

# **Annual Report**

## **North Dakota Air Quality Monitoring Data Summary 1997**



**North Dakota Department of Health  
Division of Air Quality**



# Annual Report

## North Dakota

### Air Quality Monitoring Data Summary 1997

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## EXECUTIVE SUMMARY

The North Dakota Department of Health operated eleven ambient and two special purpose air quality monitoring sites and industry operated ten source-specific air quality monitoring sites. The data from these sites indicated that the quality of the ambient air in North Dakota is generally good.

There were no nitrogen dioxide, ozone, or particulate matter exceedances of either the state or federal ambient air quality standards measured during the year. There was one exceedance of the state 24-hour sulfur dioxide. Through legislative action effective August 1, 1997, coal conversion facilities and oil refineries were exempted from the state sulfur dioxide standards. There were a total of 38 exceedances of the hydrogen sulfide 1-hour state standard.



## INTRODUCTION

The North Dakota Department of Health, Environmental Health Section, Division of Environmental Engineering, henceforth known as the Department, has the primary responsibility for protecting the health and welfare of North Dakotans from the harmful effects of air pollution. The Department ensures that the ambient air quality in North Dakota is better than the levels required by the state and federal Ambient Air Quality Standards<sup>1,2</sup> and the "Prevention of Significant Deterioration of Air Quality Rules."<sup>3</sup> To address this responsibility, the Department operates a network of ambient air quality monitors.

In addition to the ambient air quality monitoring sites operated by the Department, four industrial sources of air pollutants operated air quality monitoring sites within their immediate spheres of influence. The site locations selected are based on computer dispersion modeling and prevailing wind directions.

This report provides an overview of air quality monitoring activities conducted by the Department and industry during the 12-month period beginning Jan. 1, 1997, and ending Dec. 31, 1997. The report includes data summaries for the monitored pollutants and significant changes that occurred to the monitoring program. Also included are wind and pollution star charts and trend graphs. The pollution star charts (Appendix 3) indicate the percentage of time a pollutant is detected when the wind is from each direction. The trend graphs (Appendix 4) show the maximum concentration for each pollutant standard and the percentage of time a concentration is above the minimum detectable limit for the specific analysis method.

## NETWORK DESCRIPTION

### Department Sites

During 1997, the Department operated 13 air quality monitoring sites. Eleven were ambient monitoring sites, and two were special purpose monitoring (SPM) sites. SPM sites include one in the Whiskey Joe oil field near the Theodore Roosevelt National Park South Unit and another near the AMOCO Refinery in Mandan, ND. Table 1 lists Department monitoring sites which were active during the year.

In general, Department ambient air quality monitoring (AAQM) sites obtain air quality data to meet four objectives: (1) determine representative concentrations in areas of high population density (urban or population oriented monitoring), (2) determine general background concentration levels, (3) to measure highest concentrations expected to occur in an area covered by an individual site, and (4) determine representative impacts on ambient air quality levels near significant sources.

The Department's ambient air quality monitoring network normally does not include source-specific monitoring, i.e., monitoring a single, specific source. However, the Mandan - SPM site was established to collect source-specific 5-minute peak and hourly dioxide averages due to impacts from the MDU Heskett Station and AMOCO Refinery.

The Department, in issuing Permits to Construct and Permits to Operate for major sources, may require these sources to operate air quality monitoring programs to assess impacts on local air quality.

### Industry Sites

Industry operated 10 source-specific air quality monitoring sites during the year. Table 1 also lists the industry networks and monitoring sites active during the year.

In general, industry air quality monitoring sites obtain data at locations expected to show high concentrations of pollution from a specific source. These source-specific site locations are selected using computer dispersion modeling programs and annual wind patterns. The distance a monitoring site is located from a source is determined by the primary pollutant being monitored.

Figure 1 displays both Department and industry monitoring sites. If an industry has more than one site, only the general location within the county is indicated.



TABLE 1

## State AAQM Network Description

Site Name	Type Station	Parameter Monitored <sup>1</sup>	Operating Schedule	Monitoring Objective <sup>2</sup>	Spatial Scale <sup>2</sup>	Date Site Began
1 Beulah Residential	SLAMS	PM <sub>10</sub> SO <sub>2</sub> , NO <sub>2</sub> , O <sub>3</sub> , MET	6th Day cont.	Population Exposure Population Exposure	Neighborhood Urban	12/95 04/80
2 Bismarck Residential	SLAMS	PM <sub>10</sub> , PM <sub>2.5</sub>	6th Day	Population Exposure	Neighborhood	07/95
3 Dickinson Residential	SLAMS	PM <sub>10</sub>	6th Day	Population Exposure	Neighborhood	07/89
4 Dunn Center	SLAMS	SO <sub>2</sub> , MET	cont.	General Background	Regional	10/79
5 Fargo Residential	SLAMS	PM <sub>10</sub> PM <sub>10</sub> SO <sub>2</sub> , NO <sub>2</sub> , O <sub>3</sub> , MET	6th Day 6th Day cont.	Population Exposure Collocated SSI Population Exposure	Neighborhood N/A Regional	08/95  08/95
7 Grand Forks - North	SLAMS	PM <sub>10</sub>	6th Day	Population Exposure	Neighborhood	07/96
8 Hannover	SLAMS	SO <sub>2</sub> , NO <sub>2</sub> , O <sub>3</sub> , MET	cont.	General Background	Regional	10/84
9 Mandan - SPM	SPM	SO <sub>2</sub> , MET	cont.	Source Impact	Neighborhood	12/95
10 Sharon	SLAMS	SO <sub>2</sub> , NO <sub>x</sub> , O <sub>3</sub> , MET PM <sub>10</sub>	cont. 6th Day	General Background General Background	Regional	07/94
11 TRNP - NU	SLAMS	SO <sub>2</sub> , O <sub>3</sub> , H <sub>2</sub> S, MET	cont.	General Background	Regional	02/80
12 Whiskey Joe - SPM <sup>3</sup>	SPM	SO <sub>2</sub> , H <sub>2</sub> S, MET	cont.	Source Impact	Neighborhood	07/95
13 Williston Residential	SLAMS	PM <sub>10</sub>	6th Day	Population Exposure	Neighborhood	08/95
Company	Site Name					
14 Amerada Hess Corporation	TIOGA #1 TIOGA #2 TIOGA #3	SO <sub>2</sub> H <sub>2</sub> S, MET SO <sub>2</sub>	cont. cont. cont.	Source Source Source	Neighborhood Neighborhood Neighborhood	07/87 07/87 11/87
15 Dakota Gasification Company	DGC #12 DGC #14 DGC #16 DGC #17	SO <sub>2</sub> , NO <sub>2</sub> , MET SO <sub>2</sub> SO <sub>2</sub> SO <sub>2</sub> , NO <sub>2</sub>	cont. cont. cont. cont.	Source Source Source Source	Neighborhood Neighborhood Neighborhood Neighborhood	01/80 01/89 10/95 10/95
16 Koch Hydrocarbon Company	KOCH #3 KOCH #4	SO <sub>2</sub> , MET H <sub>2</sub> S, MET	cont. cont.	Source Source	Neighborhood Neighborhood	11/94 05/94
17 W. H. Hunt Estate <sup>4</sup>	HUNT #5	SO <sub>2</sub> , H <sub>2</sub> S, MET	cont.	Source	Neighborhood	11/92
1. MET refers to meteorological and indicates wind speed and wind direction monitoring equipment. 2. Not applicable to MET 3. Site terminated on December 3 4. Site terminated December 31						

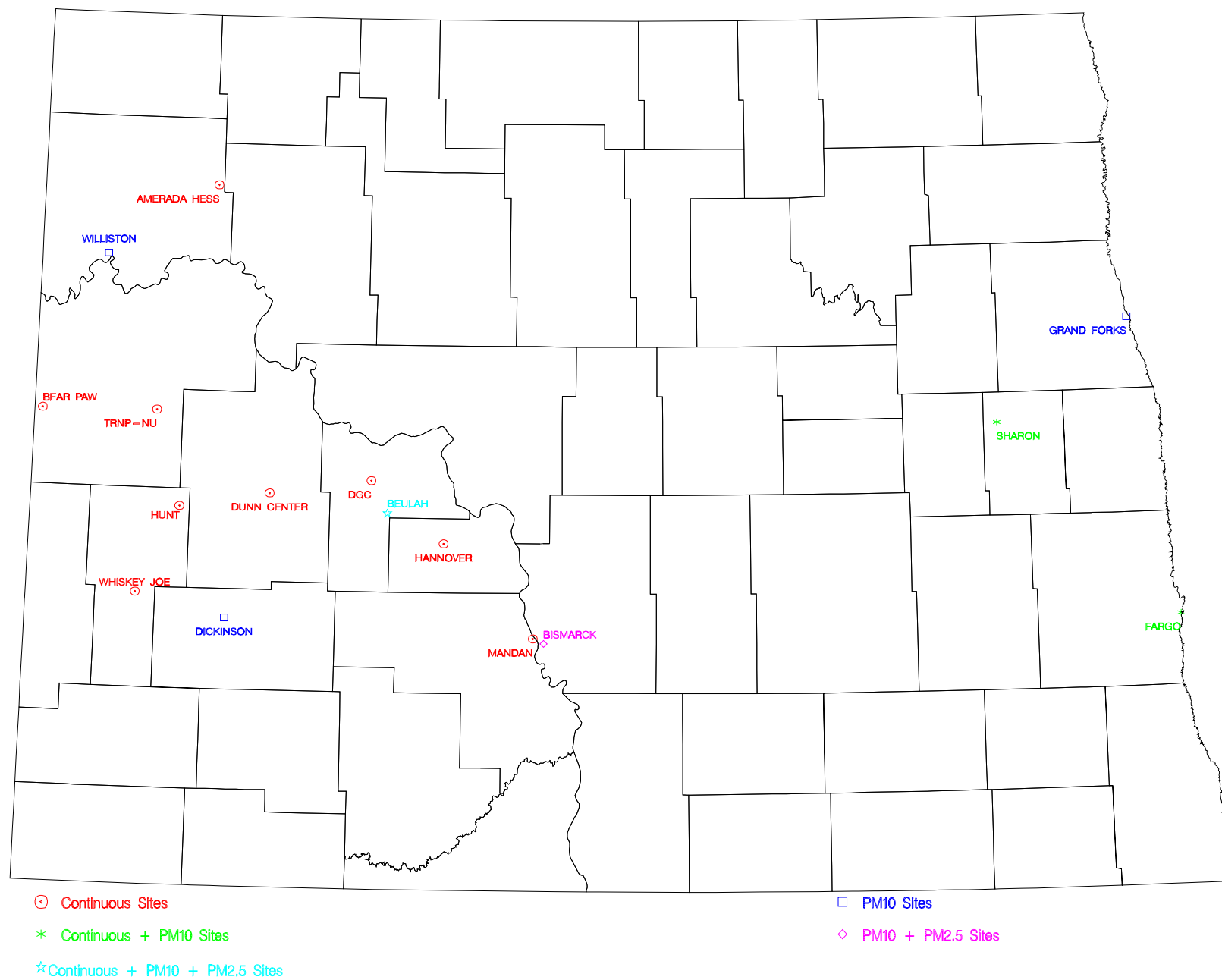


Figure 1 North Dakota Air Quality Monitoring Network

## NETWORK CHANGES

### Department Changes

Changes to the state monitoring network consisted of terminating the Whiskey Joe - SPM monitoring site on December 3.

### Industry Changes

Changes to the industry monitoring network consisted of terminating monitoring at Hunt #5 on December 31.

## MONITORING RESULTS

### Introduction

Ambient and source-specific air quality data collected during the year at monitoring sites operated by the Department and industry are summarized in tables for the following pollutants; sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), hydrogen sulfide (H<sub>2</sub>S), ozone (O<sub>3</sub>), inhalable fine particulates (PM<sub>2.5</sub>), inhalable coarse particulates (PM<sub>10</sub>), PM<sub>2.5</sub> sulfate and PM<sub>10</sub> sulfate. Each section contains a description of the physical characteristics, health effects, a comparison to the state standards, and a data summary.

The data summaries for gaseous pollutants include maximum concentrations, month/day/hour of each maximum, arithmetic means and the percentage of readings greater than the minimum detectable value (MDV) for the analytical method used for each parameter. Where applicable, the number of times a state standard was exceeded is indicated. The concentrations for gaseous pollutants are reported in parts per billion (ppb).

The PM<sub>2.5</sub>, PM<sub>10</sub>, PM<sub>2.5</sub> sulfate and PM<sub>10</sub> sulfate data summaries contain the three highest 24-hour average concentrations, month/day of each maxima, annual arithmetic mean and the number of times the 24-hour standard was exceeded, if applicable, and an asterisk (\*) if the annual standard is exceeded. The concentrations are reported in micrograms per cubic meter (µg/m<sup>3</sup>).

The PM sulfate/PM total mass ratio summaries contain the three highest 24-hour average ratios, month/day of each maxima and the annual arithmetic mean. Ratios are reported in percentage.

For statistical purposes, pollutant concentrations less than the minimum detectable value (MDV) for the analytical method used are assigned a value equal to one-half the MDV. The MDV for SO<sub>2</sub>, H<sub>2</sub>S and NO<sub>2</sub> is 2 ppb; O<sub>3</sub> is 4 ppb; PM<sub>2.5</sub> and PM<sub>10</sub> is 4 µg/m<sup>3</sup>; and, PM<sub>2.5</sub> and PM<sub>10</sub> sulfate is 0.5 µg/m<sup>3</sup>. Annual means are calculated for SO<sub>2</sub>, NO<sub>2</sub>, H<sub>2</sub>S, PM<sub>2.5</sub>, and PM<sub>10</sub>, however, only those means with more than 75 percent of data greater than the MDV are unbiased calculations. The PM sulfate/PM ratios are calculated only when both the PM sulfate and PM total mass are greater than the respective MDV.

As part of the statistical evaluation, the data recovery rate (NUM OBS) is evaluated to determine if the data recovery complies with the state's required 80 percent data recovery rate. A continuous analyzer operating less than 7,008 hours per year may achieve at least an 80 percent data recovery for the period operated; however, it does not meet the 80 percent data recovery for the year. Each analyzer at a site not meeting the 80 percent data recovery for the year is flagged in the "NUM OBS" column by placing "\*\*\*" underneath the number of observations. Particulate matter samplers must collect at least 48 samples per year to meet the 80 percent data recovery rate. In the PM sulfate/PM total mass ratio summaries, the "NUM OBS" column indicates the number of valid data pairs.

Ozone monitoring is an exception to the flagging procedures outlined above. Ozone monitoring is required from May 1 through September 30. However, to provide a complete quarter of data for the second quarter, the analyzers are started April 1. Three sites, Fargo Residential, Hannover and Sharon, are run year-round. Ozone data collected at these three sites is used by the Environmental Engineering Air Quality Impact Analysis Branch in performing NO<sub>x</sub> and SO<sub>2</sub> analysis for permit reviews.

## Sulfur Dioxide

### Physical Characteristics and Sources

Sulfur dioxide is a colorless gas with a pungent odor detectable by the human nose at concentrations of 500 to 800 ppb.<sup>4</sup> It is highly soluble in water where it forms sulfurous acid ( $H_2SO_3$ ). In the atmosphere, sulfurous acid is easily converted to sulfuric acid ( $H_2SO_4$ ), the major acidic component of “acid rain.” On a worldwide basis,  $SO_2$  is considered to be a major pollutant. It is emitted mainly from stationary sources that burn coal and oil – such as utility boilers. Other sources of  $SO_2$  include refineries and natural gas processing plants.

### Health Effects

Sulfur dioxide can be converted in the atmosphere to sulfuric acid aerosols and particulate sulfate compounds which are corrosive and potentially carcinogenic (cancer-causing). The major health effects of  $SO_2$  appear when it is associated with high levels of other pollutants such as particulate. Sulfur dioxide also may play an important role in the aggravation of chronic illnesses such as asthma. The incidence and intensity of asthma attacks have increased when asthmatics are exposed to higher levels of sulfur dioxide and particulate matter sulfates which are products of atmospheric  $SO_2$  reactions.<sup>4</sup>

### Standards Comparison

Sulfur dioxide was monitored at 16 sites. Eight sites were run by the Department and eight by industry. As a result of legislative action effective August 1, coal conversion and oil refineries were exempted from the state sulfur dioxide standards leaving these two classes of sources subject only to the federal standards. Therefore, DGC and Mandan Refinery - SPM are compared only to the federal standards.

