

Analysis of impact of Evansville Urban Area on Dubois County PM_{2.5} Concentrations

Summary

The Jasper, Indiana monitoring site, in Dubois County, currently has a design value exceeding the PM_{2.5} National Ambient Air Quality Standard (NAAQS). Jasper is located approximately 45 miles northeast of Evansville. Because the Evansville (Vanderburgh County) design value from 2001 - 2003 also exceeded the NAAQS, that area is also being considered for nonattainment designation. However, it appears that 2004 data will drive the design value below the NAAQS in Vanderburgh County. Discussions have recently centered around whether or not EPA should proceed with a nonattainment designation of Vanderburgh County (and other Evansville Urban Area counties) because of its possible impact on the Dubois County monitor value.

The Dubois County monitor is one of three non-urban PM_{2.5} sites operated by IDEM in southwest Indiana. Additional sites are in Knox and Spencer Counties. In addition, there is an Interagency Monitoring of Protected Visual Environments (IMPROVE) site operated at Livonia in Washington County. The site in Spencer County is in Dale, approximately 15 miles due south of Jasper, almost on the southern Dubois County border. There is a map of the monitoring locations on the following page.

The Dubois County site has consistently averaged higher than any other non-urban sites in southwest Indiana. Table 1 shows these differences from 2001 - 2003.

Table 1 Design values for southwestern Indiana PM_{2.5} sites

| County | 2001 | 2002 | 2003 |
|---------|-------|-------|-------|
| Dubois | 16.54 | 16.34 | 15.72 |
| Knox | 13.39 | 14.20 | 13.96 |
| Spencer | 14.52 | 14.06 | 14.63 |
| Livonia | 13.30 | 12.26 | 12.30 |

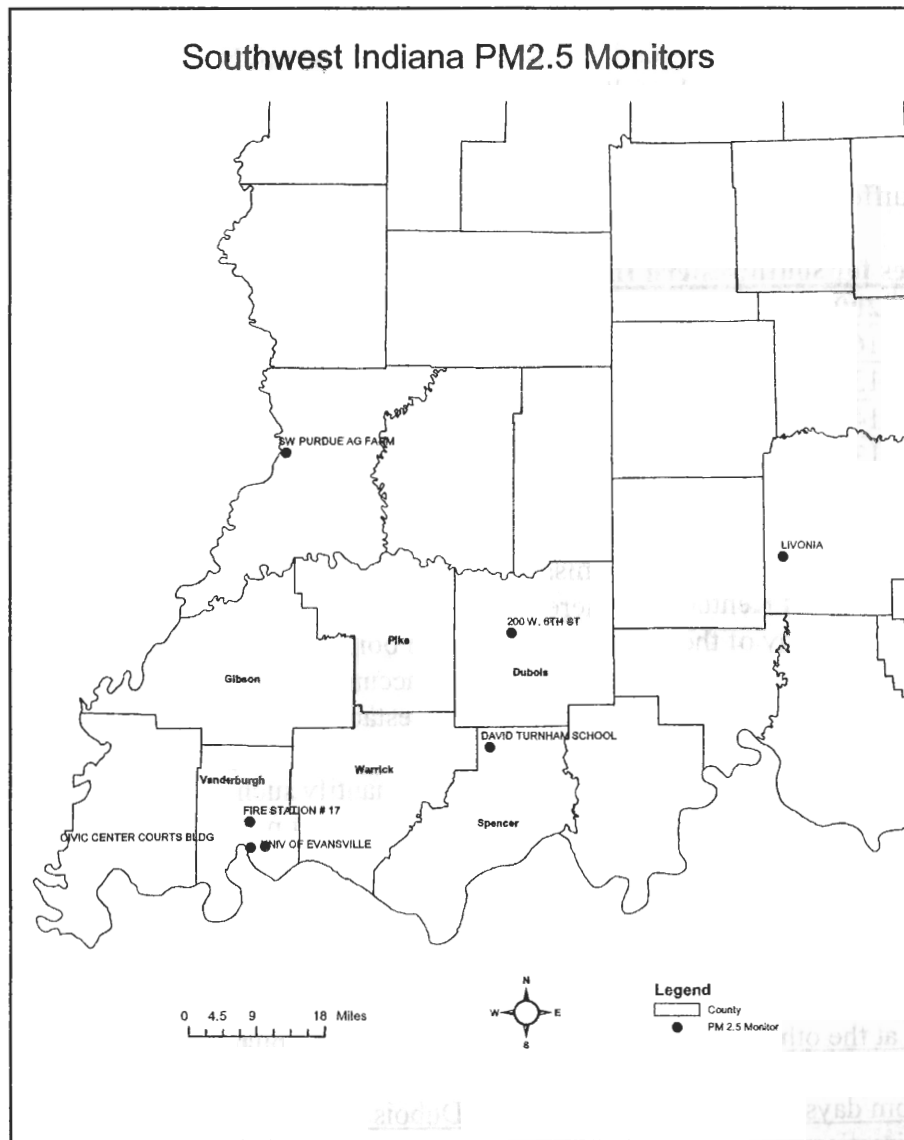
In attempting to determine why Dubois County has had higher values, several analyses have been performed. Regionally, there are significant amounts of emissions from large utilities in southwestern Indiana, as well as utilities in southern Illinois and Kentucky. There are a significant number of wood furniture manufacturers located in the Jasper area. Many of these burn scrap wood in boilers. Emissions from these sources are not large annually, but wood is generally burned when supplies accumulate. These sources could impact the monitoring site on certain days, but this has not been clearly established. Emissions from heavy-duty diesel trucks and other traffic along US 231, a major north-south highway which passes several hundred yards west of the site, may also be impacting monitored values, but data to quantify such an impact are not available. Therefore, an analysis of meteorological data and monitoring values at nearby sites was performed.

The following conclusions about Dubois County data were reached based upon this analysis:

1. Average wind directions for the 2002 - 2003 time period were primarily from the south and southwest.
2. Background levels at the other sites were all 12 - 14 $\mu\text{g}/\text{m}^3$ for an annual average.
3. Wind directions from days with high PM_{2.5} values at Dubois County are seldom from Vanderburgh County. An analysis of wind direction on days with the highest values, e.g. over 20 $\mu\text{g}/\text{m}^3$, at the Jasper site in Dubois County showed that the wind direction seldom was from the south or southwest (origin of Vanderburgh County).

4. On days with high values at Dubois County, the other sites are usually high also. This analysis also showed that generally when one non-urban site in southwest Indiana was over $20 \mu\text{g}/\text{m}^3$, the others were also. On these days, these sites were seldom impacted by an air mass that moved over the Evansville area. On days in which Evansville was directly upwind of Dubois County, the Dubois values were relatively the same as the other sites not impacted by Evansville. For the Dubois County site, the mass for the days with values above $20 \mu\text{g}/\text{m}^3$ contributed about $3 \mu\text{g}/\text{m}^3$ to the annual average.

5. $\text{PM}_{2.5}$ values for this area are greatly impacted by regional transport. Speciated data are not available from sites operated by IDEM. However, the Livonia IMPROVE site and others in the general area show that sulfate is the predominate portion of the sample, followed by organic carbon. This indicates emissions from regional transport sources, such as utilities, is a major contributor to concentrations in the area. For Vanderburgh County, SO_2 emissions for the past three years have averaged less than 40 tons per year. Reducing these emissions to zero would likely have little to no impact on Dubois County.



