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Final Report: ETCOG Rider 7 Local Air Quality Planning Grant

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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List of Acronyms and Abbreviations

BVOC	Biogenic Volatile Organic Compound
CAMS	Continuous Air Monitoring Station
CO	Carbon Monoxide
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
HONO	Nitrous acid
HOTCOG	Heart of Texas Council of Governments
JJA	June July August
LAI	Leaf Area Index
MDA8	Maximum Daily 8-hr Average
MEGAN	Model of Emissions of Gases and Aerosols from Nature
NAAQS	National Ambient Air Quality Standard
NASA	National Aeronautics and Space Administration
NEI	National Emissions Inventory (from the EPA)
NO	Nitric Oxide
NO ₂	Nitrogen Dioxide
NO _x	Oxides of Nitrogen
O ₃	Ozone
S2/MSI	Sentinel-2 satellite Multispectral Instrument
SIP	State Implementation Plan (for the ozone NAAQS)
SON	September October November
TCEQ	Texas Commission on Environmental Quality
TEMPO	Tropospheric Emissions: Monitoring of Pollution
TLMA	Tyler-Longview-Marshall-Athens
VOC	Volatile Organic Compound

1.0 EXECUTIVE SUMMARY

The Texas Commission on Environmental Quality (TCEQ) is responsible for air quality planning in Texas to ensure compliance with the federal National Ambient Air Quality Standards (NAAQS) for several air pollutants, including ozone. The US Environmental Protection Agency (EPA) establishes these National Ambient Air Quality Standards (NAAQS) to protect public health and welfare and is required under the Clean Air Act to periodically review and update them. In 2015, EPA lowered the ozone NAAQS from the 2008 level of 75 ppb to 70 ppb. Compliance with the ozone NAAQS is assessed at individual monitoring sites by comparing each monitor's Design Value¹ to the standard. For ozone, the Design Value is defined as the three-year running average of the annual fourth-highest daily maximum 8-hour (MDA8) concentrations. Failure to comply with the NAAQS can adversely affect public health and inhibit economic development.

Ozone forms in the atmosphere when nitrogen oxides (NO_x), volatile organic compounds (VOC) and carbon monoxide (CO) are exposed to sunlight. Consequently, NO_x, VOC and CO are referred to as ozone precursors, and they can be emitted into the atmosphere by human (anthropogenic) as well as natural (biogenic) processes. For parts of Texas where measured ground-level ozone concentrations violate the NAAQS, the TCEQ develops a State Implementation Plan (SIP) to reduce anthropogenic ozone precursor emissions and bring those areas into compliance with the ozone NAAQS. Other parts of Texas comply with the ozone NAAQS but have measured ozone levels that suggest local air quality planning activities can be beneficial for maintaining compliance with the ozone NAAQS. Consequently, the Texas legislature provided funding to the TCEQ under Rider 7 to support local air quality planning grants. The East Texas Council of Governments (ETCOG) received a Rider 7 grant for Tyler-Longview-Marshall-Athens (TLMA) area of Northeast Texas (TCEQ contract 582-20-11978) in Fiscal Years 2024 and 2025 and this document reports on how that funding was deployed. The report is structured in accordance with TCEQ's guidance as an Executive Summary followed by appendices that provide details for all the activities.

1.1 Air Quality in the Tyler-Longview-Marshall Area

The TCEQ operates three Continuous Air Monitoring Stations (CAMS; Longview CAMS 19, Tyler CAMS 82, and Karnack CAMS 85) in the TLMA area. The measured ozone concentration at these monitors determines whether the area is attaining the NAAQS for ozone. The TLMA area is in compliance with the ozone NAAQS through 2025.

The location of these monitors is shown in Figure 1.1 with urban areas shaded, including Tyler in Smith County and Longview in Gregg County. I-20 is the largest highway passing through the TLMA area. Several smaller state highways (e.g., 271, 80, and 59) are also shown. The Tyler CAMS 82 monitor is located west of Tyler in Smith County and the Karnack CAMS85 monitor is in northeastern Harrison County. The Longview CAMS19 monitor is located south of Longview in Gregg County.

