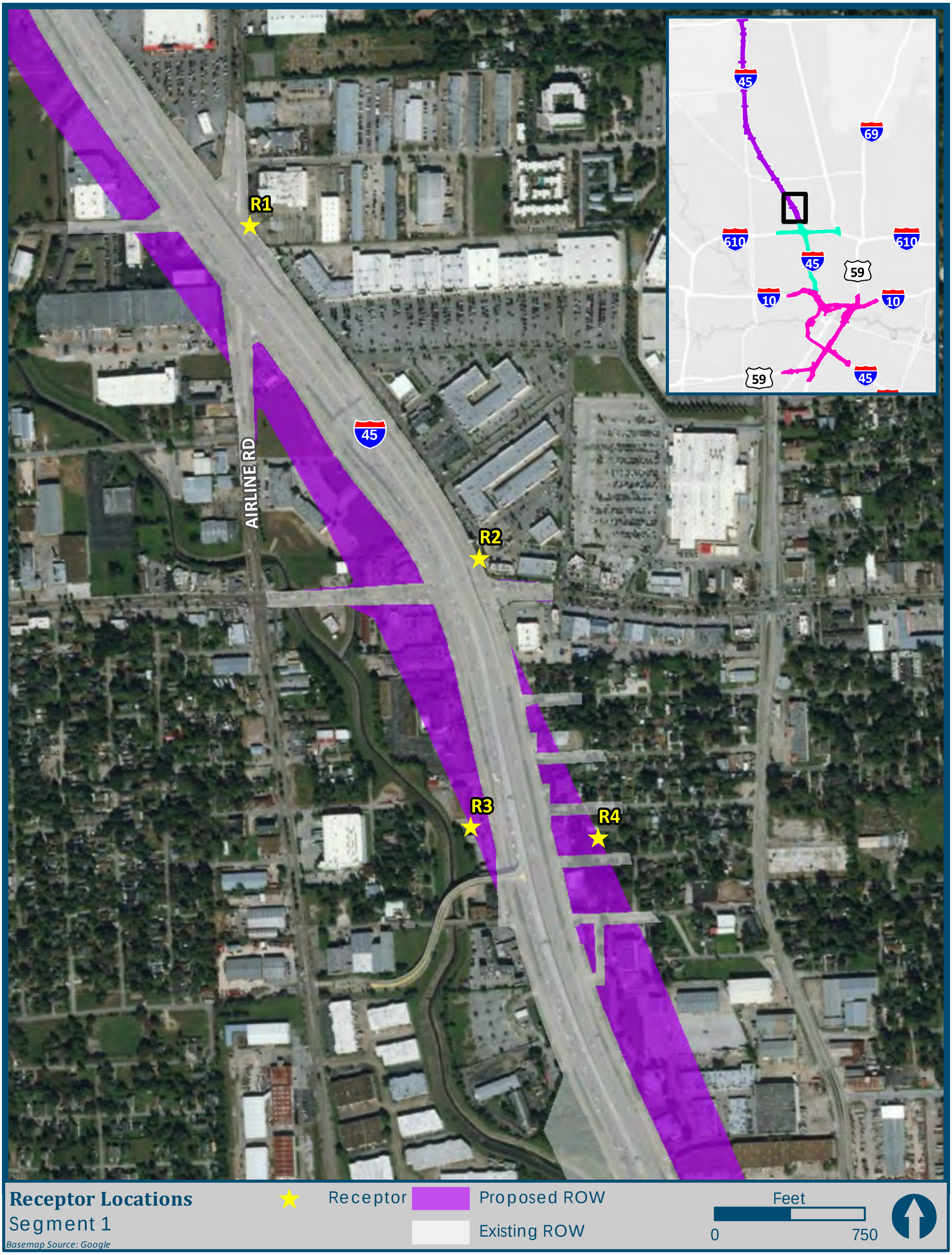
Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
US 59 NB MAINLANES	93,500	108,000	0.13	6.1%	2.7%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	93.9%	97.3%			
Medium Duty	2.5%	1.1%			
Heavy Duty	3.6%	1.6%			

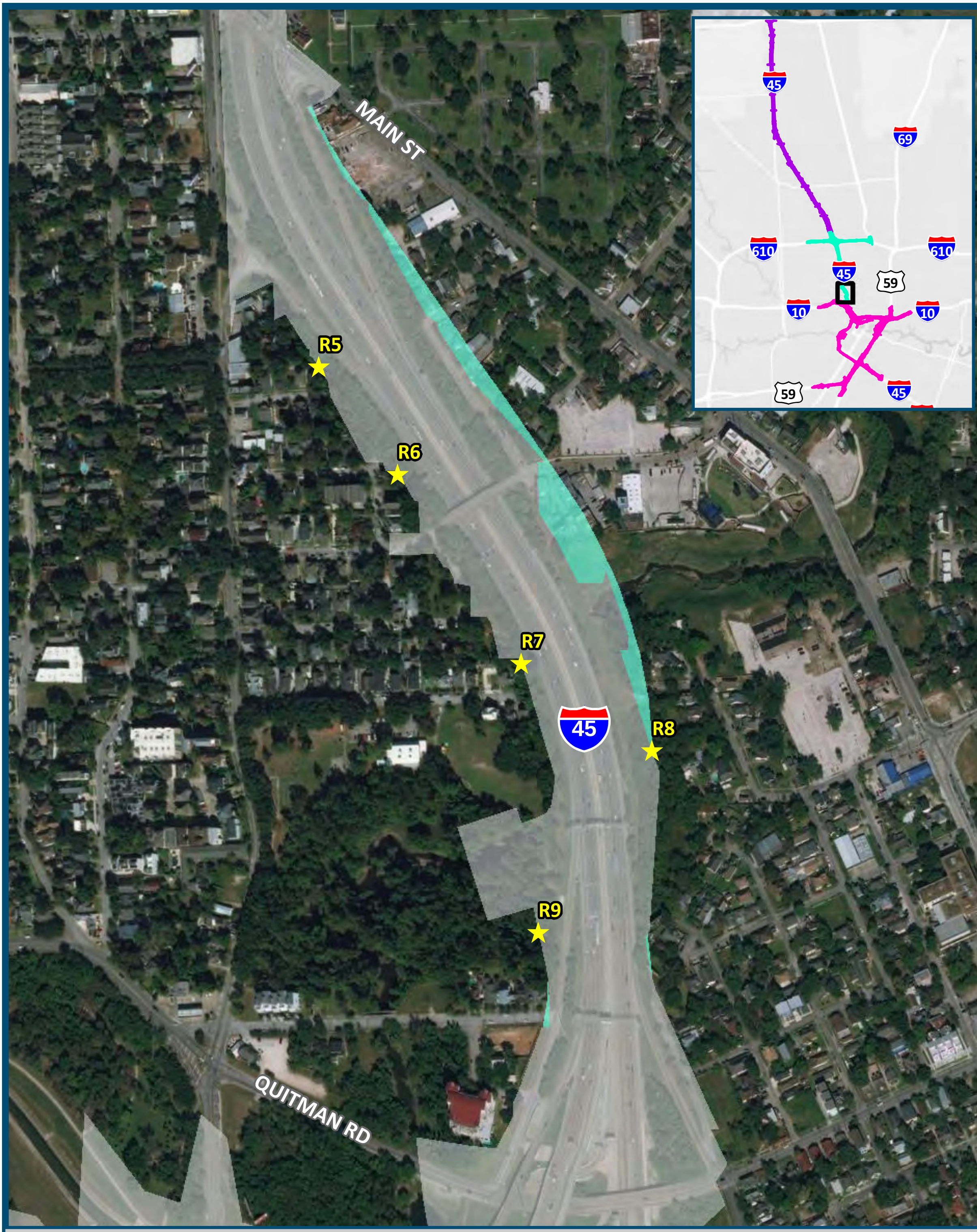
Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
SH 288 SB MAINLANES	95,300	105,300	0.11	9.6%	6.3%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	90.4%	93.7%			
Medium Duty	7.1%	4.7%			
Heavy Duty	2.5%	1.6%			

Description of Location	Average Daily Traffic		k-factor	Percent Trucks	
	2017	2040		ADT	DHV
SH 288 NB MAINLANES	94,600	124,400	0.11	9.6%	6.3%
Data for Use in Air & Noise Analysis					
Vehicle Class	Mainlanes				
	% of ADT	% of DHV			
Light Duty	90.4%	93.7%			
Medium Duty	6.0%	4.0%			
Heavy Duty	3.5%	2.3%			