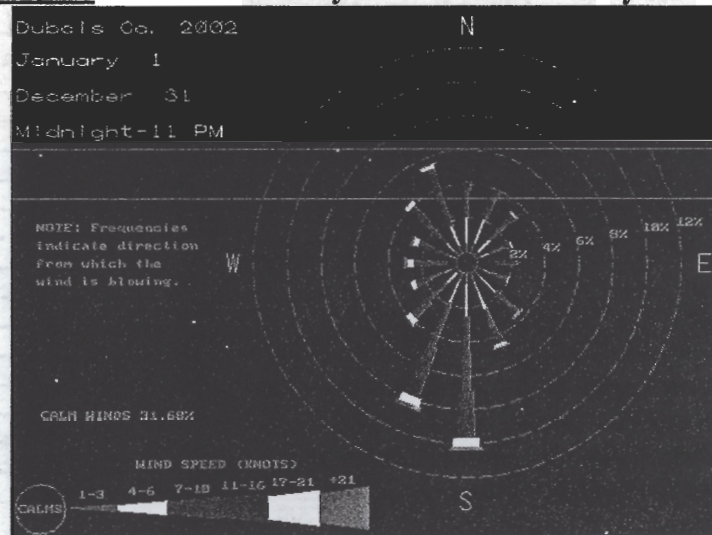
Detailed Analysis

Data Used for Analysis

Information was gathered through the Indiana climate page on the Purdue Applied Meteorology Group – Department of Agronomy website <http://shadow.agry.purdue.edu/sc.hly-geog.html>. Southern Purdue Agricultural Research Center in Dubois, Dubois County was selected.

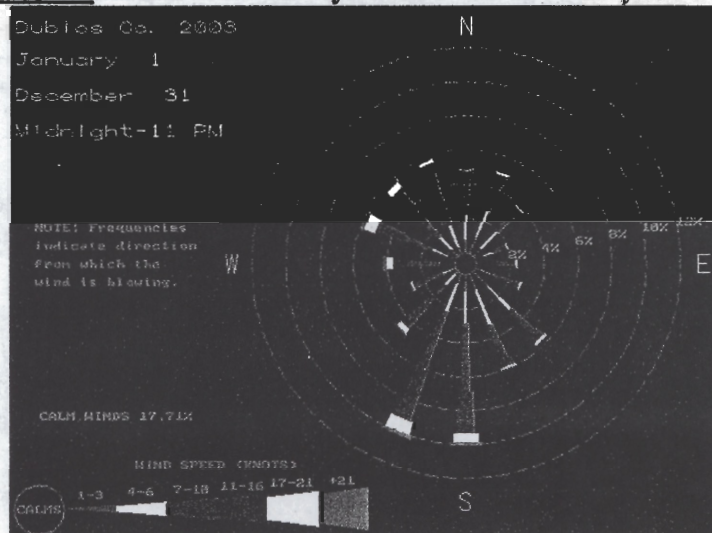
Graph 1 shows the wind rose from Dubois County for 2002. The wind blows most frequently from the south, south-southwest, north-northwest, south-southeast, southwest and northwest.

Graph 1 Wind Rose Analysis for Dubois County for 2002



Graph 2 shows the wind rose from Dubois County for 2003. The wind blows most frequently from the south-southwest, south, south-southeast, west-northwest, northwest, southeast and north-northwest.

Graph 2 Wind Rose Analysis for Dubois County for 2003



Analysis of data values 20 ug/m3 and over

An analysis was performed to determine if high values were associated with different wind directions. IDEM had made wind roses for 2002 and 2003 high days earlier, so these were used for the analysis. The days used for this analysis are in Table 2.

Table 2

| | 2002 | | | | | 2003 | | | | | Wind Direction |
|------------|--------|------|---------|---------|----------------|------------|------|---------|---------|----------------|----------------|
| | Dubois | Knox | Spencer | Livonia | Wind Direction | Dubois | Knox | Spencer | Livonia | Wind Direction | |
| 1/2/2002 | 21.6 | 13.2 | 20.2 | | NW - NE | 1/30/2003 | 38.2 | 27.2 | 23.9 | NE-S | |
| 1/20/2002 | 20.6 | 15.6 | 18.6 | 15.2 | SE-S | 2/26/2003 | 29.1 | 24.0 | 22.4 | 16.8 | NE-S |
| 3/18/2002 | 23.9 | 18.0 | | 18.3 | N-NE | 3/1/2003 | 52.9 | 49.8 | | 29.6 | NW |
| 6/4/2002 | 24.7 | | | 28.0 | S-SW | 3/7/2003 | 18.1 | 21.6 | | 11.5 | SE-SW |
| 6/10/2002 | 21.9 | 21.9 | | 18.9 | SE-S | 3/13/2003 | 50.0 | 29.3 | | 22.3 | NW-SE |
| 6/19/2002 | 28.2 | 28.3 | 27.8 | | SE-S | 4/18/2003 | 30.2 | 28.3 | | 23.5 | SW-NW |
| 6/22/2002 | 31.6 | 38.6 | | 32.0 | E-SE | 6/17/2003 | 25.1 | 27.7 | | 22.0 | NW-NE |
| 6/25/2002 | 20.8 | 15.5 | 20.5 | 14.3 | SE-SW | 6/23/2003 | 16.4 | 24.2 | | 20.2 | SE |
| 7/1/2002 | 27.2 | 25.3 | 27.2 | 27.2 | N* | 6/29/2003 | 21.4 | 22.1 | | 17.7 | SE-SW |
| 7/4/2002 | 33.9 | 35.9 | | 27.8 | NE* | 7/2/2003 | 21.4 | 34.4 | 24.7 | 18.2 | NW |
| 7/10/2002 | 22.0 | 19.9 | | 18.0 | NE* | 7/5/2003 | 20.8 | 18.6 | | 24.2 | SW |
| 7/13/2002 | 29.4 | 28.7 | 26.5 | 24.4 | NE* | 7/14/2003 | 22.0 | 25.7 | 22.9 | 22.1 | SE |
| 7/16/2002 | 43.1 | 43.8 | | 33.7 | SE* | 7/20/2003 | 38.0 | 29.0 | | 35.3 | S-SW |
| 7/22/2002 | 23.5 | | | 23.9 | | 7/26/2003 | 24.6 | 22.0 | 24.8 | 25.6 | S-SW |
| 7/25/2002 | 20.3 | 21.4 | 25.3 | 15.7 | NE-SE* | 8/1/2003 | 31.4 | 26.4 | 27.9 | 27.3 | SW |
| 7/31/2002 | 23.3 | 18.9 | 26.7 | | | 8/13/2003 | 38.0 | 33.9 | 34.6 | 37.2 | NE-SE |
| 8/3/2002 | 45.6 | | | | SE* | 8/16/2003 | 26.0 | 21.9 | | 27.0 | NW |
| 8/12/2002 | 24.5 | 24.0 | 24.3 | 22.6 | SE-SE* | 8/19/2003 | 24.4 | 22.7 | | 24.0 | N-SE |
| 8/21/2002 | 25.1 | 26.2 | | 22.0 | SE-S | 8/22/2003 | 25.7 | 25.7 | | 22.1 | S-SW |
| 8/27/2002 | 23.8 | | | 20.3 | N-NE | 8/25/2003 | 31.6 | 27.8 | 31.0 | 31.6 | SW |
| 8/30/2002 | 25.5 | | 22.3 | 19.9 | NE-E | 8/28/2003 | 21.7 | 18.6 | | 20.4 | S-SW |
| 9/2/2002 | 21.3 | | | 21.1 | SE-SW | 9/12/2003 | 39.5 | 37.9 | 38.1 | 32.2 | SE |
| 9/8/2002 | 36.3 | | | 31.0 | SE-SW | 9/18/2003 | 20.5 | 19.7 | 20.0 | 21.2 | NE |
| 9/17/2002 | 27.8 | 24.7 | 28.4 | 22.0 | SE | 9/21/2003 | 20.8 | 17.4 | | 22.8 | NE-SE |
| 9/29/2002 | 21.7 | 25.2 | 20.6 | 19.9 | E-SE | 10/9/2003 | 24.2 | 28.5 | | 18.3 | SE |
| 11/28/2002 | 20.4 | | 18.2 | 13.7 | SW | 11/11/2003 | 22.0 | 22.4 | 18.9 | 16.6 | SW |
| 12/7/2002 | 31.5 | | | 19.7 | S-SW | | | | | | |
| 12/10/2002 | 25.0 | | 21.5 | 16.2 | NE | | | | | | |

*Wind directions taken from Evansville NWS site. See the attachments for a complete set of wind roses for Dubois and Evansville meteorological sites. Data from the two sites are comparable so Evansville data was substituted where Dubois County data was unavailable.

