Annual Report

North Dakota
Air Quality Monitoring
Data Summary
1999

North Dakota Department of Health
Division of Air Quality

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EXECUTIVE SUMMARY

The North Dakota Department of Health operated nine ambient and four special purpose air quality monitoring sites and industry operated nine 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 during 1999.

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 were three sulfur dioxide exceedances of the State 1-hour standard: These exceedances occurred during Department approved plant maintenance operations. Through legislative action effective August 1, 1997, coal conversion facilities and oil refineries were exempted from the state sulfur dioxide standards. Therefore, any values listed as an exceedance in the data summaries are subject to further manual review to determine the most likely source(s) causing the listed exceedance.

INTRODUCTION

The North Dakota Department of Health, Environmental Health Section, Division of Air Quality, 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[1,2] and the "Prevention of Significant Deterioration of Air Quality Rules."[3] To address this responsibility, the Department operates a network of ambient air quality monitors.

In addition to the state operated ambient air quality monitoring sites, three industrial sources of air pollutants operated air quality monitoring sites within their immediate spheres of influence. These site locations are selected 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, 1999, and ending Dec. 31, 1999. 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 1999, the Department operated 13 air quality monitoring sites. Nine were ambient monitoring sites, and four were special purpose monitoring (SPM) sites. The SPM sites are Short Creek, Lignite and two sites near the AMOCO Refinery and MDU Heskett Power Plant at Mandan. 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 two Mandan - SPM sites were established to collect source-specific 5-minute peak and hourly sulfur dioxide averages due to impacts from the MDU Heskett Power Plant and AMOCO Refinery. The Short Creek - SPM and Lignite - SPM sites were established to monitor the current impact of SaskPower's Boundary Dam Power Plant located South of Estevan, Saskatchewan. SASKPower is in the process of adding electrostatic precipitators (ESP) to the uncontrolled stacks. As the ESPs come on line, these two sites will monitor the change in the air quality.

The Department is working with Environment Canada, EPA, Saskatchewan Environment and Resource Management (SERM) and SASKPower to establish a SK-ND Trans-Boundary ambient air quality monitoring network with three sites in Saskatchewan and the two sites (Short Creek, Lignite) in North Dakota. As soon as the three sites in Saskatchewan are operational, the two North Dakota sites will be transferred to the SK-ND Trans-Boundary Network. The data collected at these five sites will be reported in reports specific to that network.

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 nine 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 sites 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. The Mandan location represents the two sites at Mandan.

TABLE 1

State AAQM Network Description

Site Name AQS Site #	Type Station	Parameter Monitored[1]	Operating Schedule	Monitoring Objective[2]	Spatial Scale[2]	Date Site Began
1 Beulah North	SLAMS	$PM_{2.5}$ SO_2, NO_2, O_3, MET	6^{th} Day cont.	Population Exposure Population Exposure	Neighborhood Neighborhood	12/98 04/80
2 Bismarck Residential	SLAMS	$PM_{2.5}$	3^{rd} Day	Population Exposure	Urban	12/98
3 Dickinson Residential	SLAMS	PM_{10}	6^{th} Day	Population Exposure	Urban	07/89
4 Dunn Center	SLAMS	SO_2, NO_2, O_3, MET	cont.	General Background	Regional	10/79
5 Fargo NW	SLAMS	PM_{10} PM_{10} $PM_{2.5}$ $PM_{2.5}$ SO_2, NO_2, O_3, MET	6^{th} Day 6^{th} Day 3^{rd} day 3^{rd} Day cont.	Population Exposure Collocated SSI Population Exposure Collocated Population Exposure	Urban N/A Urban N/A Urban	05/98 12/98 05/98
6 Grand Forks North	SLAMS	$PM_{2.5}$	3^{rd} Day	Population Exposure	Urban	12/98
7 Hannover	SLAMS	SO_2, NO_2, O_3, MET	cont.	General Background	Regional	10/84
8 Lignite - SPM	SPM	$PM_{2.5}$ $PM_{2.5}$	6^{th} Day 6^{th} Day	Population Exposure Collocated	Regional N/A	10/99
9 Mandan Refinery - SPM	SPM	SO_2, MET	cont.	Source Impact	Neighborhood	12/95
10 Mandan Refinery NW - SPM	SPM	SO_2, MET	cont.	Source Impact	Neighborhood	09/98
11 Sharon	SLAMS	SO_2, NO_2 O_3, MET $PM_{2.5}$	cont. 6^{th} Day	General Background	Regional	07/94 12/98
12 Short Creek - SPM	SPM	SO_2, NO_2, MET PM_{10} $PM_{2.5}$	Cont. 6^{th} Day 6^{th} Day	Source Impact	Regional	02/99 09/98 04/99
13 TRNP - SU	SPM	SO_2, O_3 MET	cont.	General Background	Regional	07/95
Company	**Site Name**					
14 Amerada Hess Corporation	TIOGA #1 TIOGA #2 TIOGA #3	SO_2 H_2S, MET SO_2	cont. cont. cont.	Source Impact Source Impact Source Impact	Urban Urban Urban	07/87 07/87 11/87
15 Bear Paw Energy, Inc.	MGP #3 MGP #5	SO_2, MET SO_2, MET	cont. cont.	Source Impact Source Impact	Urban Urban	11/94 01/98
16 Dakota Gasification Company	DGC #12 DGC #14 DGC #16 DGC #17	SO_2, NO_2, MET SO_2 SO_2 SO_2, NO_2	cont. cont. cont. cont.	Source Impact Source Impact Source Impact Source Impact	Urban Urban Urban Urban	01/80 01/89 10/95 10/95

1. MET refers to meteorological and indicates wind speed and wind direction monitoring equipment.
2. Not applicable to MET.

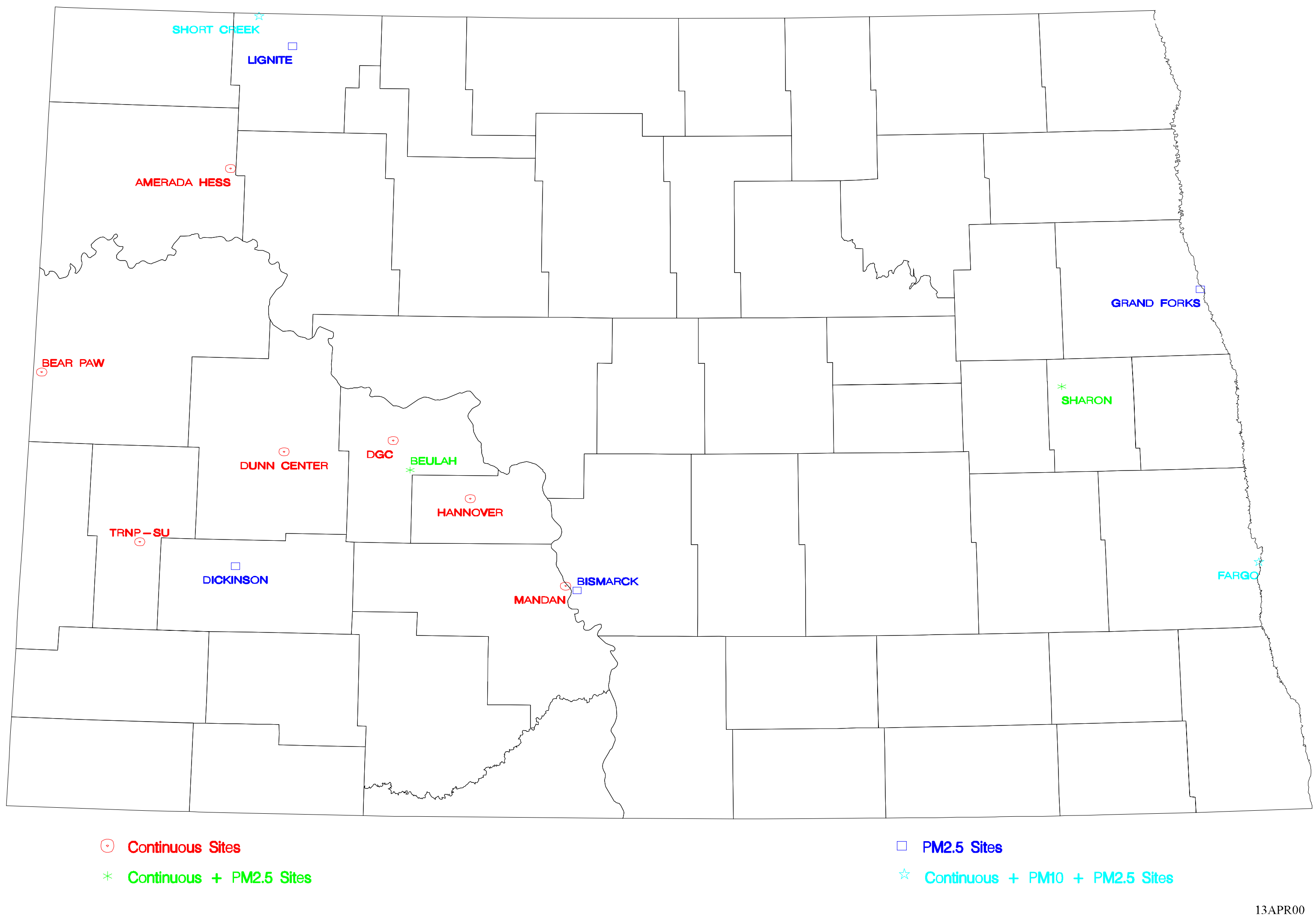

Figure 1 North Dakota Air Quality Monitoring Network

NETWORK CHANGES

Department Changes

Changes to the state monitoring network consisted of terminating and moving the following sites to new locations and adding a new site: Beulah Residential was terminated January 14 and moved to the Beulah North site; Lignite was added on September 3.

Industry Changes

Amerada Hess - Tioga terminated H_2S monitoring effective December 31. As a part of the termination agreement, the MET equipment will be moved from Site #2 to Site #1 as soon as arrangements for additional space are completed and weather permits. The completion date was June 14, 2000.

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_2), nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), ozone (O_3), federal reference method (FRM) inhalable fine particulates ($PM_{2.5}$), inhalable course particulates (PM_{10}), and PM_{10} 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 FRM $PM_{2.5}$, PM_{10}, and PM_{10} 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, if applicable. The concentrations are reported in micrograms per cubic meter ($\mu g/m^3$).

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_2, H_2S and NO_2 is 2 ppb; O_3 is 4 ppb; FRM $PM_{2.5}$ is 2.0 $\mu g/m^3$; PM_{10} is 4 $\mu g/m^3$; and PM_{10} sulfate is 0.5 $\mu g/m^3$. Annual means are calculated for SO_2, NO_2, H_2S, *FRM* $PM_{2.5}$, non-FRM $PM_{2.5}$, and PM_{10}. 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 (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.

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.[4] 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," which then may convert to a sulfate. 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, natural gas processing plants, oil well heaters, and flares.

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.[4]

Standards Comparison

Sulfur dioxide was monitored at 18 sites. Ten sites were run by the Department and eight by industry. As a result of legislative action effective August 1, 1997, coal conversion facilities and oil refineries were exempted from the state sulfur dioxide standards leaving these two classes of sources subject only to the federal standards. Therefore, the DGC network, Mandan NW - SPM, and Mandan - SPM are compared only to the federal standards.

The 1-hour state standard (273 ppb) was exceeded three times during the year by an applicable source. The maximum 1-hour concentration was 401 ppb at Amerada Hess - Tioga #3.

The 3-hour federal secondary standard (500 ppb) was not exceeded during the year. The maximum 3-hour average concentration was 346 ppb at Amerada Hess - Tioga #3.

The 24-hour state standard (99 ppb) was not exceeded twice during the year. The maximum 24-hour average concentration was 97 ppb at Mandan - SPM. .

Among those sites that collected at least 80 percent of the possible data during the year, the maximum annual arithmetic mean was 6.3 ppb at Mandan - SPM. Beulah Residential is not included in the summary because only 14 days of data were collected.