APPENDIX B

Receptor Locations


R1
R2
R3
R4
AIRLINE RD
45
610
69
59
10
Receptor Locations
Segment 1
Basemap Source: Google
Receptor
Proposed ROW
Existing ROW
Feet
0
750



Receptor Locations

Segment 2

Basemap Source: Google

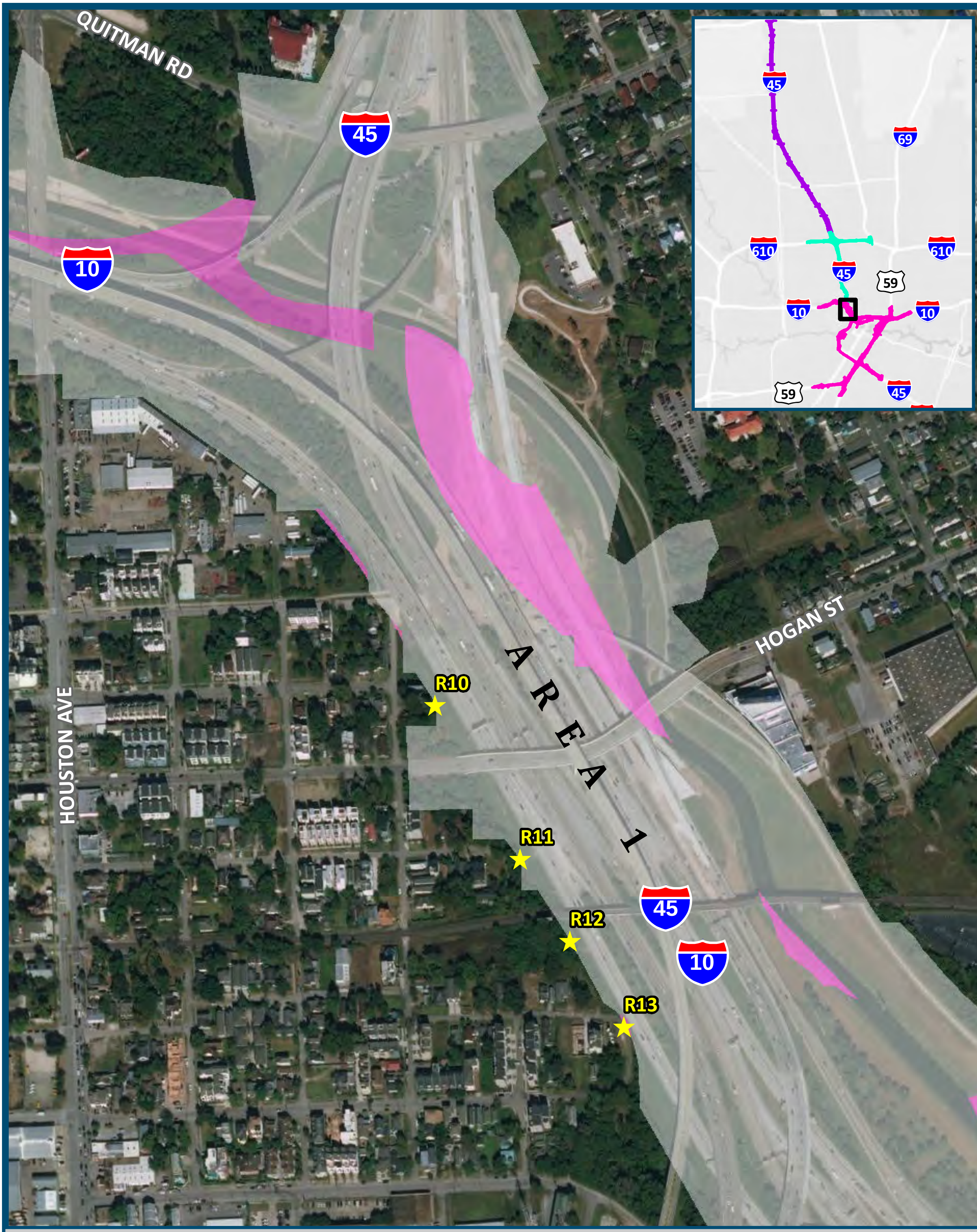
Receptor

Proposed ROW

Existing ROW

Feet

0 500



Receptor Locations

Segment 3: Area 1

Basemap Source: Google

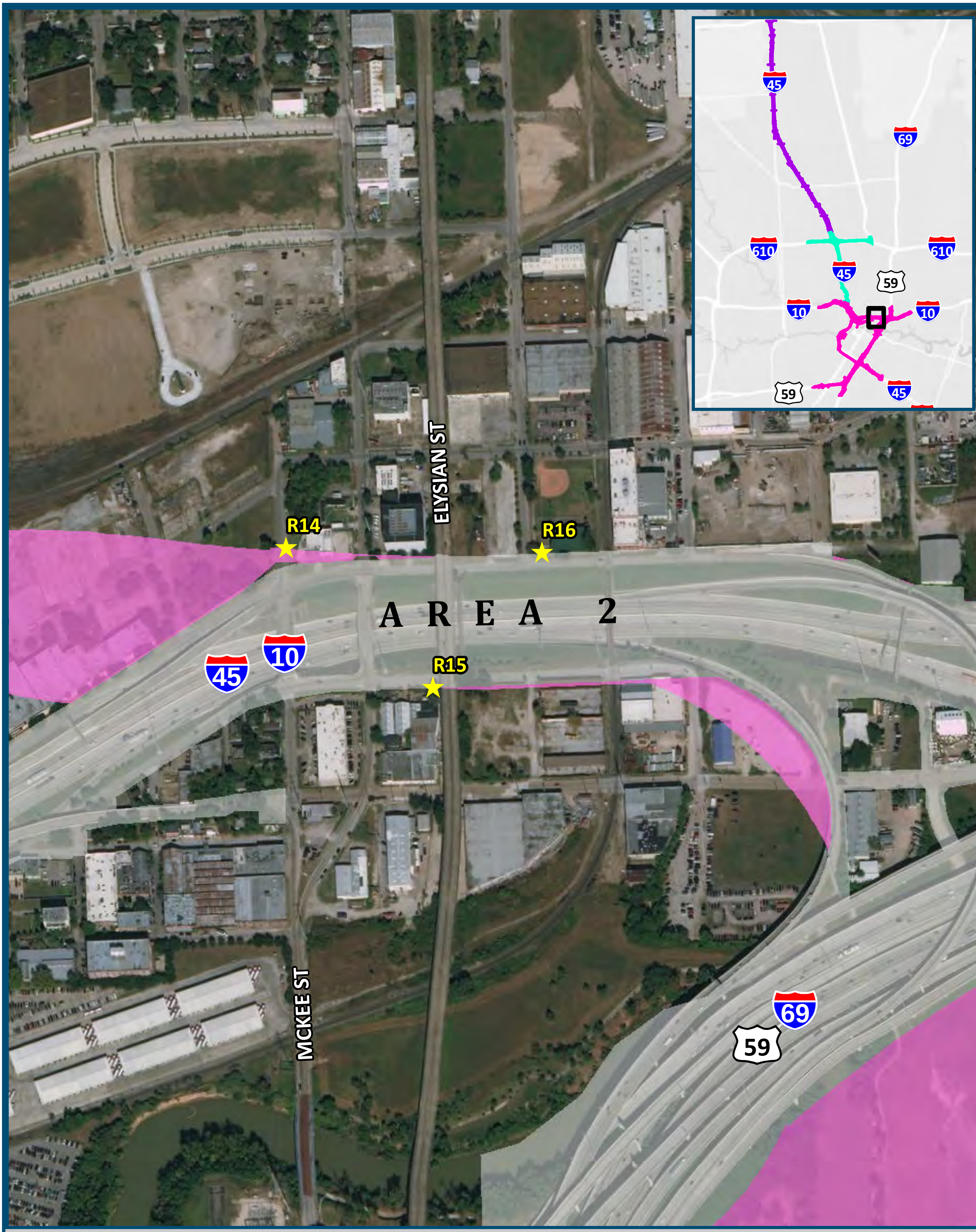
★ Receptor

Proposed ROW

Existing ROW

Feet

0 500



Receptor Locations
Segment 3: Area 2
Basemap Source: Google

Receptor
Proposed ROW
Existing ROW

Feet
0 500

Receptor Locations

Segment 3: Area 3

Basemap Source: Google

Receptor

Proposed ROW

Existing ROW

Feet

0 750

APPENDIX C

CO Concentration Result per Receptor

Segment/Area	2035: Estimated Time of Completion (ETC)				2040: Design Year			
Receptor	1 Hour CO Concentration	1 Hour CO Background Concentration	8 Hour CO Background Concentration	8 Hour CO Concentration	1 Hour CO Concentration	1 Hour CO Background Concentration	8 Hour CO Background Concentration	8 Hour CO Concentration
Segment 1, Preferred Alternative: Airline Rd to Stokes Rd								
Receptor 1	2.7	2.5	1.9	**2.02**	2.6	2.5	1.9	**1.96**
Receptor 2	2.7	2.5	1.9	**2.02**	2.8	2.5	1.9	**2.08**
Receptor 3	2.7	2.5	1.9	**2.02**	2.7	2.5	1.9	**2.02**
Receptor 4	2.7	2.5	1.9	**2.02**	2.6	2.5	1.9	**1.96**
Segment 2, Preferred Alternative: Main St to Quitman Rd								
Receptor 5	2.6	2.5	1.9	**1.96**	2.6	2.5	1.9	**1.96**
Receptor 6	2.6	2.5	1.9	**1.96**	2.6	2.5	1.9	**1.96**
Receptor 7	2.8	2.5	1.9	**2.08**	2.8	2.5	1.9	**2.08**
Receptor 8	2.7	2.5	1.9	**2.02**	2.6	2.5	1.9	**1.96**
Receptor 9	2.7	2.5	1.9	**2.02**	2.7	2.5	1.9	**2.02**
Segment 3, Preferred Alternative: Downtown Loop System								
Area 1: IH45/IH10 to Downtown Connectors								
Receptor 10	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Receptor 11	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Receptor 12	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Receptor 13	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Area 2: Downtown Connectors to IH 69/US 59								
Receptor 14	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Receptor 15	2.9	2.5	1.9	**2.14**	2.9	2.5	1.9	**2.14**
Receptor 16	2.8	2.5	1.9	**2.08**	2.9	2.5	1.9	**2.14**
Area 3: IH 69/US 59 to SH 288								
Receptor 17	3.7	2.5	1.9	**2.62**	3.7	2.5	1.9	**2.62**
Receptor 18	3.9	2.5	1.9	**2.74**	3.6	2.5	1.9	**2.56**
Receptor 19	3.6	2.5	1.9	**2.56**	3.5	2.5	1.9	**2.50**

Highlighted Highest CO Concentration per Segment/Area (2035)

Highlighted Highest CO Concentration per Segment/Area (2040)

APPENDIX D

Additional Information

Overview

Based upon public comment, TxDOT examined additional information regarding localized air quality including: 1) national near-road monitoring network, 2) air quality monitoring data for the Houston area under the heading EPA "Monitor Values Report," 3) TCEQ Trends Report for on-road mobile source projected emissions over time demonstrating a downward trend in emissions even with increasing vehicle miles of travel (VMT), 4) EPA national air quality trends showing downward trend in emissions with increasing population, and 5) TCEQ air quality successes showing a downward trend in ozone levels for the Houston area. The area attains or is unclassifiable for all NAAQS pollutants except for ozone.