PM_{2.5} data used for the Livonia site is from <http://vista.cira.colostate.edu/improve/>. This sampler uses a different protocol than the FRM sites, but results are similar. The Dubois, Knox, and Livonia sites operate on a 1 in 3 day schedule, while Spencer County is 1 in 6 days. Therefore, the analysis was done on a 1 in 6 day schedule so that data would be comparable.

This analysis showed:

- When Dubois County site was high, generally, so also were the other non-urban sites, indicating a regional contribution to the samples

- The days with values over 20 ug/m^3 contributed nearly 3 ug/m^3 to the annual average. This was calculated by the following method:

1. summing the values of the 28 days for 2002, sum = 744.5, 26 days for 2003 = 734
2. calculating the baseline of 15 ug/m^3 for those days; $28 \times 15 = 420$ for 2002, $26 \times 15 = 390$ for 2003
3. subtracting the baseline from the sum of the values; $744.5 - 420 = 324.5$, $734 - 390 = 344$
4. dividing each by 122 sample days for an entire year; $324.5/122 = 2.66$ for 2002, 2.82 for 2003

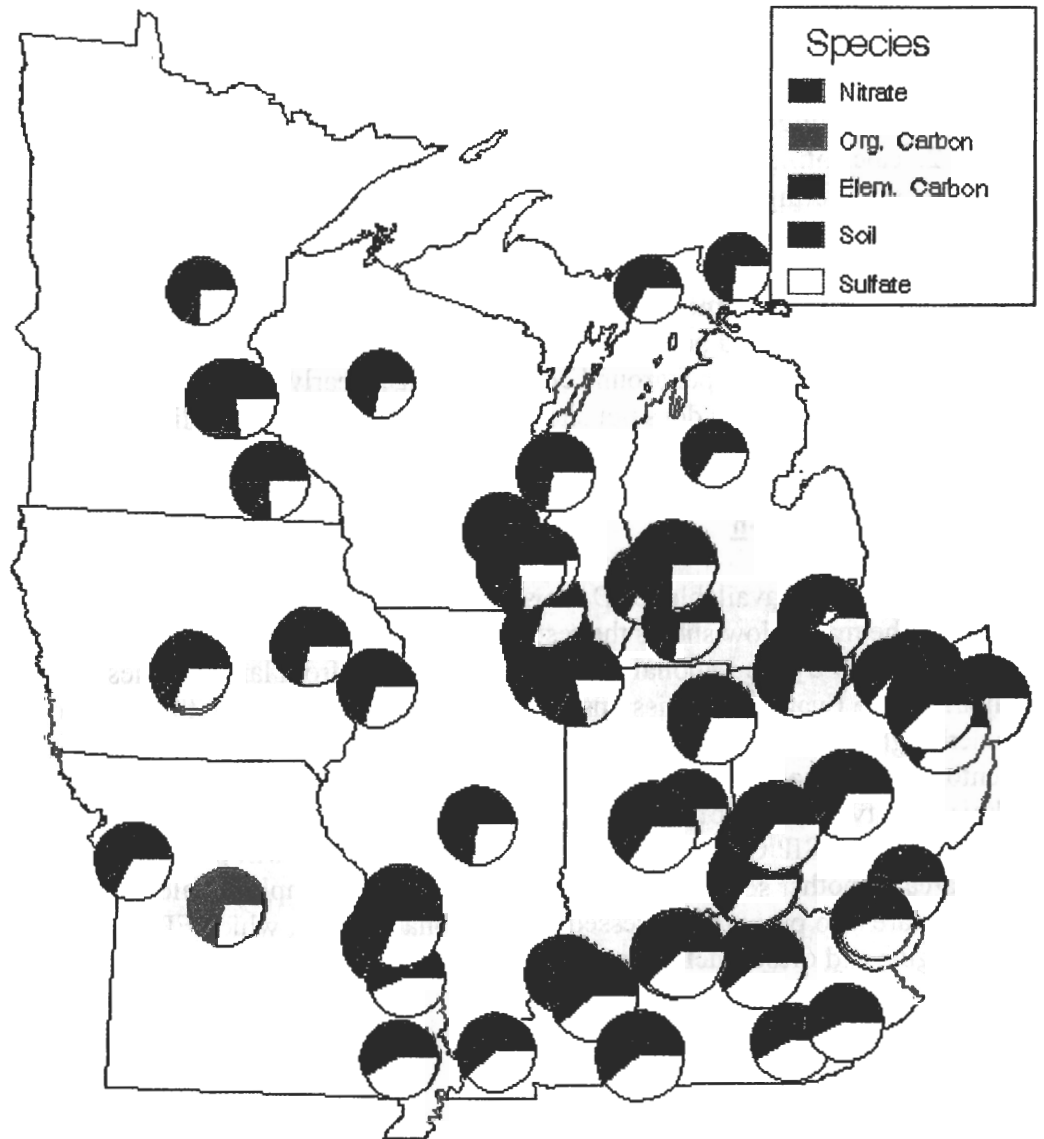
When these values are removed from the 2001 - 2003 design value of 16.2 ug/m^3 for Dubois County, it can be seen that the value would be well below the NAAQS of 15 ug/m^3 . While an impact from Vanderburgh County could be included in the background concentrations, clearly **there is** a regional component that needs to be examined. Available data does not show that high values are more likely to occur at the Jasper site when the air mass is from the Evansville area.

Speciation information

No speciated data is available for Dubois County. However, it is available for Livonia and several other sites in the area. The map below shows the results. Sulfates are a major component of the sample in this area, impacted greatly by the regional transport of emissions from large utilities. In this area, most pie charts look similar. While Evansville emissions could impact Dubois County, the point source emissions from Vanderburgh County have averaged under 40 tons/year from 2001 - 2003. See the attachments for the inventory spreadsheet. Reducing these emissions to zero will not likely solve the attainment problems in Dubois County. Several of the counties in the area have large utilities. Addressing their regional impact through the NOx SIP Call and the Clean Air Interstate Rule will provide a better means of achieving attainment in this area. Another source of emissions impacting the samples could be mobile source emissions. These emissions are also properly addressed by a regional process, which EPA has already started with heavy duty diesel engine and diesel fuel rules, for both on- and off-road vehicles.

