Chapter 2: NO_2 Emissions and Monitoring Data

Synopsis

This chapter describes the available NO_2 emissions and air quality data used to inform and develop the controls strategies outlined in this RIA. We first describe data on NO_2 emission sources contained in available EPA emission inventories. We then provide an overview of data sources for air quality measurement. For a more in-depth discussion of NO_2 emissions and air quality data, see the Integrated Science Assessment for the NO_2 NAAQS.[1]

2.1 Sources of NO_2

The primary data source for this discussion is the National Emissions Inventory (NEI) for 2002 (USEPA, 2007a). Ambient levels of NO_2 are the product of both direct NO_2 emissions and emissions of other NOx (e.g, NO), which can then be converted to NO_2. Nationally, anthropogenic sources account for approximately 87% of total NOx emissions. (Apart from these anthropogenic sources, there are also natural sources of NOx including microbial activity in soils, lightning, and wildfires.) As a result of Clean Air Act requirements, emissions standards promulgated for many source categories that have taken effect since 2002, including numerous mobile source standards for gasoline and diesel vehicles/engines, are projected to result in much lower emissions of both direct NO_2 and other NOx at the current time or in the near future.

Stationary sources (e.g., electrical utilities and industry) account for about 40% of the national NOx emissions in the 2002 NEI. The main stationary sources of NOx emissions in the 2002 NEI are combustion-related emissions and industrial process-related emissions. Table 2-1 presents emissions estimates for stationary sources grouped into descriptive categories. Presence and relative position of a source category on this list does not necessarily provide an indication of the significance of the emissions from individual sources within the source category. A source category, for example, may be composed of many small (i.e., low-emitting) sources, or of just a few very large (high-emitting) sources.

---

[1] U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for NO_2: Policy Assessment of Scientific and Technical Information, Integrated Science Assessment, Chapter 2, EPA-452/R-08-xxx, Office of Air Quality Planning and Standards, RTP, NC.

Mobile sources (both on-road and off-road) account for about 60% of the national NOx emissions in the 2002 NEI. Highway vehicles represent the major mobile source component. In the United States, approximately half the mobile source emissions are contributed by diesel engines and half are emitted by gasoline-fueled vehicles and other sources.

Table 2-1. NOx Sources (2002 NEI)

NOx Source Category	Emissions (tons/year)
Electric Utility Fuel Combustion	3,792,292
Industrial Fuel Combustion	1,897,944
Fuel Combustion, other	730,259
Chemical and Allied Product Manufacturing	60,901
Metals Processing	66,173
Petroleum and Related Industries	358,223
Industrial Processes, other	482,007
Solvent Utilization	4,365
Storage and Transport	16,109
Waste Disposal and Recycling	145,678
Highway Vehicles	6,491,821
Off-highway Vehicles	6,027,085
Miscellaneous Source Categories	270,913
Total	**20,343,770**

2.2 Air Quality Monitoring Data

2.2.1 Background on NO_2 monitoring network

From its inception in the late 1970’s through the present (2008), the NO_2 network has remained relatively stable with regard to the number of monitoring sites (see memo by Watkins, 2008). As of October 2008, there were 409 NOx monitors within the U.S. actively reporting NO_2 data into the air quality system AQS. The NO_2 network was originally deployed to support implementation of the NO_2 NAAQS established in 1971. Despite the establishment of an NO_2 standard, the first requirements for NO_2 monitoring did not come out until May of 1979. At that time, 40 CFR Part 58, Appendix D, section 3.5 stated:

> “Nitrogen Dioxide NAMS [National Ambient Monitoring Stations, now a defunct term] will be required in those areas of the country which have a population greater than 1,000,000. These areas will have two NO_2 NAMS. It is felt that stations in these major metropolitan areas would provide sufficient data for a

> national analysis of the data, and also because NO_2 problems occur in areas of greater than 1,000,000. Within urban areas requiring [NO_2] NAMS, two permanent monitors are sufficient. The first station (category (a), middle scale or neighborhood scale) would be to measure the photochemical production of NO_2 and would best be located in that part of the urban area where the emission density of NOx is the highest. The second station (category (b) urban scale), would be to measure the NO_2 produced from the reaction of NO with O_3 and should be downwind of the area peak NOx emission areas."

In the October, 2006 monitoring rule, this language was removed from the CFR. Removal was driven by the fact that there is no NO_2 non-attainment problem under the current standards. In the 2006 rule, EPA chose to rewrite 40 CFR Part 58, Appendix D, section 4.3 to state that:

> "There are no minimum requirements for the number of NO_2 monitoring sites. Continued operation of existing SLAMS [State and Local Ambient Monitoring Station] NO_2 sites using FRM [Federal Reference Method] or FEM [Federal Equivalent Method] is required until discontinuation is approved by the EPA Regional Administrator. Where SLAMS NO_2 monitoring is ongoing, at least one NO_2 site in the area must be located to measure the maximum concentration of NO_2."