National Near-Road Monitoring Network

EPA established near road monitoring requirements for the nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter 2.5 microns ($PM_{2.5}$) NAAQS that required deployment of a near road monitor (NRM) network between 1/1/2014 to 1/1/2017. The criteria for the NRM network included:

- NO_2
  - 1 NRM for core-based statistical areas (CBSAs) with population ≥ 500,000
  - A second NRM for CBSAs with population ≥ 2,500,000 population or with one or more road segments with an annual average daily traffic ≥ 250,000 vehicles
  - 68 monitors nationwide for areas representing susceptible and vulnerable populations, including disproportionately exposed groups at risk for NO_2 related health effects in areas with the potential to exceed the NAAQS (due to emissions from motor vehicles, point sources or area sources). The Regional EPA Administrator chooses locations for the susceptible and vulnerable population monitors for their Region.
- CO: 1 monitor for CBSA's with population ≥ 1,000,000,
- PM2.5: 1 monitor for CBSAs with population ≥1,000,000,

The two near-road monitors established in the Houston area include:

1. Houston North Loop
EPA Site Number: 482011052
CAMS: 1052
CO, NO_x, $PM_{2.5}$, Temp., Wind
2. Houston Southwest Freeway
EPA Site Number: 482011066
CAMS: 1066
NO_x, Temp, Wind.

See the excerpted charts below from the *National Near-Road Data Assessment: Report No. 3 with 2016 Data*[1], Washington State Department of Transportation (WSDOT)[2], February 2018. Note that neither NO_2 nor CO are reaching levels of concern (i.e., above the applicable NAAQS) nationally, statewide, or in Houston specifically with regards to the near-road monitoring network. For 2016, the data was incomplete in order to evaluate $PM_{2.5}$ from the applicable near-road monitor in Houston.

As a prelude to reading the charts below, for the 8-hour CO concentrations and NO_2 concentrations there are dashed-lines showing where the applicable NAAQS are in relation to the monitored values; however, the 1-hour CO concentrations do not show this NAAQS line because the measured CO

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[1] Funded by the Near-Road Air Quality Research Transportation Pooled Fund (TPF) as TPF-5(284)

[2] WSDOT is the lead agency for this TPF

concentrations trend significantly lower than the NAAQS. The orange circles represent the annual mean concentrations and the blue boxes in the NO_2 chart represent the 98th percentile of 1-hour daily maximum concentrations. These should be compared to the orange NAAQS lines and blue NAAQS line, respectively. The box represents the 25th and 75th percentile of data and the line in the box represents the 50th percentile (median). The whiskers represent the interquartile range (IQR) and any data beyond these were plotted individually.