Annual Average Species Contribution to Fine M₁₀

Data from EPA Speciation Network, July 2002—June 2003



Attachments to Dubois County Analysis

Dubois County Wind Roses, 2002

Dubois County Wind Roses, 2003

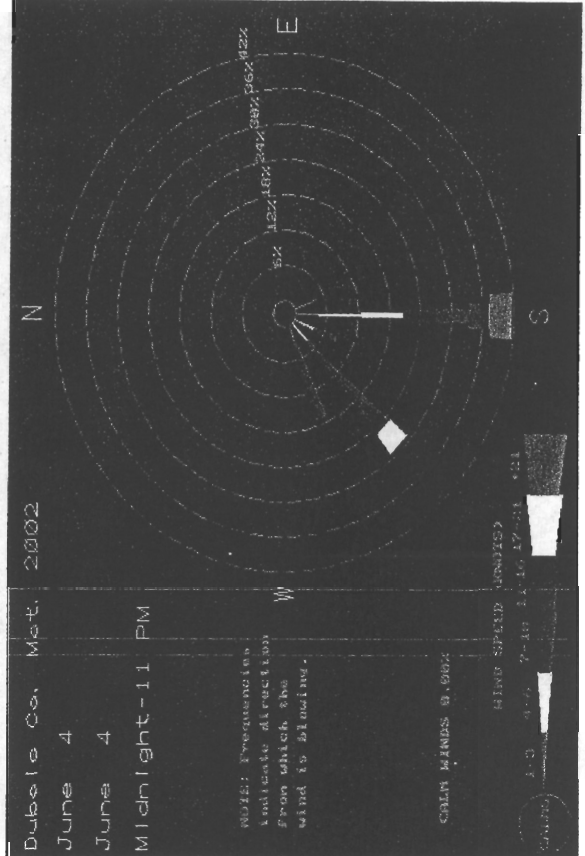
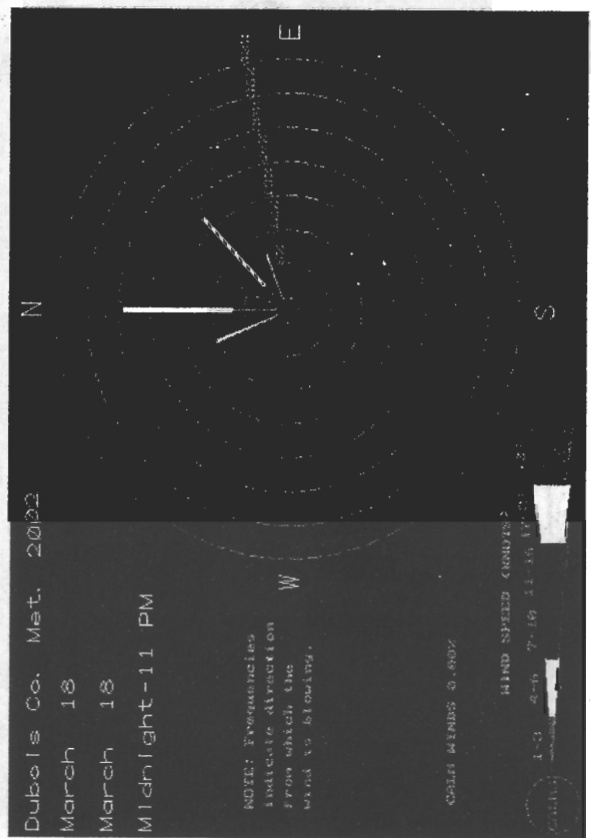
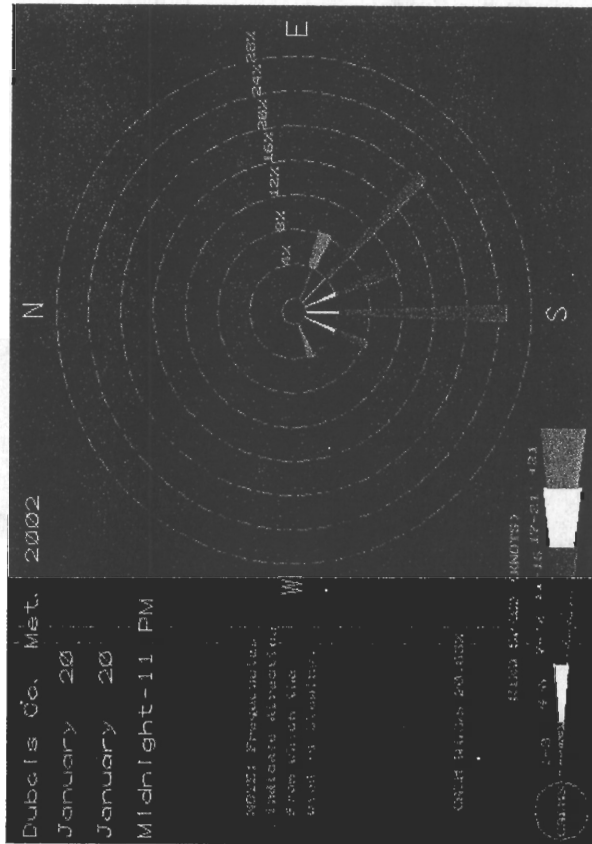
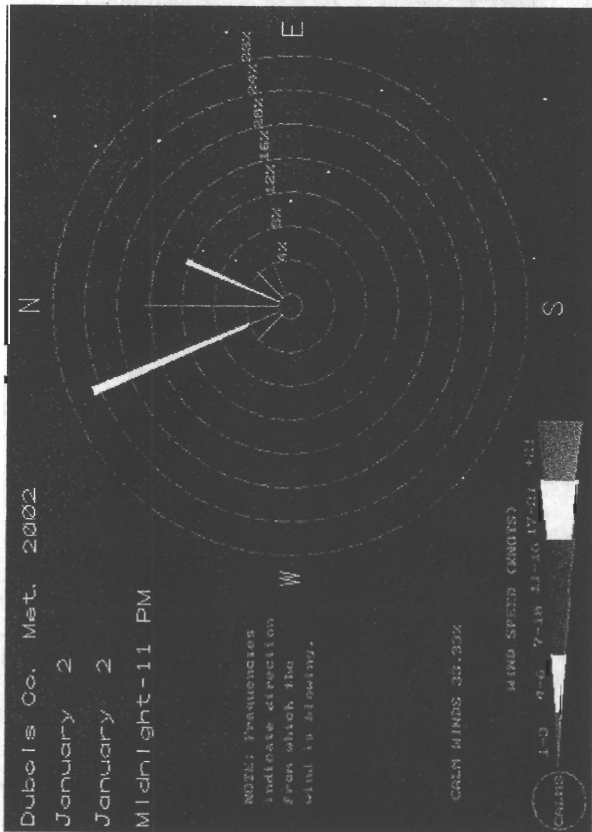
Evansville Wind Roses, 2002

Evansville Wind Roses, 2003

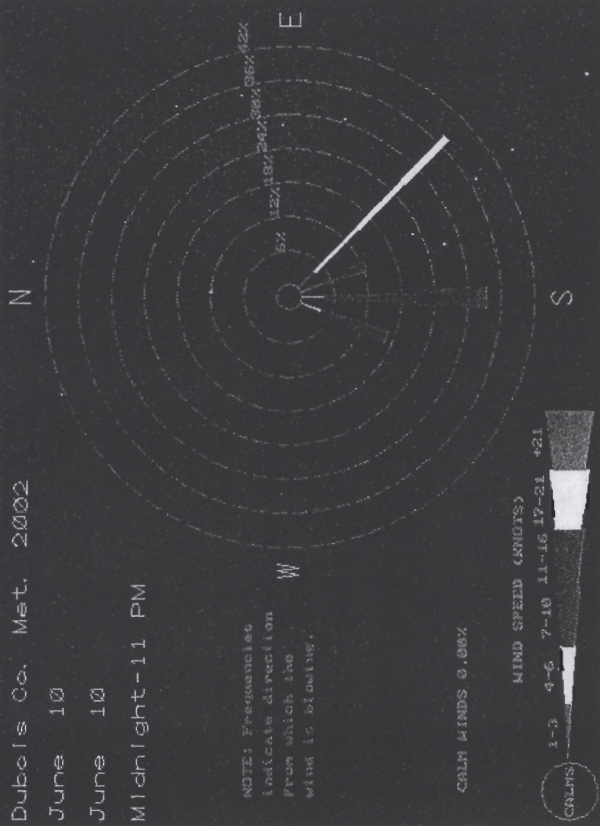
Vanderburgh County SO2 Emissions Inventory