¹ <https://www.epa.gov/air-trends/air-quality-design-values> accessed 8 December 2025

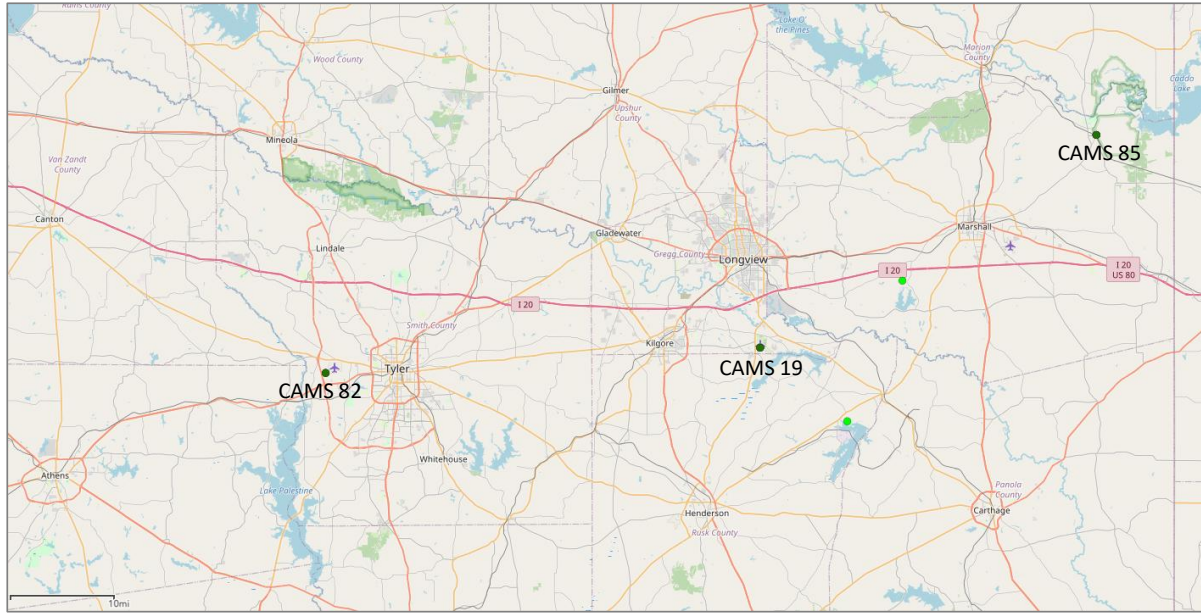


Figure 1.1. Locations of Tyler CAMS 82, Longview CAMS 19, and Karnack CAMS 85 in Northeast Texas also showing roads and urban areas (Map from TCEQ GeoTAM²).

Based on data through November 2025, the annual fourth-highest MDA8 ozone values are 67 ppb at the Longview monitor (CAMS 19) in Gregg County, 64 ppb at the Tyler monitor (CAMS 82) in Smith County, and 57 ppb at the Karnack monitor (CAMS 85) in Harrison County. Since 2020, the fourth highest MDA8 ozone values (Figure 1.2) have generally trended upward, likely due to increased ozone precursor emissions, although year-to-year weather variability and the associated frequency of ozone-conducive conditions also play roles.

Preliminary 2025 data show that all three monitors recorded lower fourth-highest MDA8 ozone values compared to 2024. Using ozone data for 2023-2025, the design values are 67 ppb for the Longview monitor (CAMS 19), 67 ppb for the Tyler monitor (CAMS 82), and 61 ppb for the Karnack monitor (CAMS 85) (Figure 1.3). All TLMA area CAMS are currently in compliance with the 2015 ozone NAAQS of 70 ppb.

² TCEQ GeoTAM accessed at <https://tceq.maps.arcgis.com/apps/webappviewer/index.html> accessed 8 December 2025

Annual 4th Highest 8-Hour Ozone Value

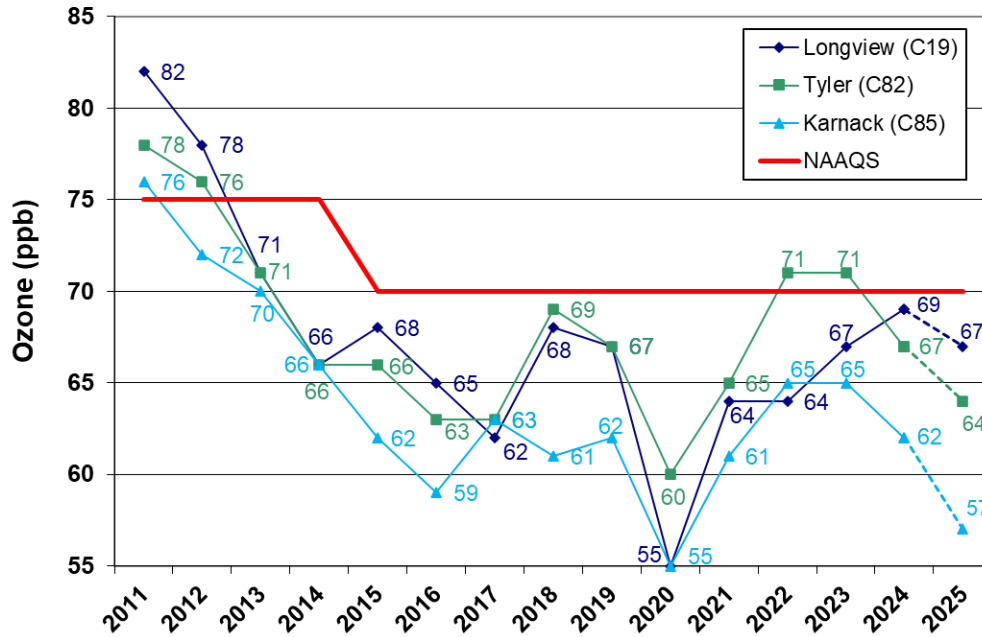


Figure 1.2. Annual 4th highest 8-hr ozone values measured in the TLMA area compared to the level of the ozone NAAQS over time.