The 1-hour state standard (273 ppb) was not exceeded during the year by an applicable source. The maximum 1-hour concentration was 612 ppb at DGC #12.

The 3-hour federal secondary standard (500 ppb) was not exceeded during the year. The maximum 3-hour average concentration was 288 ppb at DGC #12.

The 24-hour state standard (99 ppb) was exceeded once during the year at Mandan Refinery - SPM. The maximum 24-hour average concentration was 104 ppb at Mandan Refinery - SPM. .

Among those sites that collected at least 80 percent of the possible data during the year, the maximum annual arithmetic mean was 7.5 ppb at Mandan Refinery - SPM. At the remaining sites, the maximum arithmetic mean was 1.7 ppb at Bear Paw - MGP #3.

The Whiskey Joe - SPM SO<sub>2</sub> monitoring was terminated September 30. The purpose, to identify potential PSD exceedances, had been satisfied: No exceedances were identified.

The sulfur dioxide data are summarized in Table 2.

TABLE 2

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Sulfur Dioxide (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	1 - HOUR		M A X I M A		24 - HOUR		ARITH MEAN	1HR #>273	24HR #>99	% >MDV
				1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD	2ND MM/DD				
AMERADA HESS - TIOGA #1	1997	JAN-DEC	8662	54 07/31/08	36 05/04/09	23 07/31/08	23 12/20/05	8 01/26	8 12/20	1.6			15.4
AMERADA HESS - TIOGA #3	1997	JAN-DEC	8658	192 11/02/15	130 01/09/09	94 11/02/17	63 06/17/11	28 01/09	22 11/02	2.8			21.0
BEAR PAW - MGP #3	1997	JAN-DEC	6558 ***	170 09/27/02	131 05/10/17	101 09/27/02	91 05/10/17	23 05/10	22 05/07	1.7			9.6
BEULAH	1997	JAN-DEC	8713	53 04/18/11	53 06/02/12	31 11/19/14	27 06/02/11	8 03/12	8 11/19	2.1			29.6
DGC #12	1997	JAN-DEC	8669	612 09/08/22	233 09/08/23	288 09/08/23	140 09/08/20	55 09/08	9 06/01	2.5	1		35.7
DGC #14	1997	JAN-DEC	8479	144 11/16/13	99 01/30/17	75 11/16/14	46 01/30/17	16 01/30	13 11/16	2.6			40.3
DGC #16	1997	JAN-DEC	8304	140 03/31/10	122 07/23/13	79 02/02/17	72 03/31/11	28 09/03	20 09/02	3.6			62.4
DGC #17	1997	JAN-DEC	8327	164 06/06/08	143 06/06/06	137 06/06/08	70 04/20/11	30 06/06	27 04/20	3.7			67.7
DUNN CENTER	1997	JAN-DEC	8500	58 03/12/02	26 03/12/01	30 03/12/02	18 03/12/17	14 03/12	5 03/17	1.3			13.1
FARGO RESIDENTIAL	1997	JAN-DEC	8716	43 02/09/06	31 02/08/12	24 02/09/08	23 02/11/11	11 11/19	8 02/08	1.6			20.7
HANNOVER	1997	JAN-DEC	8509	101 06/03/08	73 10/06/08	42 06/03/11	40 08/23/11	12 06/03	10 04/09	2.2			24.1
LITTLE KNIFE #5	1997	JAN-DEC	8704	61 10/10/10	40 10/09/12	31 10/10/11	21 10/09/14	7 03/12	5 10/10	1.3			13.9
MANDAN REFINERY - SPM	1997	JAN-DEC	8700	159 12/27/20	158 01/09/04	141 11/02/05	138 01/09/05	104 01/09	60 11/02	7.5		1	46.3
SHARON	1997	JAN-DEC	8044	15 01/13/15	14 01/27/21	11 01/27/23	8 01/05/17	4 01/07	4 11/16	1.3			21.5
TRNP - NU	1997	JAN-DEC	8233	18 04/10/07	16 01/22/22	10 01/22/23	10 06/06/02	4 01/28	4 06/05	1.2			11.3
WHISKEY JOE - SPM	1997	JAN-SEP	6331	27 05/08/20	22 06/25/21	14 05/08/20	11 06/03/20	5 06/03	4 09/23	1.5			23.2
WHITE SHIELD	1997	APR-DEC	6487	70 09/02/10	49 04/16/11	34 09/02/11	29 09/03/08	15 09/03	8 09/02	1.7			25.6

The maximum 1-hour concentration is 612 ppb at DGC #12 on 09/08/22

The maximum 3-hour concentration is 288 ppb at DGC #12 on 09/08/23

The maximum 24-hour concentration is 104 ppb at MANDAN REFINERY - SPM on 01/09

\* The air quality standards are:

STATE Standards -

- 1) 273 ppb maximum 1-hour average concentration.
- 2) 99 ppb maximum 24-hour average concentration.
- 3) 23 ppb maximum annual arithmetic mean concentration.

FEDERAL Standards -

- 1) 500 ppb maximum 3-hour concentration not to be exceeded more than once per year.
- 2) 140 ppb maximum 24-hour concentration not to be exceeded more than once per year.
- 3) 30 ppb annual arithmetic mean.

\*\*\* Less than 80% of the possible samples (data) were collected.



### Sulfur Dioxide 5-Minute Average

Sulfur dioxide 5-minute averages were collected only at state-operated sites. The maximum 5-minute average was 348 ppb at Mandan Refinery - SPM.

The sulfur dioxide 5-minute data is presented in Table 3.

TABLE 3

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : SO<sub>2</sub> 5-Minute Averages (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	5 - M I N U T E M A X I M A						# HOURS >600	% >MDV
				1ST	DATE MM/DD/HH	2ND	DATE MM/DD/HH	3RD	DATE MM/DD/HH		
BEULAH	1997	APR-DEC	6568	99	11/19/11	79	04/19/11	79	06/02/12	0	31.1
DUNN CENTER	1997	APR-DEC	5857	48	06/10/10	21	05/10/07	21	05/26/09	0	20.0
FARGO RESIDENTIAL	1997	APR-DEC	6566	26	11/19/09	25	05/19/20	23	11/19/04	0	8.2
HANNOVER	1997	APR-DEC	6380	164	06/03/08	122	04/03/08	122	08/19/10	0	30.0
MANDAN REFINERY - SPM	1997	JAN-DEC	8434	348	11/13/00	343	11/13/01	285	03/19/14	0	58.6
SHARON	1997	APR-DEC	5897	7	11/16/15	6	11/16/00	6	11/16/02	0	15.2
TRNP - NU	1997	APR-DEC	6560	26	04/10/07	24	06/10/17	23	06/06/01	0	14.6
WHISKEY JOE - SPM	1997	APR-SEP	4317	97	05/08/20	68	05/08/22	57	06/21/20	0	32.4

The maximum 5-minute concentration is 348 ppb at MANDAN REFINERY - SPM on 11/13/00

\* No Standard is currently in effect:

## Nitrogen Dioxide

### Physical Characteristics and Sources

In its pure state, nitrogen dioxide is a reddish-orangeish-brown gas with a characteristic pungent odor. It is corrosive and a strong oxidizing agent. As a pollutant in ambient air, however, it is virtually colorless and odorless, although it may be an irritant to the eyes and throat. Oxides of nitrogen,  $NO$  and  $NO_2$  are formed when the nitrogen and oxygen in the air are combined in high-temperature combustion.  $NO$  released into ambient air combines with oxygen to form  $NO_2$ .

### Health Effects

The negative effects of  $NO_2$  on personal comfort, well being, and the environment include respiratory distress, as well as impacts on vegetation, materials, visibility and acid deposition.<sup>5</sup> Nitrate aerosols, which result from  $NO$  and  $NO_2$  combining with water vapor in the air, have been consistently linked to visibility problems.

### Standards Comparison

Nitrogen dioxide was monitored at six sites. Four were operated by the department and two by industry.

The state annual standard (53 ppb) was not exceeded during the year. The maximum annual arithmetic mean of those sites collecting at least 80 percent of the possible data for the year was 4.3 ppb at DGC #12.

The nitrogen dioxide data are summarized in Table 4.

TABLE 4

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Nitrogen Dioxide (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	M A X I M A 1 - HOUR		ARITH MEAN	% >MDV
				1ST MM/DD/HH	2ND MM/DD/HH		
BEULAH	1997	JAN-DEC	8700	39 01/02/16	39 03/07/06	3.9	72.2
DGC #12	1997	JAN-DEC	8634	45 04/11/21	45 10/13/18	4.3	99.1
DGC #17	1997	JAN-DEC	8094	207 11/29/13	108 08/22/04	3.9	86.6
FARGO RESIDENTIAL	1997	JAN-DEC	6574 ***	65 03/05/07	64 02/12/08	7.9	86.1
HANNOVER	1997	JAN-DEC	8684	33 01/20/21	27 01/02/21	2.2	46.7
SHARON	1997	JAN-DEC	8261	16 01/14/13	13 08/26/20	1.4	24.1

The maximum 1-hour concentration is 207 ppb at DGC #17 on 11/29/13

\* The air quality standards are:  
STATE - 53 ppb maximum annual arithmetic mean.

FEDERAL - 53 ppb annual arithmetic mean.

\*\*\* Less than 80% of the possible samples (data) were collected.

## Hydrogen Sulfide

### Physical Characteristics

Hydrogen sulfide has a strong, rotten egg odor. It is incompatible with strong oxidizers and reacts violently with metal oxides. It will attack many metals, forming sulfides.<sup>6</sup>

### Health Effects

A 5-minute exposure to 800 ppm has resulted in death. Inhalation of 1,000 to 2,000 ppm may cause coma after a single breath. Exposure to lower concentrations may cause headache, dizziness and upset stomach. Low concentrations (20 to 150 ppm) can cause eye irritation which may be delayed in onset. Although the odor is detectable at very low concentrations, it rapidly causes olfactory fatigue at higher levels, and, therefore, is not considered to have adequate warning.<sup>6</sup>

### Standards Comparison

Hydrogen sulfide was monitored at five sites. Two sites were run by the Department and three by industry.

The 1-hour state standard (200 ppb) was exceeded 38 times during the year at Whiskey Joe - SPM. The maximum 1-hour concentration was 400 ppb at Whiskey Joe - SPM.

The 24-hour state standard (100 ppb) was not exceeded during the year. The maximum 24-hour average concentration was 65 ppb at Whiskey Joe - SPM.

The 3-month state standard (20 ppb) was not exceeded during the year. The maximum 3-month average concentration was 15 ppb at Whiskey Joe - SPM.

The hydrogen sulfide data are summarized in Table 5.

TABLE 5

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Hydrogen Sulfide (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	1 - HOUR		24 - HOUR		3 - MONTH		ARITH MEAN	1HR #>200	24HR #>100	% >MDV
				1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD	2ND MM/DD	1ST MM	2ND MM				
AMERADA HESS - TIOGA #2	1997	JAN-DEC	8634	72 04/13/00	66 05/09/00	13 09/10	12 05/04	3 05	3 06	2.1			21.1
BEAR PAW - MGP #4	1997	JAN-DEC	7157	161 09/18/10	156 09/18/09	58 09/18	31 09/19	4 09	4 11	2.4			25.7
LITTLE KNIFE #5	1997	JAN-DEC	8407	144 05/12/04	118 07/21/20	21 07/20	20 07/21	4 07	3 12	3.1			45.8
TRNP - NU	1997	JAN-DEC	8231	29 02/18/21	25 02/18/20	4 02/18	3 02/19	1 03	1 12	1.1			5.1
WHISKEY JOE - SPM	1997	JAN-NOV	7923	400 04/03/19	355 11/09/18	65 04/11	56 10/19	15 11	13 04	10.6	38		38.1

The maximum 1-hour concentration is 400 ppb at WHISKEY JOE - SPM on 04/03/19  
the maximum 24-hour concentration is 65 ppb at WHISKEY JOE - SPM on 04/11  
The maximum 3-month concentration is 15 ppb at WHISKEY JOE - SPM on 11

\* The State air quality standards are:

- 1) 10 ppm maximum instantaneous (ceiling) concentration not to be exceeded.
- 2) 200 ppb maximum 1-hour average concentration not to be exceeded more than once per month.
- 3) 100 ppb maximum 24-hour average concentration not to be exceeded more than once per year.
- 4) 20 ppb maximum arithmetic mean concentration averaged over three consecutive months.

## Ozone

### Physical Characteristics and Sources

Ozone is a highly reactive form of oxygen. At very high concentrations, it is a blue, unstable gas with a characteristic pungent odor. It often can be detected around an arcing electric motor, lightning storms or other electrical discharges. However, at ambient concentrations, ozone is colorless and odorless. Ozone concentrations at urban and rural locations, such as Fargo and Sharon, ND, range from 40 - 50 ppb year-round.

At ground level where it can be breathed, ozone is a pollutant.<sup>7</sup> However, ground-level ozone should not be confused with the stratospheric ozone located between 12 and 30 miles above the earth's surface. The stratospheric ozone layer shields the earth from intense cancer-causing ultraviolet radiation.<sup>8</sup> Concentrations of ozone in this layer are approximately 10,000 to 12,000 ppb or one hundred times the SAAQS for ozone. Occasionally, meteorological conditions can result in stratospheric ozone being brought to ground level. This can increase concentrations by 50 to 100 ppb.

Ozone is not emitted directly from a source like other pollutants, but forms as a secondary pollutant. Its precursors are certain hydrocarbons and nitrogen oxides which react chemically in sunlight to form ozone. The sources for these reactive hydrocarbons are: automobile exhaust; gasoline and oil storage and transfer; industrial paint solvents; degreasing agents; cleaning fluids; and ink solvents. Nitrogen oxides are created when nitrogen and oxygen in the air combine during high-temperature combustion. Also, vegetation gives off some reactive hydrocarbons; for example, pine trees give off terpene.<sup>7</sup>

Ozone production is a year-round phenomenon. However, the highest ozone levels generally occur during the summer season, when sunlight is stronger and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Ozone produced under these conditions can be transported many miles.

### Health Effects

Short-term exposure to ozone in the range of 150 to 250 ppb may impair mechanical functions of the lungs and may induce respiratory difficulties and related symptoms in sensitive individuals (those with asthma, emphysema or reduced lung function). Symptoms and effects of ozone exposure are more readily induced in people who are exercising.

Ozone is the major component of photochemical “smog,” although the haziness and odors of smog are caused by other components. The deterioration and degradation of material, especially the splitting and cracking of rubber tires and windshield wiper blades, is associated with ozone. Many plants, such as soybeans and alfalfa, are sensitive to ozone and can be damaged by extended exposure to low levels of ozone.

#### Standards Comparison

Ozone was monitored at five state run sites. Two sites operated only during the second and third quarters. This extends one month longer than the defined peak ozone season (May–September) for the state. Three sites, Fargo Residential, Hannover and Sharon, have been selected to collect data during the entire year. This data will be used in computer dispersion models as part of the primary and secondary chemical transformations.

The 1-hour state and federal standard (120 ppb) was not exceeded during the year. The maximum 1-hour concentration was 82 ppb at TRNP - NU.

As part of preparing for a new 8-hour standard, 8-hour averages have been added to the data summary. The 8-hour standard uses the fourth highest daily maximum for comparison to the standard. However, since the third highest concentration is less than the 8-hour standard, the fourth highest concentration was not added to the data summary. The maximum 8-hour concentration was 80 ppb at TRNP - NU.

The ozone data are summarized in Table 6.