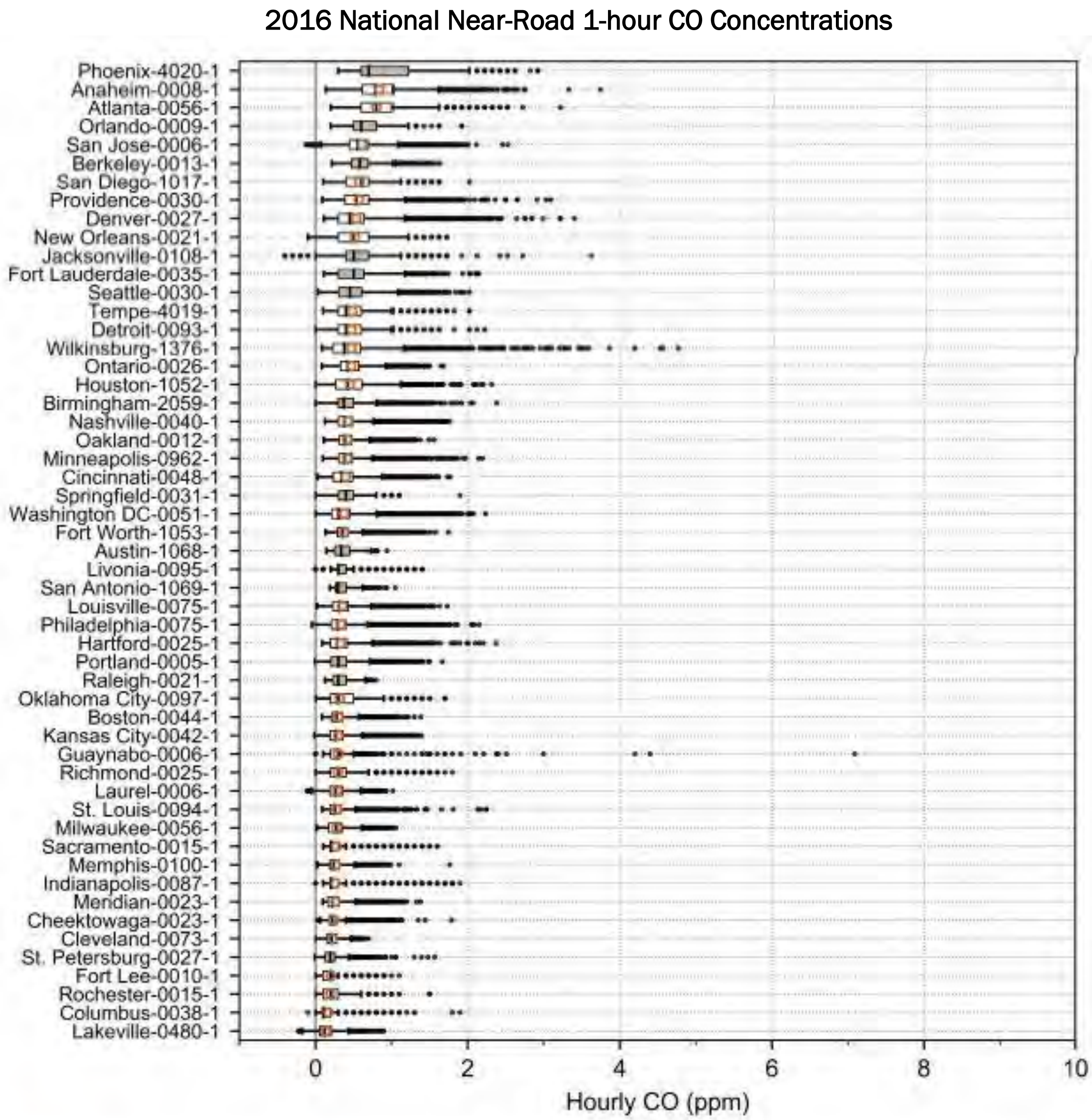


Figure 10. Distribution of 1-hour CO concentrations at near-road monitoring sites in 2016. Monitors with datasets that did not meet the 75% completeness criteria are shaded in gray. The annual mean (orange circle) is displayed for monitors with complete annual datasets. The 1-hour NAAQS for CO is 35 ppm (not shown).

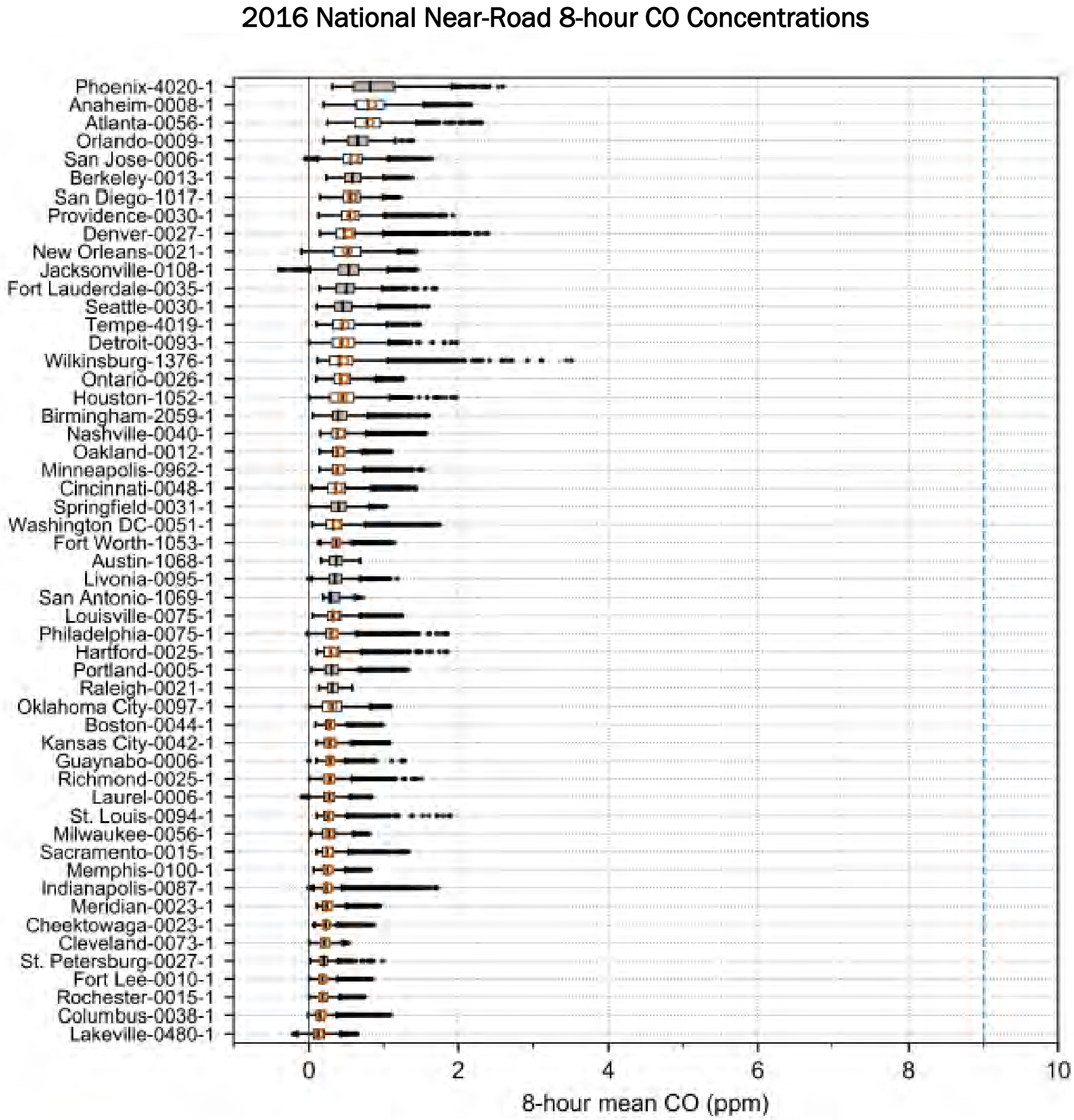


Figure 11. Distribution of 8-hour CO concentrations at near-road monitoring sites in 2016. Monitors with datasets that did not meet the 75% completeness criteria are shaded in gray. The annual mean (orange circle) is displayed for monitors with complete annual datasets. The blue dashed lined denotes the 8-hour NAAQS threshold (9 ppm).