8-hour Ozone Design Value

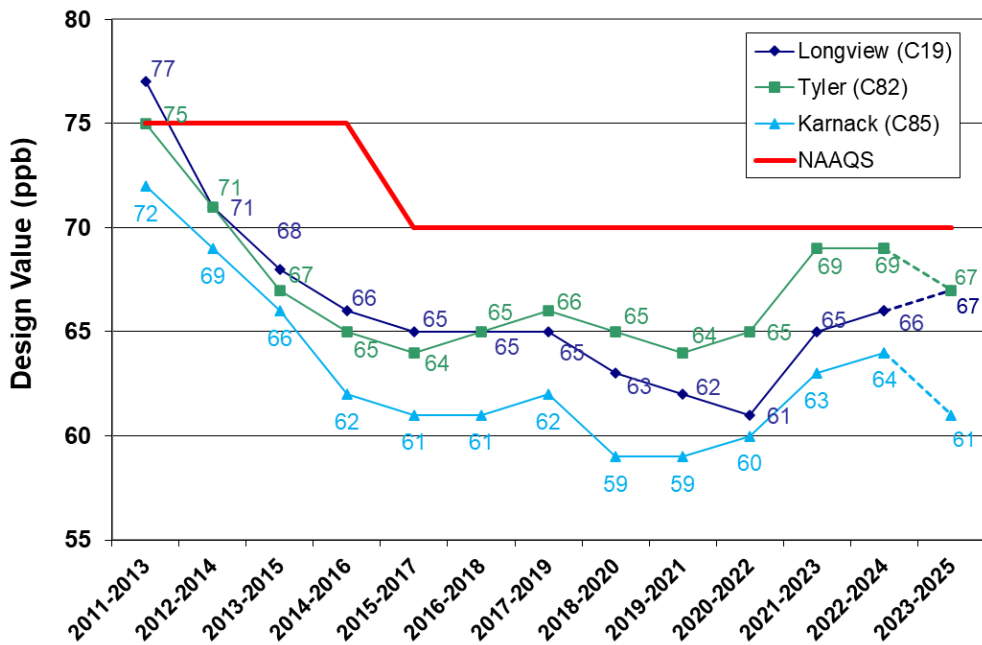


Figure 1.3. Ozone design values measured in the TLMA area compared to the ozone NAAQS showing that all monitors are in attainment of the NAAQS through 2025.

1.2 ETCOG Rider 7 Activities

ETCOG undertook two projects that are outlined below and described in detail in appendices to this report. The Rider 7 Grant allowed ETCOG to improve estimates for biogenic soil NO_x emissions (a natural ozone precursor) and to conduct ambient monitoring for the TLMA area. Emission improvements for the TLMA area also benefit TCEQ's SIP activities that rely on statewide emission inventories. Ambient monitoring for NO_x complements the data collected by the TCEQ at CAMS in the TLMA area to help characterize ozone precursor levels and trends more accurately.

1.2.1 Biogenic Emission Inventory Improvements

NO_x emissions play a crucial role as a precursor to ozone formation and there are biogenic sources of NO_x from microbial activity in soil. As anthropogenic NO_x emissions from fossil fuel combustion continue to decline, the relative contribution of biogenic NO_x emissions from both managed and unmanaged soils has been increasing.

ETCOG improved soil NO_x emissions estimate by updating the Model of Emissions of Gases and Aerosols from Nature version 3.2 (MEGAN3.2) with new input datasets and algorithm enhancements based on recent scientific advances. Key updates included refining the temperature and soil moisture response functions, incorporating updated nitrogen deposition data, and adding soil nitrous acid (HONO) emissions. Around the same time, a parallel Rider 7 effort for the Heart of Texas Council of Governments (HOTCOG) incorporated finer-resolution and more current fertilizer application data into MEGAN. The updated MEGAN version 3.21 integrates both the HOTCOG improvements and the ETCOG soil NO_x updates.