TABLE 6

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Ozone (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	M A X I M A - HOUR			8 - HOUR			1HR #>120	8HR #>80
				1ST MM/DD/HH	2ND MM/DD/HH	3RD MM/DD/HH	1ST MM/DD/HH	2ND MM/DD/HH	3RD MM/DD/HH		
BEULAH	1997	APR-SEP	4373	74 06/12/10	73 06/12/11	71 06/11/10	71 06/12/08	65 06/12/09	65 06/12/07		
FARGO RESIDENTIAL	1997	JAN-DEC	8716	76 06/12/11	76 06/12/12	74 06/11/13	72 06/11/10	68 06/11/09	68 06/11/11		
HANNOVER	1997	JAN-DEC	8703	75 06/12/12	74 06/12/10	74 06/12/11	71 06/12/09	69 06/12/10	69 05/30/09		
SHARON	1997	JAN-DEC	8270	73 06/11/11	73 06/11/13	72 06/11/12	72 06/11/09	65 06/11/10	65 06/11/08		
TRNP - NU	1997	APR-SEP	4368	82 06/12/12	80 06/12/10	80 06/12/11	80 06/12/11	72 06/12/10	72 06/12/09		

The maximum 1-hour concentration is 82 ppb at TRNP - NU on 06/12/12  
The maximum 8-hour concentration is 80 ppb at TRNP - NU on 06/12/11

\* The air quality standards for ozone are:  
STATE - 120 ppb not to be exceeded more than once per year.

FEDERAL Standards -

- 1) 120 ppb maximum 1-hour concentration with no more than one expected exceedance per year.
- 2) Fourth highest daily maximum 8-hour average for a 3-year period not to exceed 80 ppb.

## Particulate Matter ( $PM_{2.5}$ & $PM_{10}$ )

### Physical Characteristics and Sources

Particulate matter is the term given to the tiny particles of solid or semi-solid material found in the atmosphere. Particulate ranging in size from less than 0.1 micrometer to 50 micrometers are called Total Suspended Particulate (*TSP*). Particles larger than 50 micrometers tend to settle out of the air quickly and are not considered to have a health impact. Particulate matter 10 micrometers in diameter and smaller is considered inhalable. This particulate matter is called  $PM_{10}$ .<sup>9</sup>

The majority of anthropogenic (man-made) particulate are in the 0.1 to 10 micrometer diameter range. Particles larger than 10 micrometers usually are due to “fugitive dust” (wind-blown sand and dirt from roadways, fields and construction sites) and contain large amounts of silica (sand-like) materials.  $PM_{10}$  particulate, on the other hand, is generally created during a burning process and includes fly ash (from power plants), carbon black (from automobiles and diesel engines) and soot (from fireplaces and woodstoves).  $PM_{10}$  particulates from these sources contain a large percentage of elemental and organic carbon which play a role in both visual haze and health issues.<sup>9</sup>

In addition, particles less than 2.5 micrometers ( $PM_{2.5}$ ) are major contributors to visibility problems because of their ability to “scatter” light.

### Health Effects

The health risk from an inhaled dose of particulate matter depends on the size and concentration of the particulate. Size determines how deeply the inhaled particulate will penetrate into the respiratory tract where it can persist and cause respiratory damage. Particles less than 10 micrometers in diameter are easily inhaled deep into the lungs.

Fine particulate pollution ( $PM_{2.5}$ ) affects the health of certain sub-groups. Such groups can be identified as potentially “at risk” of adverse health effects from air borne pollutants. There is very strong evidence that asthmatics are much more sensitive (i.e., respond with symptoms at relatively low concentrations) to the effects of particulates than the general healthy population.<sup>9</sup>

The effects of particulate exposure may be the most widespread of all pollutants. Because of the potential for extremely long-range transport of fine particles and because of the chemical reactions that occur, no place on earth has been spared from the particulate generated by

urban and rural sources. The effects of particulate range from visibility degradation to climate changes to vegetation damage. General soiling, commonly thought to be just a nuisance, can have long term effects on paint and other materials.<sup>10</sup> Acid deposition can be detected in the most remote areas of the world.

#### Inhalable PM<sub>2.5</sub> Particulates

Inhalable PM<sub>2.5</sub> particulates were monitored at two sites, both operated by the Department.

#### Standards Comparison

The 24-hour federal standard ( $65 \mu\text{g}/\text{m}^3$ ) was not exceeded during the year. The maximum 24-hour average concentration was  $20.3 \mu\text{g}/\text{m}^3$  at Beulah.

The federal annual standard ( $15 \mu\text{g}/\text{m}^3$ ) was not exceeded for the year. The maximum annual average was  $10.2 \mu\text{g}/\text{m}^3$  at Bismarck Residential.

The inhalable PM<sub>2.5</sub> data are summarized in Table 7.

TABLE 7

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Inhalable PM<sub>2.5</sub> Particulates (µg/m<sup>3</sup>)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M	A	X	I	M	A	ARITH MEAN	#>150	AM>50	% >MDV
					1ST	2ND	3RD	MM/DD	MM/DD	MM/DD				
BEULAH	1997	JAN-DEC	61	3.6	20.3	17.0	14.6				8.1			91.8
					11/18	05/16	05/22							
BISMARCK RESIDENTIAL	1997	JAN-DEC	58	5.0	19.0	18.5	17.2				10.2			100.0
					11/18	05/16	05/10							

The maximum 24-hour concentration is 20.3 µg/m<sup>3</sup> at BEULAH on 11/18

\* The ambient air quality standards are:  
FEDERAL Standards -

- 1) 24-hour: 3-year average of 98th percentiles not to exceed 65 µg/m<sup>3</sup>.
- 2) Annual: 3-year average not to exceed 15µg/m<sup>3</sup>.

### Inhalable PM<sub>10</sub> Particulates

Inhalable PM<sub>10</sub> particulate concentrations were monitored at eight sites run by the Department. The Grand Forks site terminated June 30, 1996, and the Grand Forks - North site began operation July 1, 1996.

### Standards Comparison

The 24-hour state and federal standard (150 µg/m<sup>3</sup>) was not exceeded during the year. The maximum 24-hour concentration was 81.7 µg/m<sup>3</sup> at Grand Forks - North.

The annual state and federal standard (50 µg/m<sup>3</sup>) was not exceeded. The maximum annual mean for sites collecting at least 80 percent of the possible data for the year was 22.8 µg/m<sup>3</sup> at Grand Forks - North.

The inhalable particulate (PM<sub>10</sub>) data are summarized in Table 8.

TABLE 8

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : Inhalable PM<sub>10</sub> Particulates (µg/m<sup>3</sup>)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M 1ST MM/DD	A X MM/DD	I 2ND MM/DD	M 3RD MM/DD	ARITH MEAN	#>150	AM>50	% >MDV
BEULAH	1997	JAN-DEC	55	4.0	31.8 10/01	30.3 05/16	28.2 08/02		13.2			100.0
BISMARCK RESIDENTIAL	1997	JAN-DEC	58	5.0	27.0 05/16	26.0 08/08	25.7 11/18		13.2			100.0
DICKINSON RESIDENTIAL	1997	JAN-DEC	49	1.1	28.7 05/16	23.7 09/25	23.3 10/01		11.0			81.6
DRAGSWOLF	1997	APR-DEC	42	1.0	23.0 05/16	18.0 06/09	17.0 05/22		10.9			97.6
FARGO RESIDENTIAL	1997	JAN-DEC	57	0.7	67.0 08/08	63.2 06/09	50.4 06/27		18.3			96.4
GRAND FORKS - NORTH	1997	JAN-DEC	54	5.5	81.7 06/09	64.4 08/08	59.8 05/04		22.8			100.0
SHARON	1997	JAN-DEC	61	1.2	47.6 10/01	37.0 06/09	33.1 05/28		13.1			90.1
WHITE SHIELD	1997	APR-DEC	42	2.0	23.0 05/16	20.0 09/25	19.0 06/09		10.5			97.6
WILLISTON RESIDENTIAL	1997	JAN-DEC	54	2.2	35.9 09/26	34.3 05/16	31.9 06/11		13.6			92.5

The maximum 24-hour concentration is 81.7 µg/m<sup>3</sup> at GRAND FORKS - NORTH on 06/09

\* The STATE and FEDERAL air quality standards are:

- 1) 150 µg/m<sup>3</sup> maximum averaged over a 24-hour period with no more than one expected exceedance per year.
- 2) 50 µg/m<sup>3</sup> expected annual arithmetic mean.

## Sulfates ( $\text{SO}_4^{=}$ )

### Physical Characteristics and Sources

Sulfates are any of the group of compounds that contain the sulfate ( $\text{SO}_4^{=}$ ) ion. Sulfates are generally found as fine particulate or aerosols. Natural sources of sulfates include sea spray and volcanic eruptions. Sulfates also can be emitted directly from the application of fertilizers and from some industrial sources. Most sulfates are secondary particulate, those not directly emitted from a source, but created by the oxidation of  $\text{SO}_2$ . Sulfur dioxide emitted from a source can be transformed into  $\text{SO}_4^{=}$  by a number of atmospheric chemical reactions. These various reactions may involve water vapor, ozone, hydrocarbons or peroxides. Atmospheric sulfates usually exist as sulfuric acid or ammonium sulfate.<sup>11</sup>

### Health Effects

Health impacts generally are associated with acidic sulfate aerosols. Short-term exposures of  $100 \mu\text{g}/\text{m}^3$  of sulfuric acid ( $\text{H}_2\text{SO}_4$ ), (a level at the extreme high end of the ambient concentrations) have shown respiratory impairment in some healthy adults and no effect in others. Other studies have shown decreased lung function in exercising adolescent asthmatics, while other studies of asthmatics have shown no adverse effects at  $100 \mu\text{g}/\text{m}^3$   $\text{H}_2\text{SO}_4$ . Enhanced respiratory difficulties are seen with exposures to  $\text{SO}_2$  and  $\text{H}_2\text{SO}_4$ . Further sensitivity studies are necessary to determine the health impacts of  $\text{SO}_4^{=}$ .<sup>11,12,13</sup>

Fine particulate sulfate is efficient at scattering light, thus it is a factor in visibility degradation. Even at low concentrations, below  $3 \mu\text{g}/\text{m}^3$ , sulfate will affect visibility. The light-scattering potential of sulfate increases with increasing relative humidity. Seasonal changes in sulfate levels are associated with seasonal changes in visual range.

Sulfate compounds, as acid deposition, can adversely affect aquatic and terrestrial ecosystems. Water supplies are affected when minerals are leached from the soil by acid deposition. Drinking water containing either sulfates or leached metals can cause human health problems.

### Inhalable $\text{PM}_{2.5}$ Sulfate

Inhalable  $\text{PM}_{2.5}$  sulfate was monitored at two sites, both operated by the Department.

### Standards Comparison

No standard is currently in effect. The maximum 24-hour average concentration was  $7.8 \mu\text{g}/\text{m}^3$  at Beulah. The maximum annual mean for the year was  $2.2 \mu\text{g}/\text{m}^3$  at Bismarck Residential.

The inhalable  $\text{PM}_{2.5}$  sulfate data are summarized in Table 9.

Table 9

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : PM<sub>2.5</sub> Sulfate (µg/m<sup>3</sup>)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M A X I 1ST	M A X I 2ND	M A 3RD	ARITH MEAN	#>15.	AM>5.	% >MDV
					MM/DD	MM/DD	MM/DD				
BEULAH	1997	JAN-DEC	61	0.5	6.6 01/04	6.6 11/18	5.5 05/22	2.2			100.0
BISMARCK RESIDENTIAL	1997	JAN-DEC	58	0.3	7.5 11/18	6.0 01/04	5.1 02/09	2.2			98.2

The maximum 24-hour concentration is 7.5 µg/m<sup>3</sup> at BISMARCK RESIDENTIAL on 11/18

\* No standard is currently in effect.



#### Inhalable PM<sub>10</sub> Sulfate

Inhalable PM<sub>10</sub> sulfate concentrations were monitored at eight sites run by the Department.

#### Standards Comparison

No standard is currently in effect. The maximum 24-hour concentration was 7.8  $\mu\text{g}/\text{m}^3$  at Bismarck Residential.

The maximum annual mean for the year was 2.2  $\mu\text{g}/\text{m}^3$  at Beulah.

The inhalable PM<sub>10</sub> sulfate data are summarized in Table 10.

Table 10

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : PM<sub>10</sub> Sulfate (µg/m<sup>3</sup>)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M 1ST MM/DD	A X MM/DD	I 2ND MM/DD	M 3RD MM/DD	ARITH MEAN	#>15.	AM>5.	% >MDV
BEULAH	1997	JAN-DEC	57	0.5	7.2 11/18	6.2 01/04	5.5 05/22		2.2			100.0
BISMARCK RESIDENTIAL	1997	JAN-DEC	58	0.3	7.8 11/18	5.6 02/09	4.9 12/06		2.0			98.2
DICKINSON RESIDENTIAL	1997	JAN-DEC	49	0.4	4.7 06/09	3.8 05/22	3.0 03/17		1.6			97.9
FARGO RESIDENTIAL	1997	JAN-DEC	57	0.1	6.6 03/05	5.2 06/09	4.6 02/09		2.1			96.4
GRAND FORKS - NORTH	1997	JAN-DEC	54	0.1	6.3 02/03	5.1 06/09	4.9 03/23		2.0			98.1
SHARON	1997	JAN-DEC	61	0.4	5.0 02/09	4.8 06/09	3.8 02/03		1.7			98.3
WILLISTON RESIDENTIAL	1997	JAN-DEC	54	0.4	6.5 01/04	6.4 06/11	6.2 11/18		1.8			98.1

The maximum 24-hour concentration is 7.8 µg/m<sup>3</sup> at BISMARCK RESIDENTIAL on 11/18

\* No standard is currently in effect.

## Inhalable PM Sulfate/PM Total Mass Ratios

Because sulfates have an effect on visibility as well as health, the department wanted to know what percentage of the particulate matter collected is made up of sulfates. To provide some insight into this comparison, it was decided to determine the ratio of sulfates to total mass collected for both the PM<sub>2.5</sub> and PM<sub>10</sub> data.

The PM sulfate/PM total mass tables present statistics for PM sulfate and PM total mass when both concentrations are greater than the respective minimum detectable concentration: 0.5 µg/m<sup>3</sup> for sulfate analysis; 4 µg/m<sup>3</sup> for PM total mass. Statistics for the ratio are produced by evaluating the ratio of the PM sulfate concentration to the PM total mass concentration for each data pair. In the individual summaries, one-half of the minimum detectable concentration is substituted for those concentrations less than the minimum detectable value. However, when the PM total mass concentration is less than 4 µg/m<sup>3</sup>, the PM sulfate concentration can be higher than the PM total mass concentration. This is because of the variability in the sulfate analysis procedure at low concentrations. Therefore, when calculating the ratio of PM sulfate concentration to PM total mass concentration, only data pairs where both the PM sulfate and PM total mass concentrations are greater than the minimum detectable concentrations are used. When the ratio is multiplied by 100, it becomes the percentage of total mass which is sulfate.

### PM<sub>2.5</sub> Sulfate /PM<sub>2.5</sub> Analysis

The maximum ratio was 65.6 percent at Beulah. The highest annual average was 27.5 percent, at Beulah. The PM<sub>2.5</sub> sulfate /PM<sub>2.5</sub> total mass ratio data are summarized in Table 11.

### PM<sub>10</sub> Sulfate /PM<sub>10</sub> Analysis

The maximum ratio was 81.0 percent at Beulah. The highest annual average for sites with at least 80 percent of the possible samples was 20.4 percent at Beulah. For the remaining sites, the maximum annual average was 15.5 percent at Dickinson Residential. The PM<sub>10</sub> sulfate /PM<sub>10</sub> total mass ratio data are summarized in Table 12.

Table 11

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : PM<sub>2.5</sub> Sulfate/PM<sub>2.5</sub> Total Mass Ratio (Percentage)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M A X I 1ST MM/DD	M A X I 2ND MM/DD	M A 3RD MM/DD	ARITH MEAN
BEULAH	1997	JAN-DEC	56	7.1	65.6 12/06	62.9 01/04	53.1 11/30	27.5
BISMARCK RESIDENTIAL	1997	JAN-DEC	57	5.0	65.2 01/04	61.1 01/10	57.3 12/06	23.4

The maximum 24-hour ratio is 65.6 percent at BEULAH on 12/06

\* No standard is currently in effect.