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)

				M A X I M A									
				1 - HOUR		3 - HOUR		24 - HOUR					
LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD	2ND MM/DD	ARITH MEAN	1HR #>273	24HR #>99	% >MDV
Amerada Hess - Tioga #1	1999	JAN-DEC	8676	48 02/07/14	42 01/18/18	37 01/14/23	36 01/18/20	7 01/14	7 02/07	1.5			13.5
Amerada Hess - Tioga #3	1999	JAN-DEC	8673	401 05/05/21	375 05/05/22	346 05/05/23	265 05/06/02	72 05/06	64 05/05	3.3	3		21.3
Bear Paw - MGP #3	1999	JAN-DEC	8666	66 08/31/15	64 01/01/16	43 08/31/17	26 05/22/11	9 08/31	5 01/01	1.2			7.7
Bear Paw - MGP #5	1999	JAN-DEC	8118	134 10/06/06	85 08/31/01	57 08/31/02	54 09/01/11	13 09/01	10 08/31	1.4			10.6
Beulah - North	1999	JAN-DEC	8286	66 06/29/17	64 03/17/05	36 06/29/17	30 03/17/08	16 03/17	8 01/18	2.1			24.8
DGC #12	1999	JAN-DEC	8704	136 09/27/09	131 03/15/11	68 09/27/11	56 09/09/14	17 09/09	12 09/30	2.2			27.4
DGC #14	1999	JAN-DEC	8681	87 06/28/10	66 06/28/11	55 06/28/11	33 09/21/11	9 06/28	8 05/08	2.1			29.9
DGC #16	1999	JAN-DEC	8490	73 06/25/08	58 05/08/12	38 05/08/08	36 06/25/08	16 05/08	12 01/18	2.7			41.0
DGC #17	1999	JAN-DEC	8575	114 06/25/06	86 07/24/06	57 07/24/08	46 06/25/08	20 07/24	16 06/25	2.9			43.3
Dunn Center	1999	JAN-DEC	8689	34 09/10/08	34 09/10/09	19 12/16/02	16 09/10/11	5 08/28	5 12/16	1.3			13.1
Fargo NW	1999	JAN-DEC	8698	9 01/03/18	9 01/03/19	7 01/03/20	6 01/19/08	3 01/01	3 01/19	1.1			8.4
Hannover	1999	JAN-DEC	8683	139 11/15/12	135 09/16/11	75 09/16/11	74 11/15/14	16 03/31	14 09/16	2.4			26.3
Mandan - SPM	1999	JAN-DEC	8689	171 05/06/03	166 05/05/20	161 05/06/05	155 05/06/08	97 05/06	71 05/05	6.3			37.8
Mandan NW - SPM	1999	JAN-DEC	8708	123 05/21/20	118 01/01/10	67 01/01/11	63 02/19/20	34 02/22	26 05/13	4.0			41.2
Sharon	1999	JAN-DEC	8696	10 01/07/20	9 01/06/02	8 01/06/02	8 01/07/20	4 01/07	4 01/09	1.1			3.2
Short Creek - SPM	1999	FEB-DEC	7354	52 10/25/10	47 12/27/22	40 09/14/11	29 12/27/23	10 05/17	10 09/14	1.9			17.5
TRNP - SU (Painted Canyon)	1999	JAN-DEC	8121	12 01/11/22	11 01/11/23	9 01/01/02	9 01/20/05	4 01/01	4 01/26	1.2			7.8

The maximum 1-hour concentration is 401 ppb at Amerada Hess - Tioga #3 on 05/05/21
The maximum 3-hour concentration is 346 ppb at Amerada Hess - Tioga #3 on 05/05/23
The maximum 24-hour concentration is 97 ppb at Mandan - SPM on 05/06

* 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 at state-operated sites and the Bear Paw Energy network. The maximum 5-minute average was 422 ppb at Amerada Hess - Tioga #3

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_2 5-Minute Averages (ppb)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	5 - MINUTE MAXIMA 1ST	DATE MM/DD/HH	2ND	DATE MM/DD/HH	3RD	DATE MM/DD/HH	# HOURS >600	% >MDV
Bear Paw - MGP #3	1999	JAN-DEC	8668	387	05/22/10	281	01/22/16	233	08/31/15	0	14.6
Bear Paw - MGP #5	1999	JAN-DEC	8119	422	10/06/06	216	08/06/16	163	08/31/02	0	20.9
Beulah - North	1999	JAN-DEC	8286	260	06/29/17	162	03/29/15	157	06/29/16	0	34.3
Dunn Center	1999	JAN-DEC	8689	59	09/10/08	54	01/10/22	51	09/10/09	0	21.1
Fargo NW	1999	JAN-DEC	8698	9	01/03/18	9	01/03/19	7	01/11/06	0	8.4
Hannover	1999	JAN-DEC	8683	207	10/05/07	197	09/05/10	196	11/15/12	0	36.6
Mandan - SPM	1999	JAN-DEC	8689	248	02/27/19	228	05/27/20	217	02/11/00	0	49.3
Mandan NW - SPM	1999	JAN-DEC	8708	378	11/15/12	232	11/15/13	174	01/31/18	0	52.3
Sharon	1999	JAN-DEC	8696	10	01/07/20	9	01/07/02	8	01/07/18	0	3.2
Short Creek - SPM	1999	FEB-DEC	7354	172	03/01/13	135	03/01/13	130	03/01/12	0	26.2
TRNP - SU (Painted Canyon)	1999	JAN-DEC	8121	12	01/11/22	11	01/11/23	11	01/20/04	0	7.8

The maximum 5-minute concentration is 422 ppb at Bear Paw - MGP #5 on 10/06/06

* No Standard is currently in effect:

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

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. Major NO_2 sources are coal conversion processes, natural gas processing plants, and natural gas compressor stations.

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.[5] 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 eight sites. Six 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 6.4 ppb at Fargo NW. Beulah Residential is not included because there is only 14 days of data.

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	MAXIMA 1 - HOUR 1ST MM/DD/HH	MAXIMA 1 - HOUR 2ND MM/DD/HH	ARITH MEAN	% >MDV
Beulah - North	1999	JAN-DEC	7201	27 10/31/22	24 02/16/01	3.2	72.2
DGC #12	1999	JAN-DEC	8594	108 11/01/02	89 03/05/09	4.5	96.9
DGC #17	1999	JAN-DEC	8450	49 03/29/22	41 07/24/06	3.9	95.1
Dunn Center	1999	JAN-DEC	8675	25 12/16/00	22 03/24/04	1.7	37.5
Fargo NW	1999	JAN-DEC	8683	55 12/10/10	53 03/11/19	6.4	79.3
Hannover	1999	JAN-DEC	8659	31 04/09/19	30 09/16/11	2.6	65.8
Sharon	1999	JAN-DEC	7973	14 11/29/06	13 01/20/01	1.7	37.4
Short Creek - SPM	1999	FEB-DEC	7336	24 12/27/22	22 04/14/03	2.6	71.3

The maximum 1-hour concentration is 108 ppb at DGC #12 on 11/01/02

* 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. [6] The major source is oil wells. Other sources are natural gas processing plants, lagoons, and sloughs.

Health Effects

A 5-minute exposure to 800 ppm has resulted in death. Inhalation of 1,000 to 2,000 ppm may cause a 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.[6]

Standards Comparison

Hydrogen sulfide was monitored at one site, operated by industry.

The 1-hour state standard (200 ppb) was not exceeded during the year. The maximum 1-hour concentration was 101 ppb at Amerada Hess - Tioga #2.

The 24-hour state standard (100 ppb) was not exceeded during the year. The maximum 24-hour average concentration was 19 ppb at Amerada Hess - Tioga #2.

The 3-month state standard (20 ppb) was not exceeded during the year. The maximum 3-month average concentration was 2 ppb at Amerada Hess - Tioga #2.

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	MAXIMA 1 - HOUR 1ST MM/DD/HH	MAXIMA 1 - HOUR 2ND MM/DD/HH	MAXIMA 24 - HOUR 1ST MM/DD	MAXIMA 24 - HOUR 2ND MM/DD	MAXIMA 3 - MONTH 1ST MM	MAXIMA 3 - MONTH 2ND MM	ARITH MEAN	1HR #>200	24HR #>100	% >MDV
Amerada Hess - Tioga #2	1999	JAN-DEC	8664	101 12/02/20	94 04/12/21	19 04/12	9 09/20	2 04	2 12	1.9			19.2

The maximum 1-hour concentration is 101 ppb at Amerada Hess - Tioga #2 on 12/02/20
the maximum 24-hour concentration is 19 ppb at Amerada Hess - Tioga #2 on 04/12
The maximum 3-month concentration is 2 ppb at Amerada Hess - Tioga #2 on 04

* 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.

At ground level where it can be breathed, ozone is a pollutant[7]. 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.[8] 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 pbb.

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.[7]

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 the 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 six state run sites. This data is used in computer dispersion models as part of the primary and secondary chemical transformations.

The 1-hour state standard (120 ppb) was not exceeded during the year. The maximum 1-hour concentration was 84 ppb at Hannover.

As part of preparing for a new 8-hour standard (80 ppb), 8-hour averages have been included in the data summary. The 8-hour standard uses the fourth highest daily maximum for comparison to the standard. The fourth highest 8-hour concentration was 68 ppb at Sharon.

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)

				MAXIMA 1-HOUR		MAXIMA 8-HOUR					
LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	1ST MM/DD/HH	2ND MM/DD/HH	1ST MM/DD/HH	2ND MM/DD/HH	3RD MM/DD/HH	4TH MM/DD/HH	1HR #>120	8HR #>80
Beulah - North	1999	JAN-DEC	7458	73 04/30/15	71 04/30/14	68 04/30/09	64 04/30/08	64 04/30/10	64 04/30/11		
Dunn Center	1999	JAN-DEC	8707	71 06/06/13	68 06/06/12	60 05/01/10	60 05/01/09	60 05/01/08	60 05/01/07		
Fargo NW	1999	JAN-DEC	8698	75 08/31/15	75 08/31/16	71 05/02/09	70 08/31/09	67 05/02/08	67 05/01/10		
Hannover	1999	JAN-DEC	8700	84 07/22/11	75 06/06/16	69 04/30/09	67 04/30/08	67 04/30/10	67 06/06/09		
Sharon	1999	JAN-DEC	8694	70 05/02/13	70 06/07/11	68 06/07/09	68 06/07/08	68 06/07/07	68 05/01/09		
TRNP - SU (Painted Canyon)	1999	JAN-DEC	8556	70 08/05/17	70 08/05/18	63 08/05/11	60 08/05/12	60 08/05/10	60 08/05/13		

The maximum 1-hour concentration is 84 ppb at Hannover on 07/22/11
The 4th highest 8-hour concentration is 68 ppb at Sharon on 05/01/09

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

FEDERAL - Fourth highest daily maximum 8-hour averages 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. Particulates 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}.[9]

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 wood-burning stoves). 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.[9]

In addition, particles less than 2.5 micrometers ($PM_{2.5}$) are major contributors to visibility degradation 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 ($PM_{2.5}$) pollution 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.[9]

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.[10] Acid deposition can be detected in the most remote areas of the world.

Inhalable $PM_{2.5}$ Particulates

Inhalable $PM_{2.5}$ particulates were monitored at seven sites operated by the Department. Single-day FRM samplers were installed at Beulah, Lignite, Sharon, and Short Creek to collect a sample once every 6 days. Sequential FRM samplers were installed at Bismarck, Fargo and Grand Forks to collect a sample once every 3 days.

Standards Comparison

The 24-hour federal standard (65 $\mu g/m^3$) was not exceeded during the year. The maximum 24-hour average concentration was 30.7 $\mu g/m^3$ at Fargo NW.

The federal annual standard (15 $\mu g/m^3$) was not exceeded for the year. The maximum annual average was 9.6 $\mu g/m^3$ at Grand Forks - North.

The inhalable $PM_{2.5}$ data are summarized in Table 7.

TABLE 7

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

POLLUTANT : Inhalable FRM $PM_{2.5}$ Particulates (µg/m³)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	MAXIMA 1ST MM/DD	2ND MM/DD	3RD MM/DD	ARITH MEAN	#> 65	AM>15	% >MDV
Beulah - North	1999	JAN-DEC	56	2.0	21.2 03/07	20.9 03/13	15.5 02/11	7.0			100.0
Bismarck Residential	1999	JAN-DEC	93 ***	0.4	24.4 03/16	23.0 02/20	22.5 03/19	7.0			95.7
Fargo NW	1999	JAN-DEC	108	1.9	30.7 01/30	27.4 11/11	26.7 02/26	9.2			99.0
Grand Forks - North	1999	JAN-DEC	93 ***	1.0	30.0 03/13	26.3 02/26	23.1 08/31	9.6			95.7
Lignite - SPM	1999	SEP-DEC	16 ***	1.8	8.1 11/08	7.6 09/09	6.5 11/14	4.6			93.7
Sharon	1999	JAN-DEC	56	1.9	27.4 03/13	21.3 01/30	16.2 10/27	7.6			98.2
Short Creek - SPM	1999	APR-DEC	35 ***	2.1	21.8 10/27	10.5 08/04	9.7 05/01	6.2			100.0

The maximum 24-hour concentration is 30.7 µg/m³ at Fargo NW on 01/30

* The ambient air quality standards are:
FEDERAL Standards -
1) 24-hour: 3-year average of 98th percentiles not to exceed 65 µg/m³.
2) Annual: 3-year average not to exceed 15µg/m³.

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

Inhalable PM_{10} Particulates

Inhalable PM_{10} particulate concentrations were monitored at two sites run by the Department.

Standards Comparison

The 24-hour state standard (150 $\mu g/m^3$) was not exceeded during the year. The maximum 24-hour concentration was 70.8 $\mu g/m^3$ at Fargo NW.

The annual state standard (50 $\mu g/m^3$) was not exceeded. The maximum annual mean for the year was 20.7 $\mu g/m^3$ at Fargo NW.

The inhalable particulate (PM_{10}) data are summarized in Table 8.

TABLE 8

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

POLLUTANT : Inhalable PM_{10} Particulates ($\mu g/m^3$)

					MAXIMA						
LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	1ST MM/DD	2ND MM/DD	3RD MM/DD	ARITH MEAN	#>150	AM>50	% >MDV
Fargo NW	1999	JAN-DEC	60	4.3	70.8 11/02	64.9 11/08	52.0 07/29	20.7			100.0
Short Creek - SPM	1999	JAN-DEC	56	5.2	52.1 08/04	44.6 07/29	42.2 10/21	17.0			100.0

The maximum 24-hour concentration is 70.8 $\mu g/m^3$ at Fargo NW on 11/02

* The STATE air quality standards are:
1) 150 µg/m3 maximum averaged over a 24-hour period with no more than one expected exceedance per year.
2) 50 µg/m3 expected annual arithmetic mean.