ETCOG replaced the older temperature function in MEGAN with a new, observation-based function derived from field studies conducted by Oikawa et al. (2015) and validated by Wang et al. (2021). To better represent the role of soil moisture, ETCOG also adopted an updated soil moisture response function from Huber et al. (2023), which introduces a more spatially dynamic relationship between soil moisture and soil NO_x emissions. In addition, ETCOG updated the global nitrogen deposition inputs using more recent values from multiple years of GEOS-Chem simulations, reflecting current pollution patterns and regulatory changes.

It is well established that soil microbes emit both HONO and nitric oxide (NO) (Oswald et al., 2013); however, the previous MEGAN3.2 soil NO_x scheme did not account for HONO emissions. ETCOG addressed this limitation by incorporating soil HONO emissions using the parameterization developed by Wang et al. (2025). Together, these updates provide a more accurate representation of soil NO_x emissions in the TLMA area and better support for air quality planning efforts.

1.2.2 Ambient Monitoring for True NO₂ near Tyler

Ozone production in the TLMA area depends on NO_x emissions to the atmosphere. The TCEQ conducts ambient monitoring for NO_x, which includes both NO and nitrogen dioxide (NO₂), using conventional instruments that are less sensitive than research-grade NO_x instruments. ETCOG conducted ambient monitoring for NO_x adjacent to the TCEQ's Tyler monitor (CAMS 82) during the 2024 and 2025 ozone seasons using a research-grade "true NO₂" instrument. From 2023 to 2025, measurements of total column NO₂ were added using a ground-based optical remote-sensing method to investigate whether NO₂ levels vary in the vicinity of CAMS 82. These activities will benefit the SIP by providing more accurate measurements of NO_x that can be analyzed in conjunction with data from the TCEQ's CAMS.

1.3 Summary of Findings

1.3.1 Biogenic Emission Inventory Improvements

As part of this project, ETCOG improved MEGAN3.2 soil NO_x emissions estimates by incorporating higher-quality input data and updated scientific understanding of how soil temperature and moisture influence emissions. ETCOG also added soil HONO emissions, which were not included in the previous model.

Overall, these updates showed that soil temperature and moisture strongly influence NO emissions from soils. Warmer summer conditions in drier regions, such as central California, led to increased emissions due to the updated temperature function, while updates to the soil moisture response had the greatest impact in wetter regions. Updating the nitrogen deposition data helped offset some of these increases, reducing soil NO estimates by 7.2% annually. When all updates were combined, the model estimated roughly 33% higher soil NO emissions across the U.S. for 2022 compared to the previous version. The inclusion of soil HONO emissions provides a more complete understanding of how soils contribute to air quality.

For the TLMA region, the updated model estimates total annual soil NO_x emissions, including both soil NO and HONO, at 33.1 tons per day, an 87% increase compared to the previous model (Figures 1.4 and 1.5). These improvements enhance the accuracy of soil NO_x emission estimates for the TLMA area and better support air quality planning efforts.

1.3.1.1 Summary of Findings

- When all updates were combined, nationwide soil NO emissions increased by 34% annually and nearly 38% during the summer.
- Adding soil HONO emissions provided a more complete understanding of reactive nitrogen from soils, contributing an estimated 0.53 Tg N yr⁻¹ nationwide in 2022.
- In the TLMA region, the updated MEGAN3.21 model estimates average soil NO_x emissions at 33.1 tons per day, an 87% increase over earlier estimates.

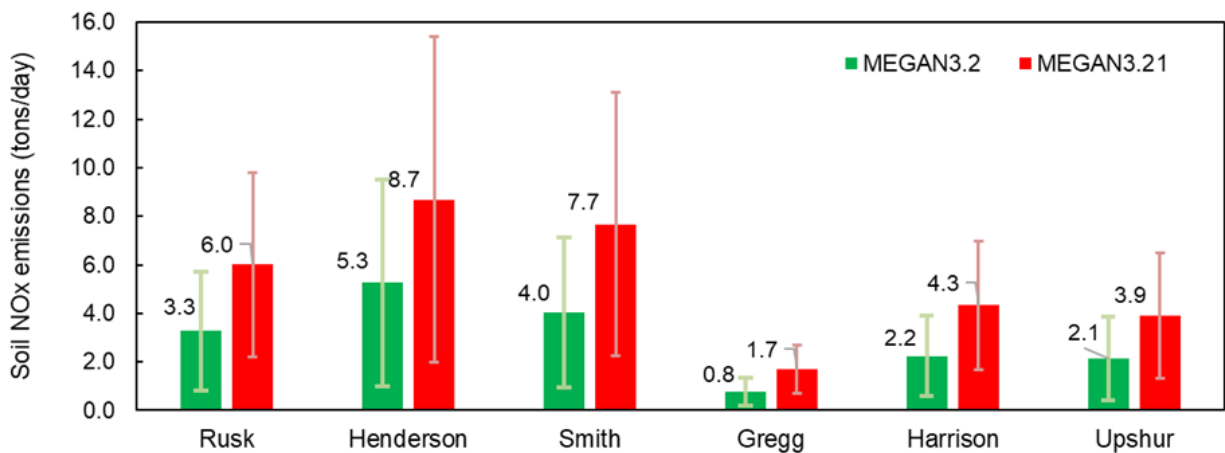


Figure 1.4. Annual soil NO_x emissions for 2022 (in tons/day) by county in the ETCOG region, estimated using MEGAN3.2 (green) and MEGAN3.21 (red). Error bars indicate the standard deviation.

