Summary of AERMOD Implementation Workgroup (AIWG) Case Studies for 1-hour NO2 and SO2 NAAQS

In 2011, EPA redirected the AERMOD Implementation Workgroup (AIWG) with a focus on the new 1-hour NO2 and SO2 NAAQS. The purpose of the workgroup was to provide insight into the potential challenges in modeling compliance under the new standards by working with “real world” examples. These examples would then provide a valuable basis to assess EPA’s existing guidance for NO2 and SO2 as well as indicate areas for new guidance. The AIWG workgroup was composed of over 50 members with EPA staff from the Regional offices and the Office of Air Quality Planning and Standards (OAQPS), and modelers from state, territorial, and local air quality agencies (see Table 4 for full list of members). The workgroup was co-chaired by Erik Snyder of Region 6 and James Thurman of OAQPS.

The workgroup was charged with completing its work in two phases:

1. Single source modeling case studies,
2. Cumulative modeling scenarios involving multiple facilities and background concentrations

For the first phase, the workgroup compiled a list of facilities that were of most interest to various state and local agencies. The workgroup began with an initial list of facility types and then workgroup members focused on those facility types that were of interest in their state or local area. Table 1 lists the final list of facility types that were modeled by the workgroup as part of the first phase.

Table 1. Facilities, pollutants and modelers of single source modeling scenarios.

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Pollutant(s)</th>
<th>Modeler(s)</th>
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<tbody>
<tr>
<td>Secondary steel mill</td>
<td>NO2</td>
<td>Doris Jung (CO)</td>
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<td>Ethanol plant</td>
<td>NO2, SO2</td>
<td>Dawn Froning (MO); Jennifer Krzak (IA)</td>
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<td>Materials recycler</td>
<td>NO2</td>
<td>Steven Sherman (IN)</td>
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<td>Natural gas turbine</td>
<td>NO2</td>
<td>Margaret Valis (NY); Bruce Ferguson (MS)</td>
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<td>Coal fired EGU</td>
<td>NO2, SO2</td>
<td>Eric Milligan (OK); James Thurman (EPA-OAQPS)</td>
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<td>Biomass facility</td>
<td>NO2</td>
<td>Dennis Becker (MN)</td>
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<td>Natural gas processing plant</td>
<td>NO2</td>
<td>Krystin Bablinskas (AK); Andy Hawkins (EPA-R7)</td>
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<td>Refinery</td>
<td>NO2, SO2</td>
<td>Glenn Reed (SJV); Leland Villalvazo (SJV)</td>
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<td>Natural gas compressors</td>
<td>NO2</td>
<td>Ashley Mohr (EPA-R6); Erik Snyder (EPA-R6); Chiu Foong (EPA-R6)</td>
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<tr>
<td>Cement kiln</td>
<td>NO2</td>
<td>Dawn Froning (MO); Tracy Price (SC)</td>
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<tr>
<td>Landfill gas turbine</td>
<td>NO2</td>
<td>Lisa Landry (NH); Todd Moore (NH)</td>
</tr>
</tbody>
</table>
For each modeled facility, emissions and source parameters were based on real facilities but were modified by the workgroup to be a generic facility type. For each facility type, there were several modeling scenarios such as addition of controls, changing stack height, varying fence-line distances, etc. Also for NO2 sources, modeling scenarios involved comparing the use of the Plume Volume Molar Ratio Method (PVPRM) and Ozone Limiting Method (OLM) techniques within AERMOD as the approaches to model NOx to NO2 conversion. Details about the modeling inputs for each scenario are provided for each facility type in Appendix A.

Summary of findings

A listing of modeled sources with maximum design values for multiple scenarios can be found in Table 2 for NO2 and Table 3 for SO2. A more detailed listing of maximum design values across scenarios for each modeled facility type can be found in Appendix A, which also contains spatial plots for several of the modeled sources. Based on the results of the modeling results, several preliminary observations have been made:

1. Many factors may contribute to NAAQS violations in addition to emissions levels. Other variables such as distance to ambient air (ethanol plant scenarios), urban/rural classification (NO2 refinery and biomass facility), presence of terrain (refinery), meteorology, downwash influences, and stack heights can affect design value concentrations.
2. Short stacks and small facility footprints (SO2 ethanol plant) can be problematic in attaining the NAAQS with violations occurring just beyond the fenceline. However, the area showing potential modeled violations in these cases may be very small.
3. In some cases the largest units in terms of emissions are not the major contributors to the maximum design values. Modeling scenarios where controls or stack height changes were made to the larger emitting stacks at times did not affect the maximum design value concentration, which were dominated by smaller units with short stacks (e.g., ethanol plant, coal fired EGU).
4. Increasing stack heights (within GEP regulations) for some sources with short stacks may be as effective as additional emission controls in eliminating modeled violations.
5. For NO2, modeling results highlight the importance of the use of the OLM or PVPRM Tier 3 options, the initial NO2/NOx in-stack ratio, and input ozone background concentrations to modeled design values.
Table 2. NO$_2$ modeling results