Table 12

COMPARISON OF AIR QUALITY DATA WITH  
THE NORTH DAKOTA AMBIENT AIR QUALITY STANDARDS \*

POLLUTANT : PM<sub>10</sub> Sulfate/PM<sub>10</sub> Total Mass Ratio (Percentage)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	M A X I 1ST MM/DD	M A X I 2ND MM/DD	M A 3RD MM/DD	ARITH MEAN
BEULAH	1997	JAN-DEC	55	4.0	81.0 12/06	49.6 01/04	45.0 01/16	20.4
BISMARCK RESIDENTIAL	1997	JAN-DEC	57	3.7	59.8 12/06	47.4 01/16	41.7 01/04	17.9
DICKINSON RESIDENTIAL	1997	JAN-NOV ***	39	3.4	41.1 01/28	36.4 04/04	36.2 03/11	15.5
FARGO RESIDENTIAL	1997	JAN-DEC	54	2.3	57.1 12/06	38.0 01/10	36.4 01/04	17.1
GRAND FORKS - NORTH	1997	JAN-DEC	53	2.5	52.2 12/18	30.3 10/25	28.9 02/09	12.7
SHARON	1997	JAN-DEC	53	2.8	63.0 03/11	50.7 02/03	46.6 11/30	18.2
WILLISTON RESIDENTIAL	1997	JAN-DEC	49	2.8	49.6 01/04	46.2 11/08	39.1 03/11	15.5

The maximum 24-hour ratio is 81.0 percent at BEULAH on 12/06

\* No standard is currently in effect.

\*\*\* Less than 80% of the possible samples (data) were collected.

## SUMMARY AND CONCLUSIONS

The State of North Dakota has relatively clean air. North Dakota is one of only 7 states to comply with all federal ambient air quality standards. With the exception of hydrogen sulfide, the air quality in North Dakota also meets all state ambient air quality standards. Site and pollutant combinations that do not meet the 80% data recovery for the full year are reported as a partial year. A summary for each pollutant is provided below.

### Sulfur Dioxide

The federal standards were not exceeded at any monitoring site. The state 24-hour standard was exceeded one time. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standard are as follows: 1-hour (exempt) – 612 ppb (224%), 1-hour (applicable) – 192 ppb (70.3%); 3-hour – 288 ppb (57.6%); 24-hour – 104 ppb (110.1%); annual (partial year) – 1.7 ppb (7.4%); annual (full year) – 7.5 ppb (32.6%).

### Sulfur Dioxide 5-Minute Averages

No standard is currently in effect. The maximum 5-minute average was 348 ppb.

### Nitrogen Dioxide

Neither state nor federal standard was exceeded at any of the monitoring sites. The maximum concentration and the maximum concentration expressed as a percentage of the applicable standard is as follows: annual – 7.9 ppb (14.9%).

### Hydrogen Sulfide

There were 38 exceedances of the 1-hour standard at Whiskey Joe - SPM. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standard are as follows: 1-hour – 400 ppb (200%); 24-hour – 65 ppb (65%); 3-month – 15 ppb (75%).

### Ozone

Neither state nor federal standard was exceeded during the year. The maximum 1-hour concentration and the maximum 1-hour concentration expressed as a percentage of the applicable standard is 82 ppb (68.3%). The maximum 8-hour average concentration was 80 ppb.

#### Inhalable PM<sub>2.5</sub> Particulates

The federal standards were not exceeded during the year. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standard are as follows: 24-hour – 20.3  $\mu\text{g}/\text{m}^3$  (31.2%); annual – 10.2  $\mu\text{g}/\text{m}^3$  (68%).

#### Inhalable PM<sub>10</sub> Particulates

Neither state nor federal standards were exceeded during the year. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standard are as follows: 24-hour – 81.7  $\mu\text{g}/\text{m}^3$  (54.5%); annual (partial year) – 10.9  $\mu\text{g}/\text{m}^3$  (21.824.2%); annual (full year) – 22.8  $\mu\text{g}/\text{m}^3$  (45.6%).

#### Inhalable PM<sub>2.5</sub> Sulfates

No standard is currently in effect. The maximum 24-hour average was 7.5  $\mu\text{g}/\text{m}^3$ .

#### Inhalable PM<sub>10</sub> Sulfates

No standard is currently in effect. The maximum 24-hour average was 7.8  $\mu\text{g}/\text{m}^3$ .

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## REFERENCES

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- 5 Environmental Protection Agency Strategies and Air Standards Division, Preliminary Assessment of Health and Welfare Effects Associated with Nitrogen Oxides for Standards-Setting Purposes, U.S. Government Printing Office, Washington; October 1981, pp I-iii.
- 6 LCSS: Hydrogen Sulfide, HHMI Laboratory Safety, <http://www.hhmi.org/science/labsafe/lcss/lcss53.htm>.
- 7 National Primary and Secondary Ambient Air Quality Standard for Ozone, Title 40 Code of Federal Regulations, Part 50.9 (as amended), United States Government Printing Office, Washington, DC.
- 8 Miller, R. and M. J. Utell, Elements of Meteorology, C. E. Merrill Co., Columbus, Ohio, 1975.
- 9 The Perils of Particulates. American Lung Association, New York, March 1994.
- 10 Sulfur Dioxide, Minimum Lethal Exposure & Maximum Tolerated Exposure, in TOMES Medical Management file [database online]. Colorado Department of Public Health and Environment, 1995 [cited 12 September 1995]. Available from Micromedex Inc. Englewood, Co.

- 11 Morrow P. E. and M. J. Utell, Technology and Methodology of Clinical Exposures to Aerosols, Aerosols, S. D. Lee, Editor, Lewis Publishers, Inc., 1986, pp 671-681.
- 12 Hackney, J. D., W. S. Linn and E. L. Avol, controlled Exposures of Human Volunteers to Particulate Pollution: Recent Findings and Current Research Questions, Aerosols, S. D. Lee, Editor, Lewis Publishers, Inc., 1986, pp 699-709.
- 13 Liroy, P. J. and M. Lipmann, Measurements of Exposure to Acid Sulfur Aerosols, Aerosols, S. D. Lee, Editor, Lewis Publishers, Inc., 1986, pp 743-751.

## APPENDICES



## APPENDIX 1

### North Dakota and Federal Ambient Air Quality Standards

## STANDARDS

In general, air pollutants are divided into two classes: primary pollutants such as  $\text{SO}_2$ ,  $\text{CO}$ ,  $\text{NO}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  and secondary pollutants which are formed as the result of a chemical reaction. Sources of primary pollutants include power plants, natural gas processing plants, oil wells, oil refineries, asphalt plants, factories, wind-blown dirt, automobiles, fireplaces and incinerators. Secondary pollutants result from a primary pollutant undergoing a chemical reaction; for example, ozone ( $\text{O}_3$ ) is formed as a result of a photochemical reaction between hydrocarbons (HC) and oxides of nitrogen ( $\text{NO}_x$ ).

The North Dakota Ambient Air Quality Standards are established to protect public health and welfare. Effective August 1, 1997, coal conversion and oil refineries were exempted from the state sulfur dioxide standards.

Table A1-1 presents the current North Dakota Ambient Air Quality Standards. Table A1-2 presents the federal Ambient Air Quality Standards. State standards must be as stringent as (but may be more stringent than) federal standards.

TABLE A1-1  
North Dakota  
Ambient Air Quality Standards

Air Contaminants	Standards (Maximum Permissible Concentrations)	
Inhalable Particulate (PM <sub>10</sub> )	50	micrograms per cubic meter of air, expected annual arithmetic mean micrograms per cubic meter of air maximum
	150	24-hour average concentration with no more than one expected exceedance per year
Sulfur Dioxide*	0.023	parts per million (60 micrograms per cubic meter of air), maximum annual arithmetic mean concentration
	0.099	parts per million (260 micrograms per cubic meter of air), maximum 24-hour average concentration
	0.273	parts per million (715 micrograms per cubic meter of air), maximum 1-hour average concentration
Hydrogen Sulfide	10.0	parts per million (14 milligrams per cubic meter of air), maximum instantaneous (ceiling) concentration not to be exceeded
	0.20	parts per million (280 micrograms per cubic meter of air), maximum 1-hour average concentration not to be exceeded more than once per month
	0.10	parts per million (140 micrograms per cubic meter of air), maximum 24-hour average concentration not to be exceeded more than once per year
	0.02	parts per million (28 micrograms per cubic meter of air), maximum arithmetic mean concentration averaged over three consecutive months
Carbon Monoxide	9	parts per million (10 milligrams per cubic meter of air), maximum 8-hour concentration not to be exceeded more than once per year
	35	parts per million (40 milligrams per cubic meter of air), maximum 1-hour concentration not to be exceeded more than once per year
Ozone	0.12	parts per million (235 micrograms per cubic meter of air), maximum 1-hour concentration not to be exceeded more than once per year
Nitrogen Dioxide	0.053	parts per million (100 micrograms per cubic meter of air), maximum annual arithmetic mean
Lead	1.5	micrograms per cubic meter of air, maximum arithmetic mean averaged over a calendar quarter

\* After August 1, 1997, coal conversion facilities and oil refineries are subject only to the federal SO<sub>2</sub> standards.

TABLE A1-2  
Federal Ambient Air Quality Standards

<u>Pollutant</u>	<u>Description</u>	<u>Primary</u>	<u>Secondary</u>
PM <sub>2.5</sub>	3-year average of annual arithmetic mean concentrations.	15 µg/m <sup>3</sup>	15 µg/m <sup>3</sup>
	3-year average of the 98 <sup>th</sup> percentile of the 24-hour concentrations.	65 µg/m <sup>3</sup>	65 µg/m <sup>3</sup>
PM <sub>10</sub>	Expected annual arithmetic mean.	50 µg/m <sup>3</sup>	50 µg/m <sup>3</sup>
	99 <sup>th</sup> percentile of the 24-hour concentrations averaged over 3 years.	150 µg/m <sup>3</sup>	150 µg/m <sup>3</sup>
SO <sub>2</sub>	Annual arithmetic mean.	0.03 ppm (80 µg/m <sup>3</sup> )	-
	Maximum 24-hour concentration not to be exceeded more than once per year.	0.14 ppm (365 µg/m <sup>3</sup> )	-
	Maximum 3-hour concentration not to be exceeded more than once per year.	-	0.5 ppm (1300 µg/m <sup>3</sup> )
CO	8-hour concentration not to be exceeded more than once per year.	9 ppm (10 µg/m <sup>3</sup> )	-
	1-hour average concentration not to be exceeded more than once per year.	35 ppm (40 µg/m <sup>3</sup> )	-
O <sub>3</sub>	3-year average of the annual 4 <sup>th</sup> highest daily maximum 8-hour concentrations, not to be exceeded.	0.08 ppm	0.08 ppm
NO <sub>2</sub>	Annual arithmetic mean.	0.053 ppm (100 µg/m <sup>3</sup> )	0.053 ppm (100 µg/m <sup>3</sup> )
Pb	Maximum arithmetic mean averaged over a calendar quarter.	1.5 µg/m <sup>3</sup>	1.5 µg/m <sup>3</sup>

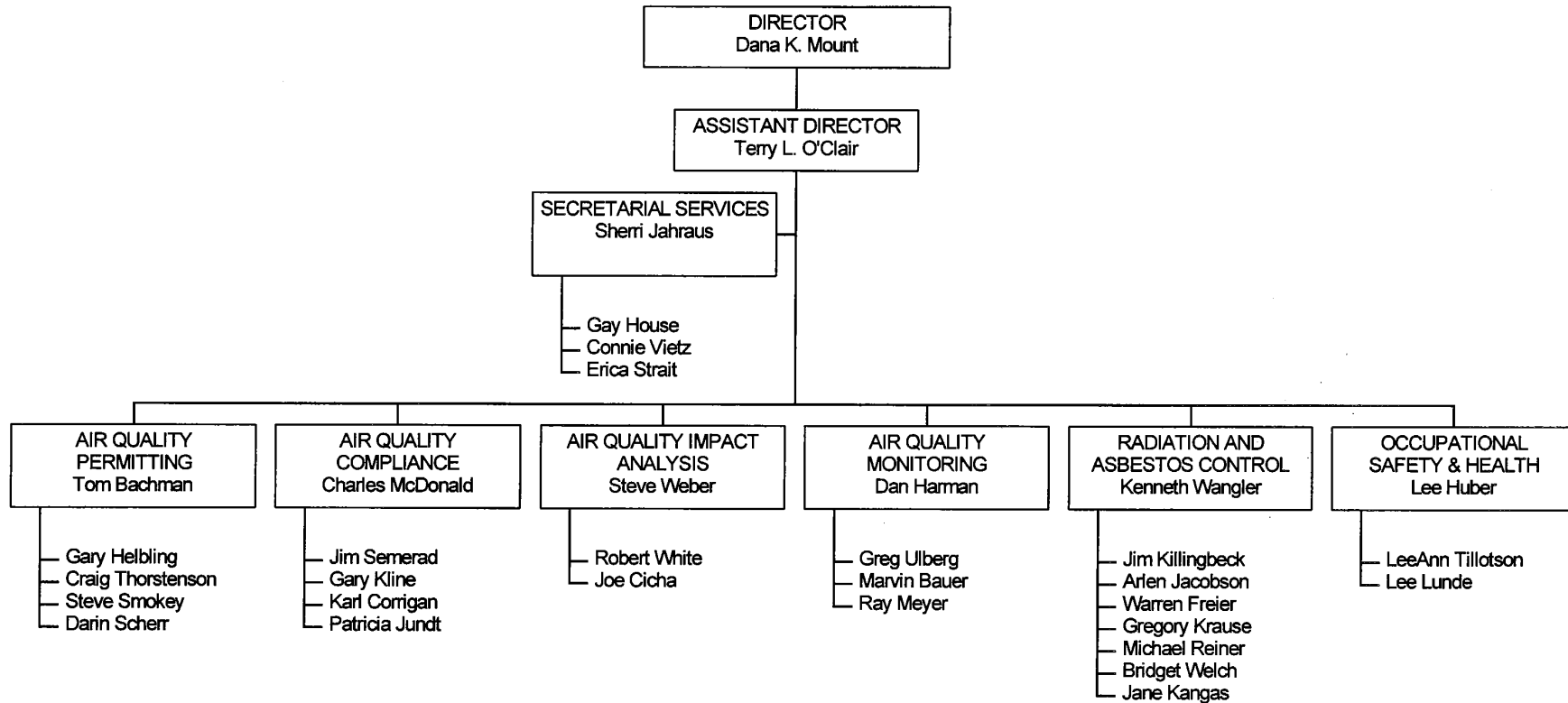


## APPENDIX 2

### Air Quality Personnel Organizational Chart

The following Division of Environmental Engineering organizational chart includes the Air Pollution Control Program.

NORTH DAKOTA DEPARTMENT OF HEALTH  
DIVISION OF ENVIRONMENTAL ENGINEERING



A2-1 Environmental Engineering Organizational Chart



## **APPENDIX 3**

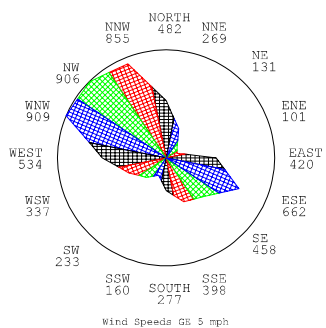
### **Wind and Pollution Star Charts**

The figures in this appendix are arranged with the site's wind star chart in the upper left-hand position. To remove most of the wind direction bias caused by low wind speeds, wind speeds of less than 5 mph were removed from the data. For Department-operated sites the pollution star charts are arranged with sulfur dioxide in the upper right-hand position. Next is either hydrogen sulfide or nitrogen dioxide. For industry networks, the wind star chart is presented first followed by the parameters monitored at each site. Except for the Bear Paw - McKenzie Gas Plant network which has wind direction at each site, there is only one MET station for each network.