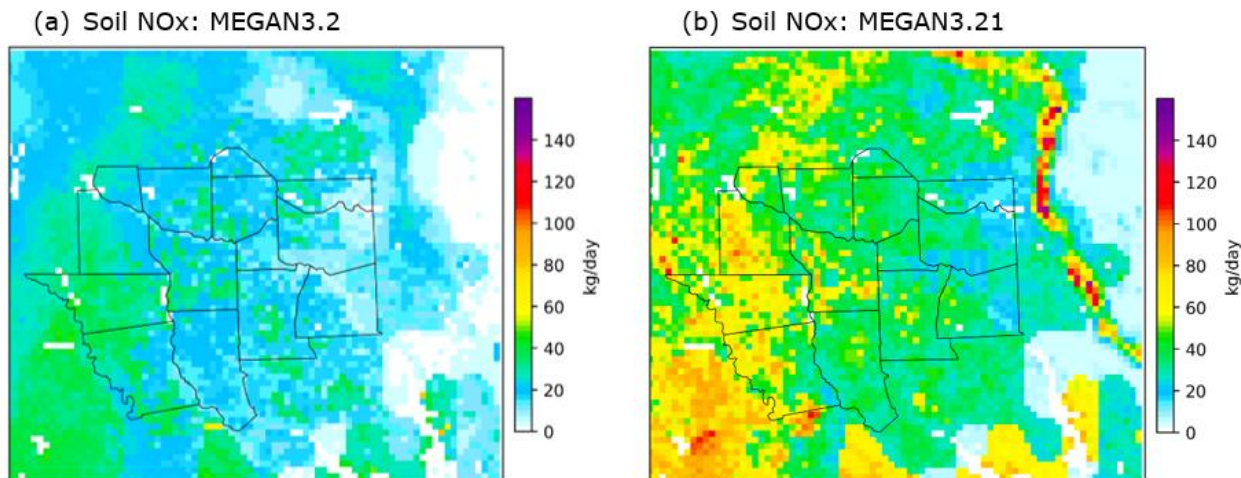


Figure 1.5. Annual soil NO_x emissions for 2022 (in kg/day) for the ETCOG region estimated using: (a) MEGAN3.2, (b) the updated MEGAN3.21.

1.3.2 Ambient monitoring for True NO₂ near Tyler

ETCOG collected robust datasets for research-grade ambient NO_x adjacent to the TCEQ CAMS 82 site during the 2024 and 2025 ozone seasons (May to October). These data complement a similar dataset collected by ETCOG from 2021 through 2023. Figure 1.6 compares the average (i.e., median) diurnal patterns of 1-hour average NO_x in each ozone season. All years have similar diurnal patterns with NO_x tending to be higher overnight, peak in the morning coincident with rush hour traffic, and then decline through the day in response to atmospheric dilution and chemical reactions. The highest overall NO_x values were seen in 2024, and 2025 was significantly lower. The 6-9 AM median NO_x in Figure 1.7 appears to increase, but this is driven by a higher value in 2024; excluding 2024, the trend is essentially flat. In contrast, the 12-4 PM median NO_x in Figure 1.8 shows a clear downward trend. Overall, no clear trend in surface NO_x emerges from monitoring adjacent to CAMS 82.