As noted earlier, the size of the NO_2 network has been fairly stable through time, even though an actual requirement for state and local air agencies to monitor NO_2, other than for Photochemical Assessment Monitoring Stations (PAMS) or Prevention of Significant Deterioration (PSD), was removed in the 2006 monitoring rule. The maintenance of the NO_2 monitoring network has been driven by several factors, including the need to support ozone modeling and forecasting, the need to track PM precursors, and a general desire on the part of states to continue to understand trends in ambient NO_2.

To characterize the current NO_2 network, staff has reviewed the NO_2 network meta-data. The data reviewed are those available from AQS in October 2008, for monitors reporting data in 2008. The meta-data fields are typically created by state and local agencies when a monitor site is opened, moved, or re-characterized. While these files are useful for characterizing specific monitors, there is some uncertainty surrounding this meta-data given that there is no routine or enforced process for updating or correcting meta-data fields. With this uncertainty in mind, staff has compiled information on the monitoring objectives and measurement scales for monitors in the NO_2 network.

The monitor objective meta-data field describes the purpose of the monitor. For example the purpose of a particular monitor could be to characterize health effects, photochemical activity, transport, and/or welfare effects. As of October 2008, there were 489 records of NO_2 monitor objective values (some monitors have multiple monitor objectives). Table 2-2 lists the distribution of monitoring objectives across the network. There are 11 categories of monitor objectives for NO_2 monitors within AQS. The "other" category is for sites likely addressing a state or local need outside of the routine objectives, and the "unknown" category represents missing meta-data. The remaining categories stem directly from categorizations of site types within CFR. In 40 CFR Part 58 Appendix D, there are six examples of NO_2 site types:

1. Sites located to determine the highest concentration expected to occur in the area covered by the network (Highest Concentration).
2. Sites located to measure typical concentrations in areas of high population (Population Exposure).
3. Sites located to determine the impact of significant sources or source categories on air quality (Source Oriented).
4. Sites located to determine general background concentration levels (General Background).
5. Sites located to determine the extent of regional pollutant transport among populated areas; and in support of secondary standards (Regional Transport).
6. Sites located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts (Welfare Related Impacts).

The remaining four categories available are a result of updating the AQS database. In the more recent upgrade to AQS, the data handlers inserted the available site types for Photochemical Assessment Monitoring Stations (PAMS) network. These PAMS site types are spelled out in 40 CFR Part 58 Appendix D:

1. Type 1 sites are established to characterize upwind background and transported ozone and its precursor concentrations entering the area and will identify those areas which are subjected to transport (Upwind Background).

2. Type 2 sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact and are suited for the monitoring of urban air toxic pollutants (Max. Precursor Impact).
3. Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions (Max. Ozone Concentration).
4. Type 4 sites are established to characterize the downwind transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas (Extreme Downwind).

Table 2-2. NOx Network Distribution of Monitor Objectives

NOx Monitor Objective	Number of Monitor Objective Records	Percent Distribution
Population Exposure	177	36.20
Highest Concentration	58	11.86
General Background	51	10.43
Max. Precursor Impact (PAMS Type 2 Site)	21	4.29
Source Oriented	19	3.89
Upwind Background (PAMS Type 1 Site)	18	3.68
Regional Transport	12	2.45
Other	9	1.84
Max. Ozone Concentration (PAMS Type 3 Site)	8	1.64
Extreme Downwind (PAMS Type 4 Site)	3	0.61
Welfare Related Impacts	1	0.20
Unknown	112	22.90
Totals:	**489**	**100%**

The spatial measurement scales are laid out in 40 CFR Part 58, Appendix D, Section 1 “Monitoring Objectives and Spatial Scales.” This part of the regulation spells out what data from a monitor can represent in terms of air volumes associated with area dimensions:

Microscale - 0 to 100 meters

Middle Scale -	100 to 500 meters
Neighborhood Scale -	500 meters to 4 kilometers
Urban Scale -	4 to 50 kilometers
Regional Scale -	50 kilometers up to 1000km

There are meta-data records for the NO_2 network to indicate what the measurement scale of a particular monitor represents. There are 386 NO_2 monitor records in AQS with available measurement scale information. Table 2-3 shows the measurement scale distribution across all NO_2 sites form the available data in AQS of monitors reporting data in 2008.

Table 2-3. NOx Network Distribution across Measurement Scales.