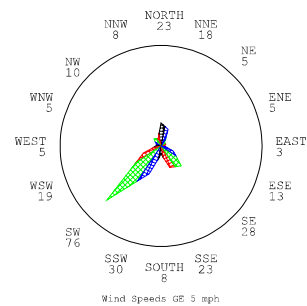
The pollution star charts present the percentage of time a pollutant is detected when the wind is from a given direction. For example, a wind star chart shows a frequency of 122, and a pollution star chart shows a 66 for the same direction. This means that 66 percent of the time (80 of the possible 122 hours) the wind was greater than 5 mph from that direction and an hourly average for that pollutant had a detectable concentration.

Ozone pollution star charts are not presented because the percentage of time would be essentially 100 percent for each wind sector.

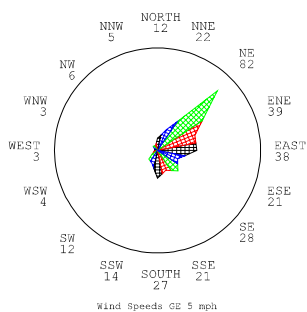
Amerada Hess - Tioga #2 Wind Direction Star Chart during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Amerada Hess - Tioga #1 during 1997



Percent of Time H<sub>2</sub>S Detected for a Given Wind Sector for Amerada Hess - Tioga #2 during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Amerada Hess - Tioga #3 during 1997

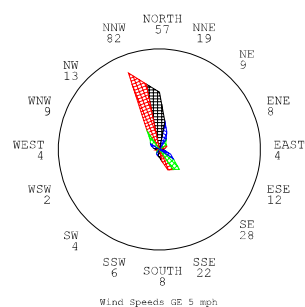
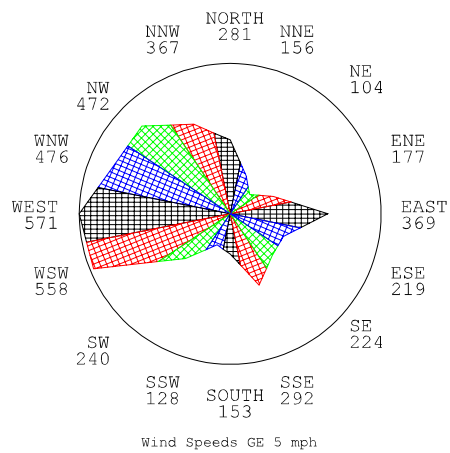
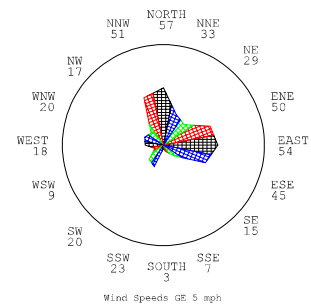


Figure A3-1 Amerada Hess Star Charts

# Beulah Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Beulah during 1997



## Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector for Beulah during 1997

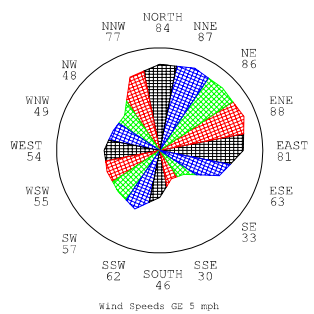
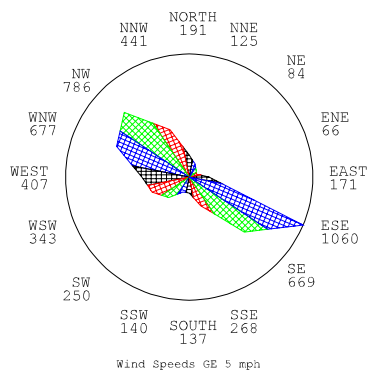


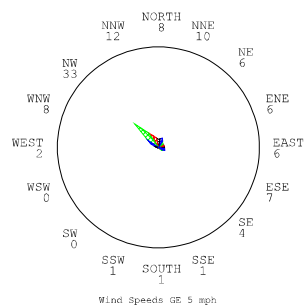
Figure A3-2 Beulah Star Charts



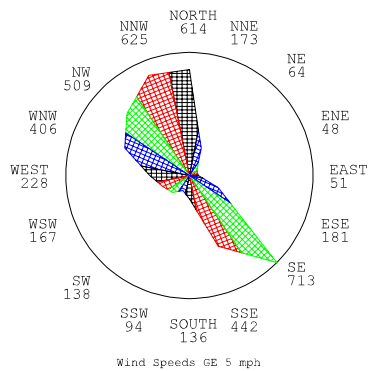
Bear Paw - MGP #3 Wind Direction Star Chart  
during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector  
for Bear Paw - MGP #3 during 1997



Bear Paw - MGP #4 Wind Direction Star Chart  
during 1997



Percent of Time H<sub>2</sub>S Detected for a Given Wind Sector  
for Bear Paw - MGP #4 during 1997

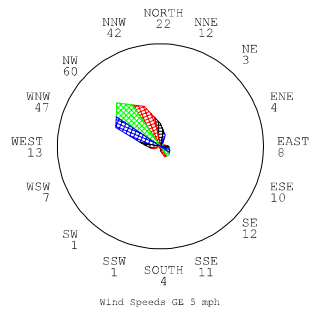
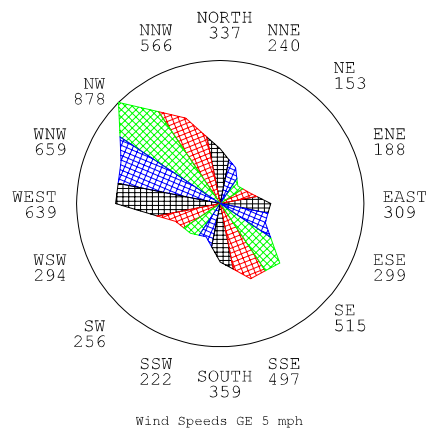


Figure A3-3 Bear Paw Star Charts

# Dunn Center Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Dunn Center during 1997

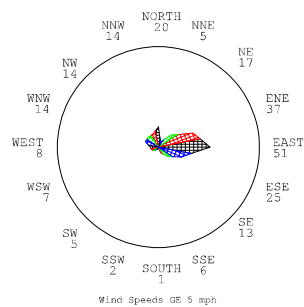
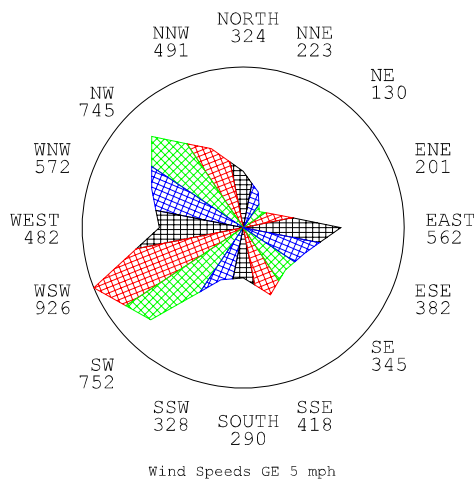
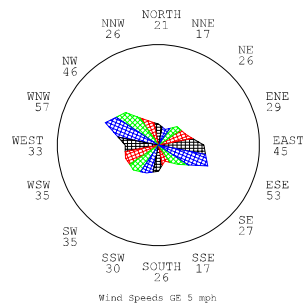


Figure A3-4 Dunn Center Star Charts

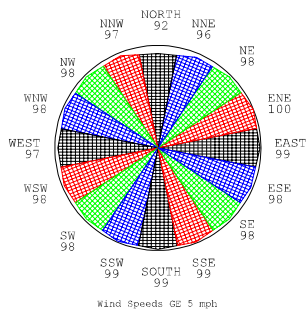
# DGC #12 Wind Direction Star Chart during 1997



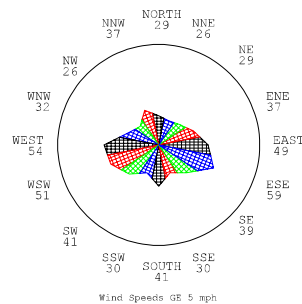
## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for DGC #12 during 1997



## Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector for DGC #12 during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for DGC #14 during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for DGC #16 during 1997

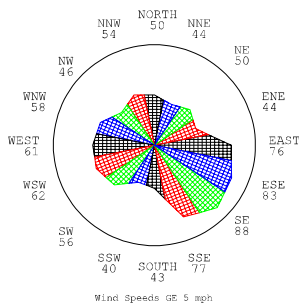
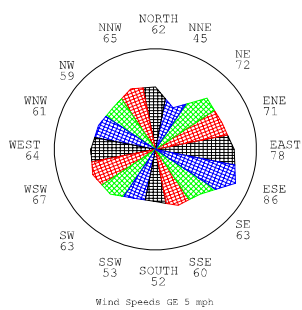


Figure A3-5 DGC Star Charts

Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector  
for DGC #17 during 1997



Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector  
for DGC #17 during 1997

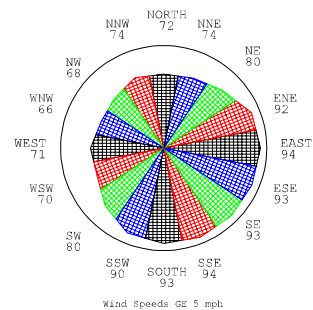
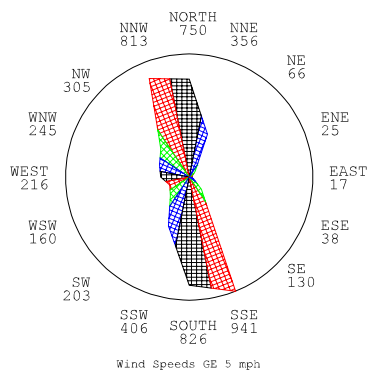
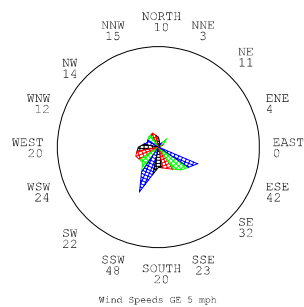


Figure A3-5 DGC Star Charts (cont.)

Fargo Residential Wind Direction Star Chart  
during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector  
for Fargo Residential during 1997



Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector  
for Fargo Residential during 1997

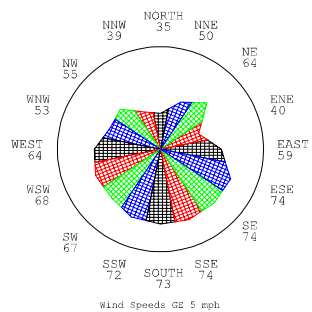
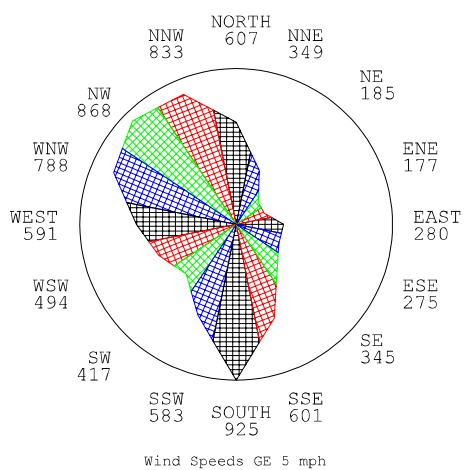
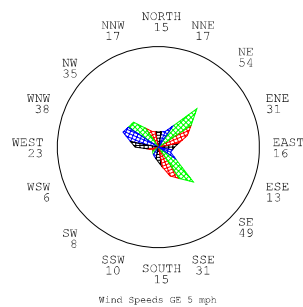


Figure A3-6 Fargo Star Charts

# Hannover Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Hannover during 1997



## Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector for Hannover during 1997

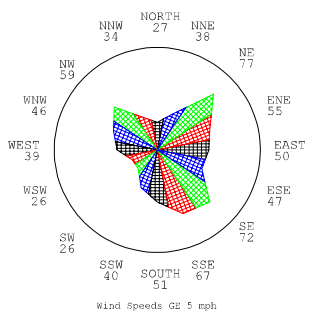
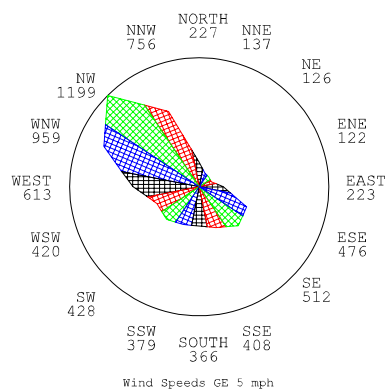
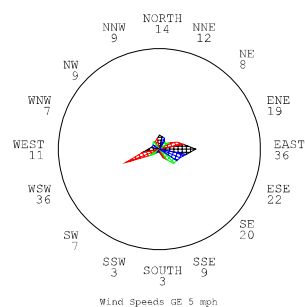


Figure A3-7 Hannover Star Charts

Little Knife #5 Wind Direction Star Chart  
during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector  
for Little Knife #5 during 1997



Percent of Time H<sub>2</sub>S Detected for a Given Wind Sector  
for Little Knife #5 during 1997

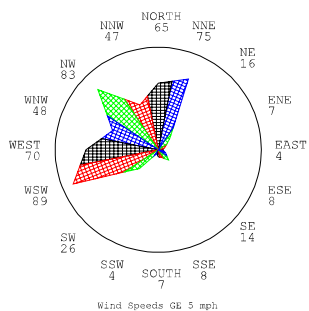
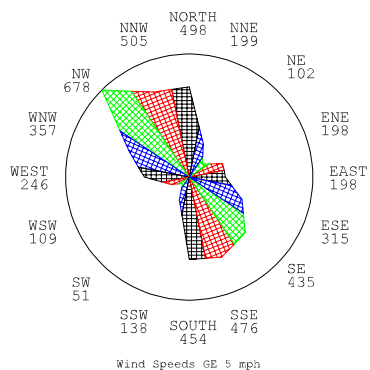


Figure A3-8 Little Knife Star Charts

Mandan - Refinery Wind Direction Star Chart  
during 1997



Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector  
for Mandan - Refinery during 1997

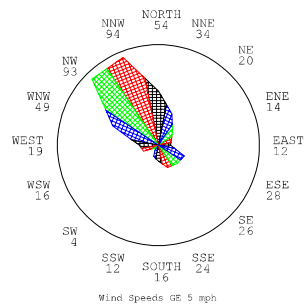
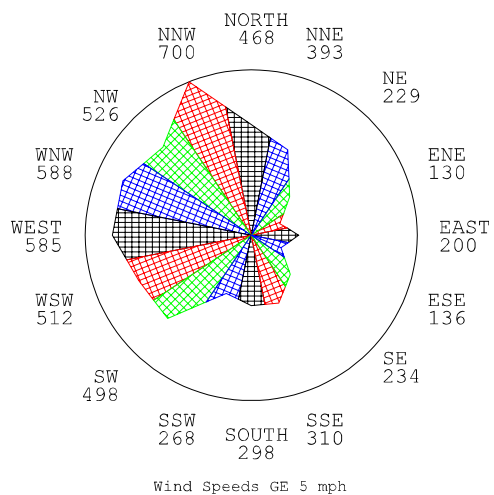


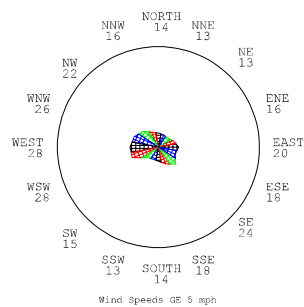
Figure A3-9 Mandan-SPM Star Charts



# Sharon Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Sharon during 1997



## Percent of Time NO<sub>2</sub> Detected for a Given Wind Sector for Sharon during 1997

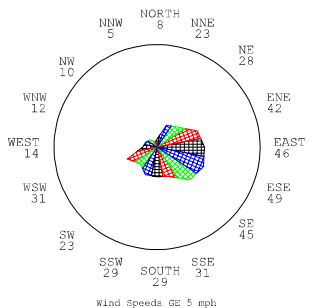
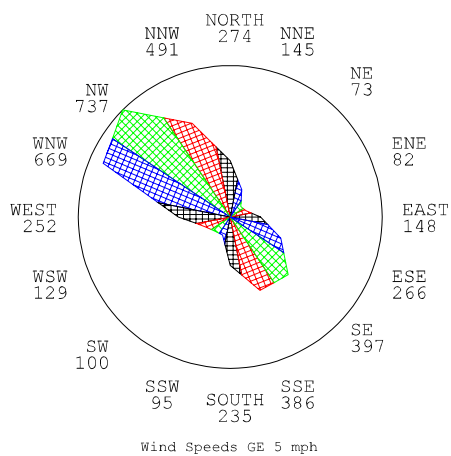
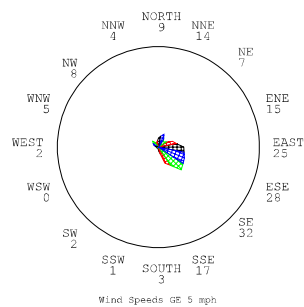