<table>
<thead>
<tr>
<th>Facility</th>
<th>Emissions (tpy)</th>
<th>Maximum DV (µg/m$^3$) (ppb)</th>
<th>Sensitivity test</th>
<th>Maximum DV (µg/m$^3$) (ppb)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel mill</td>
<td>Base: 711</td>
<td>318 (169) – OLM; 300(160)- PVMRM; &lt; 1% receptors exceed</td>
<td>65 m stack ht (units &gt; 1 g/s); Emissions unchanged.</td>
<td>128 (68) – OLM; 250 (133) – PVMRM; 1 receptor exceeds</td>
<td>Sensitivity to NOx to NO$_2$ method</td>
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<td>Ethanol plant</td>
<td>Base: 1,180</td>
<td>1,289 (685); 5% receptors exceed</td>
<td>NO$_2$/NOx ratio 0.5, controls &amp; increased stack ht on one unit; Emissions: 170 tpy</td>
<td>1,289 (685); 5% receptors exceed</td>
<td>50 m fenceline; no change in maximum DV with controls &amp; stack ht increase</td>
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<tr>
<td>Materials recycler</td>
<td>Base: 70</td>
<td>401 (214); NO$_2$/NOx ratio 0.2; &lt; 1% receptors exceed</td>
<td>Stack ht increase (&gt; 25 m); Emissions unchanged</td>
<td>17 (9)</td>
<td>Violations &lt; 500 m for base case.</td>
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<tr>
<td>Natural gas turbine (NY)</td>
<td>Base: 450</td>
<td>145 (77)</td>
<td>Increase stack ht &amp; controls (390 tpy)</td>
<td>122 (65)</td>
<td>No downwash</td>
</tr>
<tr>
<td>Natural gas turbine (MS)</td>
<td>Base: 450</td>
<td>16 (8)</td>
<td>Increase stack ht &amp; controls (390 tpy)</td>
<td></td>
<td>No downwash</td>
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<tr>
<td>Coal EGU</td>
<td>Base 1,870</td>
<td>234 (125); &lt; 1% receptors exceed</td>
<td>Stack ht increase, controls &amp; higher exit velocity (610 tpy)</td>
<td>234 (125); &lt; 1% receptors exceed</td>
<td>No change in maximum DV with controls &amp; stack ht increase</td>
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<td>Biomass facility</td>
<td>Base: 240</td>
<td>22 (11)</td>
<td>Stack height increase &amp; no controls (1,220 tpy)</td>
<td>45 (24)</td>
<td>Sensitivities to urban/rural classification &amp; NOx to NO$_2$ algorithm.</td>
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<tr>
<td>Natural gas processing plant</td>
<td>Uncontrolled: 3,190</td>
<td>1,440 (766); 60% receptors exceed</td>
<td>Increase stack ht &amp; controls (330 tpy)</td>
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<tr>
<td>Refinery</td>
<td>Base: 8,770</td>
<td>189 (100)</td>
<td>Increase stack ht &amp; controls (5200 tpy)</td>
<td>171 (91)</td>
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<tr>
<td>Natural gas compressors</td>
<td>Uncontrolled (4069)</td>
<td>1,674 (890); 21% receptors exceed;</td>
<td>Increase stack ht &amp; controls (626 tpy)</td>
<td>43 (23)</td>
<td>Violations &lt; 7 km</td>
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<tr>
<td>Cement kiln</td>
<td>Base: 7,170</td>
<td>44 (24)</td>
<td>Controls (2,180 tpy)</td>
<td>8 (4)</td>
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<td>Landfill gas turbine</td>
<td>Base: 80</td>
<td>29 (15)</td>
<td>Increase stack ht; emissions unchanged</td>
<td>4 (2)</td>
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<tr>
<td>Fuel oil turbine</td>
<td>Less controlled: 2,230</td>
<td>484 (257); 1% receptors exceed</td>
<td>Increase stack ht &amp; controls (1,190 tpy)</td>
<td>337 (179); &lt; 1% receptors exceed</td>
<td>Violations &lt; 2 km</td>
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Table 3. SO$_2$ modeling results.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Emissions (tpy)</th>
<th>Maximum DV ($\mu$g/m$^3$) (ppb)</th>
<th>Sensitivity test</th>
<th>Maximum DV ($\mu$g/m$^3$) (ppb)</th>
<th>Comments</th>
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<tr>
<td>Ethanol plant</td>
<td>Base: 890</td>
<td>296 (113); 1 receptor exceed</td>
<td>65 m stack ht &amp; controls on one unit (195 tpy)</td>
<td>296 (113); 1 receptor exceed</td>
<td>Sensitivity to fenceline distance. 300 m fenceline – no exceedances</td>
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<td>Coal EGU (OAQPS)</td>
<td>Uncontrolled: 10,713</td>
<td>905 (346); &lt; 1% receptors exceed</td>
<td>Stack increase, controls &amp; higher exit velocity; Emissions 2,074 tpy</td>
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<td>Exceedances &lt; 8km; stack ht=65 m</td>
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<td>Coal EGU (OK)</td>
<td>Base: 4,959</td>
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<td>Base: 4,020</td>
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<td>Sensitivity to urban/rural classification and terrain</td>
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<td>Controls; Emissions 348 tpy</td>
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<td>Pulp &amp; paper</td>
<td>Base: 3,403</td>
<td>924 (353); 28% receptors exceed</td>
<td>Stack height increase &amp; controls; Emissions 1,630</td>
<td>212 (81); &lt; 1% receptors violate;</td>
<td>Exceedances &lt; 4 km for base case; Exceedances &lt; 1 km for stack ht increase &amp; controls</td>
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<td>Landfill gas turbine</td>
<td>Base: 45</td>
<td>17 (7)</td>
<td>Stack height increases; Emissions unchanged</td>
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<td>Fuel oil turbine</td>
<td>Base: 417</td>
<td>257 (98); &lt; 1% receptors exceed</td>
<td>Stack height increases; Emissions unchanged</td>
<td>178 (63)</td>
<td>Base case exceedances 0.5 to 1 km from source</td>
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<td>Flare</td>
<td>Base: 6,083</td>
<td>324 (124); &lt; 1% receptors exceed</td>
<td>65 m stack ht &amp; controls; Emissions 626 tpy</td>
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<td>Exceedances 6 to 7 km from source</td>
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Table 4. AERMOD Implementation Workgroup (AIWG) Members.

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<tr>
<th>Name</th>
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<tr>
<td>Tyer Fox</td>
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* AIWG co-chairs
Appendix A: Model Inputs for Phase 1 Case Studies

Following are the model inputs for the various single source scenarios modeled by AIWG.
Steel mill

Pollutant(s): NO₂

Terrain: Yes

Meteorology: Alva, OK (2006-2010)

Ozone data: Oklahoma (2006-2010)

Scenarios:

1. Base

2. Increase in stack height to 45 for stack with emissions > 2 g/s (Stack ht 2)

3. Increase in stack height to 65 m for stacks with emissions > 2 g/s (Stack ht 3)

All scenarios modeled with 0.1 NO₂/NOx in-stack ratio and results were compared using OLM and PVMRM
<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
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</table>

Steel mill volume sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>Center of volume (m)</th>
<th>σ_y (m)</th>
<th>σ_z (m)</th>
</tr>
</thead>
<tbody>
<tr>
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Ethanol plant