Duboais County Wind Rose Analysis - 2002

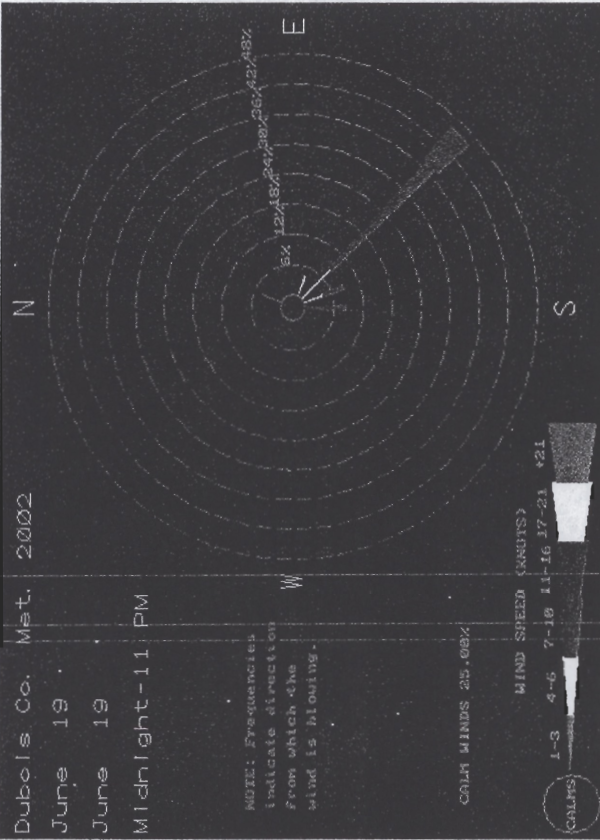
Wind Speed and Wind Direction on Days where PM2.5 readings were $\geq 20 \mu\text{g}/\text{m}^3$



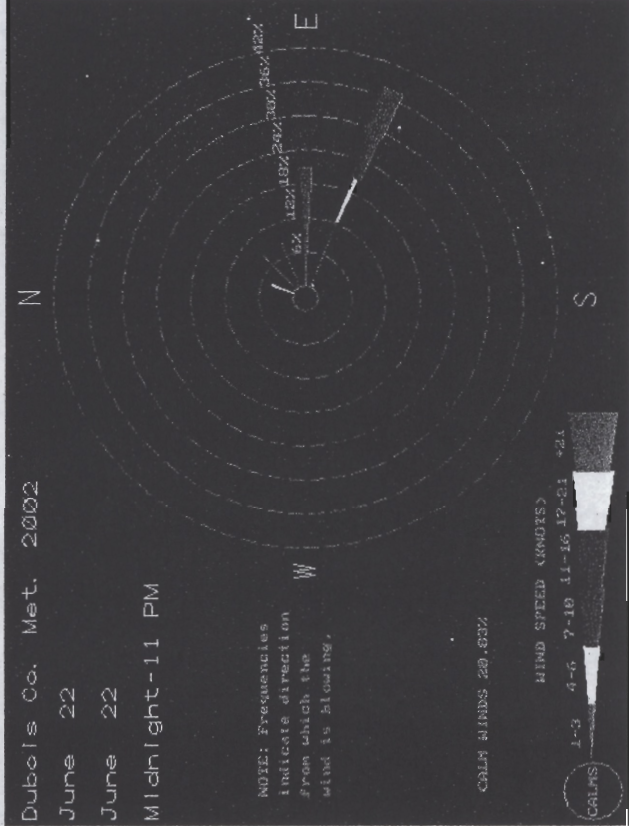
Dubois Co. Met. 2002
June 10
June 10
Midnight-11 PM



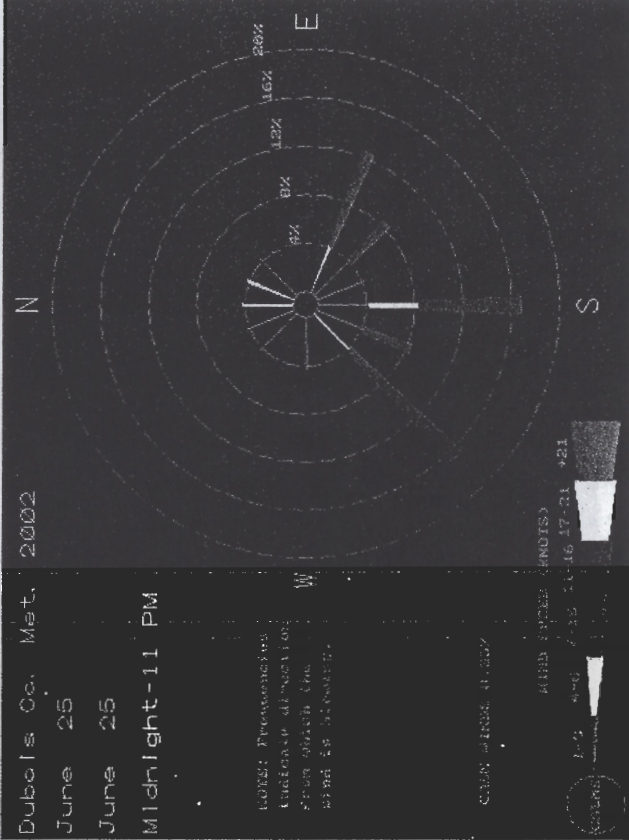
Dubois Co. Met. 2002
June 19
June 19
Midnight-11 PM