Figure A3-10 Sharon Star Charts

# TRNP - NU Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for TRNP - NU during 1997



## Percent of Time H<sub>2</sub>S Detected for a Given Wind Sector for TRNP - NU during 1997

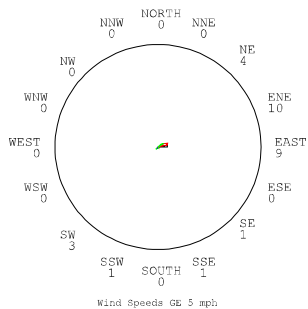
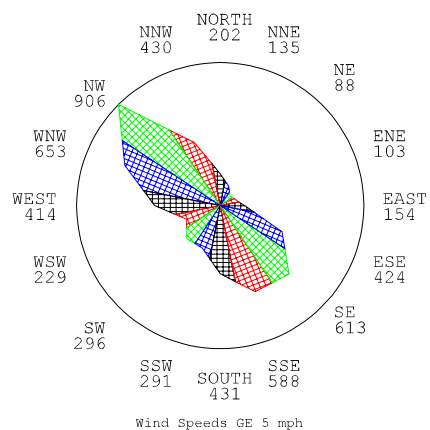
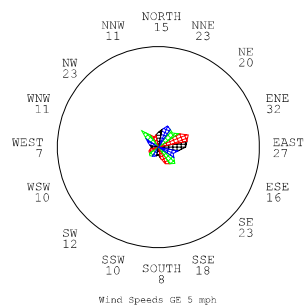


Figure A3-11 TRNP/NU Star Charts

# Whiskey Joe Wind Direction Star Chart during 1997



## Percent of Time SO<sub>2</sub> Detected for a Given Wind Sector for Whiskey Joe during 1997



## Percent of Time H<sub>2</sub>S Detected for a Given Wind Sector for Whiskey Joe during 1997

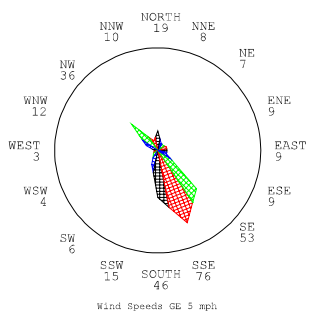


Figure A3-12 Whiskey Joe Star Charts



**APPENDIX 4**  
**1988-1997 Trends**

The trend graphs for 1988 through 1997 are presented in alphabetical order, grouped by site, unless multiple sites would fit on a single page. Each graph depicts the maximum concentration for each applicable standard (left scale) and percentage of time an hourly concentration is detected (right scale).

Graphs are not presented for  $PM_{2.5}$  for two reasons. First, it is collected with a non-reference method; and second, there is only one full year of data. Sulfates are not presented because there is only one year of data available.

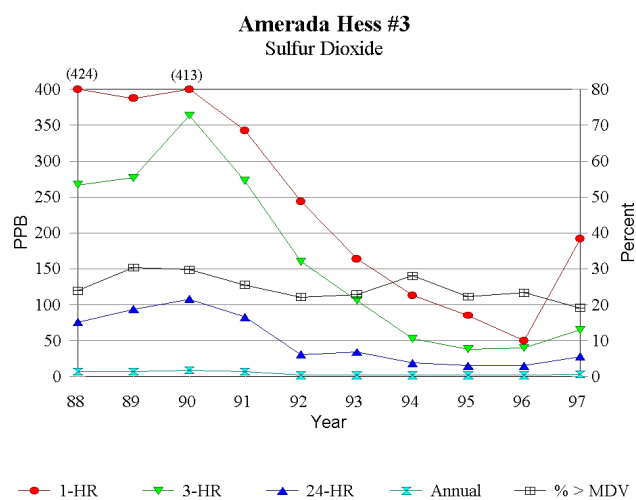
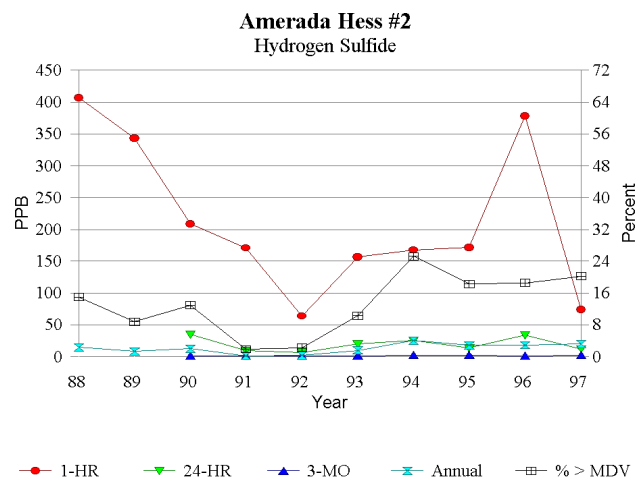
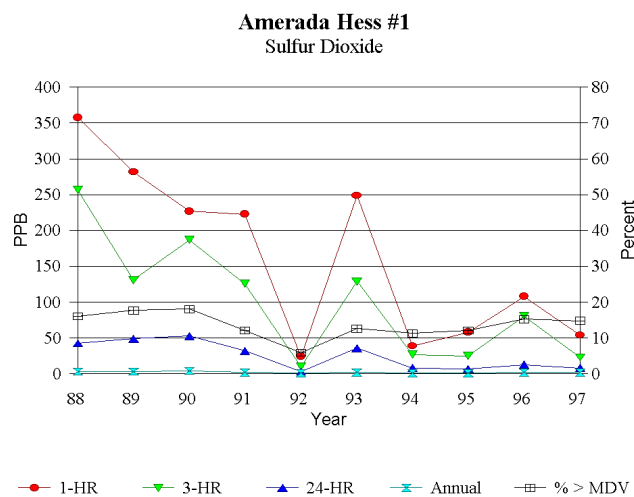


Figure A4-1 Amerada Hess Trends

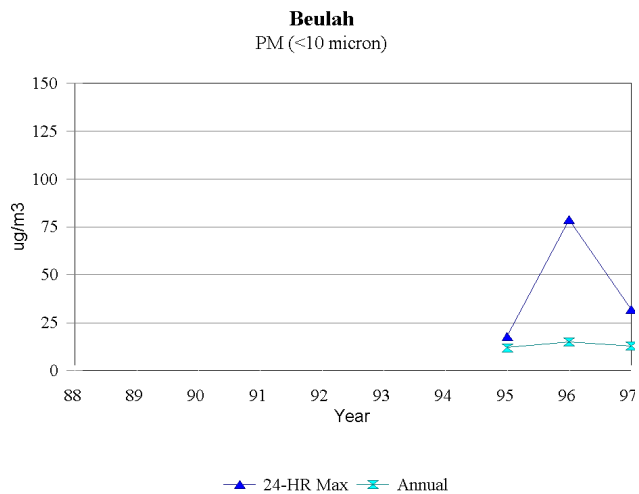
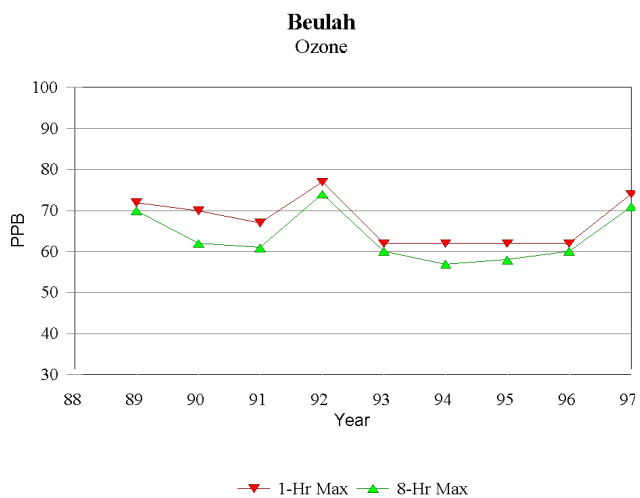
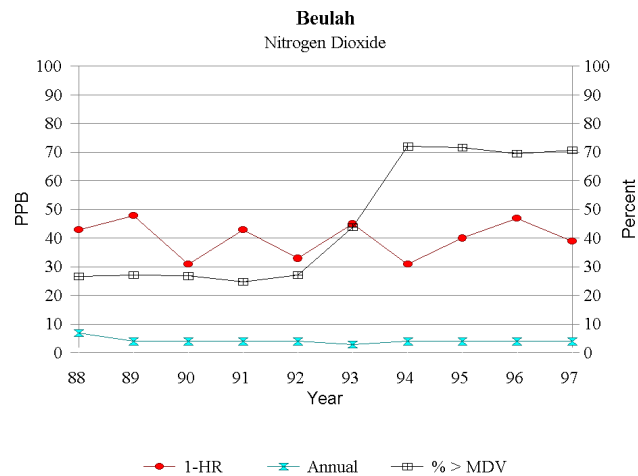
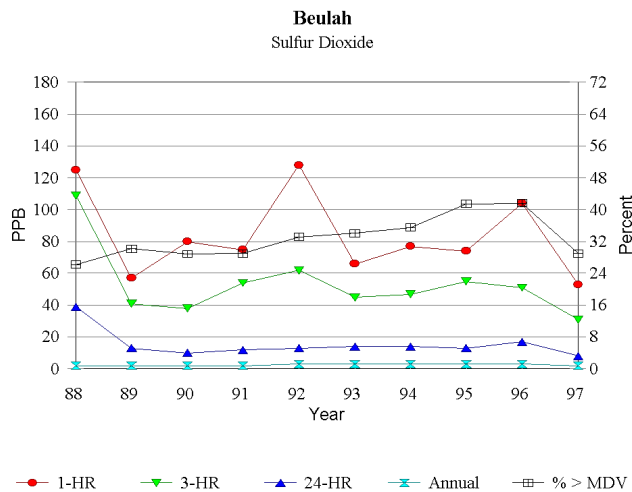
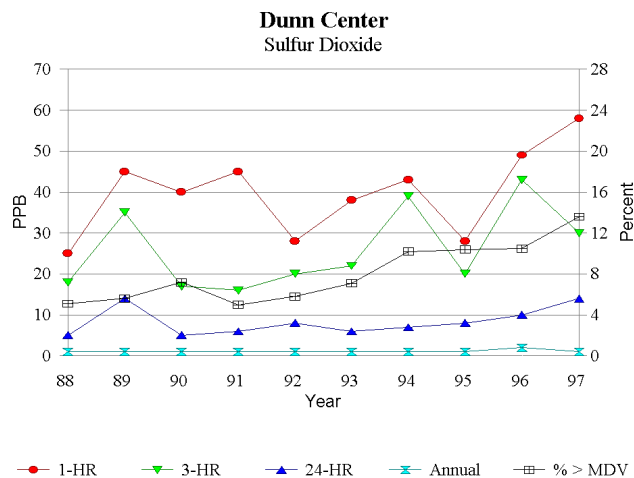
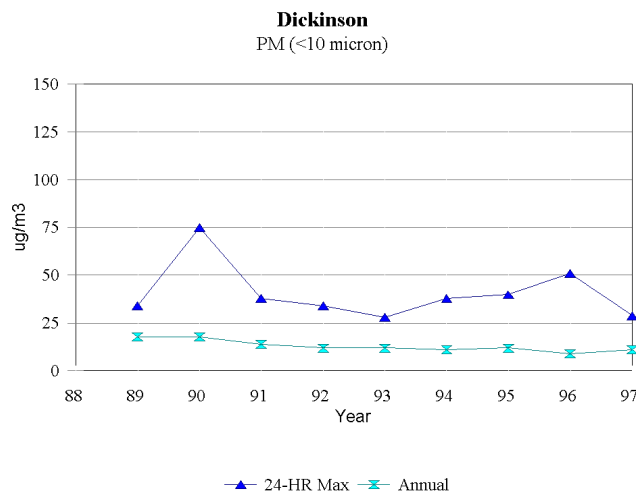
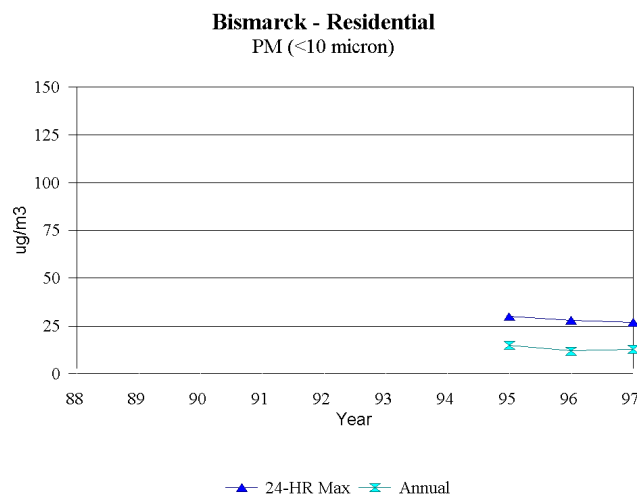
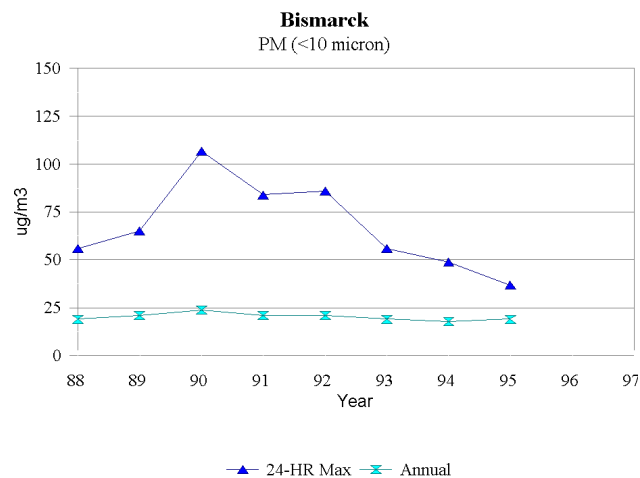
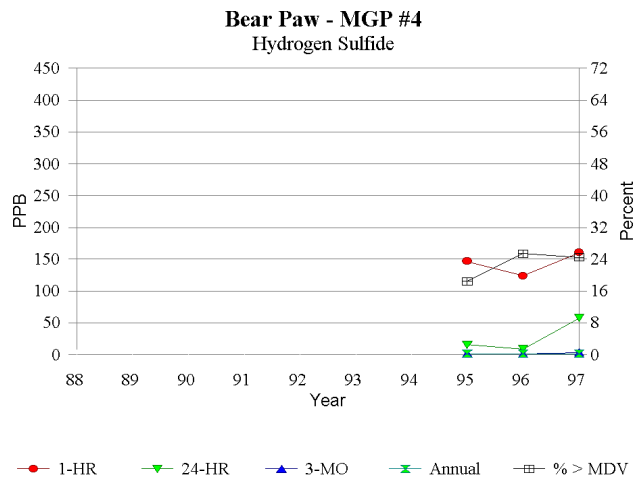
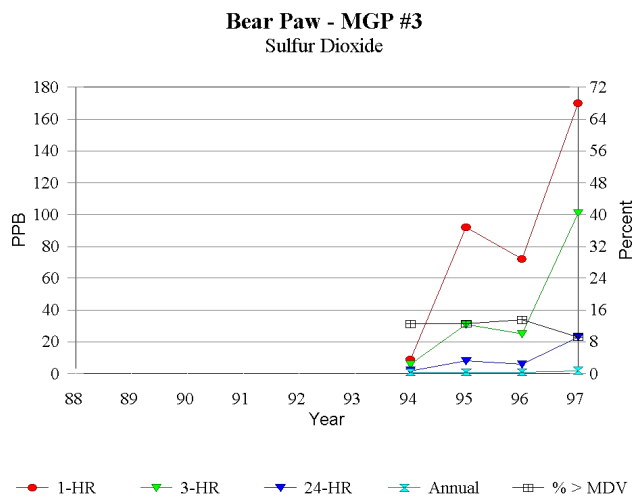