Sulfates ($SO_4^=$)

Physical Characteristics and Sources

Sulfates are any of the group of compounds that contain the sulfate ($SO_4^=$) 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 SO_2. Sulfur dioxide emitted from a source can be transformed into $SO_4^=$ 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.[11]

Health Effects

Health impacts generally are associated with acidic sulfate aerosols. Short-term exposures of 100 µg/m^3 of sulfuric acid (H_2SO_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 µg/m^3 H_2SO_4. Enhanced respiratory difficulties are seen with exposures to SO_2 and H_2SO_4. Further sensitivity studies are necessary to determine the health impacts of $SO_4^=$.[11,12,13]

Fine particulate sulfate is efficient at scattering light, thus it is a factor in visibility degradation. Even at low concentrations, below 3 µg/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 PM_{10} Sulfate

Inhalable PM_{10} 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 5.7 µg/m^3 at Short Creek - SPM.

The maximum annual mean at sites collecting at least 80% of the data for the year was 1.3 µg/m^3 at Short Creek - SPM.

The inhalable PM_{10} sulfate data are summarized in Table 9.

Table 9

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

POLLUTANT : Inhalable PM_{10} Sulfate ($\mu g/m^3$)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	MAXIMA 1ST MM/DD	MAXIMA 2ND MM/DD	MAXIMA 3RD MM/DD	ARITH MEAN	#>15	AM>5	% >MDV
Fargo NW	1999	JAN-DEC	60	0.2	3.7 08/22	2.7 03/13	2.5 03/01	1.1			88.3
Short Creek - SPM	1999	JAN-DEC	56	0.3	5.7 04/30	5.5 03/13	5.2 03/07	1.3			92.8

The maximum 24-hour concentration is 5.7 $\mu g/m^3$ at Short Creek - SPM on 04/30.

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 $PM_{2.5}$ and PM_{10} 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 $\mu g/m^3$ for sulfate analysis; 4 $\mu g/m^3$ 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 $\mu g/m^3$, 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_{10} Sulfate /PM_{10} Analysis

The maximum 24-hour ratio was 33.1 percent at Short Creek - SPM. The highest annual average was 10.4 percent at Short Creek - SPM. The PM_{10} sulfate /PM_{10} total mass ratio data are summarized in Table 10.

Table 10

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

POLLUTANT : PM_{10} Sulfate/PM_{10} Total Mass Ratio (Percentage)

LOCATION	YEAR	SAMPLING PERIOD	NUM OBS	MIN	MAXIMA 1ST MM/DD	MAXIMA 2ND MM/DD	MAXIMA 3RD MM/DD	ARITH MEAN
Fargo NW	1999	JAN-DEC	53	0.7	26.9 03/01	20.0 01/18	18.6 01/24	7.9
Short Creek - SPM	1999	JAN-DEC	52	2.0	33.1 03/13	28.8 01/12	27.8 04/30	10.4

The maximum 24-hour ratio is 33.1 percent at Short Creek - SPM on 03/1.

SUMMARY AND CONCLUSIONS

The State of North Dakota has relatively clean air. North Dakota is one of only 14 states to comply with all federal ambient air quality standards. 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 1-hour standard was exceeded three times. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standard are as follows: 1-hour – 401 ppb (146.7%); 3-hour – 346 ppb (70.7%); 24-hour – 97 ppb (98.0%); annual – 6.3 ppb (27.4%).

Sulfur Dioxide 5-Minute Averages

No standard is currently in effect. The maximum 5-minute average was 422 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 – 6.4 ppb (12.1%).

Hydrogen Sulfide

There was no exceedance of the 1-hour standard. The maximum concentrations and the maximum concentrations expressed as a percentage of the applicable standards are as follows: 1-hour – 101 ppb (50.5%); 24-hour – 19 ppb (19%); 3-month – 2 ppb (10%).

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 84 ppb (70.0%). The maximum 8-hour average concentration was 68 ppb (85.0%).

Inhalable FRM $PM_{2.5}$ 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 – 30.7 µg/m^3 (47.2%); annual – 9.6 µg/m3 (64.0%).

Inhalable PM_{10} Particulates

The state 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 – 70.8 µg/m^3 (47.2%); annual – 20.7 µg/m^3 (41.4%).

Inhalable PM_{10} Sulfates

No standard is currently in effect. The maximum 24-hour average was 5.7 µg/m^3. The maximum annual average is 1.3 µg/m^3.

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REFERENCES

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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 SO_2, CO, NO_2, H_2S, $PM_{2.5}$ and 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 (O_3) is formed as a result of a photochemical reaction between hydrocarbons (HC) and oxides of nitrogen (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_{10})	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_2 standards.

TABLE A1-2
Federal Ambient Air Quality Standards

Pollutant	Description	Primary	Secondary
$PM_{2.5}$	3-year average of annual arithmetic mean concentrations.	15 µg/m^3	15 µg/m^3
	3-year average of the 98th percentile of the 24-hour concentrations.	65 µg/m^3	65 µg/m^3
PM_{10}*	Expected annual arithmetic mean.	50 µg/m^3	50 µg/m^3
	99th percentile of the 24-hour concentrations averaged over 3 years.	150 µg/m^3	150 µg/m^3
SO_2	Annual arithmetic mean.	0.03 ppm (80 µg/m^3)	-
	Maximum 24-hour concentration not to be exceeded more than once per year.	0.14 ppm (365 µg/m^3)	-
	Maximum 3-hour concentration not to be exceeded more than once per year.	-	0.5 ppm (1300 µg/m^3)
CO	8-hour concentration not to be exceeded more than once per year.	9 ppm (10 µg/m^3)	-
	1-hour average concentration not to be exceeded more than once per year.	35 ppm (40 µg/m^3)	-
O_3*	3-year average of the annual 4th highest daily maximum 8-hour concentrations, not to be exceeded.	0.08 ppm	0.08 ppm
NO_2	Annual arithmetic mean.	0.053 ppm (100 µg/m^3)	0.053 ppm (100 µg/m^3)
Pb	Maximum arithmetic mean averaged over a calendar quarter.	1.5 µg/m^3	1.5 µg/m^3

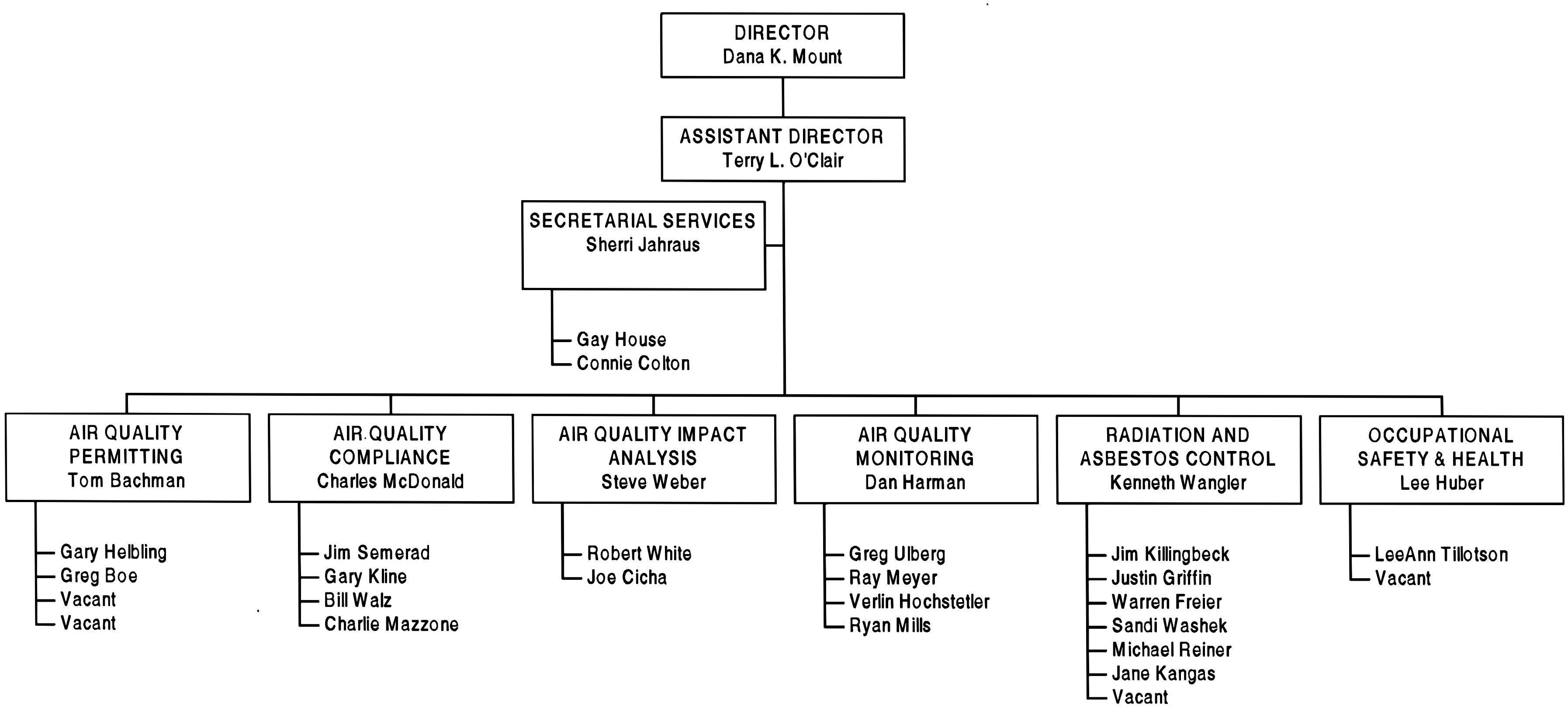
* The PM_{10} and ozone standards have been challenged in court. The final status for these standards is yet to be decided.

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

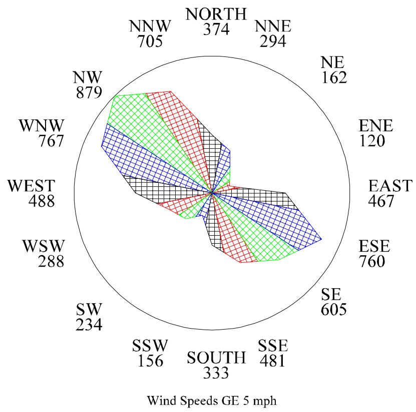
Wind and Pollution Star Charts

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 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.

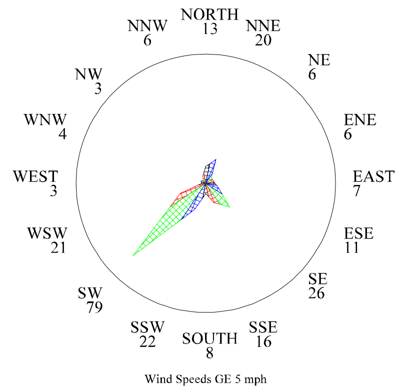
The pollution star charts present the percentage of time a pollutant is detected when the wind is from a given direction. For example, a wind star chart shows a frequency of 122, and a pollution star chart shows a 66 for the same direction. This means that 66 percent of the time (80 of the possible 122 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.

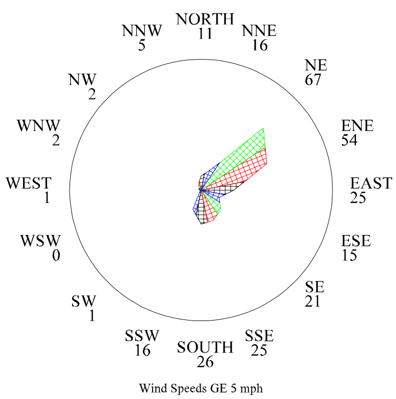
Amerada Hess - Tioga #2 Wind Direction Star Chart during 1999



Percent of Time SO_2 Detected for a Given Wind Sector for Amerada Hess - Tioga #1 during 1999



Percent of Time H_2S Detected for a Given Wind Sector for Amerada Hess - Tioga #2 during 1999



Percent of Time SO_2 Detected for a Given Wind Sector for Amerada Hess - Tioga #3 during 1999

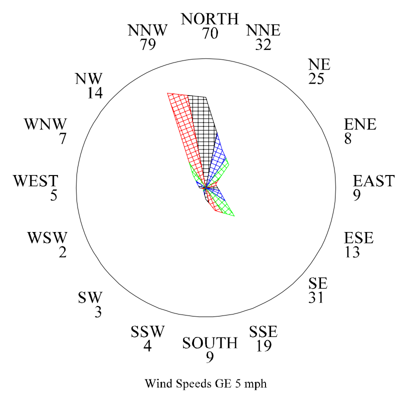
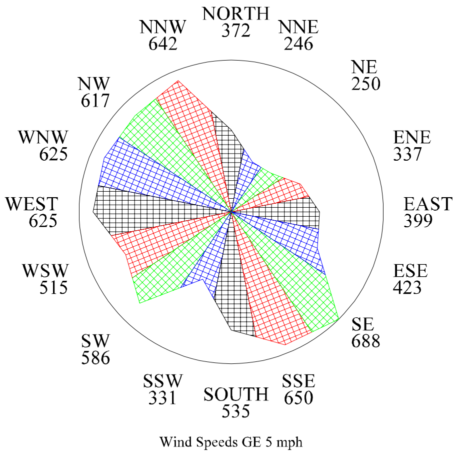
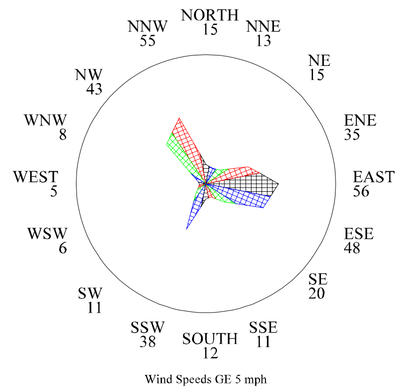