2016 National Near-Road 1-hour NO_2 Concentrations

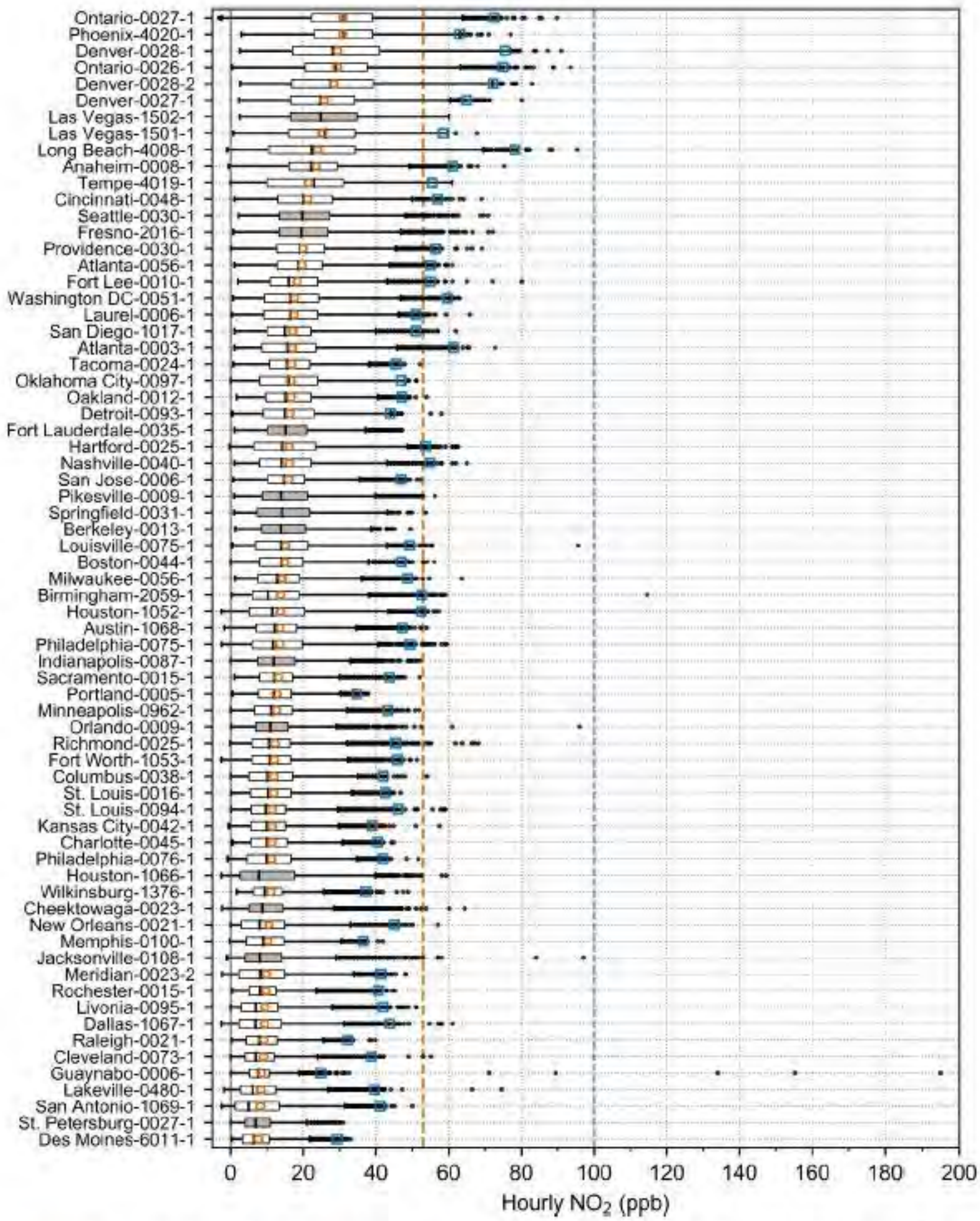
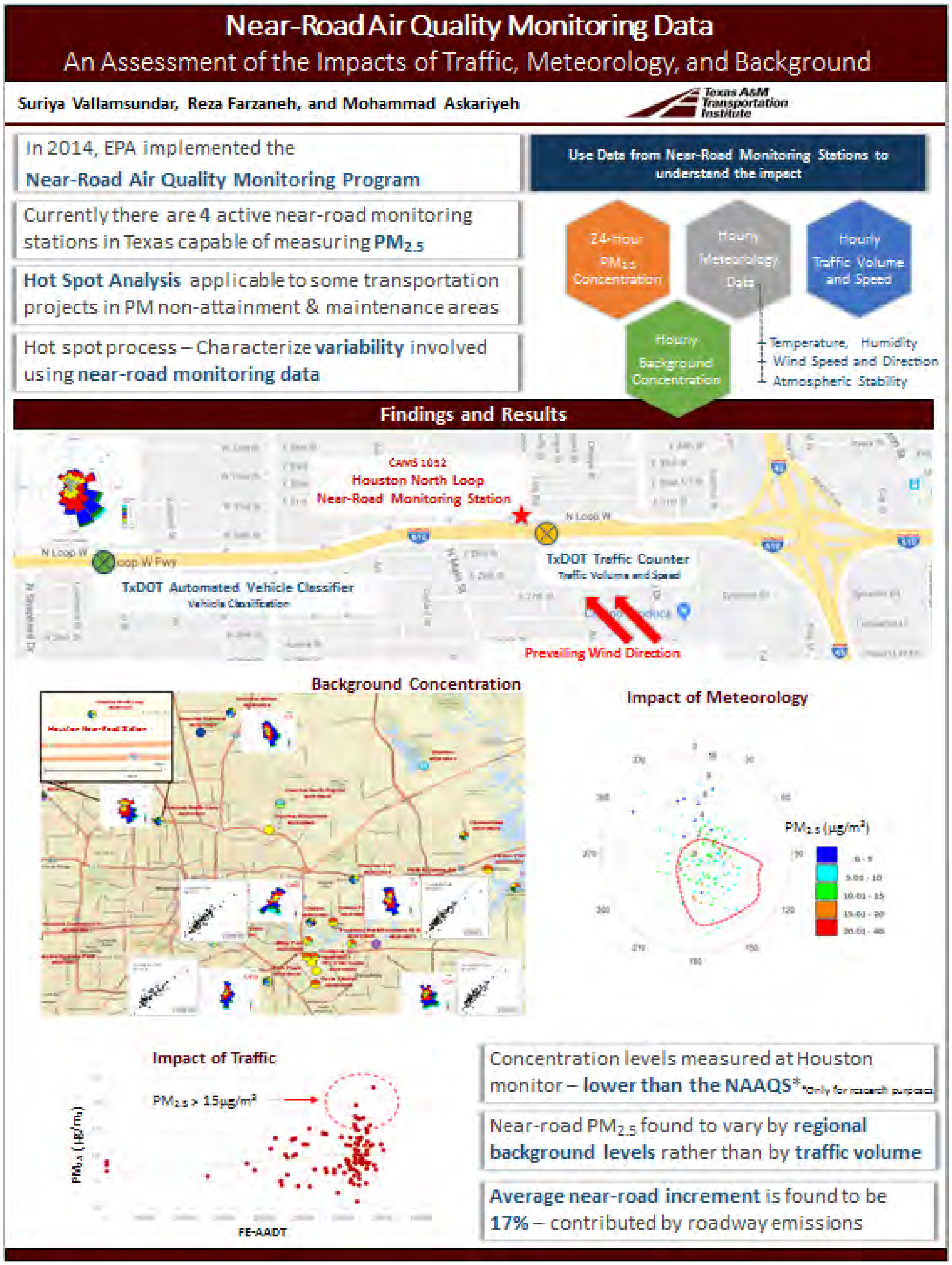


Figure 8. Distribution of 1-hour NO_2 concentrations at near-road monitoring sites in 2016.[9] Monitors with datasets that did not meet the 75% completeness criteria are shaded in gray. The annual mean (orange circle) and 98th percentile of 1-hour daily maximum concentrations (blue square) are displayed for monitors with complete annual datasets. The orange dashed lined denotes the annual NAAQS threshold (53 ppb), and the blue dashed line the 1-hr NAAQS threshold (100 ppb).

In addition to the above near-road study, the Texas Transportation Institute (TTI) has also evaluated near-road monitor data in Texas[3]. Below is a poster they developed regarding the Houston North Loop near-road monitor. It is important to note that not only were concentration levels measured at this monitor lower than the applicable NAAQS, but they also found that near-road $PM_{2.5}$ varies more by regional background levels than by traffic volume.



[3] TxDOT Transportation Research Program 0-6943; ongoing research;
Project Title: Evaluation of Air Quality Models with Near-Road Monitoring Data

EPA Monitor Value Reports

EPA has Monitor Value Reports[4] for the various monitors throughout the United States. 2018 reports are provided below for the greater Houston area including the two near-road monitors. The following table provides a breakdown of the applicable monitoring thresholds and NAAQS for use in analyzing the Monitor Value Reports. Note that the near-road monitors are highlighted in yellow in each of the below reports.

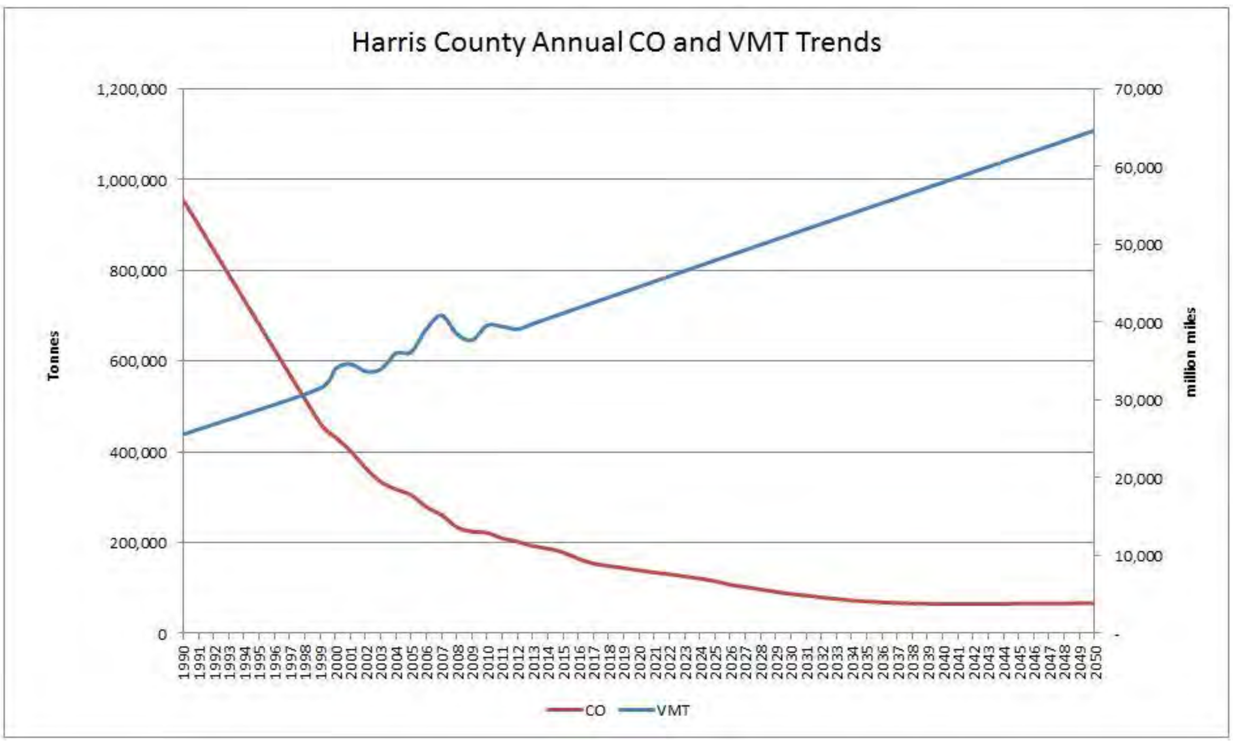
Criteria Pollutant	Compare To	NAAQS
CO 1-hr	the 2nd highest 1-hour measurement in the year	35 ppm
CO 8-hr	the 2nd highest non-overlapping 8-hour average in the year	9 ppm
NO_2 (1 hour)	the 98th percentile of the daily max 1-hour measurements in the year	100 ppb
NO_2 (1 year)	the annual mean of all the 1-hour measurements in the year	53 ppb
$PM_{2.5}$ (primary 1 year)	the Weighted Annual Mean (mean weighted by calendar quarter) for the year	12 ug/m^3
$PM_{2.5}$ (secondary 1 year)	the Weighted Annual Mean (mean weighted by calendar quarter) for the year	15 ug/m^3
$PM_{2.5}$ (primary 1 year)	the 98th percentile of the daily average measurements in the year	35 ug/m^3