Figure A4-2 Beulah Trends





FigureA4-3 Bear Paw/Bismarck/Dickinson/Dunn Center Trends

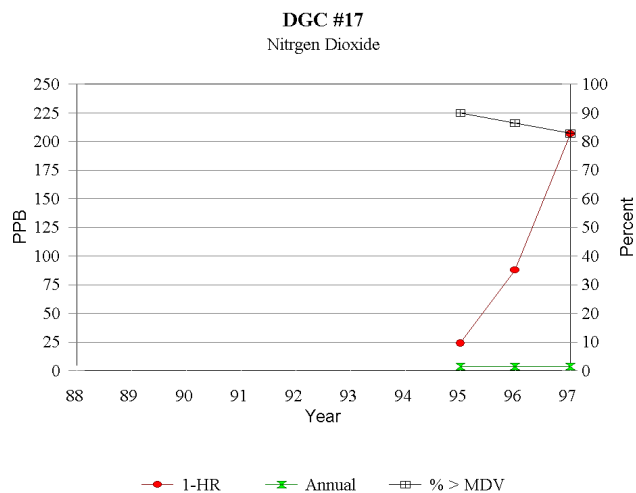
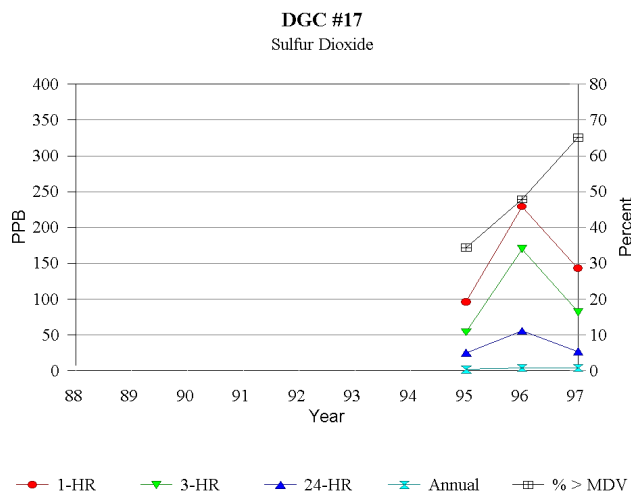
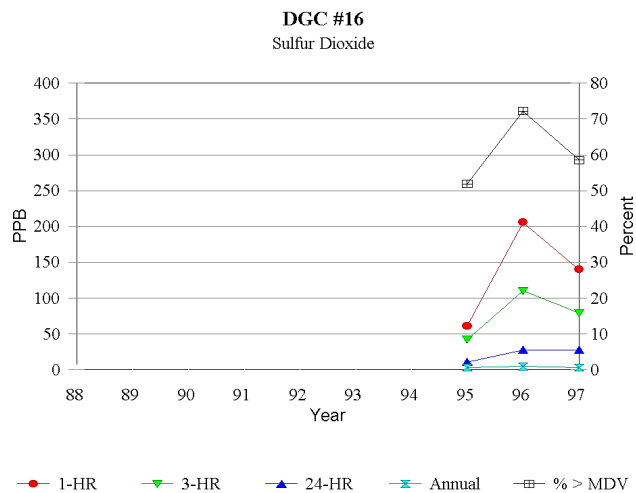
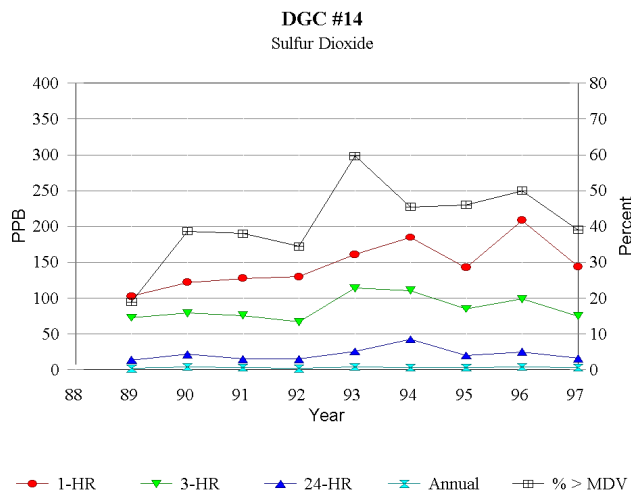
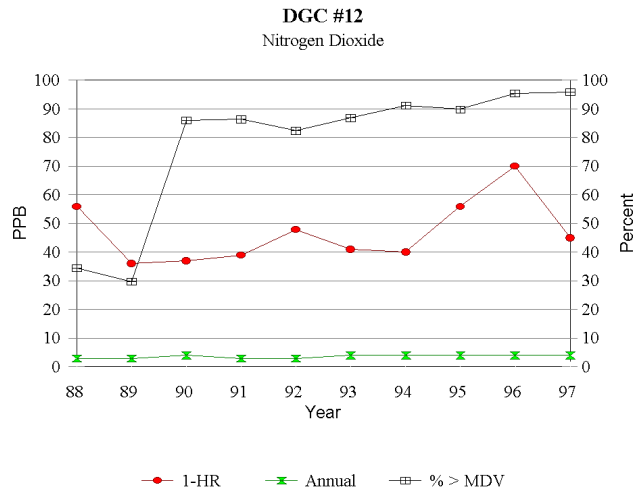
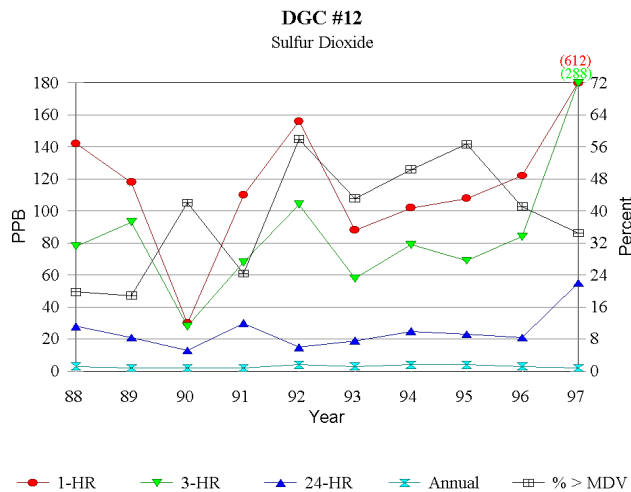
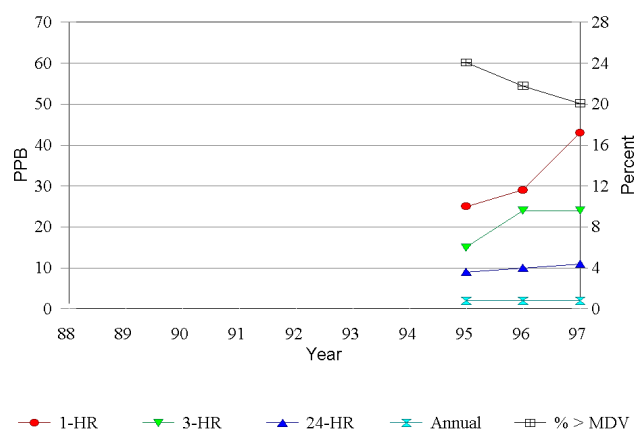
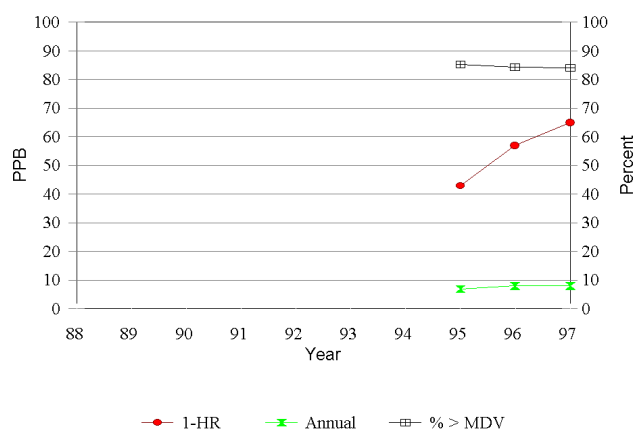


Figure A4-4 DGC Trends

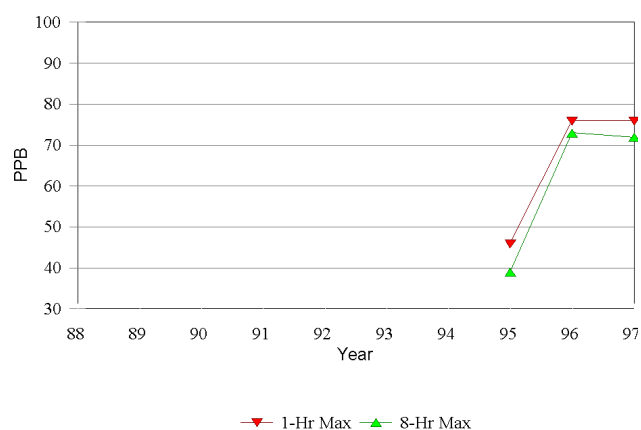
**Fargo - Residential**  
Sulfur Dioxide



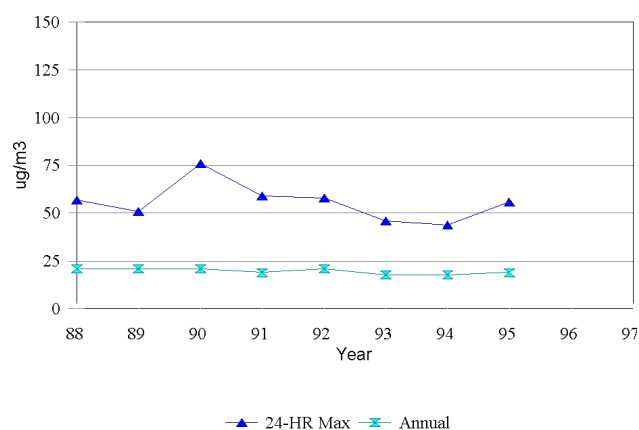
**Fargo - Residential**  
Nitrogen Dioxide



**Fargo - Residential**  
Ozone



**Fargo**  
PM (<10 micron)



**Fargo - Residential**  
PM (<10 micron)

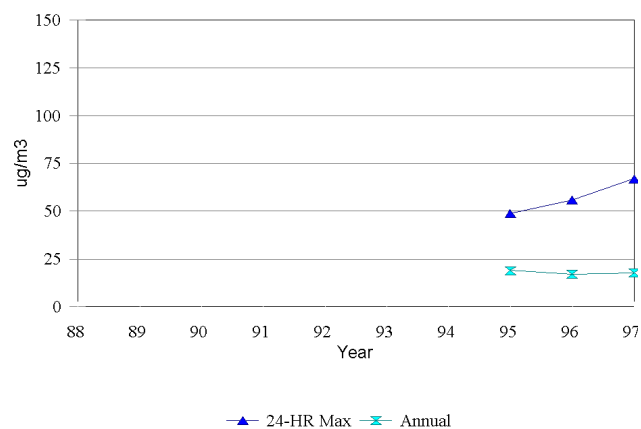
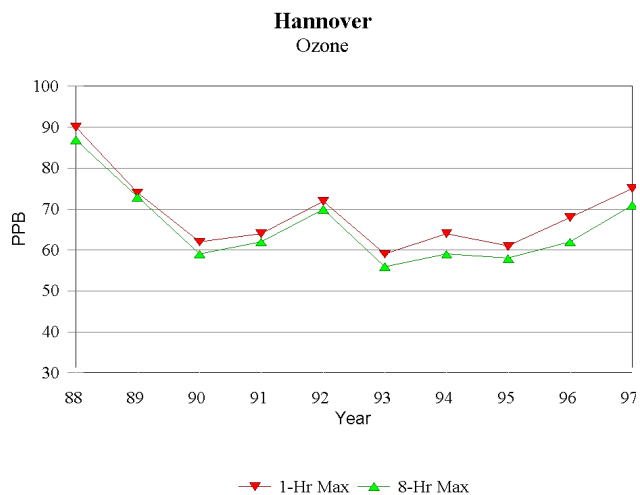
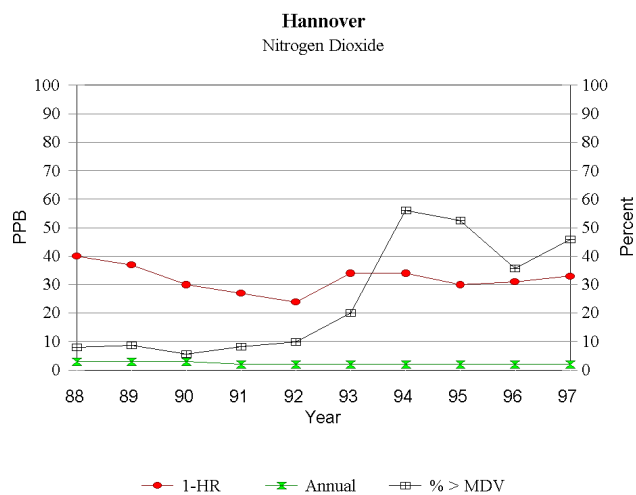
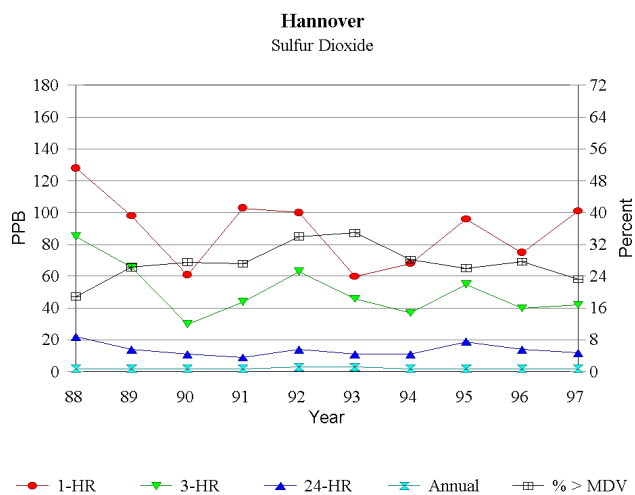
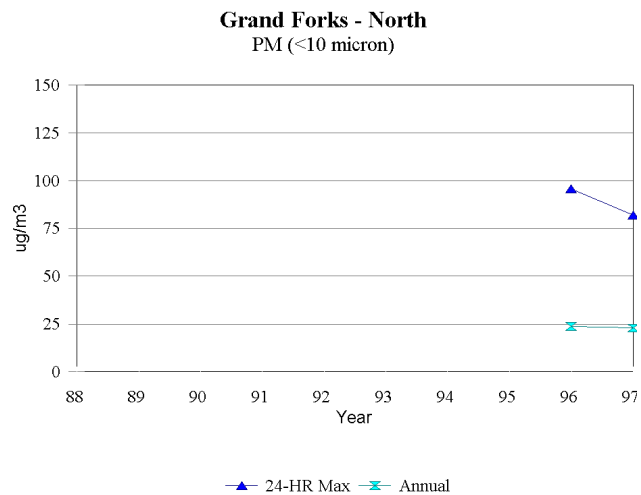
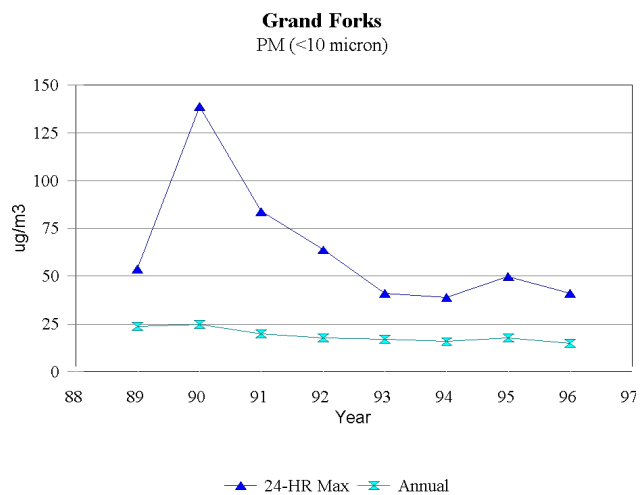