Figure A3-1 Amerada Hess Star Charts

Beulah - North Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Beulah - North during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Beulah - North during 1999

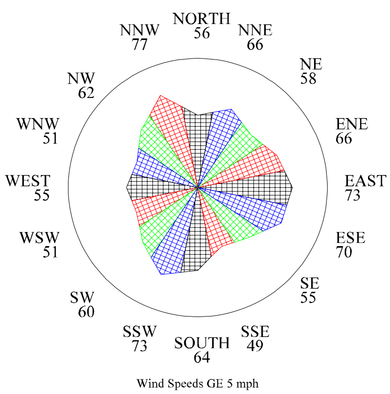
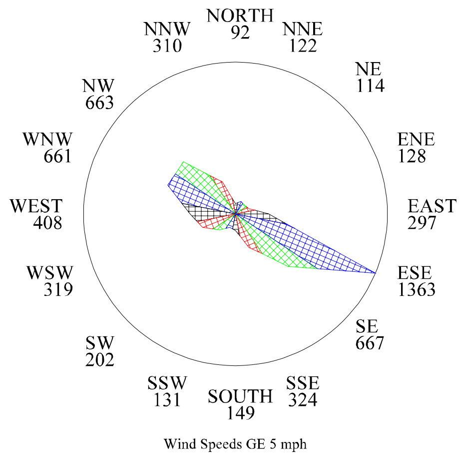
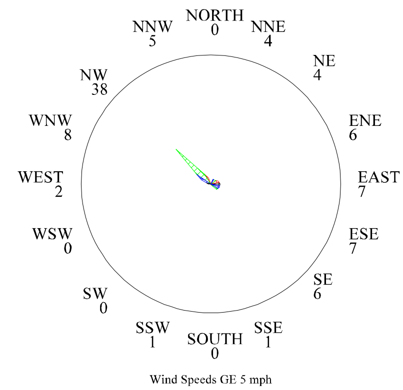


Figure A3-2 Beulah Star Charts

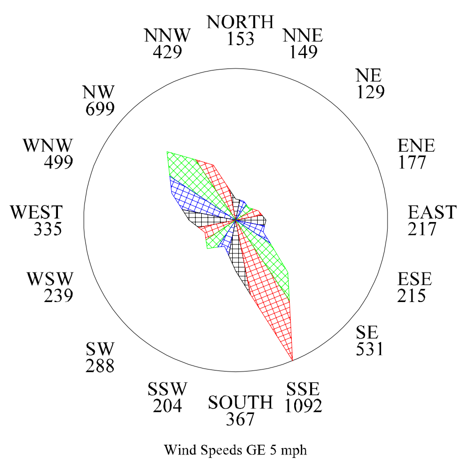
Bear Paw - MGP #3 Wind Direction Star Chart during 1999



Percent of Time SO_2 Detected for a Given Wind Sector for Bear Paw - MGP #3 during 1999



Bear Paw - MGP #5 Wind Direction Star Chart during 1999



Percent of Time SO_2 Detected for a Given Wind Sector for Bear Paw - MGP #5 during 1999

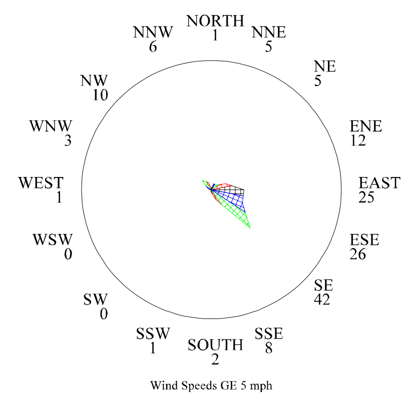
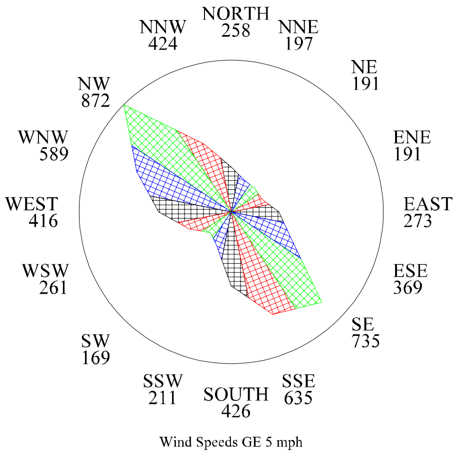
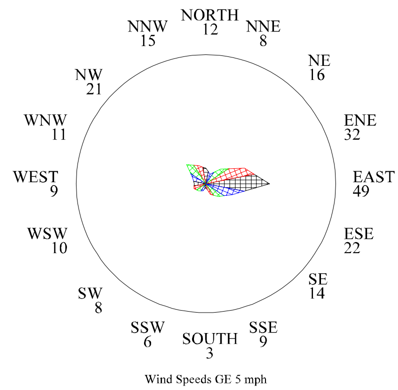


Figure A3-3 Bear Paw Star Charts

Dunn Center Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Dunn Center during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Dunn Center during 1999

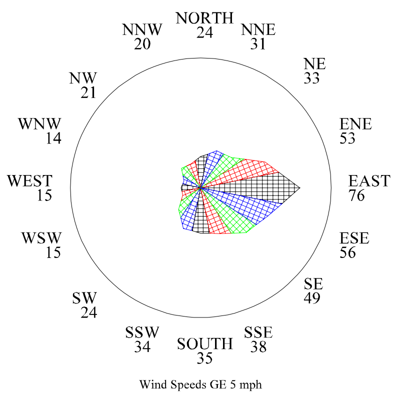
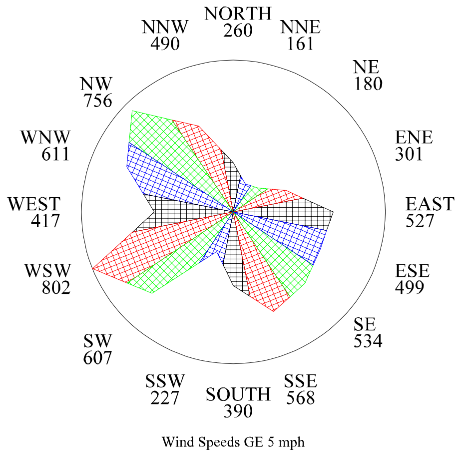
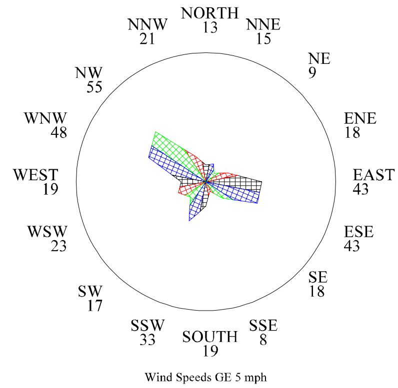


Figure A3-4 Dunn Center Star Charts

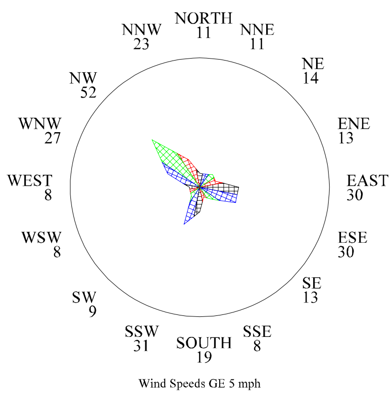
DGC #12 Wind Direction Star Chart
during 1999



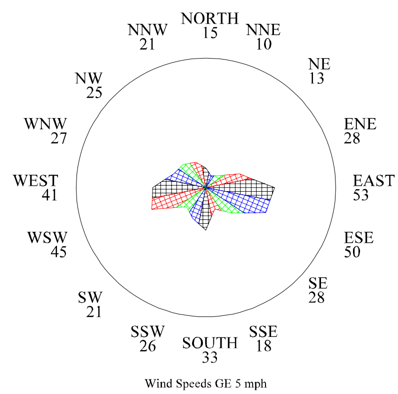
Percent of Time SO_2 Detected for a Given Wind Sector
for DGC #12 during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for DGC #12 during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for DGC #14 during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for DGC #16 during 1999

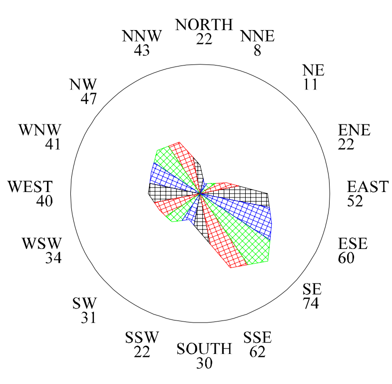
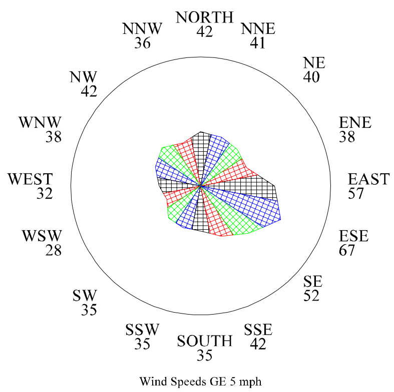


Figure A3-5 DGC Star Charts

Percent of Time SO_2 Detected for a Given Wind Sector
for DGC #17 during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for DGC #17 during 1999

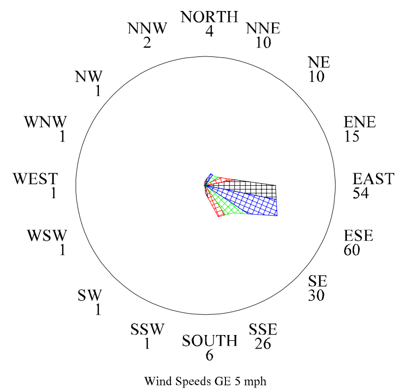
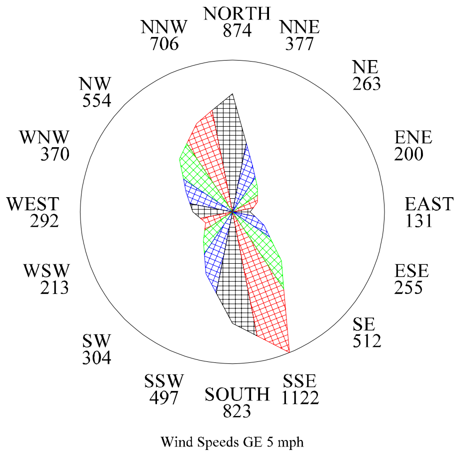
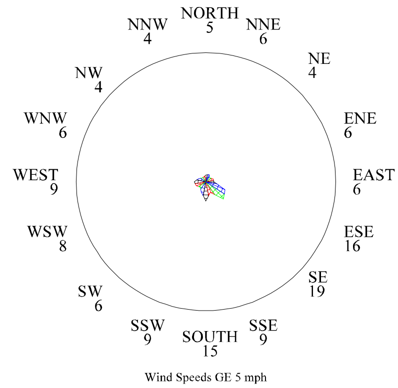


Figure A3-5 DGC Star Charts (cont.)