Pollutant(s): NO₂, SO₂

Terrain: Yes

Meteorology: Moline, IL (2000-04), Springfield, MO (2005-09), St. Louis, MO (2005-09), and Waterloo, IA (2000-04)

Ozone: Moline: 0.067 ppm; Springfield, Hillcrest (2005-09); St. Louis, Maryland Heights (2005-09); Waterloo, 0.066 ppm

Scenarios (both pollutants):

1. Base
2. Increase stack height to 65 for C0004 (Stack ht 2)
3. Controlled emissions for C0004 with 65 m stack height (NOx 2 and SO₂ 2 with Stack ht 2)
4. Additional controls for C0004 with 65 m stack height (NOx 3 and SO₂ 3 with Stack ht 2)

All scenarios modeled with the following sensitivities:

1. 300 m vs. 50 m fenceline

Additionally for NO₂, the following were modeled:

2. 0.1 NO₂/NOx in-stack ratio for all sources vs. 0.05 ratio for C0004 and 0.1 for other sources
3. 0.25 NO₂/NOx in-stack ratio vs. 0.5 ratio for all sources (50 m fenceline only)

All scenarios modeled with four different meteorological datasets listed above.
<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>SO$_2$ (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>NOx 2 (g/s)</th>
<th>SO$_2$ 2 (g/s)</th>
<th>NOx 3 (g/s)</th>
<th>SO$_2$ 3 (g/s)</th>
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<td>11</td>
<td>0.01</td>
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**Ethanol plant volume source**

<table>
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<th>Type</th>
<th>NOx (g/s)</th>
<th>SO$_2$ (g/s)</th>
<th>Center of volume (m)</th>
<th>$\sigma_x$ (m)</th>
<th>$\sigma_z$ (m)</th>
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**Materials recycler**

Pollutant(s): NO₂

Terrain: Flat

Meteorology: Indianapolis, IN (2006-10)

Scenarios:

1. Base

2. Increase stack heights #1 (Stack ht 2)

3. Increase stack heights #2 (Stack ht 3)

All scenarios modeled with 0.1 NO₂/NOx in-stack ratio, PVMRM, and 40 ppb ozone concentration.

<table>
<thead>
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<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
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Natural gas turbine

Pollutant(s): NO₂

Terrain: Yes

Meteolology: NY – Poughkeepsie, NY (2006-10); MS – Mobile, AL (2005-09)

Ozone: NY – Millbrook, NY (2006-10); MS – Average seasonal/hour of day

Scenarios:

1. Base

2. Increase stack heights #1 (Stack ht 2)

3. Increase stack heights #2 (Stack ht 3)

4. Scenario 3 stack heights with controlled emissions (NOx 2 and Stack ht 3)

New York also modeled sensitivities

1. Base with 100% and 80% conversion

2. Base with OLM with 0.05 NO₂/NOx in-stack ratio (no downwash)

3. Scenarios 2-4 with PVMRM comparing 0.05 NO₂/NOx ratio (with and without downwash) and 0.1 ratio (with downwash)

Mississippi modeled all scenarios with 0.05 NO₂/NOx ratio and 0.1 ratio
<table>
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<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
<th>NOx 2 (g/s)</th>
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<td>6</td>
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</tbody>
</table>
Coal EGU

Pollutant(s): NO₂, SO₂

Terrain: Yes

Meteorology: OAQPS – Charleston, SC (2005-09); OK- Springfield, MO (2006-10)

Ozone: OAQPS – Spartanburg, SC; OK – NEOK (2006-10)

Scenarios:

1. Base
2. Increase stack heights #1 (Stack ht 2)
3. Controlled emissions with base stack heights (NOx 2 and SO₂ 2 with Stack ht 1)
4. Scenario 2 stack heights with controlled emissions (NOx 2 and SO₂ 2 and Stack ht 2)
5. Scenario 3 emissions with further increase in stack ht (NOx 2 and SO₂ 2 and Stack ht 3)
6. Scenario 5 with higher exit velocity and new diameter ((NOx 2 and SO₂ 2, Stack ht 3, Stack velocity 2 and Diameter 2)

Note, controlled emissions for Oklahoma modeling for SO₂ were 112 g/s. OAQPS also modeled all NO₂ scenarios with 100% and 80% conversion. OAQPS also modeled all SO₂ scenarios with uncontrolled emissions (290 g/s) for C0001. For SO₂, OAQPS modeled the base scenario with a 65 m stack height for base emissions and uncontrolled emissions.
<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>SO₂ (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>NOx 2 (g/s)</th>
<th>SO₂ 2 (g/s)</th>
<th>Stack velocity 2 (m/s)</th>
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<td>150</td>
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<td>0.3</td>
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<td>25</td>
<td>0.3</td>
<td>0.01</td>
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</tbody>
</table>
Biomass facility

Pollutant(s): NO₂

Terrain: Flat
Meteorology: Twin-Cities, MN (2006-10);

Ozone: 40 ppb

Scenarios:

1. Base

2. Increase stack heights #1 (Stack ht 2)

3. Scenario 2 stack heights with no controls on emissions (NOx 2 and Stack ht 2)

All three scenarios were also modeled with the following sensitivities:

1. Urban vs. rural

2. 100% and 80% conversion

3. OLM vs. PVMRM with 0.1 NO₂/NOx in-stack ratio

4. OLM vs. PVMRM with 0.15 NO₂/NOx in-stack ratio

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>NOx 2 (g/s)</th>
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<td>52</td>
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</table>
Natural gas processing plant

Pollutant(s): NO₂

Terrain: Flat

Meteorology: Barrow, AK (2001-05)

Ozone: AK hourly data and 40 and 80 ppb constant concentrations

Scenarios:

1. Base
2. Increase stack heights #1 (Stack ht 2)
3. Increase stack heights #2 (Stack ht 3)
4. Increase stack heights #3 (Stack ht 4)
5. Base stack parameters with uncontrolled emissions (NOx 2 and Stack ht 1)

All scenarios modeled with PVMRM with the following in-stack ratios:

1. 0.1 vs. 0.25

The base scenario was also modeled with a 0.25 NO₂/NOx in-stack ratio and using a constant ozone concentration of 40 vs. 80 ppb.
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<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
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Refinery
Pollutant(s): NO₂, SO₂
Terrain: Flat, Elevated
Meteorology: Bakersfield, CA (2005-09)
Ozone: Bakersfield, CA (2005-09)
Scenarios:
For NO₂:
1. Base
2. Stack height increase #1 (Stack ht 2)
3. Stack height increase #2 (Stack ht 3)
4. Controlled emissions with base stack heights (NOx 2 and Stack ht 1)
5. Controlled emissions with Scenario 3 stack heights (NOx 2 and Stack ht 3)
All scenarios were modeled comparing OLM vs. PVMRM and flat vs. including terrain. The NO2/NOx in-stack ratio was 0.1
For SO₂:
1. Base
2. Stack height increase #1 (Stack ht 2)
3. Stack height increase #2 (Stack ht 3)
4. Uncontrolled emissions with Scenario 3 stack heights (NOx 2 and Stack ht 3)

5. Uncontrolled emissions with base stack heights (NOx 2 and Stack ht 3)

All SO$_2$ scenarios were modeled comparing urban vs. rural dispersion and flat vs. use of terrain.
### NO₂ refinery emissions

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Natural gas compressors

Pollutant(s): NO₂

Terrain: Yes

Meteorology: Austin, TX (1983-84; 1986-88)

Ozone: NEOKN

Scenarios:

1. Base

2. Less controls for 3 of 4 stations and stack height increase #2 (NOx 2 and stack ht 3)

3. Stack height increase #1 (Stack ht 2)

4. Stack height increase #2 (Stack ht 3)

5. Less controls for 3 of 4 stations and base stack heights (NOx 3 and stack ht 1)

All scenarios modeled with 0.1 NO₂/NOx in-stack ratio and PVMRM
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Cement kiln

Pollutant(s): NO₂, SO₂

Terrain: Yes

Meteorology: Charleston, SC (2002-06)

Ozone: Spartanburg, SC (2002-06)

Scenarios (both pollutants):

1. Base
2. Controls (NOx 2 and SO₂ 2)
3. Additional controls (NOx 3 and SO₂ 3)

NO₂ base scenario modeled with PVMRM and:

1. Comparison of NO₂/NOx in-stack ratios of 0.05, 0.1, 0.25, and 0.5
2. Comparison of ozone concentrations of 40 and 80 ppb with NO₂/NOx ratio of 0.1

Scenario 2 modeled with NO₂/NOx in-stack ratios of 0.05 and 0.1

Scenario 3 modeled with NO₂/NOx ratios of 0.05, 0.1, 0.25, and 0.5
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<td>90</td>
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<td>0.2</td>
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<tr>
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<td>POINT</td>
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<td>0</td>
<td>90</td>
<td>375</td>
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<td>2</td>
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<td>0.2</td>
<td>0.2</td>
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Landfill gas turbine

Pollutant(s): NO₂, SO₂

Terrain: Yes

Meteorology: Pease AFB, NH (2000-04)

Ozone: 40 ppb

Scenarios (both pollutants):

1. Base

2. Stack height increase #1 (Stack ht 2)

3. Stack height increase #2 (Stack ht 3)

For NO₂, comparisons were made for PVMRM with NO₂/NOx in-stack ratios of 0.05 and 0.1 for all scenarios

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>SO₂ (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
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<td>0.6</td>
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<td>0.4</td>
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<tr>
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Fuel oil turbine

Pollutant(s): NO₂, SO₂

Terrain: Yes

Meteorology: Bristol, TN (2004-08)

Ozone: 60 ppb and Sullivan County, TN (2004-08)

Scenarios NO₂:

1. Base
2. Stack height increase #1 (Stack ht 2)
3. Stack height increase #2 (Stack ht 3)
4. Scenario 3 heights with increased emissions (NOx 2 and Stack ht 3)

All NO₂ scenarios also compared:
1. OLM with 60 ppb ozone concentrations with NO₂/NOx in-stack ratios of 0.05 and 0.1
2. PVMRM with 60 ppb ozone concentrations with NO₂/NOx in-stack ratios of 0.05 and 0.1
3. PVMRM with actual ozone concentrations with NO₂/NOx in-stack ratios of 0.05 and 0.1

SO₂ scenarios:
1. Base
2. Stack height increase #1 (Stack ht 2)
3. Stack height increase #2 (Stack ht 3)

<table>
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<tr>
<th>Source</th>
<th>Type</th>
<th>NOx (g/s)</th>
<th>SO₂ (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
<th>NOx 2 (g/s)</th>
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<tbody>
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<td>10</td>
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Pulp & paper

Pollutant(s): SO₂

Terrain: Yes

Meteorology: Mobile, AL (2001-05)

Scenarios:

1. Base

2. Increase stack height #1 (Stack ht 2)

3. Increase stack height #2 (Stack ht 3)

4. Scenario 3 stack heights and controlled emissions (SO₂ 2 and Stack ht 3)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>SO₂ (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
<th>Stack ht 3 (m)</th>
<th>SO₂ 2 (g/s)</th>
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<td>1</td>
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**Flare**

Pollutant(s): SO\(_2\)

Terrain: Yes

Meteorology: Poughkeepsie, NY (2006-10)

Scenarios:

1. Base

2. Increase stack height #1 (Stack ht 2)

3. Increase stack height #2 (Stack ht 3)

4. Scenario 3 stack heights and controlled emissions (SO\(_2\) 2 and Stack ht 3)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>SO(_2) (g/s)</th>
<th>Stack ht 1 (m)</th>
<th>Stack temperature (K)</th>
<th>Stack velocity (m/s)</th>
<th>Diameter (m)</th>
<th>Stack ht 2 (m)</th>
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Appendix B: AIWG Phase 1 Results
Single Source Case Studies
Steel Mill: NO₂

- Base: NO₂ emissions below 1 g/s for all sources.
- 45 m stack height or higher for all sources > 1 g/s.
- 65 m stack height or higher for all sources > 1 g/s.

The emissions exceed the NAAQS (National Ambient Air Quality Standards) for the 45 m stack height condition.