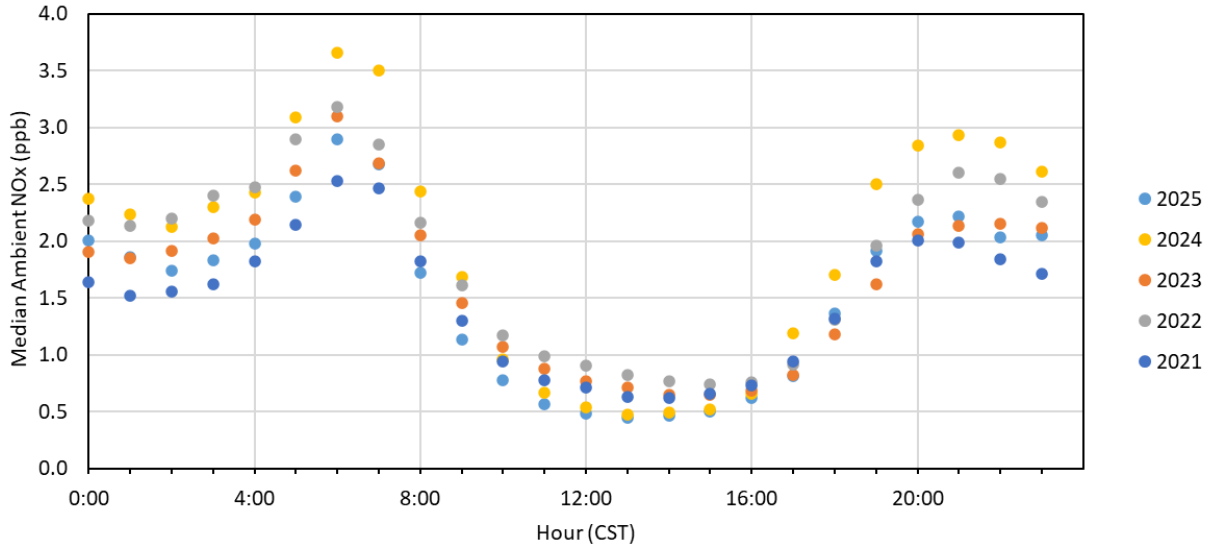


Figure 1.6. Diurnal variation of average hourly NO_x measured by ETCOG adjacent to CAMS 82 (Tyler) during the 2021-2025 ozone seasons.

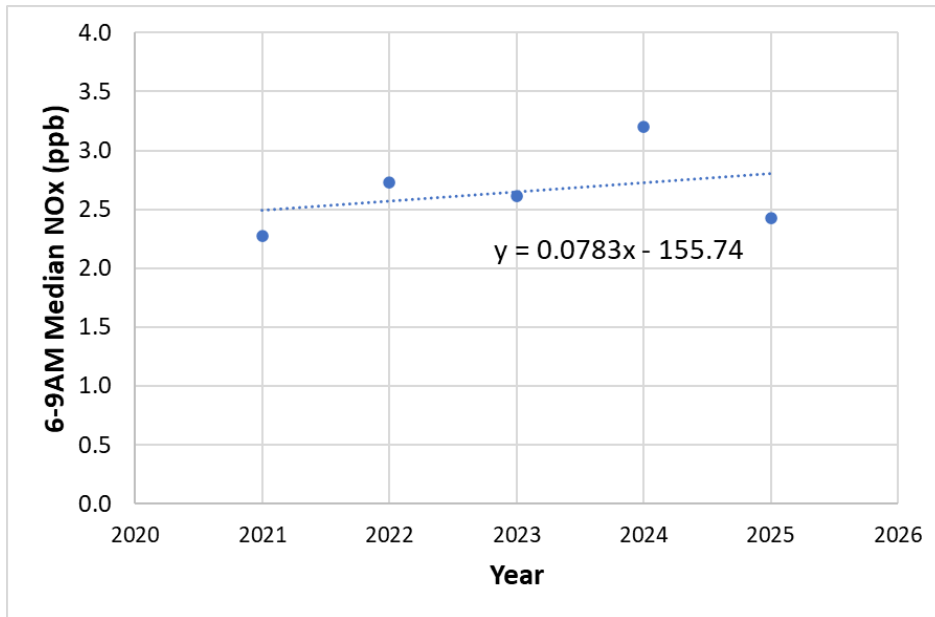


Figure 1.7. Trend in 6-9 AM median NO_x measured by ETCOG adjacent to CAMS 82 (Tyler) for 2021 through 2025.