Fargo NW Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Fargo NW during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Fargo NW during 1999

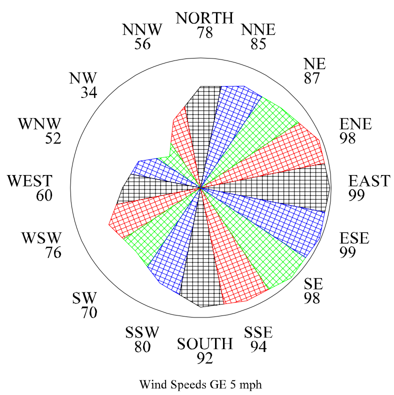
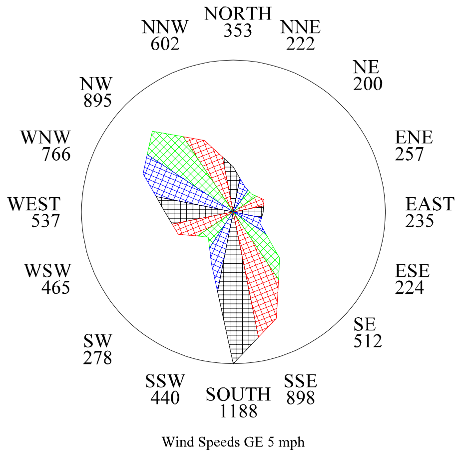
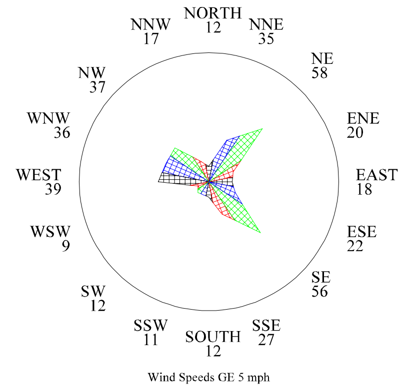


Figure A3-6 Fargo Star Charts

Hannover Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Hannover during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Hannover during 1999

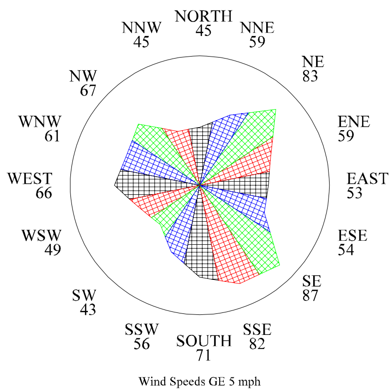
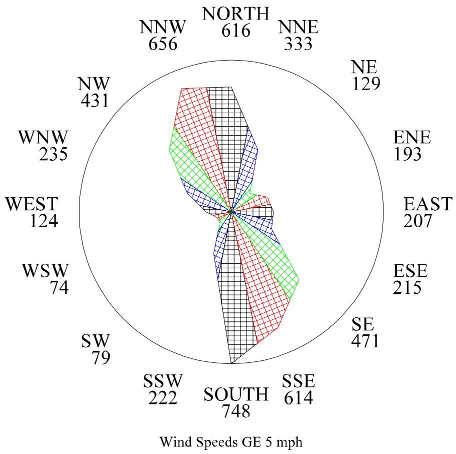
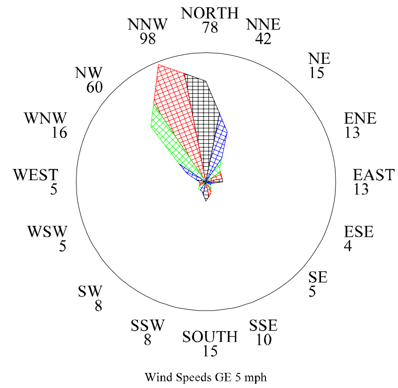


Figure A3-7 Hannover Star Charts

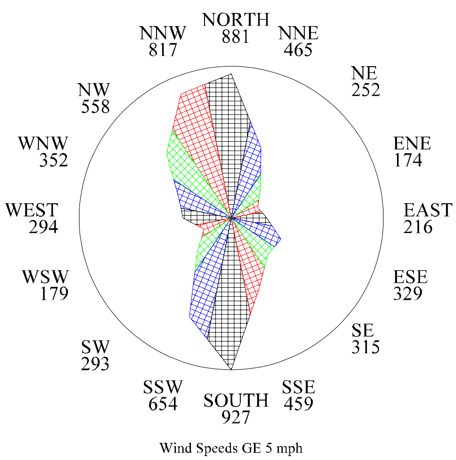
Mandan - SPM Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Mandan - SPM during 1999



Mandan NW - SPM Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Mandan NW - SPM during 1999

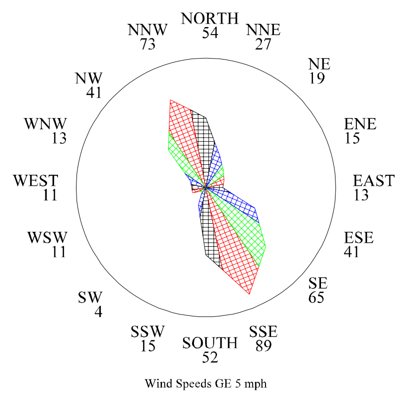
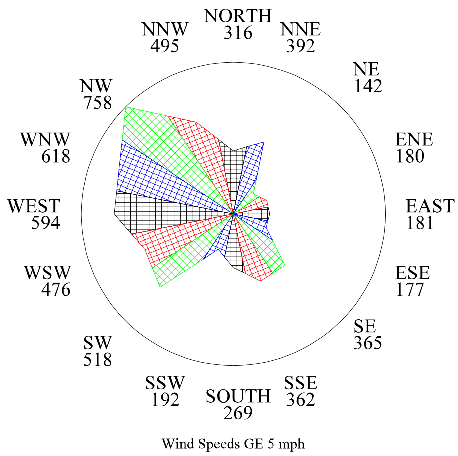
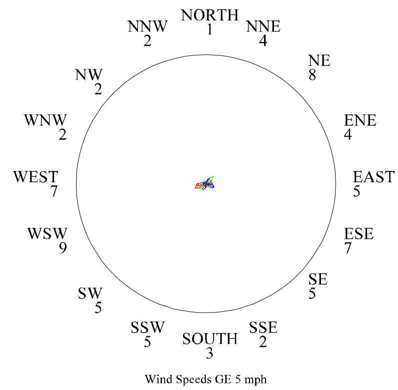


Figure A3-8 Mandan/Mandan NW Star Charts

Sharon Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for Sharon during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Sharon during 1999

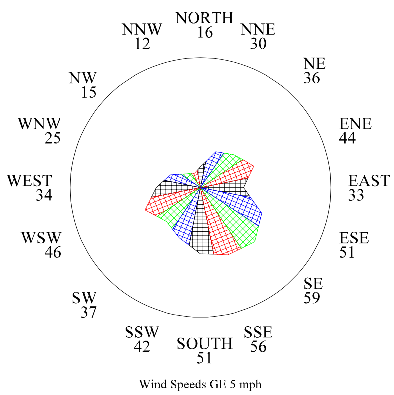
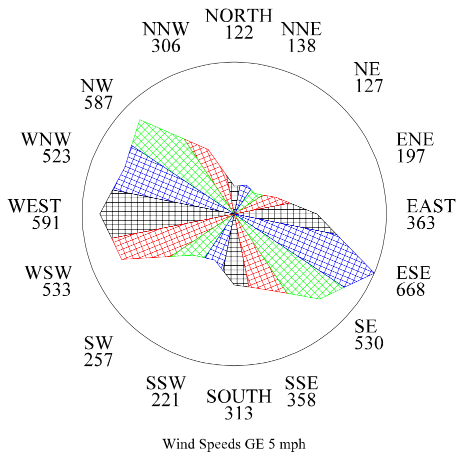
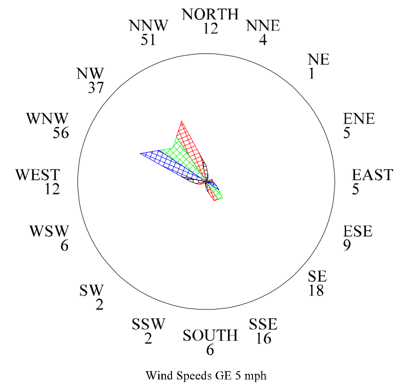


Figure A3-9 Sharon Star Charts

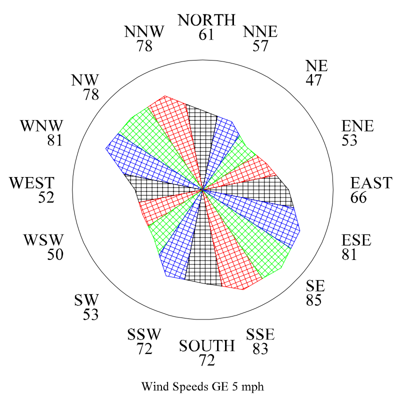
Short Creek - SPM Wind Direction Star Chart
during 1999



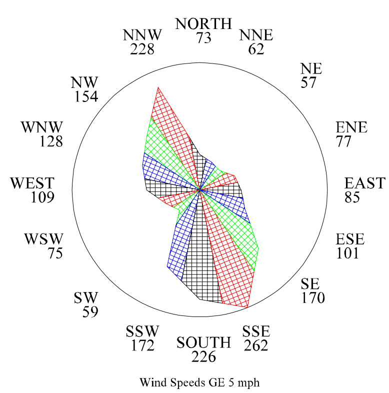
Percent of Time SO2 Detected for a Given Wind Sector
for Short Creek - SPM during 1999



Percent of Time NO_2 Detected for a Given Wind Sector
for Short Creek - SPM during 1999



TRNP - SU (Painted Canyon) Wind Direction Star Chart
during 1999



Percent of Time SO_2 Detected for a Given Wind Sector
for TRNP - SU (Painted Canyon) during 1999

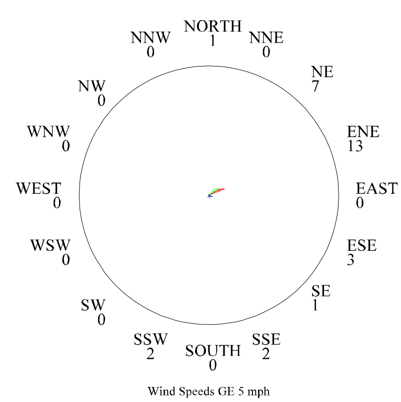
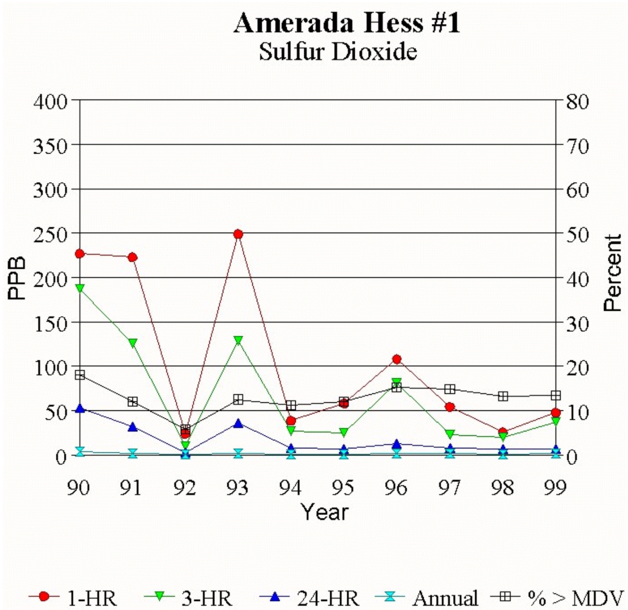


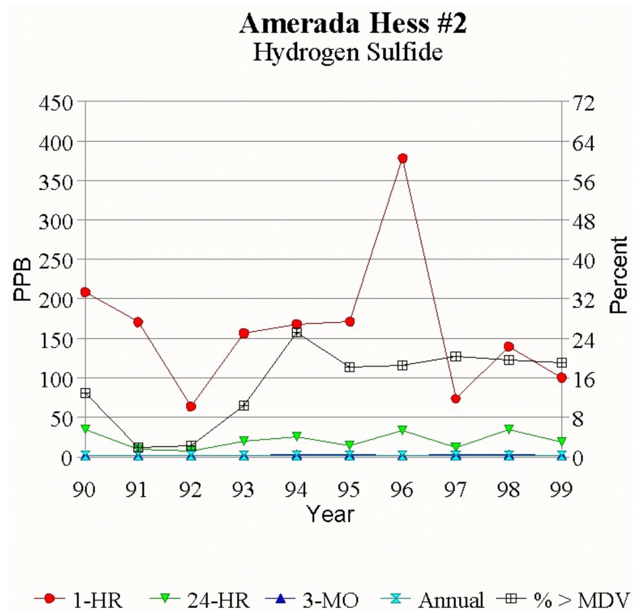
Figure A3-10 Short Creek/TRNP SU Star Charts

APPENDIX 4

1990-1999 Trends

The trend graphs for 1990 through 1999 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).





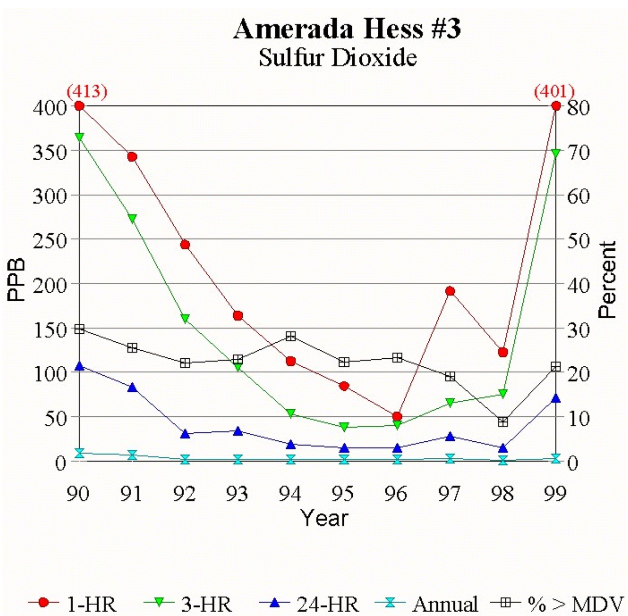
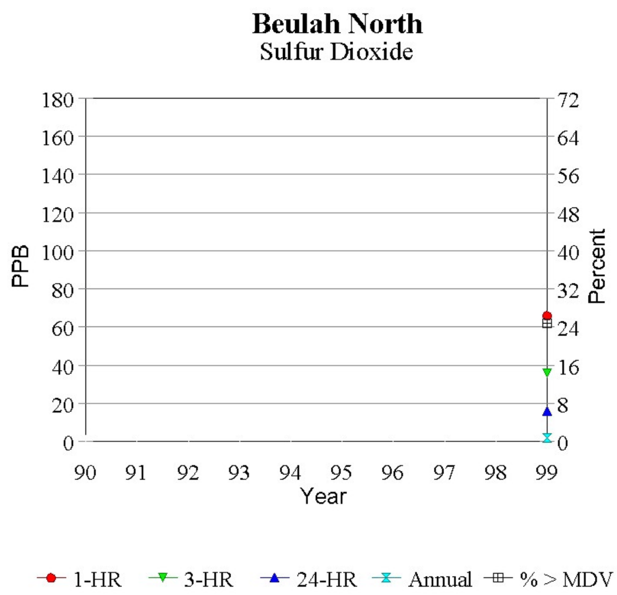
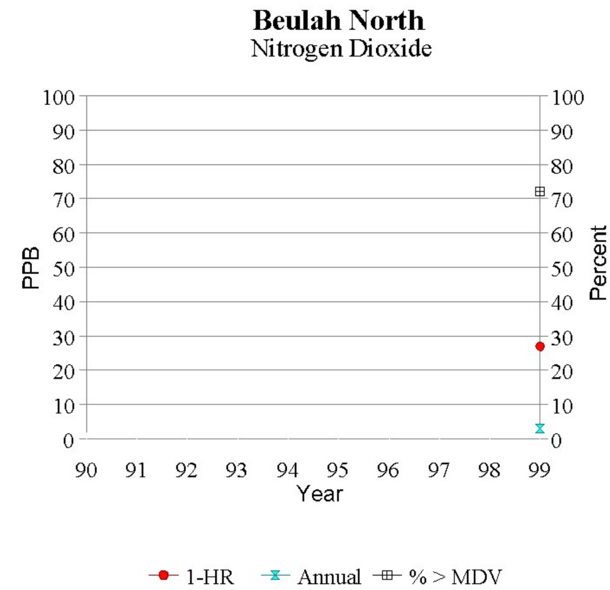