Figure A4-5 Fargo Trends



#### A4-6 Grand Forks/Hannover Trends

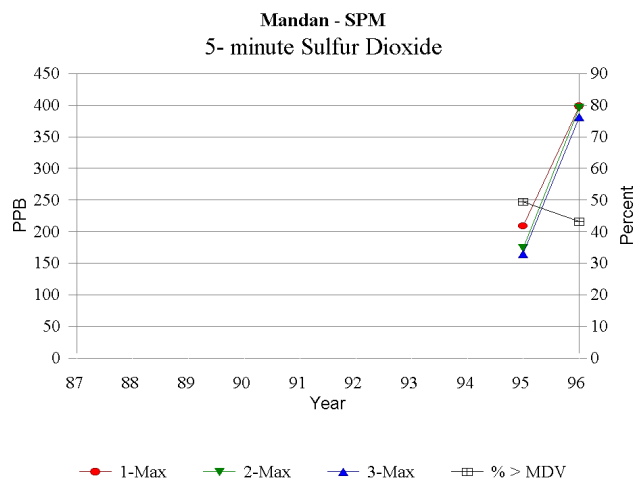
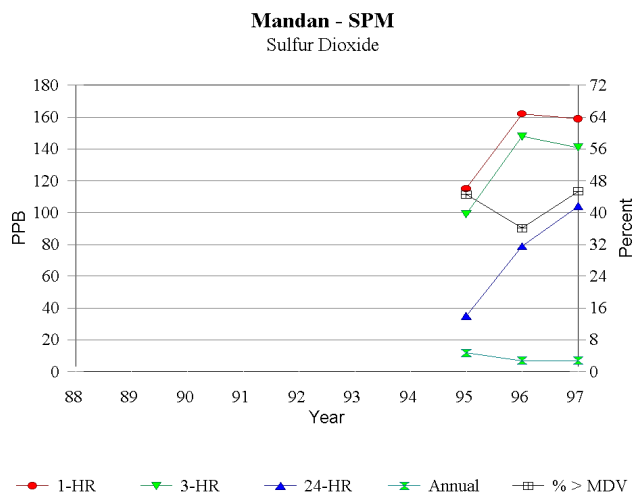
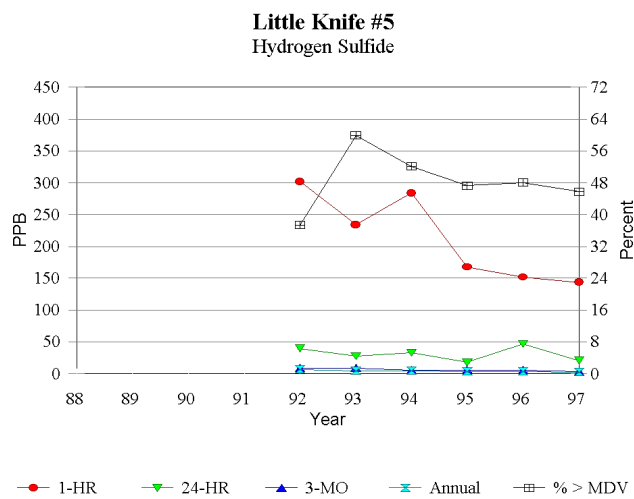
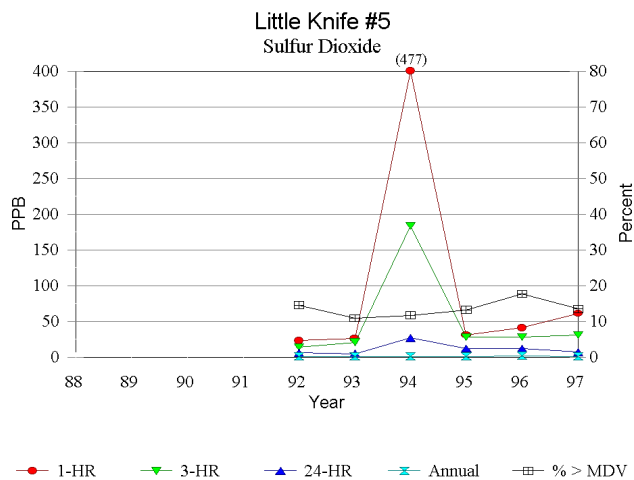


Figure A4-7 Little Knife/Mandan Trends

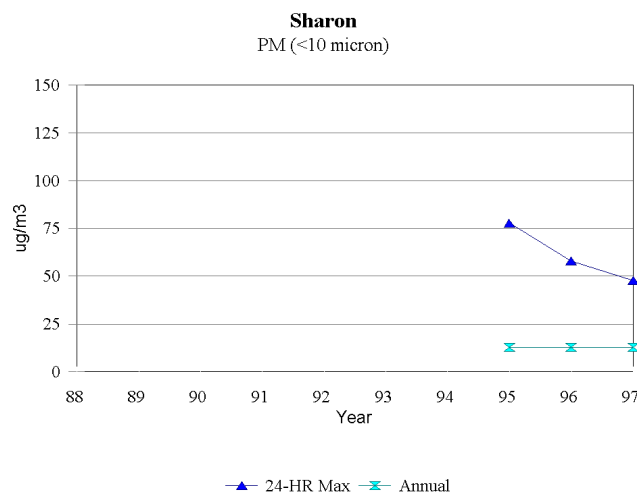
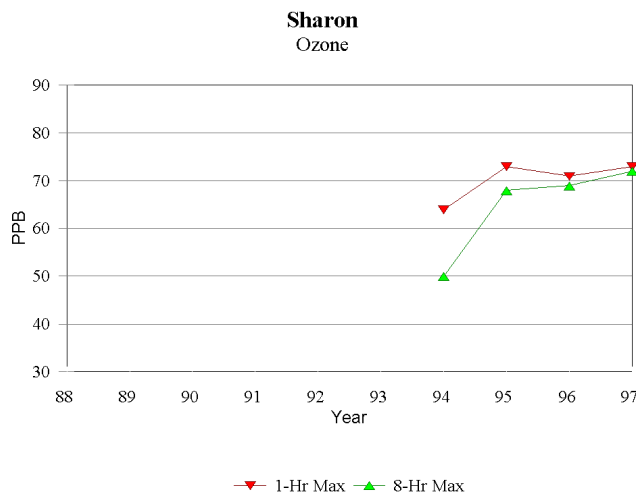
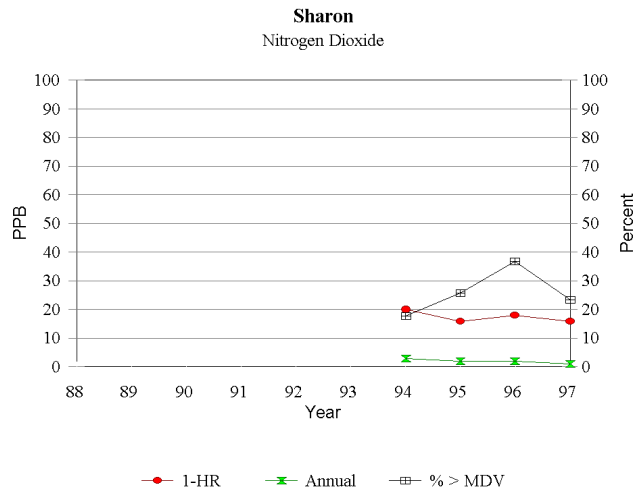
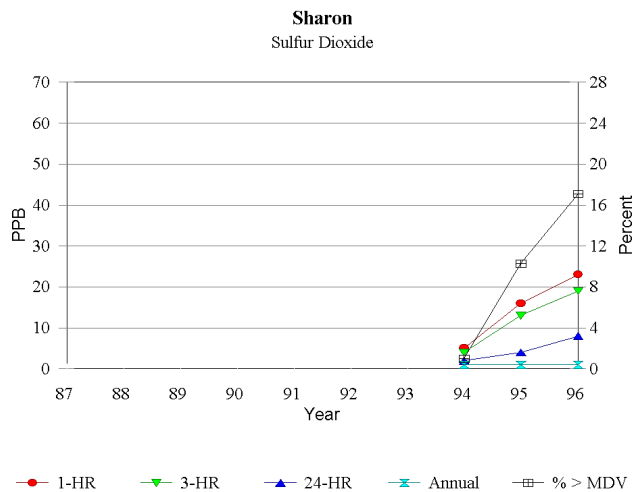


Figure A4-8 Sharon Trends

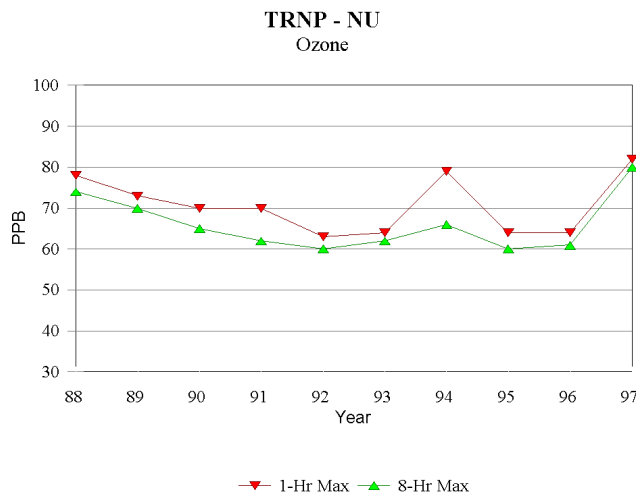
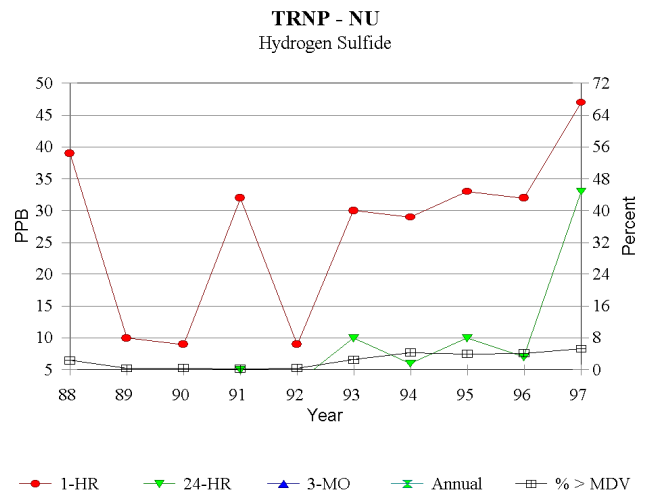
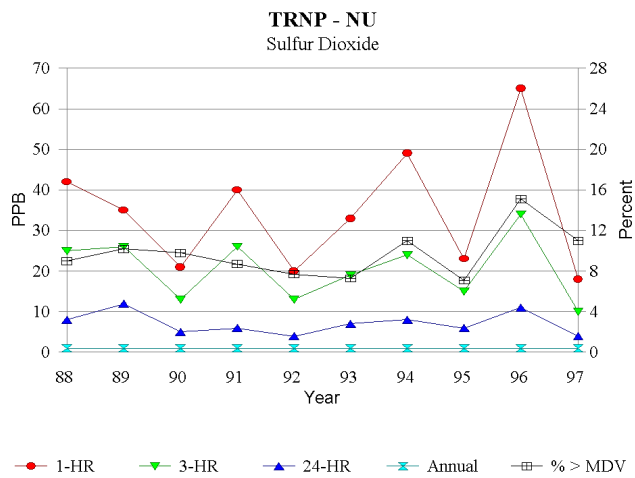


Figure A4-9 TRNP - NU Trends

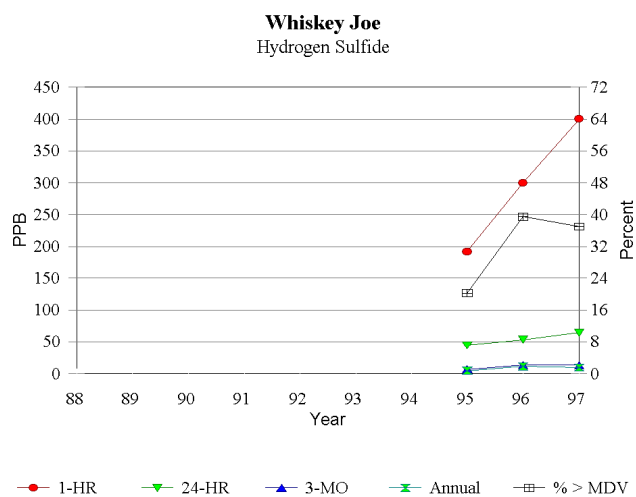
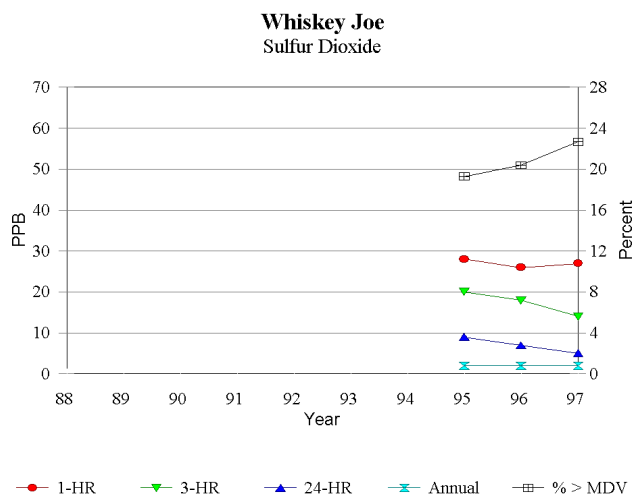
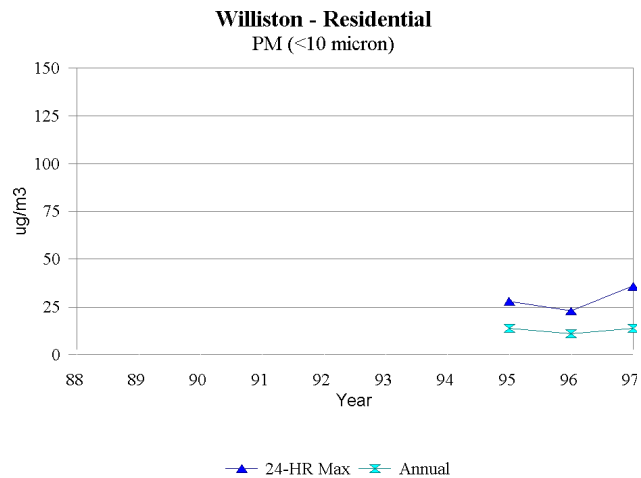
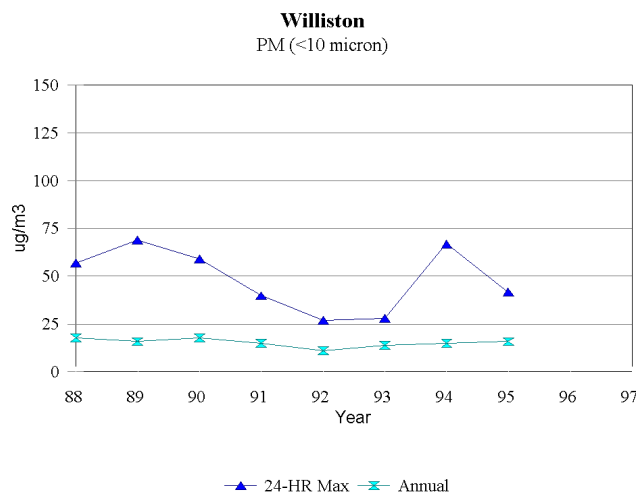


Figure A4-10 Williston/Whiskey Joe Trends