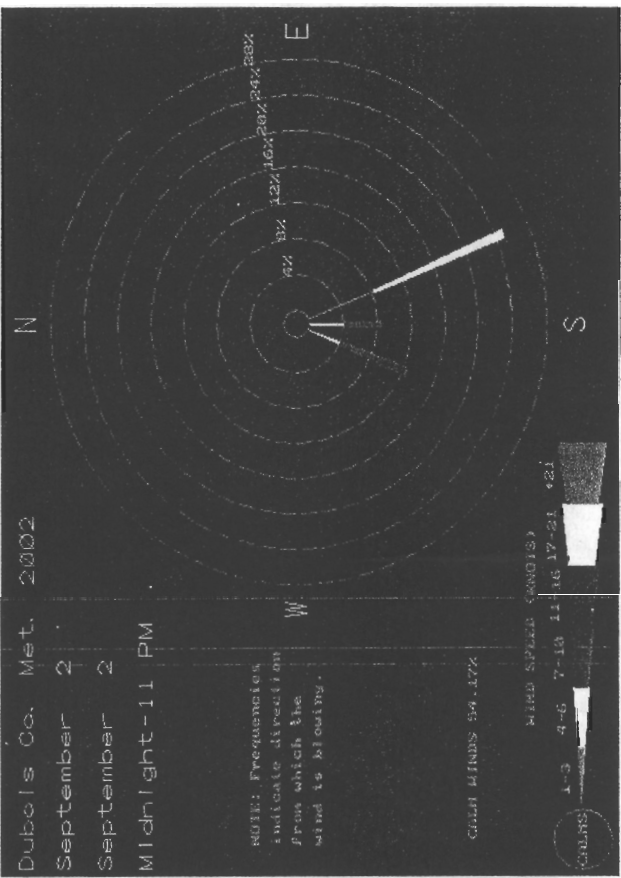
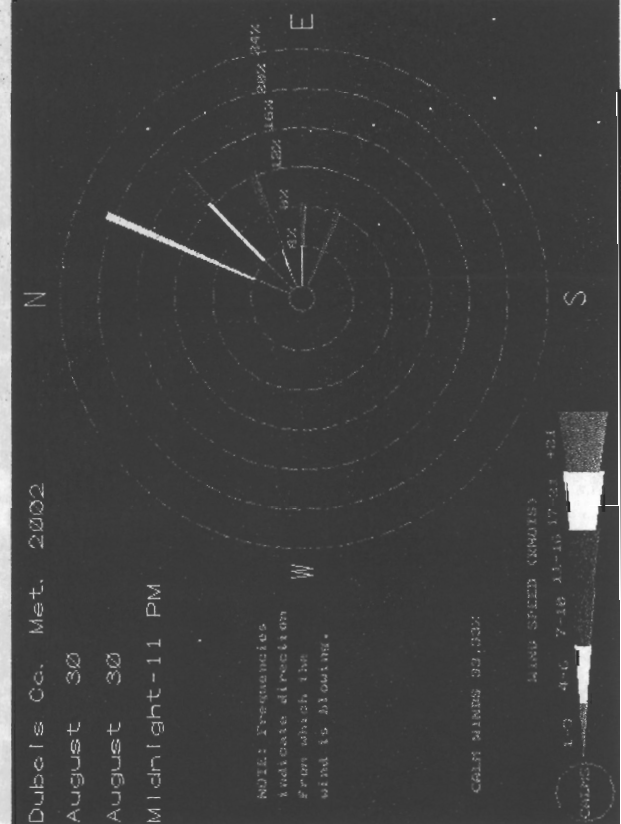
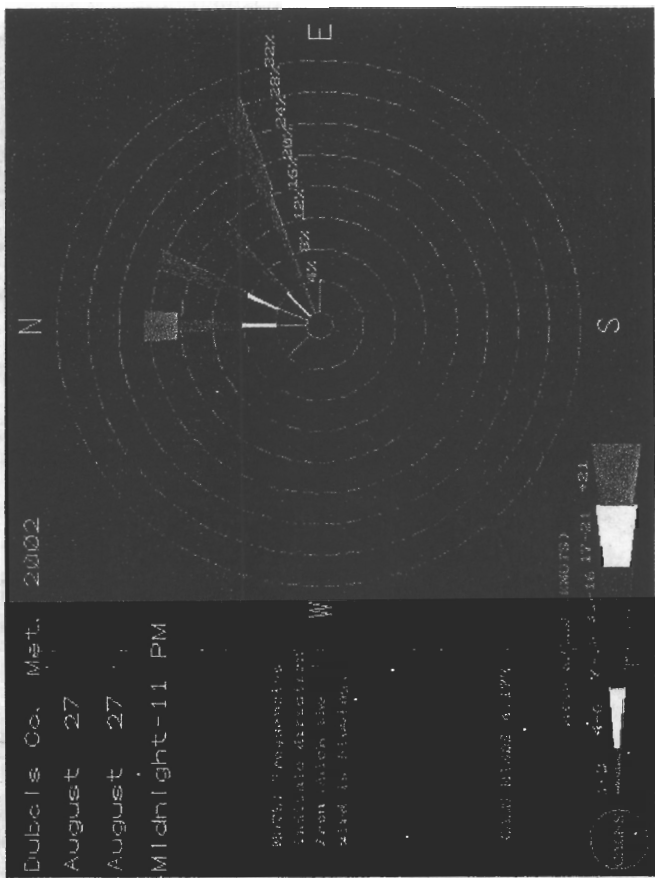
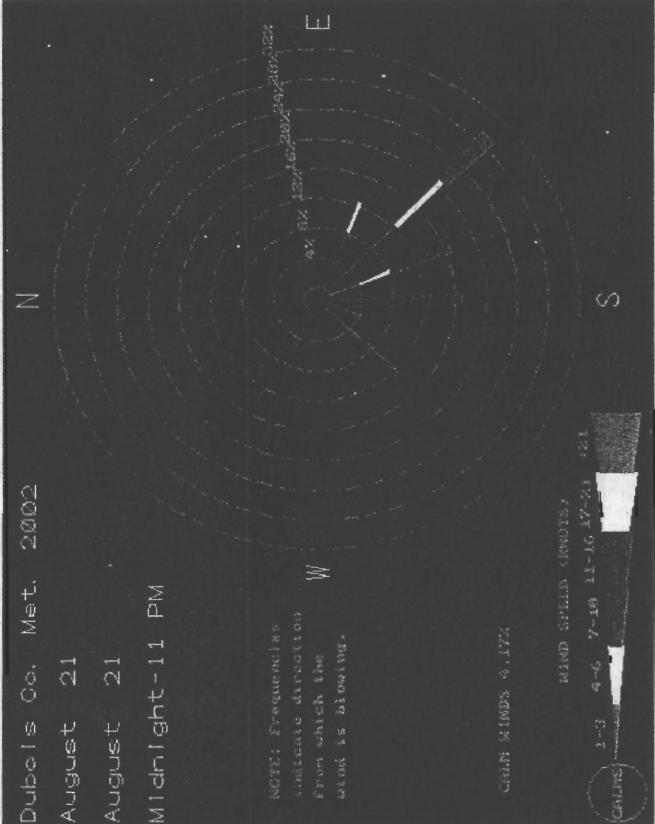