Figure A4-1 Amerada Hess Trends





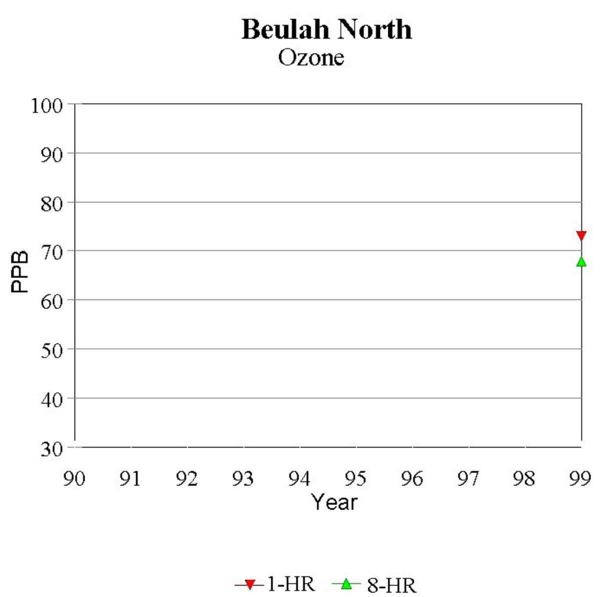
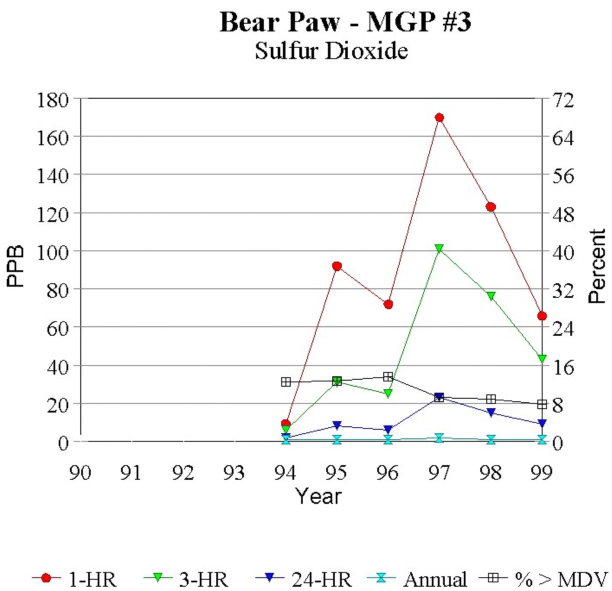
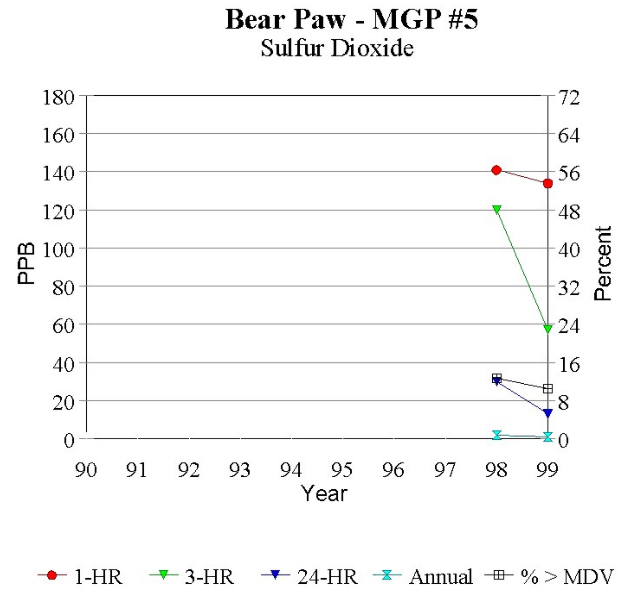
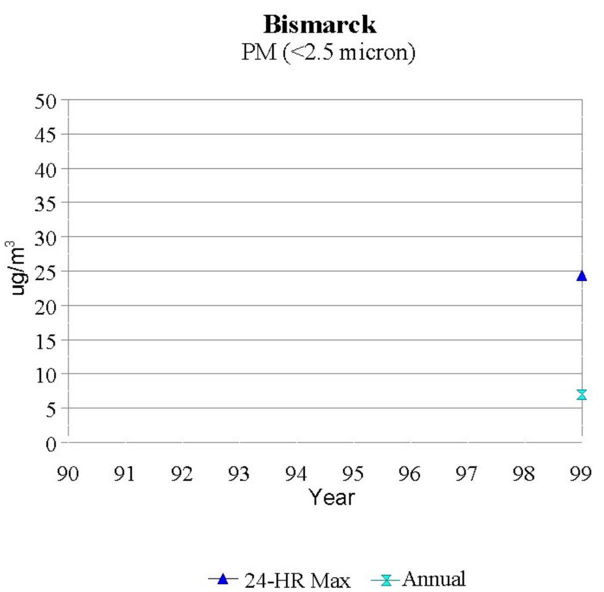
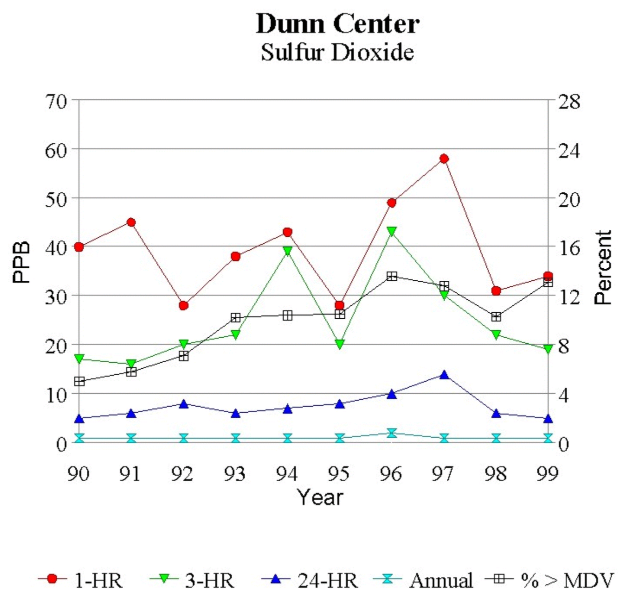


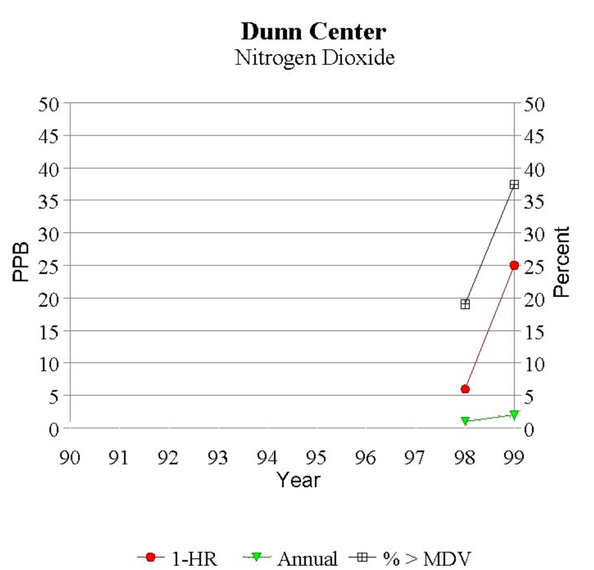
Figure A4-2 Beulah North Trends











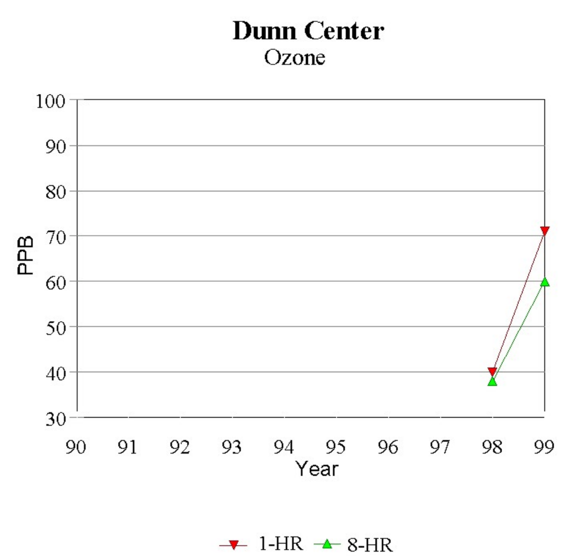
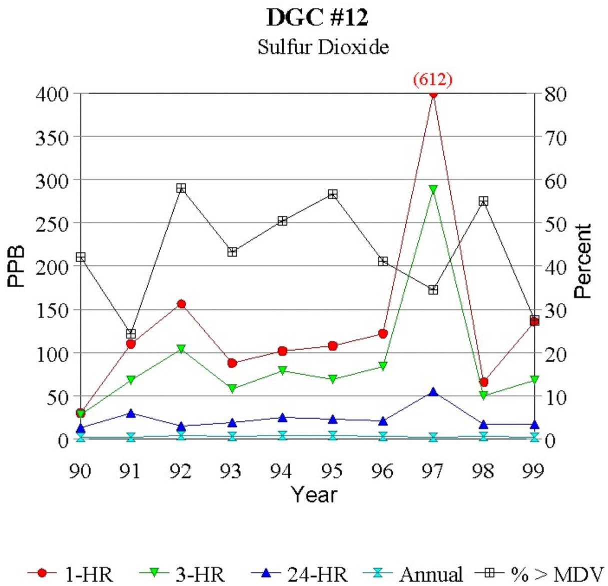
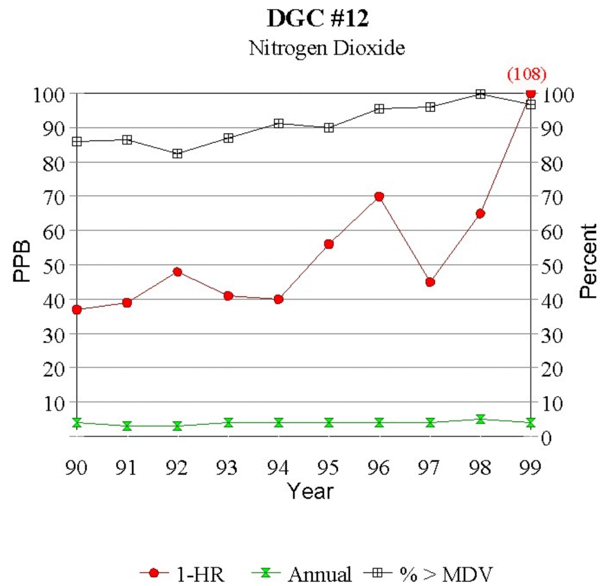
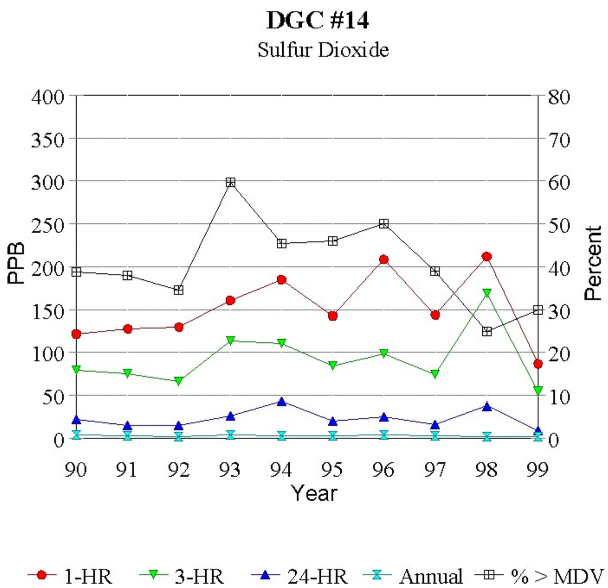
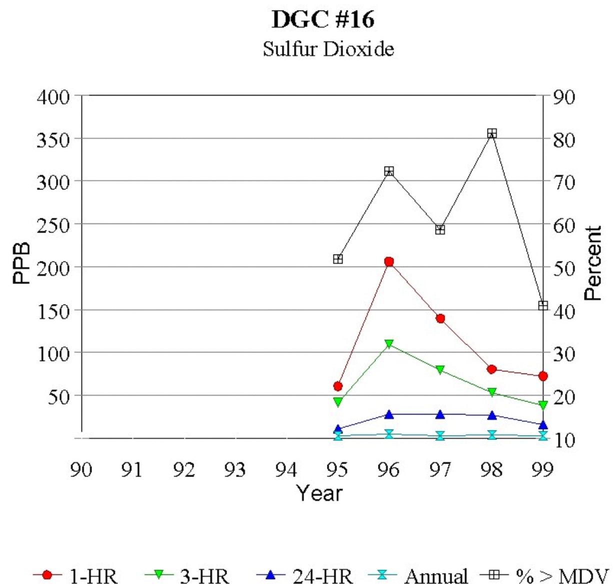