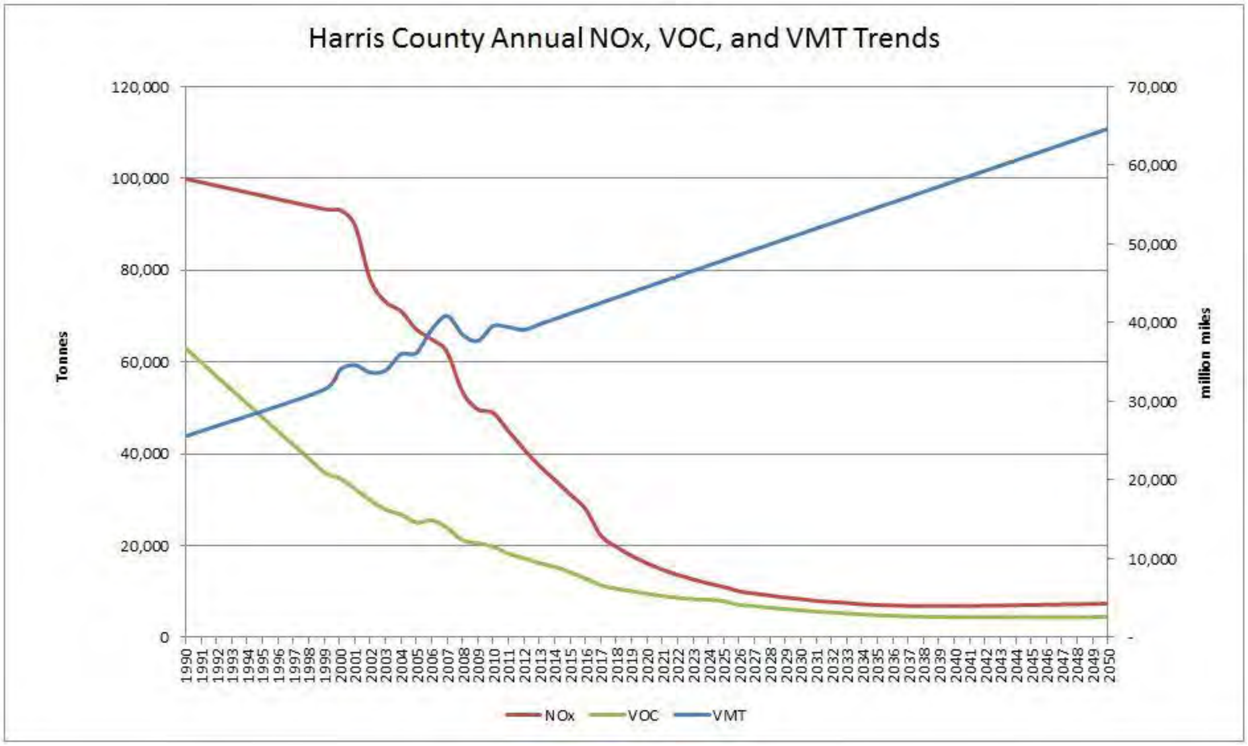
There are several important takeaways from these EPA Monitor Value Reports. The first is that none of the monitors, including the near-road monitors, exceed the applicable NAAQS for any of these criteria pollutants. The second is that in the case of $PM_{2.5}$, the near-road monitor does not have the highest monitor readings. Although the near-road monitors are a relatively new occurrence in relation to the other area monitors and more data is needed, these monitors do not indicate emissions near the roadway exceed the health-based NAAQS.

[4]Source: https://www.epa.gov/outdoor-air-quality-data/monitor-values-report

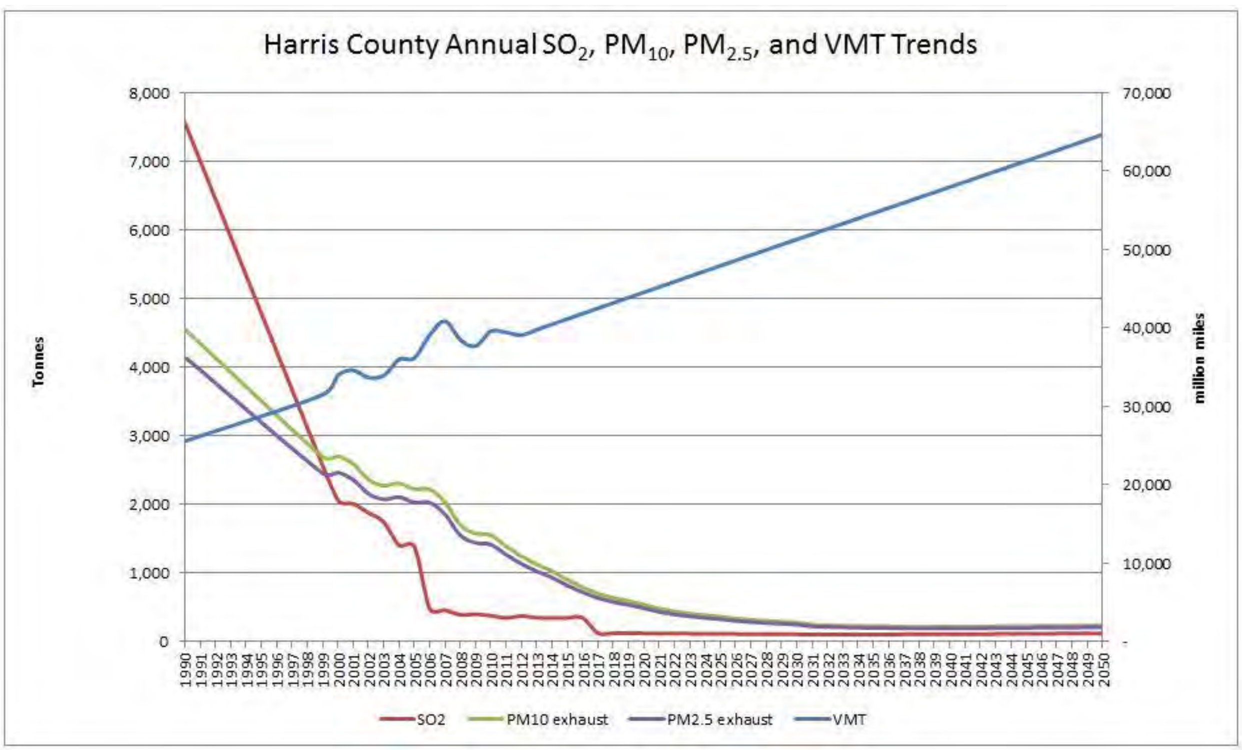
TCEQ Trends Report

In addition to maintaining the network of regulatory air quality monitors in Texas (including the above referenced near-road monitors), TCEQ also performs modeling of on-road mobile source emissions. In their document, titled *On Road, Mobile Source Trend Emissions Inventories for all 254 Counties in Texas for 1999-2050*, TCEQ provides projected trends in emissions using the MOVES2014 emission model and factoring in Texas specific characteristics. See the below charts for Harris County for various criteria pollutant and ozone precursors (VOC and NO_x). Common among these trends is that even with an increase in VMT, overall tailpipe emissions are expected to decline significantly into the future for each of the criteria pollutants and precursors evaluated. Since the area is attaining all but the ozone standard and the modeling predicts a downward trend over time, we anticipate continued attainment of these NAAQS. As for ozone, the conformity process must be followed which is intended to prevent any worsening of the existing NAAQS violation, but there are also downward trends predicted for the ozone precursors (VOC and NOx) as well.