Measurement Scale	Number of Measurement Scale Records	Percent Distribution
Microscale	3	0.78
Middle Scale	23	5.96
Neighborhood	212	54.92
Urban Scale	119	30.83
Regional Scale	29	7.51
Totals:	**386**	**100%**

In summary, upon review of the known 409 monitors reporting data to AQS in 2008, and the distribution of the available data from the categories of monitor objective and measurement scale, we see the NO_2 network is primarily targeting public health and photochemical process monitoring objectives. We note that nearly half of the monitor objective records are directly targeting public health through the population exposure (36.2%) and highest concentration (11.8%) categories alone. The other categories serve to inform public health concerns, but also address photochemistry issues where NOx serves as a precursor to ozone. Further, it appears that approximately 10% of NO_2 monitors are in place to serve the PAMS network. In reality, a large majority of sites likely could serve both public health and photochemistry related objectives due to their proximity to urban areas. The exceptions would likely be categories such as upwind background, extreme downwind, regional transport, and possibly maximum O_3 concentration. These four categories only represent approximately 7% of the NO_2 network, and have a higher likelihood of being rural and regional in scale.

2.2.2 Trends in ambient concentrations of NO_2

As noted above, NO_2 is monitored largely in urban areas and, therefore, data from the NO_2 monitoring network is generally more representative of urban areas than rural areas. According to monitoring data, nationwide levels of ambient NO_2 (annual average) decreased 41% between 1980 and 2006 (ISA, Figure 2.4-15). Between 2003 and 2005, national mean concentrations of NO_2 were about 15 ppb for averaging periods ranging from a day to a year. The average daily maximum hourly NO_2 concentrations were approximately 30 ppb. These values are about twice as high as the 24-h averages. The highest maximum hourly concentrations (~200 ppb) between 2003 and 2005 are more than a factor of ten higher than the mean hourly or 24-h concentrations (ISA, Figure 2.4-13). The highest levels of NO_2 in the United States can be found in and around Los Angeles, in the Midwest, and in the Northeast. Policy-relevant background concentrations, which are those concentrations that would occur in the United States in the absence of anthropogenic emissions in continental North America (defined here as the United States, Canada, and Mexico), are estimated to range from only 0.1 ppb to 0.3 ppb (ISA, section 2.4.6).

Ambient levels of NO_2 exhibit both seasonal and diurnal variation. In southern cities, such as Atlanta, higher concentrations are found during winter, consistent with the lowest mixing layer heights being found during that time of the year. Lower concentrations are found during summer, consistent with higher mixing layer heights and increased rates of photochemical oxidation of NO_2. For cities in the Midwest and Northeast, such as Chicago and New York City, higher levels tend to be found from late winter to early spring with lower levels occurring from summer though the fall. In Los Angeles the highest levels tend to occur from autumn though early winter and the lowest levels from spring though early summer. Mean and peak concentrations in winter can be up to a factor of two larger than in the summer at sites in Los Angeles. In terms of daily variability, NO_2 levels typically peak during the morning rush hours. Monitor siting plays a key role in evaluating diurnal variability as monitors located further away from traffic will show cycles that are less pronounced over the course of a day than monitors located closer to traffic.

2.2.3 Uncertainty Associated with the Ambient NO_2 Monitoring Method

The method for estimating ambient NO_2 levels (i.e., subtraction of NO from a measure of total NOx) is subject to interference by NOx oxidation products. Limited evidence suggests that these compounds result in an overestimate of NO_2 levels by roughly 20 to 25% at typical ambient levels. Smaller relative errors are estimated to occur in measurements taken near strong NOx sources since most of the mass emitted as NO or NO_2 would not yet have been further oxidized. Relatively larger errors appear in locations more distant from strong local NOx sources. Additionally, many NO_2 monitors are elevated above ground level in the cores of large cities. Because most sources of NO_2 are near ground level (i.e., combustion emissions from traffic), this produces a gradient of NO_2 with higher levels near ground level and lower levels being detected at the elevated monitor. One comparison has found an average of a 2.5-fold increase in NO_2 concentration measured at 4 meters above the ground compared to 15 meters above the ground. The ISA notes that levels are likely even higher at elevations below 4 meters (ISA, section 2.5.3.3). Another source of uncertainty in exposure estimates can result from monitor location. NO_2 monitors are sited for compliance with air quality standards rather than for capturing small-scale variability in NO_2 concentrations near sources such as roadway traffic. Significant gradients in NO_2 concentrations near roadways have been observed in several studies, and NO_2 concentrations have been found to be correlated with distance from roadway and traffic volume (ISA, section 2.5.3.2).