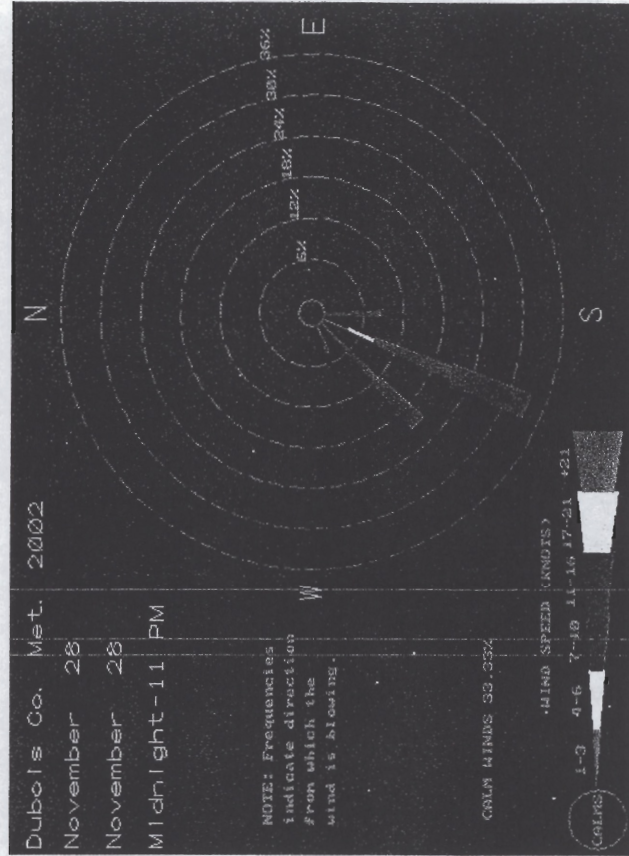
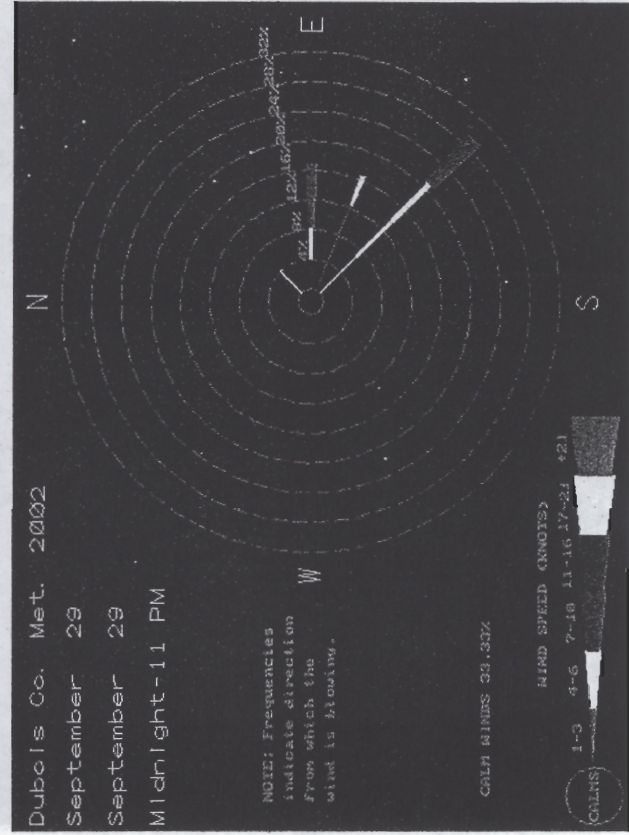
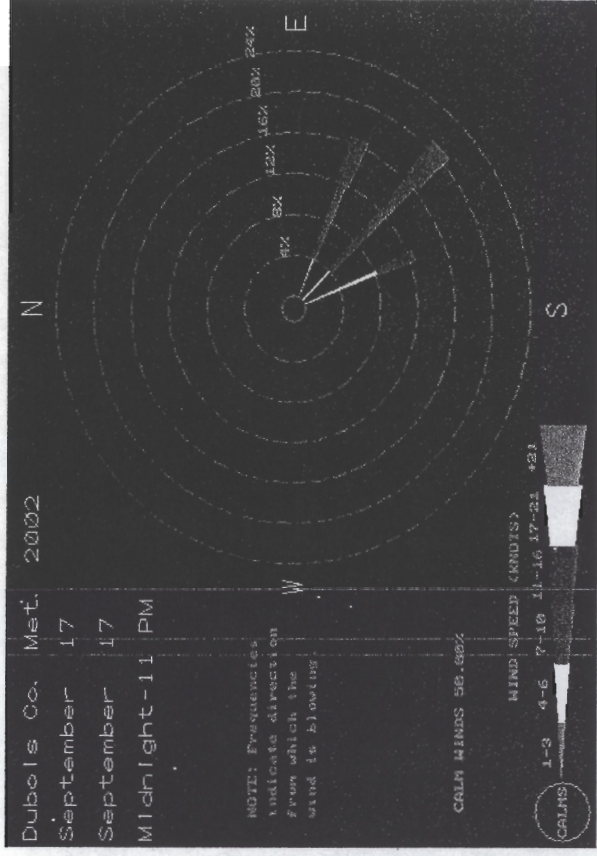
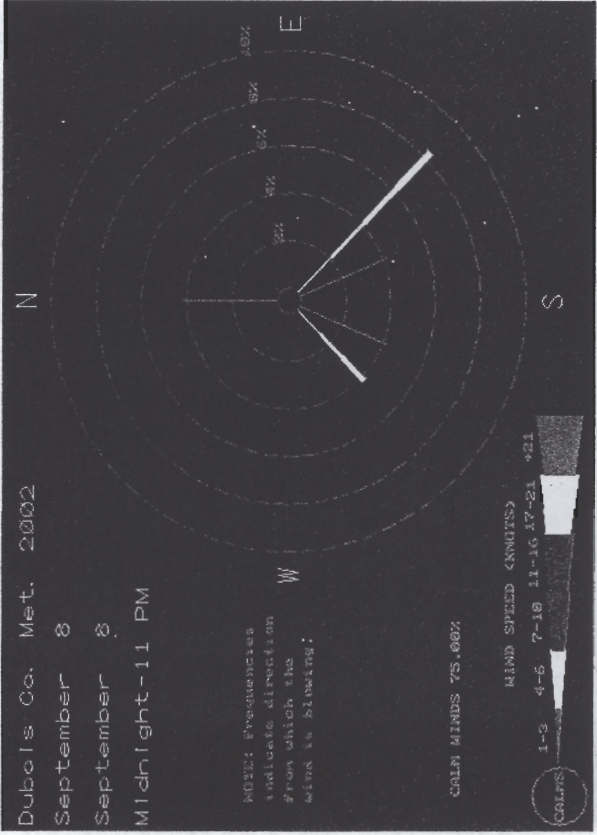
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June 22
June 22
Midnight-11 PM

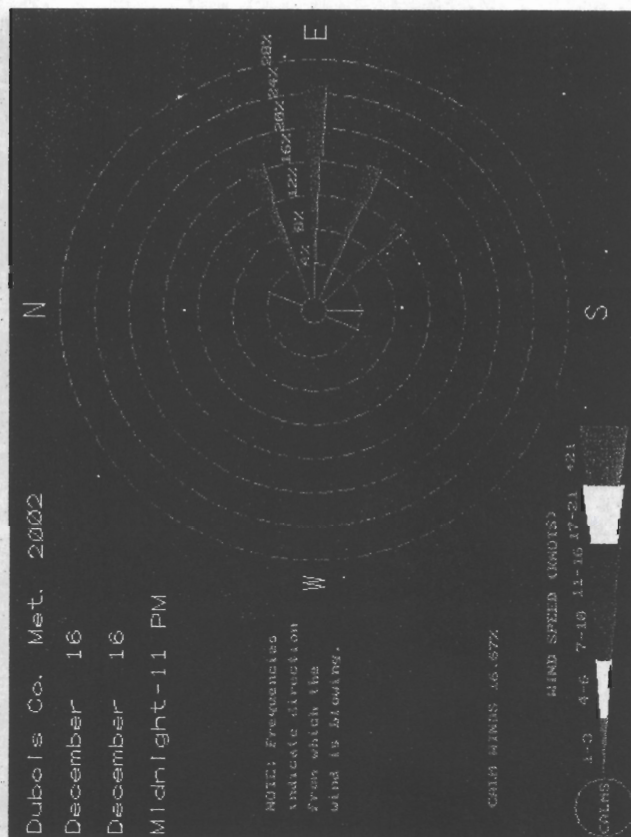
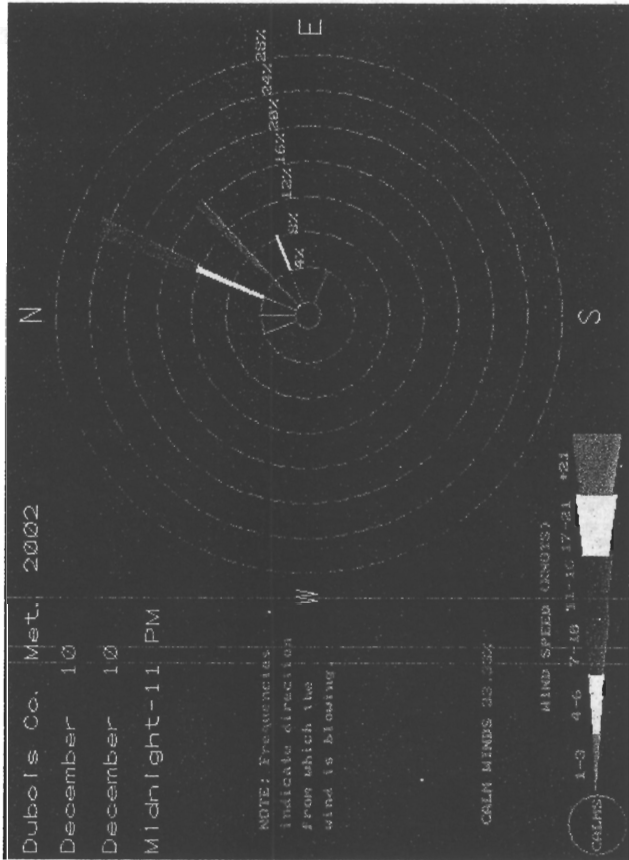
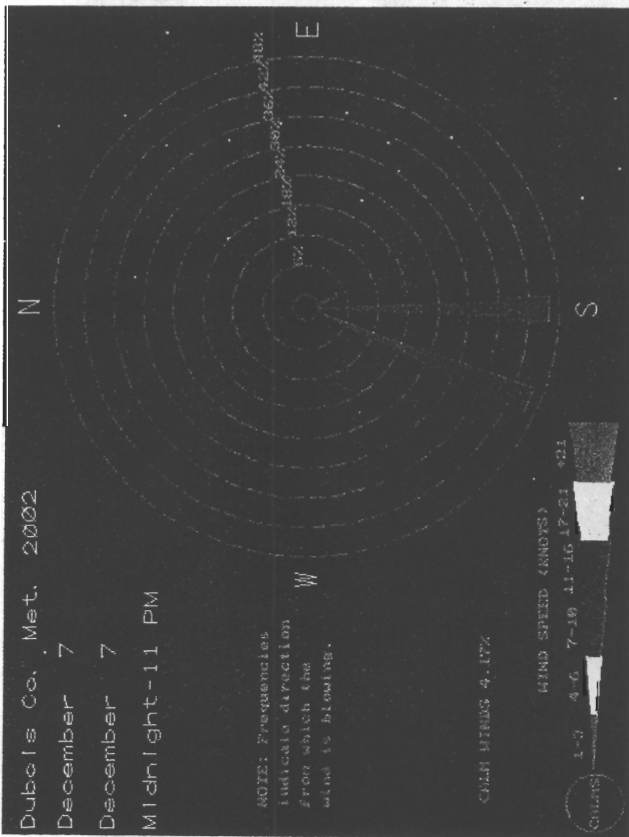