Concentration (µg/m³)

- 0
- 50
- 100
- 150
- 200
- 250
- 300
- 350

OLM (Orange Line Model)
PVMRM (Purple Vertical Model Runner Model)
Base: OLM
Max DV: 318 µg/m³
Base: PVMRM
Max DV: 300 μg/m³
45 m stack ht: OLM
Max DV: 153 μg/m³
45 m stack ht: PVMRM
Max DV: 271 µg/m³
65 m stack ht: PVMRM
Max DV: 250 μg/m³
Ethanol Plant (Moline): NO₂

- NO₂/NOx 0.1 (300 m FL)
- NO₂/NOx 0.05 Unit 4 (300 m FL)
- NO₂/NOx 0.1 (50 m FL)
- NO₂/NOx 0.05 Unit 4 (50 m FL)
- NO₂/NOx 0.25 (50 m FL)
- NO₂/NOx 0.5 (50 m FL)

Concentration (μg/m³)

- Base
- Increase stack ht Unit 4
- Increase stack ht Unit 4 w/ controls
- Increase stack ht Unit 4 w/ additional controls

NAAQS
Ethanol Plant (Springfield): NO₂

- NO₂/NOx 0.1 (300 m FL)
- NO₂/NOx 0.05 Unit 4 (300 m FL)
- NO₂/NOx 0.1 (50 m FL)
- NO₂/NOx 0.05 Unit 4 (50 m FL)
- NO₂/NOx 0.25 (50 m FL)
- NO₂/NOx 0.5 (50 m FL)

Concentration (μg/m³):
- Base
- Increase stack ht Unit 4
- Increase stack ht Unit 4 w/ controls
- Increase stack ht Unit 4 w/ additional controls

NAAQS
Ethanol Plant (St. Louis): NO₂

- NO₂/NOx 0.1 (300 m FL)
- NO₂/NOx 0.05 Unit 4 (300 m FL)
- NO₂/NOx 0.1 (50 m FL)
- NO₂/NOx 0.05 Unit 4 (50 m FL)
- NO₂/NOx 0.25 (50 m FL)
- NO₂/NOx 0.5 (50 m FL)

Concentration (µg/m³)

Base | Increase stack ht Unit 4 | Increase stack ht Unit 4 w/ controls | Increase stack ht Unit 4 w/ additional controls

NAAQS
Ethanol Plant (Waterloo): NO₂

- NO₂/NOx 0.1 (300 m FL)
- NO₂/NOx 0.05 Unit 4 (300 m FL)
- NO₂/NOx 0.1 (50 m FL)
- NO₂/NOx 0.05 Unit 4 (50 m FL)
- NO₂/NOx 0.25 (50 m FL)
- NO₂/NOx 0.5 (50 m FL)

Concentration (μg/m³)

NAAQS

Base | Increase stack ht Unit 4 | Increase stack ht Unit 4 w/ controls | Increase stack ht Unit 4 w/ additional controls
Contour plots for Moline
Base: 0.1 NO₂/NOx ratio
300 m FL
Max DV: 543 μg/m³
Base 0.05 NO$_2$/NOx ratio unit #4
300 m FL
Max DV: 543 µg/m$^3$
Baseline: 0.1 NO\textsubscript{2}/NO\textsubscript{x} ratio
50 m FL
Max DV: 810 \mu g/m\textsuperscript{3}
Baseline: 0.05 NO₂/NOx ratio  unit #4
50 m FL
Max DV: 930 μg/m³
Base: 0.25 NO₂/NOx ratio
50 m FL
Max DV: 1000 µg/m³
Base 0.5 NO$_2$/NOx ratio
50 m FL
Max DV: 1289 $\mu$g/m$^3$
Increase stack ht C0004
0.1 NO₂/NOx ratio
300 m FL
Max DV: 543 µg/m³
Increase stack ht C0004
0.05 NO₂/NOx ratio C0004
300 m FL
Max DV: 543 µg/m³
Increase stack ht C0004
0.1 NO₂/NOx ratio
50 m FL
Max DV: 810 µg/m³
Increase stack ht C0004
0.05 NO₂/NOx ratio C0004
50 m FL
Max DV: 930 µg/m³
Increase stack ht C0004 + controls
0.1 NO₂/NOx ratio
300 m FL
Max DV: 543 μg/m³
Increase stack ht C0004 + controls
0.05 NO₂/NOx ratio C0004
300 m FL
Max DV: 543 μg/m³
Increase stack ht C0004 + controls
0.1 NO$_2$/NOx ratio
300 m FL
Max DV: 810 $\mu$g/m$^3$
Increase stack ht C0004 + controls
0.05 NO₂/NOx ratio C0004
50 m FL
Max DV: 930 µg/m³
 Increase stack ht C0004 + additional controls
0.1 NO₂/NOx ratio
300 m FL
Max DV: 543 μg/m³
Increase stack ht C0004 + additional controls
0.05 NO₂/NOx ratio C0004
300 m FL
Max DV: 543 µg/m³

Legend
- 7 - 50
- 61 - 100
- 101 - 150
- 151 - 196
- 197 - 250
- 251 - 500
- 501 - 750
- 751 - 1,000
- 1,001 - 1,250
- 1,251 - 1,289
Increase stack ht C0004 + additional controls
0.1 NO₂/NOx ratio
50 m FL
Max DV: 810 μg/m³
Increase stack ht C0004 + additional controls
0.05 NO$_2$/NOx ratio C0004
50 m FL
Max DV: 930 $\mu$g/m$^3$
Increase stack ht C0004 + additional controls
0.25 NO₂/NOx ratio
50 m FL
Max DV: 1000 µg/m³
Increase stack ht C0004 + additional controls
0.50 NO\textsubscript{2}/NOx ratio
50 m FL
Max DV: 1000 \mu g/m\textsuperscript{3}
Materials Recycler: NO$_2$

<table>
<thead>
<tr>
<th>Condition</th>
<th>NO$_2$/NOx 0.1</th>
<th>NO$_2$/NOx 0.2</th>
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<tbody>
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<tr>
<td>Stack ht increase #1</td>
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<td>Stack ht increase #2</td>
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</tr>
<tr>
<td>Stack ht increase #3</td>
<td>10</td>
<td>16</td>
</tr>
</tbody>
</table>