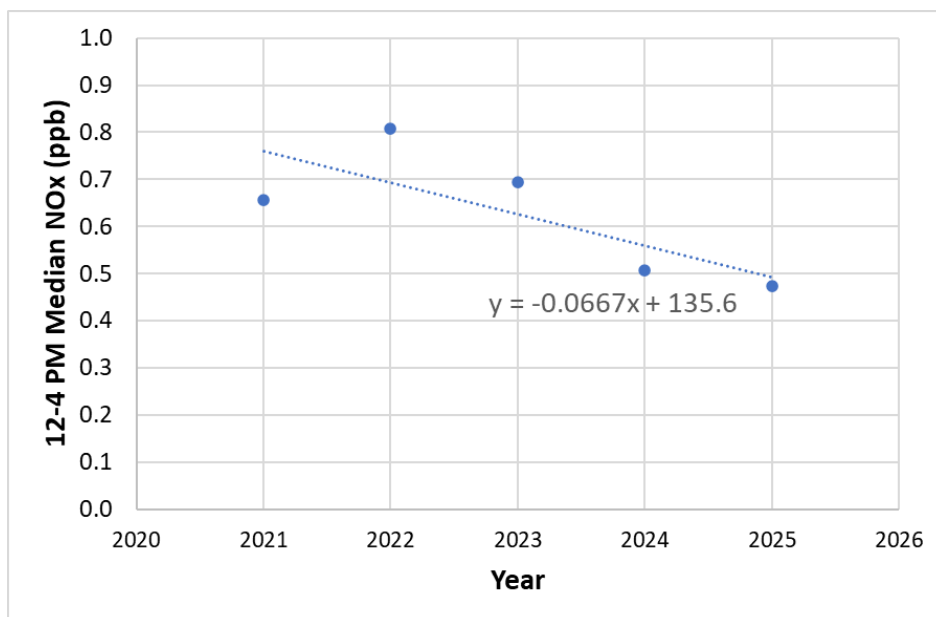


Figure 1.8. Trend in 12-4 PM median NO_x measured by ETCOG adjacent to CAMS 82 (Tyler) for 2021 through 2025.

ETCOG compared the research-grade NO_x measurements made adjacent to CAMS 82 with the TCEQ's conventional NO_x measurements at CAMS 82. Overall, both NO_x datasets are consistent although the research-grade measurements exhibit superior baseline performance (i.e., when concentrations are near zero) with fewer negative values reported. The total column NO₂ measurements from the Pandora spectrometer were used to investigate whether NO₂ levels vary in the vicinity of CAMS 82. There is no significant seasonal cycle observed at the Tyler location during the 2024-2025 period and the NO₂ total column values are characteristic of a site without significant nearby emissions sources consistently influencing the column measurements.

These NO_x data can be compared to satellite-based measurements of NO₂ that provide spatial coverage of the entire TLMA region. Seasonally averaged satellite NO₂ observations over the Tyler area from 2018 through 2024 (Figure 1.9 and Figure 1.10) show flat to decreasing NO₂ in summer (June, July, August – JJA) and slight increases in fall (September, October, November – SON), consistent with surface NO_x trends indicating that 2025 concentrations are similar to 2021. Satellite data for fall (SON) 2025 were not available in time to include in this report.

The research-grade “true NO₂” instrument and Pandora spectrometer used in this study should be redeployed to continue measuring ambient NO_x adjacent to Tyler (CAMS 82) to help establish meaningful precursor trends. The acquisition of high-quality datasets for NO₂ near Tyler, especially the total column NO₂ measurements made by ETCOG from 2023 to 2025, will be useful for comparison with the National Aeronautics and Space Administration (NASA) Tropospheric Emissions: Monitoring of Pollution (TEMPO) satellite-based measurements of NO₂ throughout the TLMA region.

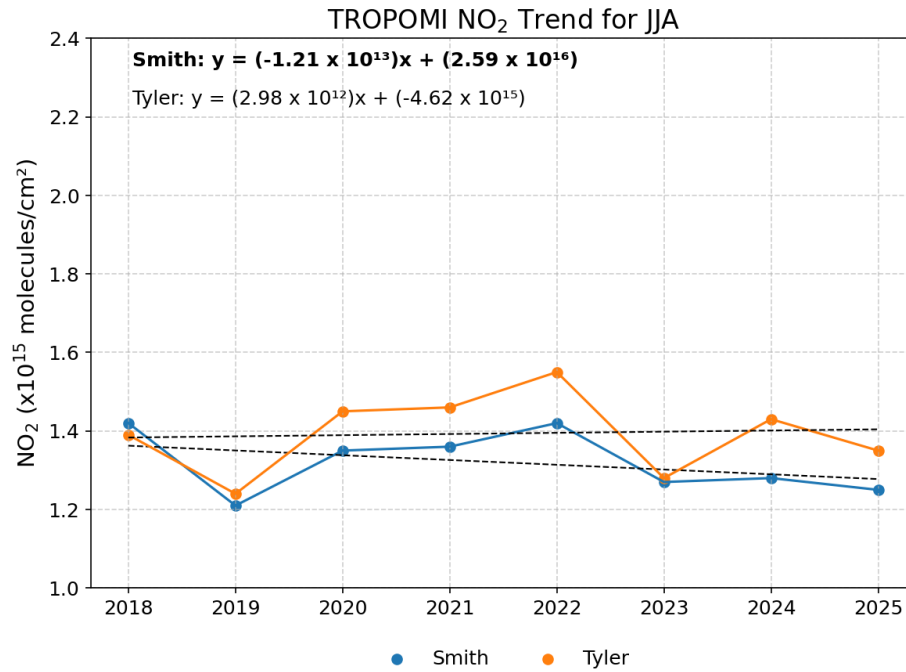


Figure 1.9. Summer average (JJA) NO₂ columns for Tyler and Smith County (symbols) from 2018 through 2025 and the fitted linear trend (dashed lines) with the trend parameters given in the legend and shown in bold if the trend is significant at 95% confidence level.