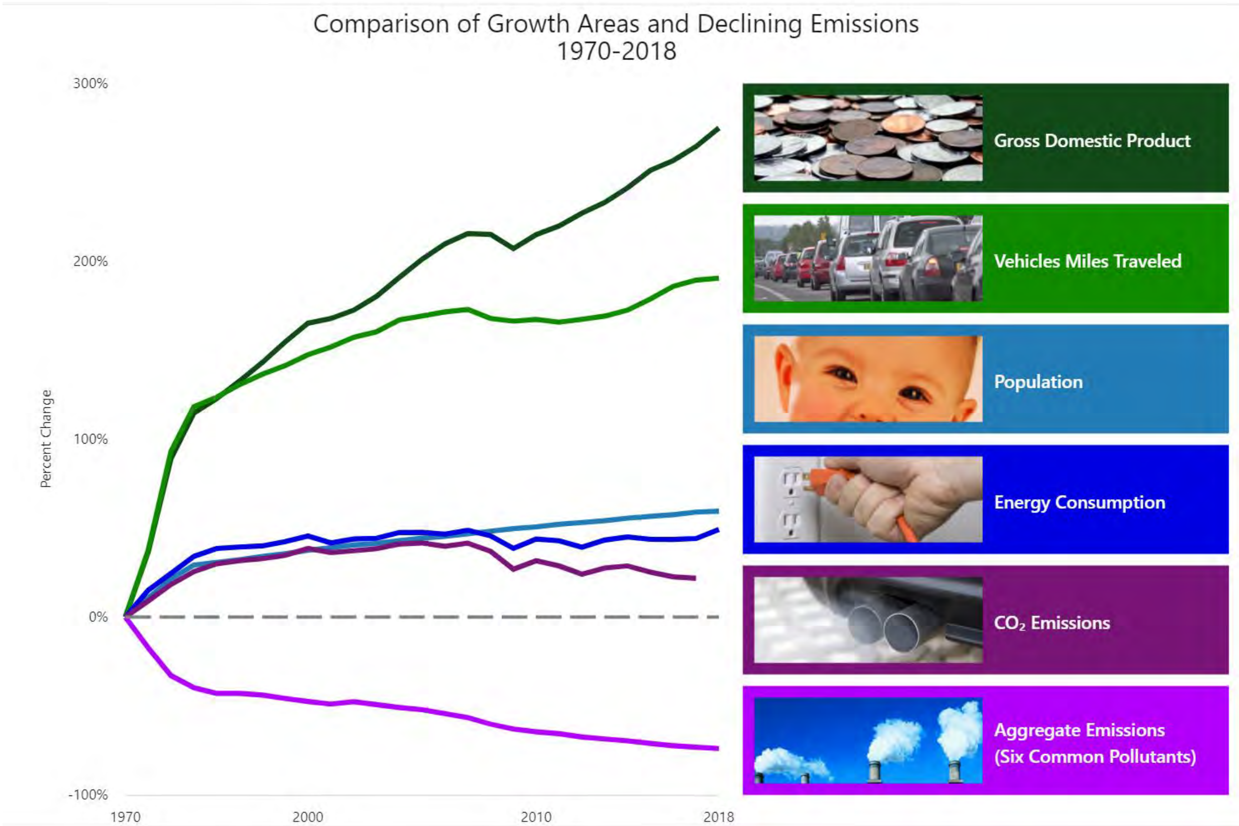
Harris County Annual NOx, VOC, and VMT Trends
Tonnes
million miles
NOx
VOC
VMT



Harris County Annual SO_2, PM_{10}, $PM_{2.5}$, and VMT Trends
Tonnes
million miles
SO2
PM10 exhaust
PM2.5 exhaust
VMT

EPA Air Quality Trends

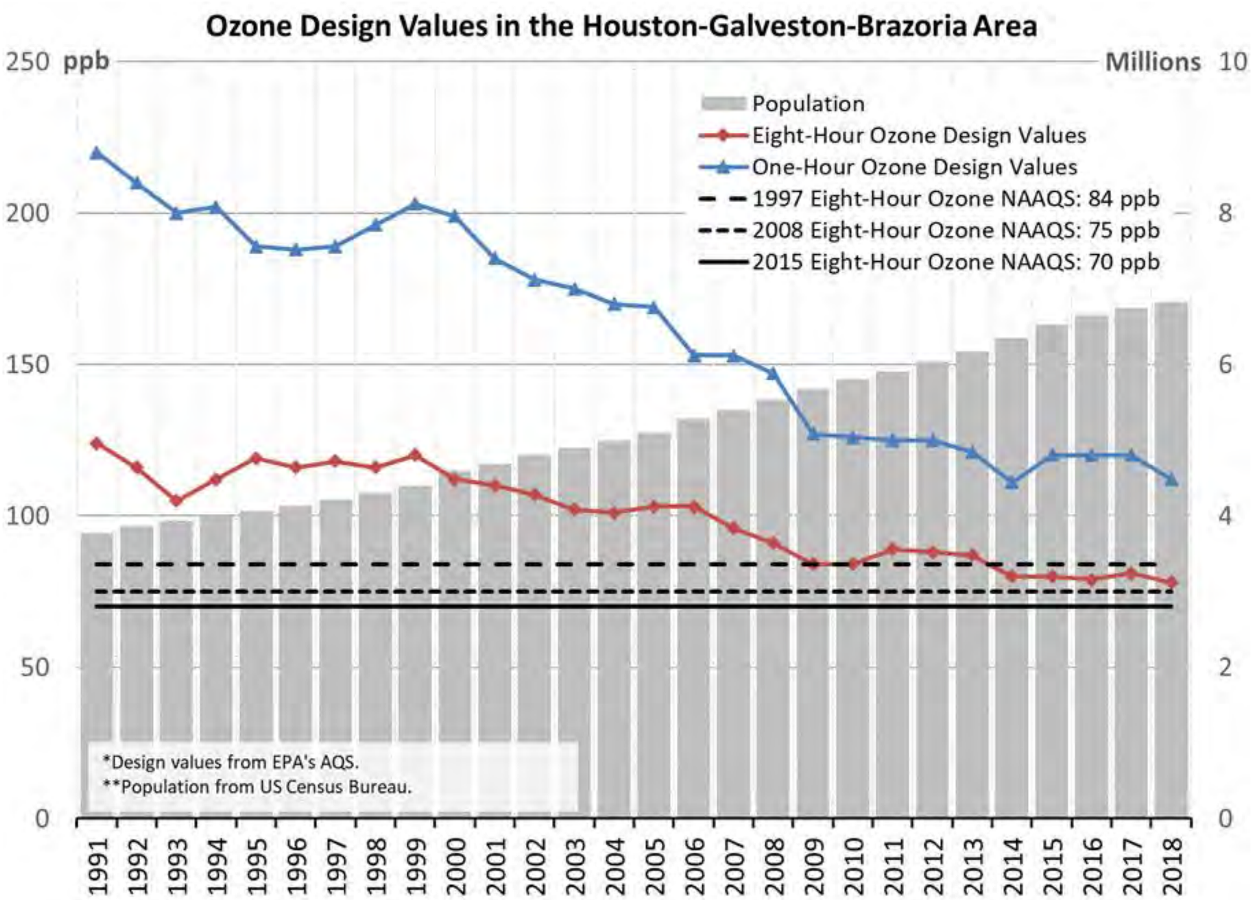
The Clean Air Act (CAA) appears to be working as evidenced by the emission reductions over the past 30+ years in the chart below for "Comparison of Growth Areas and Emissions 1970-2018." The graph shows that between 1970 and 2018, gross domestic product increased 275 percent, vehicle miles traveled increased 191 percent, energy consumption increased 49 percent, and U.S. population grew by 60 percent. During the same time period, total emissions of the six principal air pollutants dropped by 74 percent.