NAAQS
Base
0.1 NO₂/NOx ratio
Max DV: 244 µg/m³
0.2 NO₂/NOx ratio
Max DV: 401 µg/m³
Stack ht increase #1
0.1 NO₂/NOx ratio
Max DV: 39 µg/m³
Stack ht increase #1
0.2 NO₂/NOx ratio
Max DV: 46 μg/m³
Stack ht increase #2
0.1 NO₂/NOx ratio
Max DV: 22 µg/m³
Stack ht increase #2
0.2 NO\textsubscript{2}/NO\textsubscript{x} ratio
Max DV: 29 μg/m\textsuperscript{3}
Stack ht increase #3
0.1 NO₂/NOx ratio
Max DV: 16 μg/m³
Stack ht increase #3
0.2 NO₂/NOx ratio
Max DV: 17 µg/m³
Natural Gas Turbine (MS): NO₂

Baseline Stack

Stack ht increase #1

Stack ht increase #2

Stack ht increase #2 w/ controls

Concentration (µg/m³)

NAAQS

NO₂/NOx 0.05 (PVMRM no DW)

NO₂/NOx 0.1 (PVMRM no DW)
Base 100% conversion (no DW) Max DV: 195 μg/m³
Contour Plots – NY case
Base
80% conversion (no DW)
Max DV: 156 μg/m³

Legend
-3 - 26
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 188
189 - 195
Base
OLM (0.05 NO₂/NOx ratio) (no DW)
Max DV: 85 μg/m³
Base
PVMRM (0.05 NO$_2$/NOx ratio) (no DW)
Max DV: 145 µg/m$^3$
Base
PVMRM (0.05 NO₂/NOx ratio) (DW)
Max DV: 130 μg/m³
Baseline
PVMRM (0.10 NO₂/NOx ratio) (DW)
Max DV: 138 µg/m³
Stack ht increase #1
PVMRM (0.05 NO₂/NOx ratio) (no DW)
Max DV: 124 µg/m³
Stack ht increase #1
PVMRM (0.05 NO₂/NOx ratio) (DW)
Max DV: 105 µg/m³
Stack ht increase #1
PVMRM (0.10 NO$_2$/NOx ratio) (DW)
Max DV: 112 $\mu$g/m$^3$
Stack ht increase #2
PVMRM (0.05 NO₂/NOx ratio) (no DW)
Max DV: 117 μg/m³
Stack ht increase #2
PVMRM (0.05 NO$_2$/NOx ratio) (DW)
Max DV: 98 $\mu$g/m$^3$
Stack ht increase #2: PVMRM (0.10 NO$_2$/NOx ratio) (DW)
Max DV: 105 µg/m$^3$
Stack ht increase #2 + controls
PVMRM (0.05 NO₂/NOx ratio) (no DW)
Max DV: 122 µg/m³
Stack ht increase #2 + controls
PVMRM (0.05 NO$_2$/NOx ratio) (DW)
Max DV: 104 µg/m$^3$
Stack ht increase #2 + controls
PVMRM (0.10 NO₂/NOx ratio) (DW)
Max DV: 110 μg/m³
Coal EGU (OAQPS): \( NO_2 \)

- Baseline
- Stack ht increase
- Controls
- Stack ht increase w/ controls
- Stack ht increase #2 w/ controls
- Stack ht increase w/ controls & higher exit velocity

Legend:
- \( NO_2/NOx 0.05 \)
- \( NO_2/NOx 0.10 \)
- 100% conversion
- 80% ARM

NAAQS
0.05 NO₂/NOx ratio
Max DV: 226 µg/m³
Base
0.10 NO$_2$/NOx ratio
Max DV: 234 $\mu$g/m$^3$
Base
100% conversion
Max DV: 777 μg/m³
Base
80% conversion
Max DV: 621 μg/m³
Stack ht increase
0.05 NO₂/NOx ratio
Max DV: 226 μg/m³
Stack ht increase
0.10 NO₂/NOx ratio
Max DV: 234 µg/m³
Stack ht increase
100% conversion
Max DV: 777 μg/m³
Stack ht increase
80% conversion
Max DV: 621 μg/m³
Controls

0.05 NO₂/NOx ratio
Max DV: 226 μg/m³
Controls
100% conversion
Max DV: 777 μg/m³
Controls
80% conversion
Max DV: 621 μg/m³
Stack ht increase + controls
0.05 NO₂/NOx ratio
Max DV: 226 µg/m³
Stack ht increase + controls
0.10 NO₂/NOx ratio
Max DV: 234 µg/m³
Stack ht increase + controls
100% conversion
Max DV: 777 μg/m³
Stack ht increase + controls
80% conversion
Max DV: 621 µg/m³
Stack ht increase + additional controls
0.05 NO₂/NOx ratio
Max DV: 226 µg/m³
Stack ht increase + additional controls
100% conversion
Max DV: 777 µg/m³
Stack ht increase + additional controls
80% conversion
Max DV: 621 μg/m³
Stack ht increase + additional controls + higher exit velocity
0.05 NO₂/NOx ratio
Max DV: 226 μg/m³
Stack ht increase + additional controls + higher exit velocity
0.10 NO₂/NOx ratio
Max DV: 234 µg/m³
Stack ht increase + additional controls + higher exit velocity
100% conversion
Max DV: 777 \( \mu g/m^3 \)
Stack ht increase + additional controls + higher exit velocity
80% conversion
Max DV: 621 μg/m³
Biomass facility (rural): NO₂

- Baseline Stack
- Stack ht increase
- Stack ht increase w/ no controls

NAAQS:
- 100% conversion
- 80% ARM
- NO₂/NOx 0.1 (OLM)
- NO₂/NOx 0.15 (OLM)
- NO₂/NOx 0.1 (PVMRM)
- NO₂/NOx 0.15 (PVMRM)
Biomass facility (urban): NO₂

- 100% conversion
- 80% ARM
- NO₂/NOx 0.1 (OLM)
- NO₂/NOx 0.15 (OLM)
- NO₂/NOx 0.1 (PVMRM)
- NO₂/NOx 0.15 (PVMRM)

Concentration (µg/m³)

Baseline
Stack ht increase
Stack ht increase w/ no controls

NAAQS
Base (Rural)
100% conversion
Max DV: 22 μg/m³
Base (Rural)
80% conversion
Max DV: 18 μg/m³