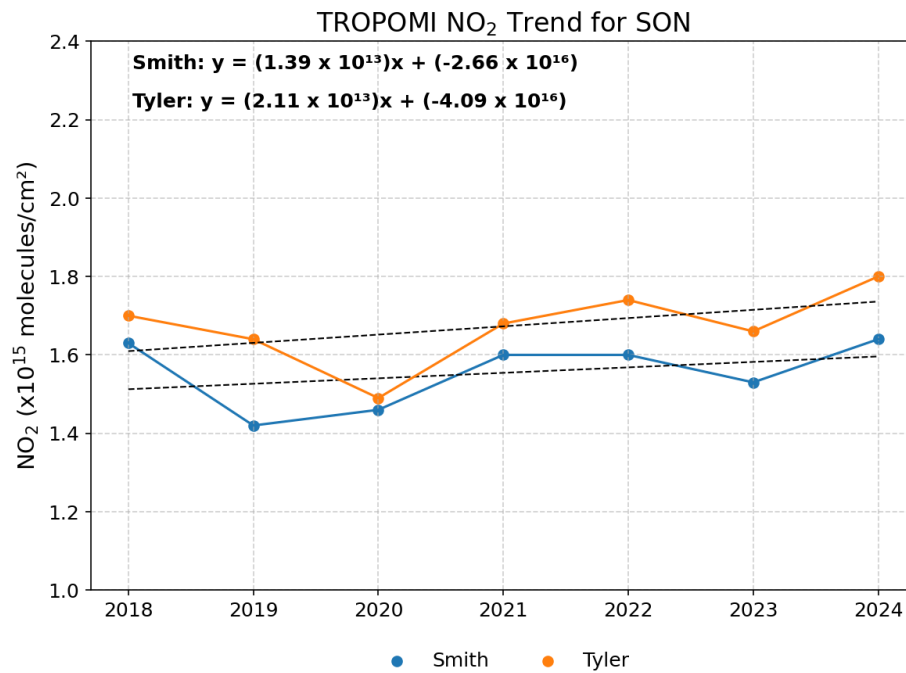


Figure 1.10. Fall average (SON) NO₂ columns for Tyler and Smith County (symbols) from 2018 through 2024 and the fitted linear trend (dashed lines) with the trend parameters given in the legend and shown in bold if the trend is significant at 95% confidence level. SON 2025 data were not available in time to include in this report.

1.4 Recommendations

The TCEQ is providing new Rider 7 funding to ETCOG for Fiscal Years 2026 and 2027 and the scope of potential activities includes emission inventory improvements, ambient monitoring, and data and chemical transport modeling analyses. This section contains recommendations for activities that could be carried out in the 2026-2027 period.

1.4.1 Emission Inventory

Key results indicated that the updated soil NO_x scheme in MEGAN led to a modest increase in biogenic soil NO emissions at the national level, with more pronounced changes in certain regions. Including soil HONO emissions, which had previously been ignored, provided a more comprehensive understanding of how reactive nitrogen influences air quality. The enhanced algorithms and updated input data in MEGAN3.21 provide an improved characterization of soil NO_x emissions, which is crucial for regional air quality planning, particularly in agricultural zones. Given these improvements, the updated MEGAN3.21 model should be used for estimating biogenic emissions in the ETCOG area. Air quality modeling using these updated estimates would provide valuable quantitative information on the potential ozone impacts from these changes.

1.4.2 Ambient Monitoring

We recommend re-deploying the research-grade “true NO₂” instrument used in this study to continue measuring ambient NO_x adjacent to CAMS 82 during the 2026 and 2027 ozone seasons. Comparing NO_x data for 2026 and 2027 to the existing data for 2021-2025 will provide information about the trends in ambient NO_x near Tyler, as shown in Figure 1.6. We recommend continuing column NO₂ measurements near CAMS 82 during the 2026 and 2027 ozone seasons and comparing the data with NASA TEMPO satellite-based measurements of NO₂ throughout the TLMA region.

APPENDIX A

Quarterly Progress Reports

Submitted as a separate document

APPENDIX B

Statement of Work

Submitted as a separate document

APPENDIX C

Quality Assurance Project Plans

Submitted as a separate document

APPENDIX D

Final Report for Subtask 3.1 Soil NO_x Emission Inventory Improvements for the East Texas Council of Governments

Submitted as a separate document

APPENDIX E

Final Report for Subtask 3.2 Ambient Monitoring near Tyler in 2024 and 2025

Submitted as a separate document