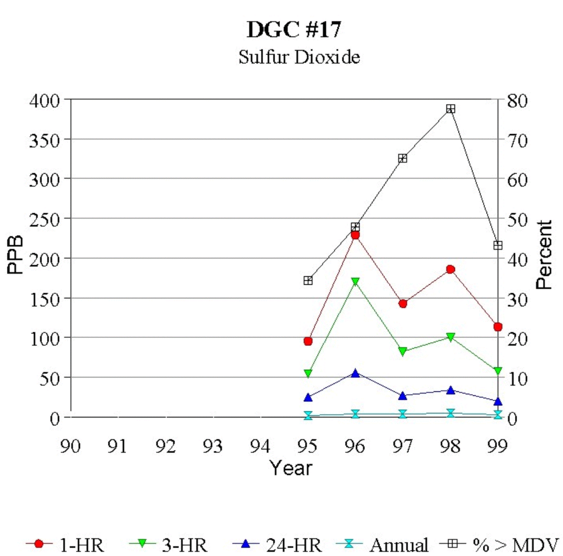
Figure A4-5 Bear Paw/Bismarck/Dunn Center Trends











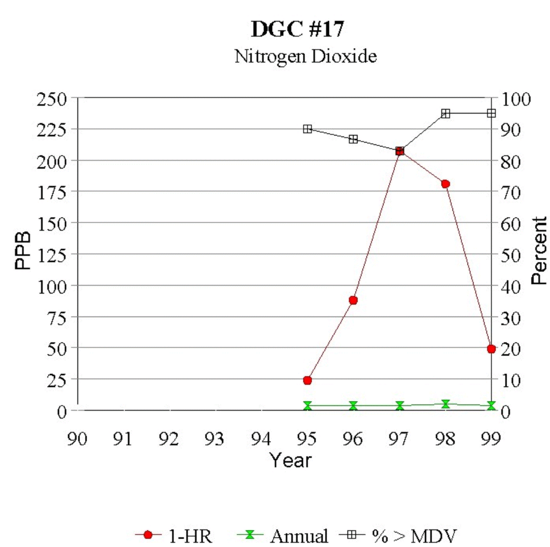
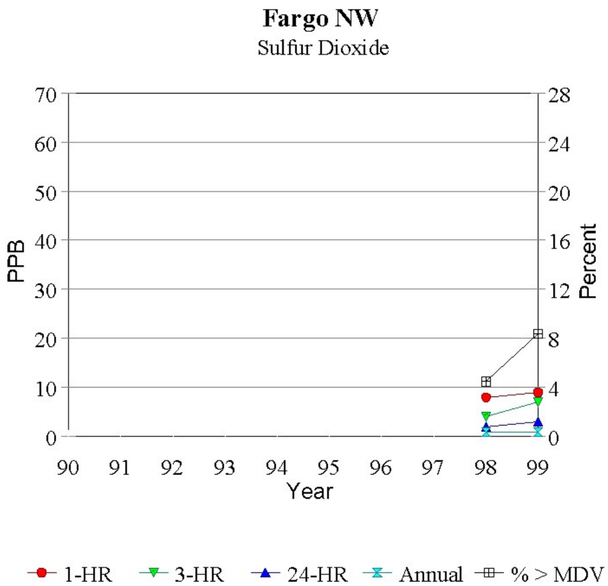
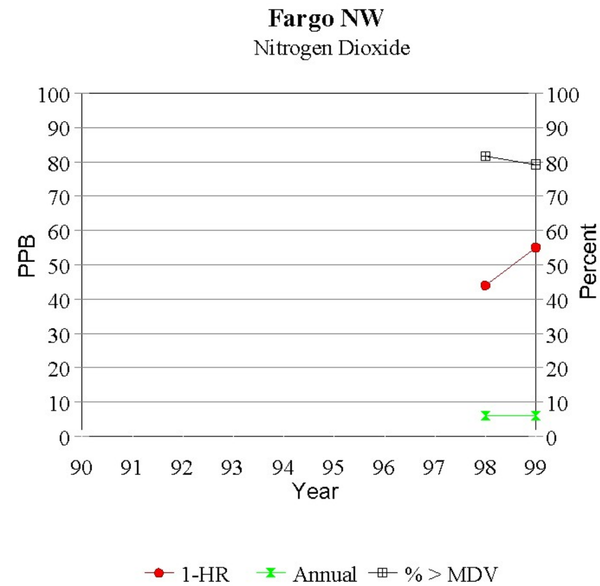
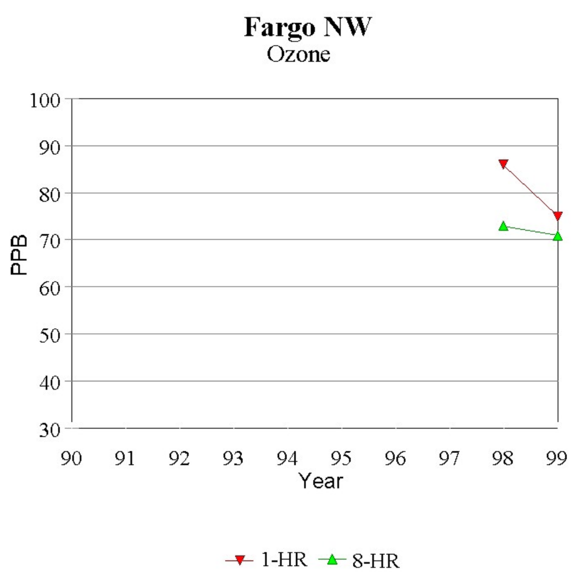
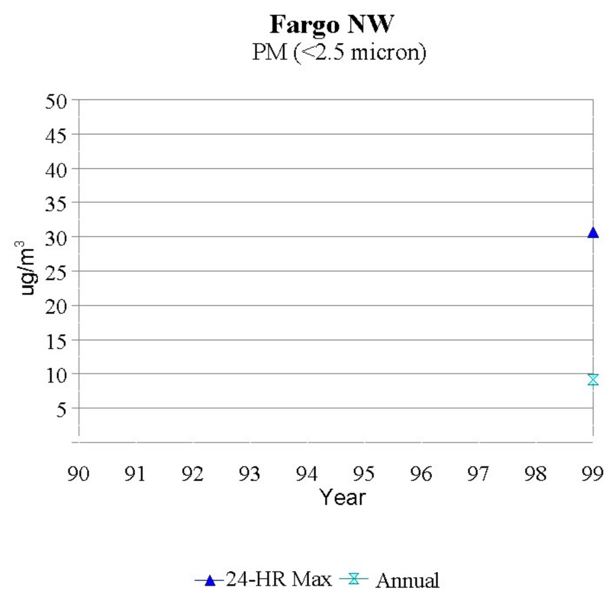


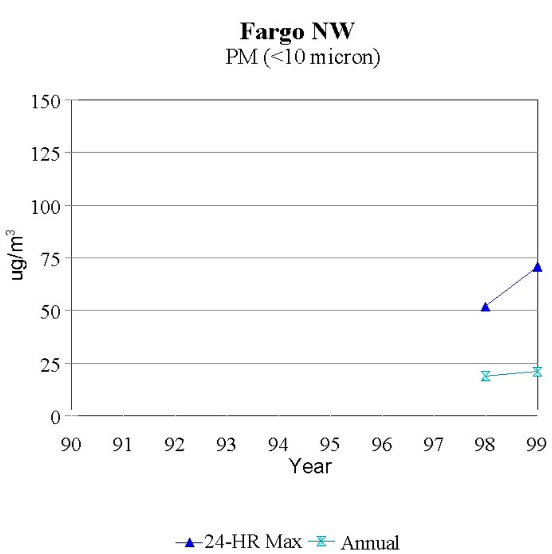
Figure A4-4 DGC Trends











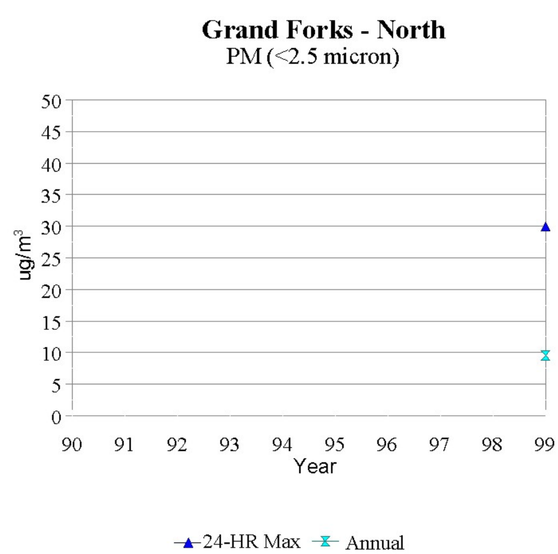
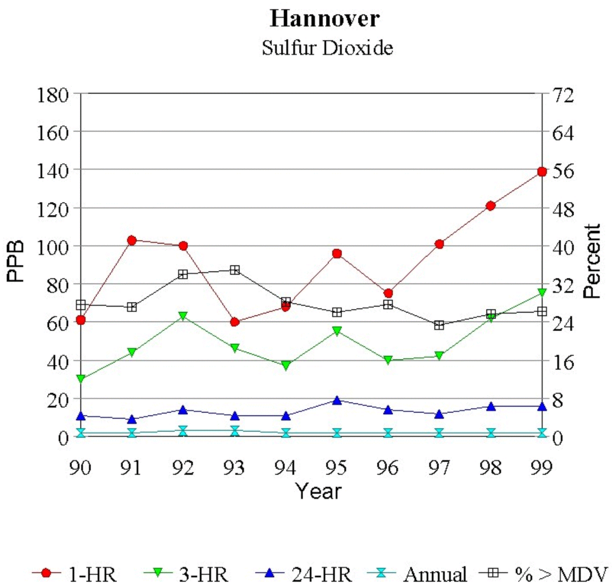
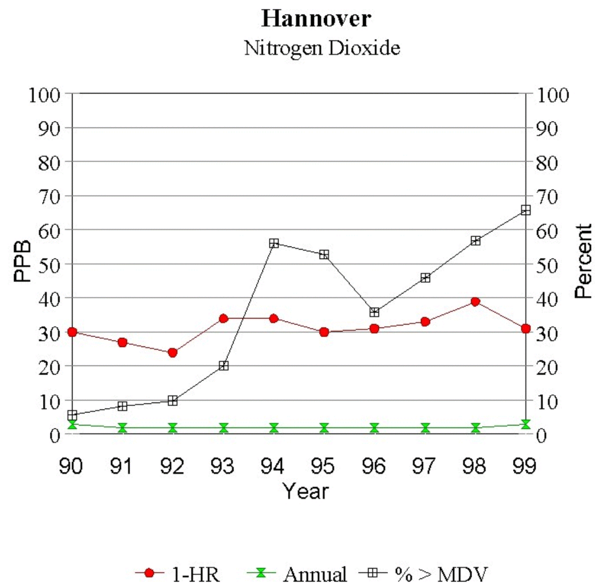
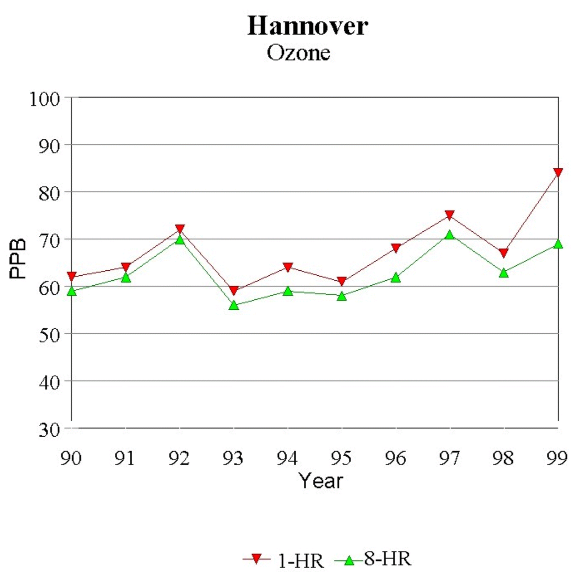
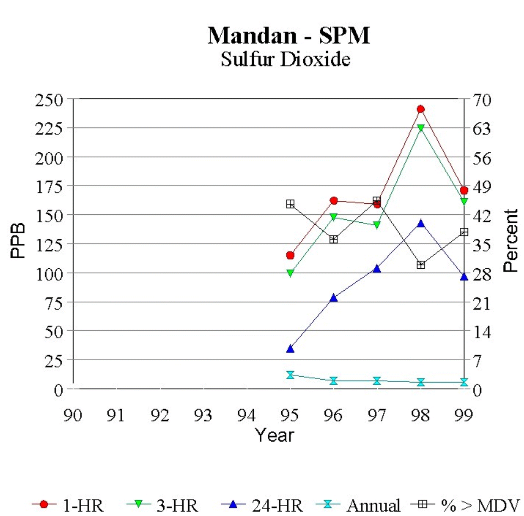