Legend
- <=5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50

0 1.250 2.500 5.000 7.500 10.000 Meters
Base (Rural)
OLM (0.1 NO₂/NOx ratio)
Max DV: 21 µg/m³
Base (Rural)
OLM (0.15 NO$_2$/NOx ratio)
Max DV: 21 µg/m$^3$
Base (Rural)
PVMRM (0.1 NO₂/NOx ratio)
Max DV: 16 μg/m³
Base (Rural)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 16 µg/m³
Stack ht increase (Rural)
100% conversion
Max DV: 8 $\mu$g/m$^3$
Stack ht increase (Rural)
80% conversion
Max DV: 6 µg/m³
Stack ht increase (Rural)
OLM (0.1 NO₂/NOx ratio)
Max DV: 7 μg/m³
Stack ht increase (Rural)
OLM (0.15 NO$_2$/NOx ratio)
Max DV: 7 $\mu$g/m$^3$
Stack ht increase (Rural)
PVMRM (0.1 NO₂/NOx ratio)
Max DV: 7 µg/m³
Stack ht increase (Rural)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 7 μg/m³
Stack ht increase + no controls (Rural)
100% conversion
Max DV: 40 µg/m³
Stack ht increase + no controls (Rural)
80% conversion
Max DV: 32 μg/m³
Stack ht increase + no controls (Rural) OLM (0.1 NO₂/NOx ratio)
Max DV: 36 μg/m³
Stack ht increase + no controls (Rural) OLM (0.15 NO₂/NOx ratio)
Max DV: 36 μg/m³
Stack ht increase + no controls (Rural)
PVMRM (0.1 NO₂/NOx ratio)
Max DV: 26 µg/m³
Stack ht increase + no controls (Rural)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 26 µg/m³
Base (Urban)
100% conversion
Max DV: 24 μg/m³

Legend
- ≤5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50

0 1,250 2,500 5,000 7,500 10,000 Meters
Base (Urban)
80% conversion
Max DV: 19 μg/m³
Base (Urban)
OLM (0.1 NO₂/NOx ratio)
Max DV: 22 µg/m³
Base (Urban)
OLM (0.15 NO₂/NOx ratio)
Max DV: 22µg/m³
Base (Urban)
PVMRM (0.1 NO₂/NOx ratio)
Max DV: 15 µg/m³
Base (Urban)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 16 μg/m³
Stack ht increase (Urban)
100% conversion
Max DV: 10 μg/m³
Stack ht increase (Urban)
80% conversion
Max DV: 8 μg/m³

Legend

- ≤5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 46
- 46 - 50

0 1,250 2,500 5,000 7,500 10,000 Meters
Stack ht increase (Urban)
OLM (0.1 \( \text{NO}_2/\text{NOx} \) ratio)
Max DV: 9 \( \mu \text{g/m}^3 \)
Stack ht increase (Urban)
OLM (0.15 NO$_2$/NOx ratio)
Max DV: 9 $\mu$g/m$^3$
Stack ht increase (Urban) PVMRM (0.1 NO₂/NOx ratio) Max DV: 9 µg/m³
Stack ht increase (Urban)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 9 µg/m³
Stack ht increase + no controls (Urban)
100% conversion
Max DV: 50 \( \mu g/m^3 \)
Stack ht increase + no controls (Urban)
80% conversion
Max DV: 40 μg/m³

Legend
- ≤5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 26
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50

0 1,250 2,500 5,000 7,500 10,000 Meters
Stack ht increase + no controls (Urban)
OLM (0.1 NO₂/NOx ratio)
Max DV: 45 μg/m³
Stack ht increase + no controls (Urban)
OLM (0.15 NO₂/NOx ratio)
Max DV: 45 μg/m³
Stack ht increase + no controls (Urban)
PVMRM (0.1 NO₂/NOx ratio)
Max DV: 36 µg/m³
Stack ht increase + no controls (Urban)
PVMRM (0.15 NO₂/NOx ratio)
Max DV: 38 µg/m³
Base + no controls
0.1 NO₂/NOx ratio
Max DV: 665 μg/m³
Base + no controls
0.25 NO₂/NOx ratio
Max DV: 1440 µg/m³
Base
0.1 NO$_2$/NOx ratio
Max DV: 289 µg/m$^3$
Base
0.25 NO$_2$/NOx ratio
Max DV: 335 $\mu$g/m$^3$
Base
0.25 NO₂/NOx ratio
O₃=40 ppb
Max DV: 351 µg/m³
Base
0.25 NO₂/NOx ratio
O₃=80 ppb
Max DV: 463 μg/m³
Stack ht increase #1
0.1 NO$_2$/NO$_x$ ratio
Max DV: 106 μg/m$^3$
Stack ht increase #1
0.25 NO₂/NOx ratio
Max DV: 110 μg/m³
Stack ht increase #2
0.1 NO₂/NOx ratio
Max DV: 86 µg/m³
Stack ht increase #2
0.25 NO$_2$/NOx ratio
Max DV: 88 $\mu$g/m$^3$
Stack ht increase #3
0.1 NO₂/NOx ratio
Max DV: 85 µg/m³
Stack ht increase #3
0.25 NO₂/NOx ratio
Max DV: 85 μg/m³
Refinery: NO₂

Concentration (µg/m³)

Baseline | Stack ht increase #1 | Stack ht increase #2 | Controls | stack ht increase #2 & controls

NAAQS
Natural Gas Compressor Station (All): NO₂

100% conversion
80% ARM
NO₂/NOx 0.1 (PVMRM)
NO₂/NOx 0.25 (PVMRM)
NO₂/NOx 0.5 (PVMRM)
NO₂/NOx 0.1 (OLM)
NO₂/NOx 0.25 (OLM)
NO₂/NOx 0.5 (OLM)

Baseline
Stack ht increase #1
Stack ht increase #2
Less controls for 3 of 4 facilities & stack ht increase #2
Less controls for 3 of 4 facilities

Concentration (μg/m³)