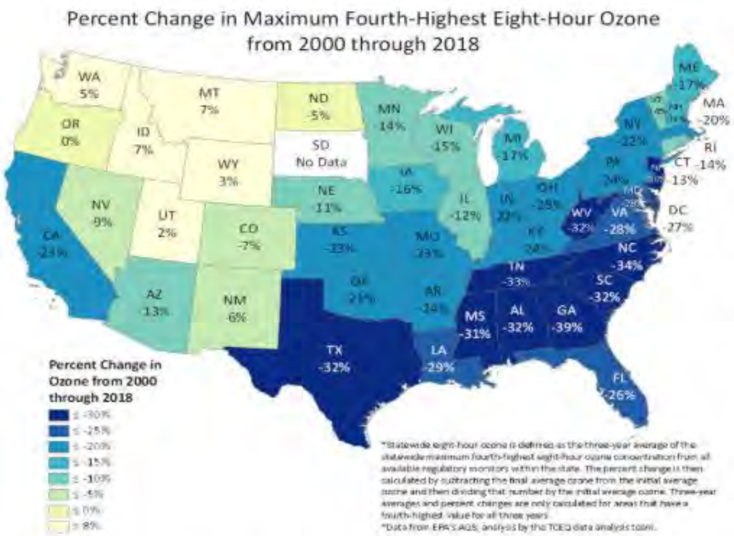
Source: EPA, Our Nation's Air 2019, accessed October 2019 at https://gispub.epa.gov/air/trendsreport/2019/#growth

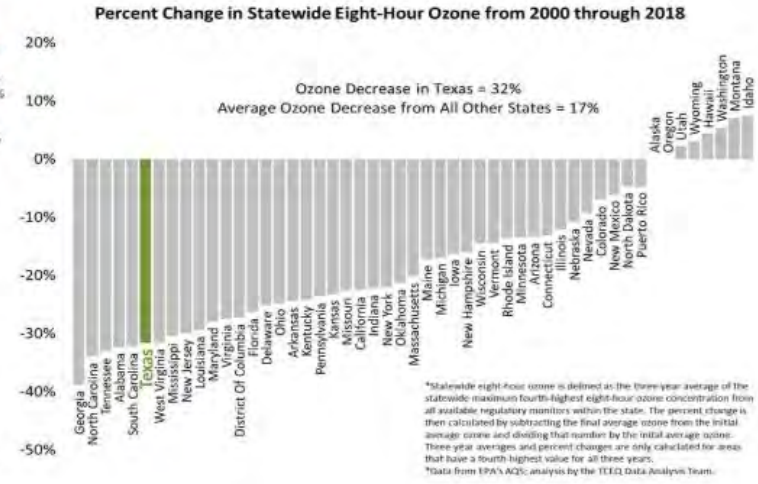
Air Quality Successes - Ozone

The only criteria pollutant for which the Houston area is nonattainment is ozone, so it is important to focus some attention on the success being made in reducing it. Below are some charts developed by TCEQ showing the ozone story that is in progress. The first chart shows design values trending downward in the Houston-Galveston-Brazoria (HGB) area, despite an increasing population. A second chart shows Texas ozone improvements when compared to the other states, with Texas having the sixth largest decrease in the nation. Project-level transportation conformity ensures the project will not: (1) cause or contribute to any new violation of the NAAQS; (2) increase the frequency or severity of any existing violation of the NAAQS; or (3) delay timely attainment of the NAAQS. In fact, the project cannot proceed to clearance without conformity being demonstrated.



Source: Texas Commission on Environmental Quality, Air Quality Successes – Texas Metropolitan Areas, accessed October 2018 at: https://www.tceq.texas.gov/airquality/airsuccess/airsuccessmetro, "HGB Ozone and Population" chart.





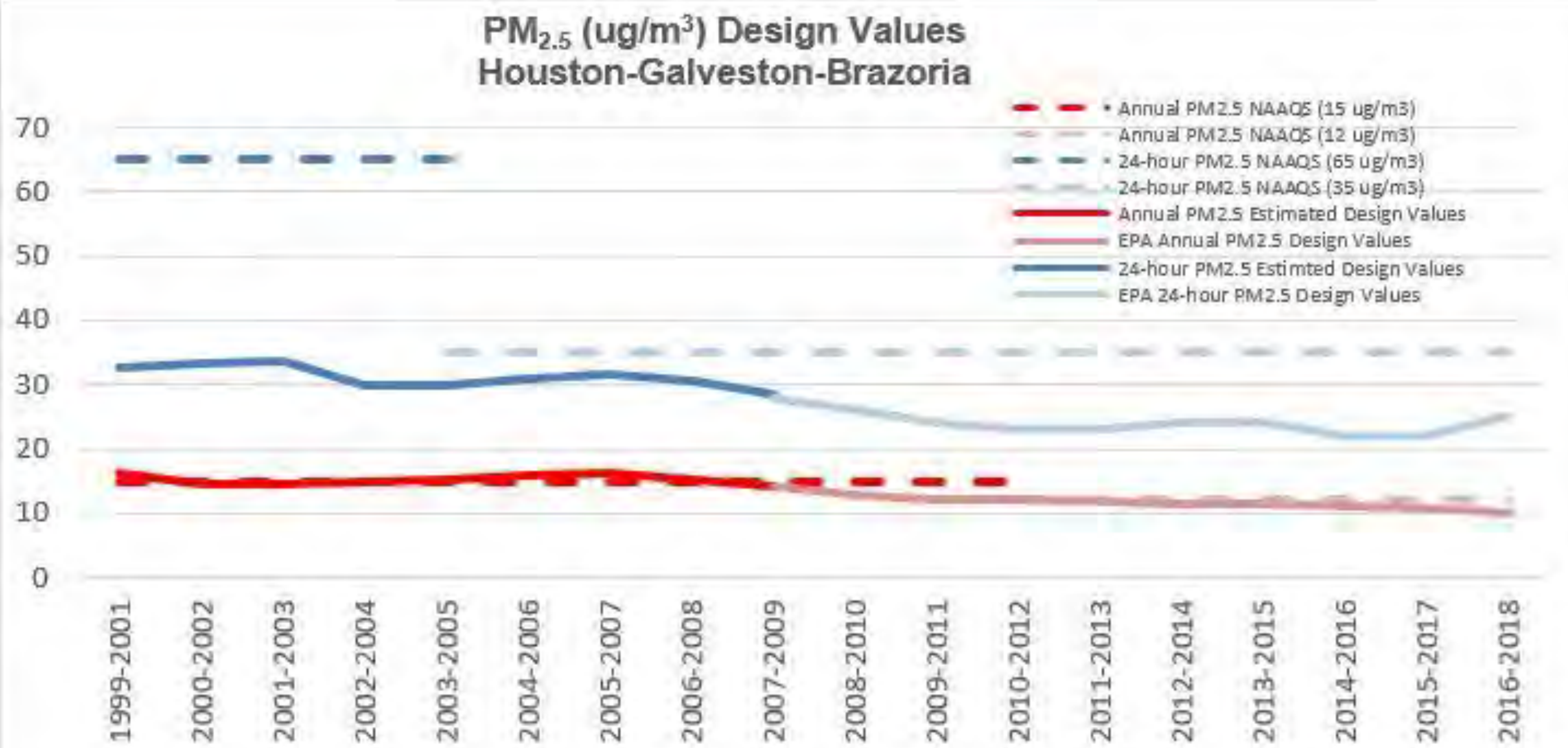
- Texas showed a 32% decrease in ozone, the 6th largest decrease in the United States.

- All other states (excluding Texas) averaged a decrease of only 17%.

- The eastern half of the US, plus Texas and California, had the largest decreases in ozone while the western US saw less of a decrease and even an increase in some states.

- Numbers are based on the three-year average of the fourth-highest eight-hour ozone concentration from all monitors operating within each state.

Source: Texas Commission on Environmental Quality, Air Quality Successes – Compared to Other States, accessed October 2018, at: https://www.tceq.texas.gov/airquality/airsuccess/airsuccesstxcompared. "Ozone Trends" chart.



*Design values from EPA design value report: https://www.epa.gov/air-trends/air-quality-design-values#report

**Estimated design values developed from EPA Monitor Values Report: https://www.epa.gov/outdoor-air-quality-data/monitor-values-report, includes exceptional events, estimated design values do not account for any data substitution by EPA or TCEQ.

Source: TxDOT, prepared from EPA DV Report and EPA Monitor Values Report

Summary

Based on the evaluation of the near-road monitoring data, future trends modeling, EPA's monitor reports and national air quality monitoring trends, and the demonstration of ozone improvement, the region is expected to continue the trend of improving air quality into the future.