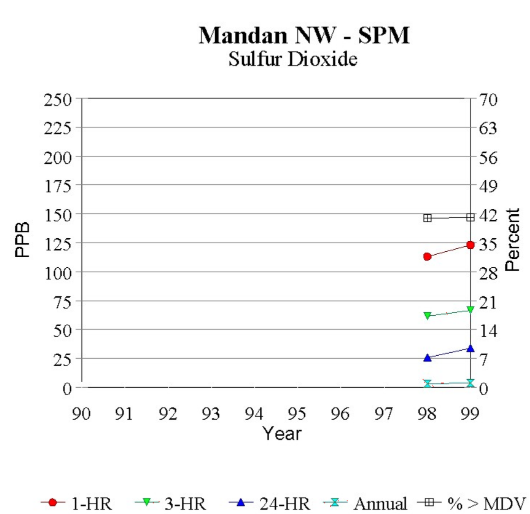
Figure A4-5 Fargo/Grand Forks Trends



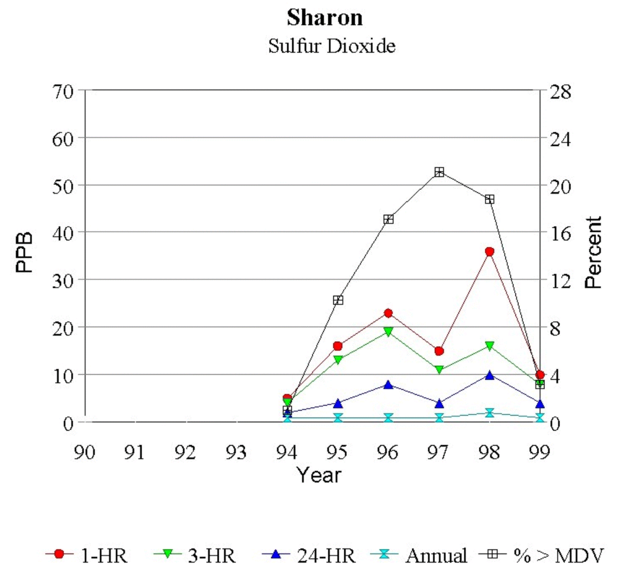


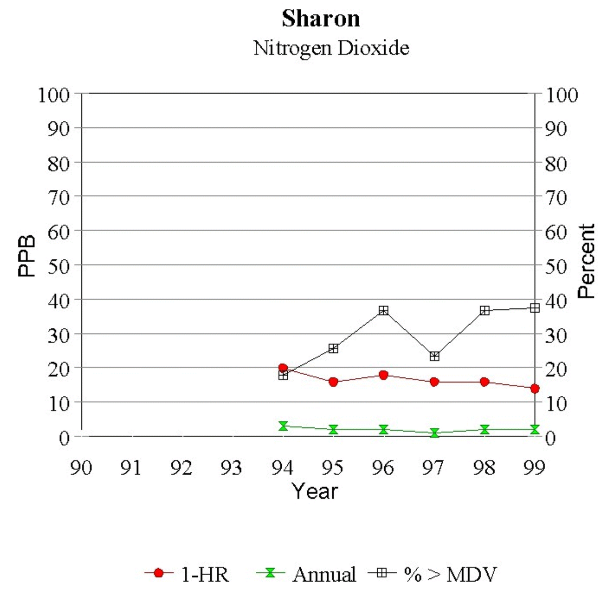


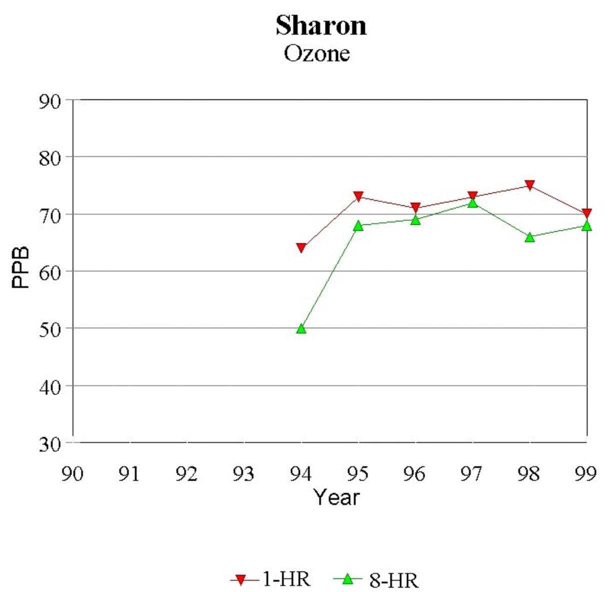




A4-6 Hannover/Mandan/Mandan NW Trends







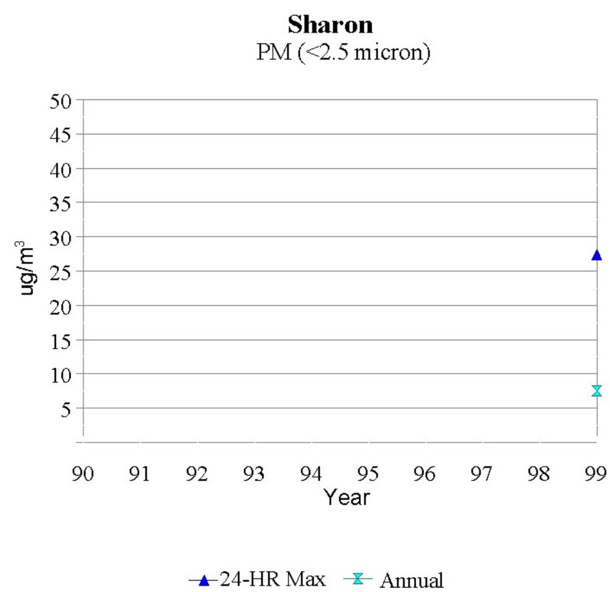
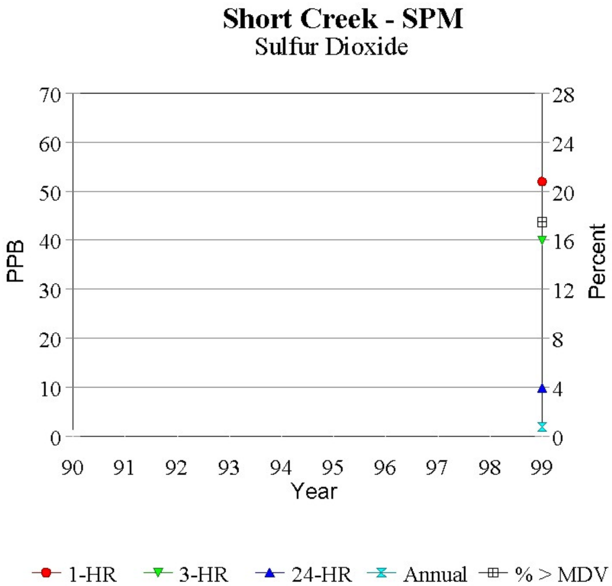
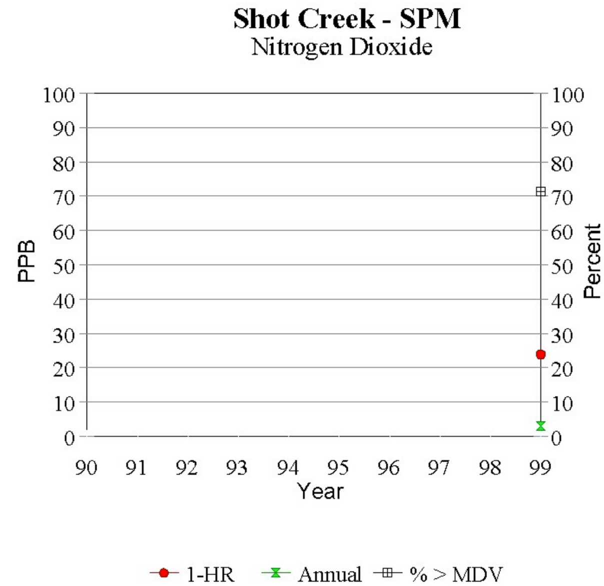
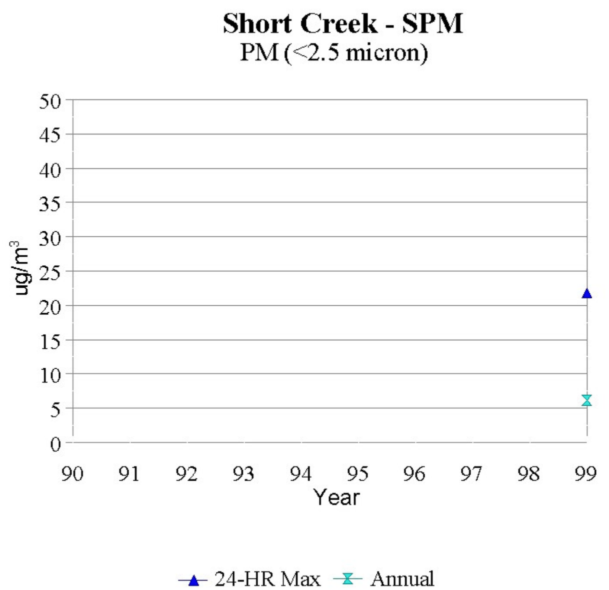
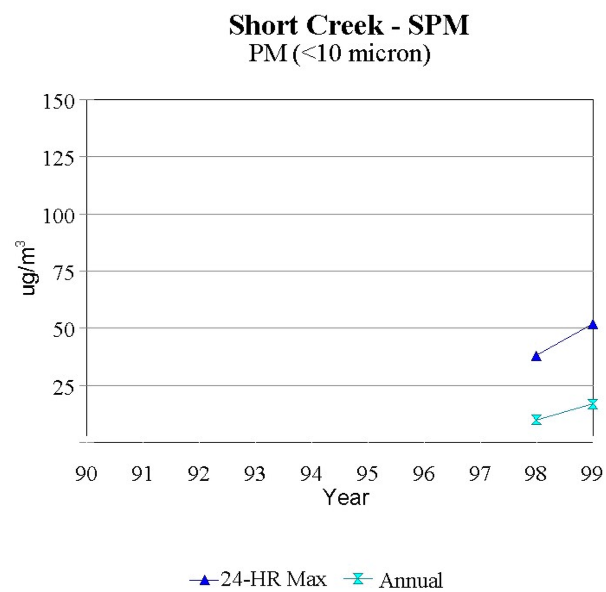


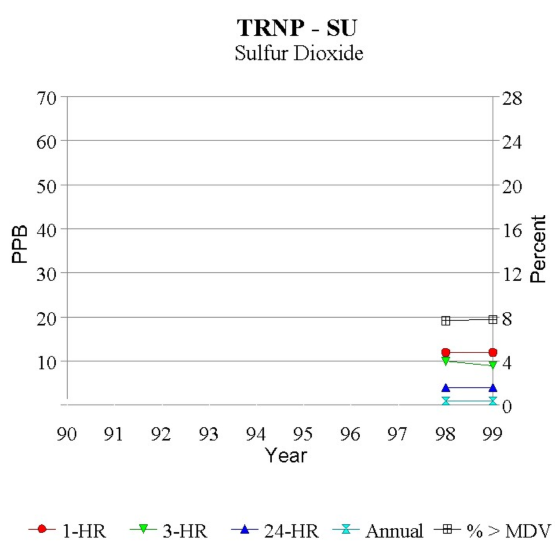
Figure A4-7 Sharon Trends











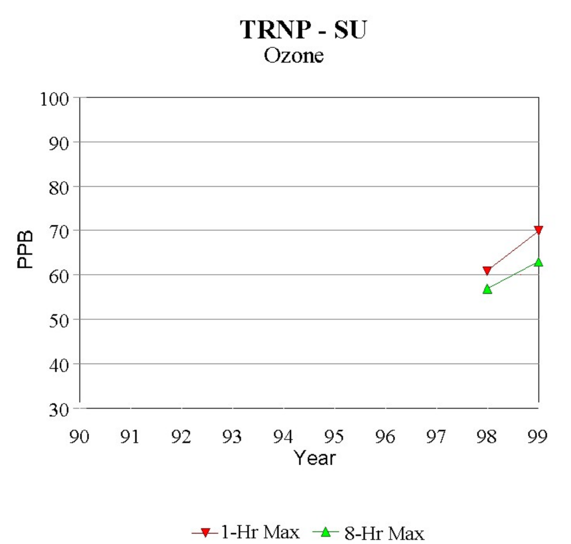


Figure A4-8 Short Creek/TRNP - SU Trends