0 2000 4000 6000 8000 10000 12000 14000
Base:
100% conversion
Max DV: 1839 μg/m³

Legend
- 14 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 125
- 126 - 150
- 151 - 188
- 189 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
Base:
80% ARM
Max DV: 1471 µg/m³
Base: PVMRM
0.1 NO₂/NOx ratio
Max DV: 1067 μg/m³
Base: PVMRM
0.25 NO₂/NOx ratio
Max DV: 1245 μg/m³
Base: PVMRM
0.5 NO₂/NOx ratio
Max DV: 1519 µg/m³
Base: OLM
0.1 NO₂/NOx ratio
Max DV: 293 μg/m³
Base: OLM
0.25 NO₂/NOx ratio
Max DV: 556 µg/m³
Base:
OLM 0.5 NO₂/NOx ratio
Max DV: 1012 μg/m³
Stack ht increase #1
100% conversion
Max DV: 191 µg/m³
Stack ht increase #1
80% ARM
Max DV: 153 µg/m³

Legend
- 14 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 125
- 126 - 150
- 151 - 160
- 189 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500

Meters
Stack ht increase #1

PVIRM

0.1 NOx/NO in stack ratio

Max DV: 65 µg/m³
Stack ht increase #1
PVMRM
0.25 NO$_2$/NOx in-stack ratio
Max DV: 83 µg/m$^3$
Stack ht increase #1
PVMRM
0.5 \( \text{NO}_2/\text{NOx} \) in-stack ratio
Max DV: 121 \( \mu \text{g/m}^3 \)
Stack ht increase #2
100% conversion
Max DV: 73 μg/m³
Stack ht increase #2
80% ARM
Max DV: 58 μg/m³
Stack ht increase #2
PVMRM
0.1 NO₂/NOx in-stack ratio
Max DV: 43 μg/m³
Stack ht increase #2
PVMRM
0.25 NO$_2$/NOx in-stack ratio
Max DV: 43 $\mu$g/m$^3$
Stack ht increase #2
PVMRM
0.5 NO$_2$/NOx in-stack ratio
Max DV: 51 μg/m$^3$
Less controls for 3 of 4 facilities & stack ht increase #2
80% ARM
Max DV: 397 μg/m³
Less controls for 3 of 4 facilities & stack ht increase #2
PVMRM
0.25 NO$_2$/NOx in-stack ratio
Max DV: 163 $\mu$g/m$^3$
Less controls for 3 of 4 facilities & stack ht increase #2
100% conversion
Max DV: 496 µg/m³
Less controls for 3 of 4 facilities & stack ht increase #2
PVMRM
0.1 NO$_2$/NOx in-stack ratio
Max DV: 162 $\mu$g/m$^3$
Less controls for 3 of 4 facilities & stack ht increase #2
PVMRM
0.5 NO₂/NOx in-stack ratio
Max DV: 1262 µg/m³
Less controls for 3 of 4 facilities
100% conversion
Max DV: 13129 μg/m³
Less controls for 3 of 4 facilities
80% ARM
Max DV: 10503 µg/m³
Less controls for 3 of 4 facilities
PVMRM
0.1 NO₂/NOx in-stack ratio
Max DV: 1674 µg/m³
Cement Kiln: NO₂

Concentration (µg/m³)

Baseline Controls More stringent controls

NO₂/NOx 0.1
NO₂/NOx 0.05
NO₂/NOx 0.25
NO₂/NOx 0.5
NO₂/NOx 0.1 O₃=40 ppb
NO₂/NOx 0.1 O₃=80 ppb

NAAQS
Base
300 m FL
Max DV: 114 μg/m³
Base
50 m FL
Max DV: 296 µg/m³
Ethanol Plant (Springfield): $\text{SO}_2$

![Graph showing concentrations of SO2 for different scenarios.](image)

- **Baseline**
- **Increase stack ht Unit 4**
- **Increase stack ht Unit 4 w/ controls**
- **Increase stack ht Unit 4 w/ additional controls**

**NAAQS**

Concentration ($\mu\text{g/m}^3$)

- 300 m FL
- 50 m FL
Ethanol Plant (Waterloo): SO$_2$

<table>
<thead>
<tr>
<th>Condition</th>
<th>300 m FL</th>
<th>50 m FL</th>
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</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase stack ht Unit 4</td>
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<tr>
<td>Increase stack ht Unit 4 w/ controls</td>
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<tr>
<td>Increase stack ht Unit 4 w/ additional controls</td>
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</tr>
</tbody>
</table>

Baseline Increase stack ht Unit 4 w/ additional controls
Uncontrolled; base parameters (h=65m)
Max DV=905 μg/m³
Base emissions/parameters (h=65m)
Max DV=445 µg/m³
Uncontrolled; base parameters (h=150 m)
Max DV=65 \mu g/m^3
Base parameters (h=150 m)
Max DV=33 μg/m³
Refinery: SO₂

- Base w/ no controls
- Stack ht increase #2 w/ no controls on 2 units
- Base
- Stack ht increase #1
- Stack ht increase #2

Concentration (µg/m³)

NAAQS
Uncontrolled: Flat, Rural
Max DV: 163 µg/m³
Uncontrolled: Flat, Urban
Max DV: 265 μg/m³
Uncontrolled: Terrain, Rural Max DV: 272 µg/m³
Uncontrolled: Terrain, Urban
Max DV: 263 μg/m³
Cement Kiln: SO₂

- Baseline
- Controls
- More stringent controls
Pulp & paper: SO$_2$

![Bar chart showing concentration (µg/m$^3$) for different scenarios.

- **Base**
- **Stack ht increase #1**
- **Stack ht increase #2**
- **Stack ht increase #2 & controls**

The chart compares concentration levels against the NAAQS (National Ambient Air Quality Standards).
Base
Max DV: 924 μg/m³
Stack ht increase #1
Max DV: 553 µg/m³
Stack ht increase #2
Max DV: 212 µg/m³
Stack ht increase #2 and controls
Max DV: 212 μg/m³
Fuel Oil Turbine: \( \text{SO}_2 \)
Baseline
Max DV: 257 μg/m³
Stack ht increase #2
Max DV: 179 μg/m³
Flare: \( \text{SO}_2 \)

Baseline: 45 m stack ht

45 m stack ht

65 m stack ht

65 m stack ht w/ controls

Concentration (\(\mu g/m^3\))

NAAQS
Baseline
Max DV: 324 µg/m³
Stack ht increase to 45
Max DV: 219 μg/m³
Stack ht increase to 65
Max DV: 92 μg/m³