Dubois Co. Met. 2002
June 25
June 25
Midnight-11 PM



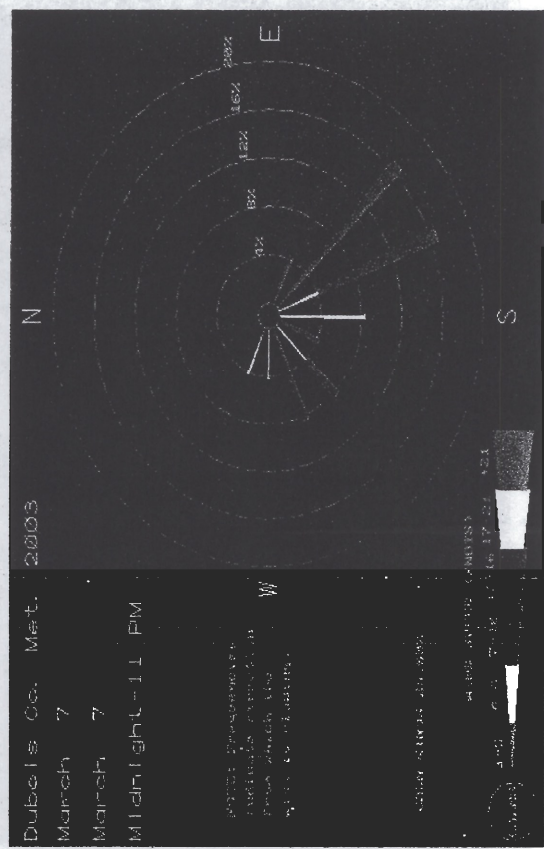
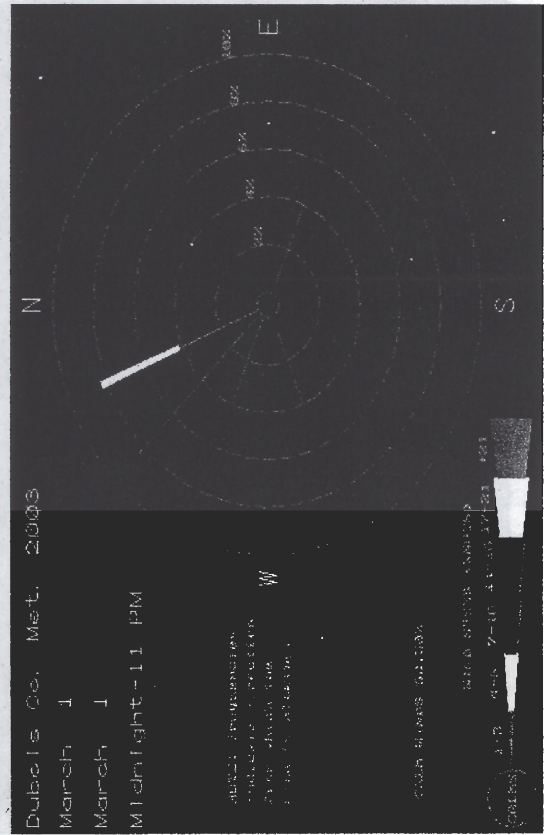
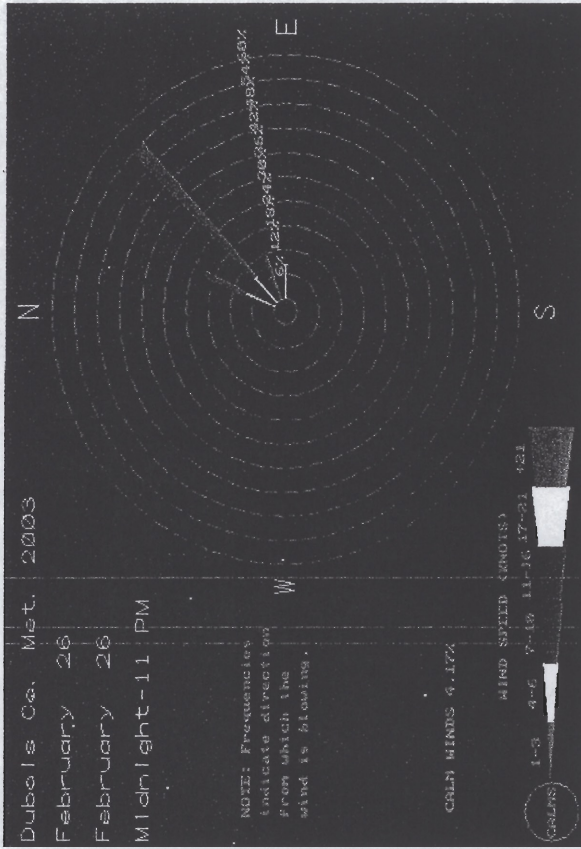
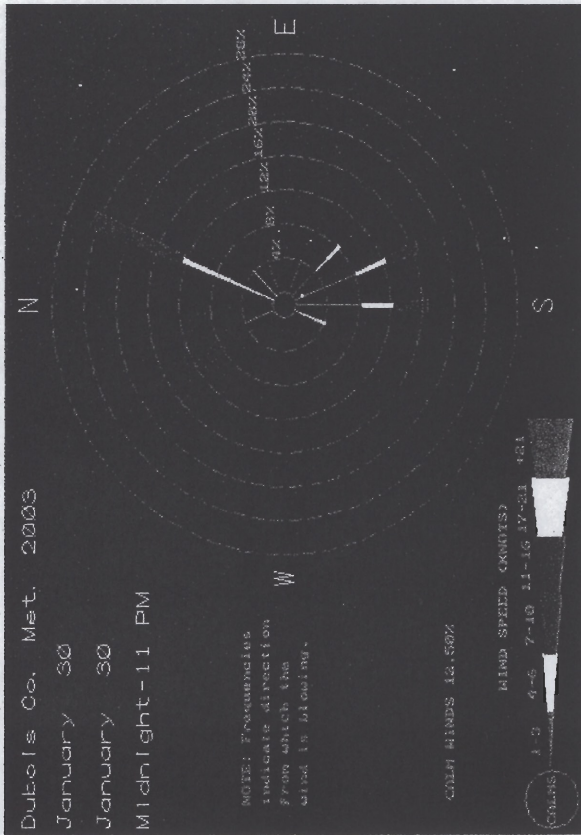


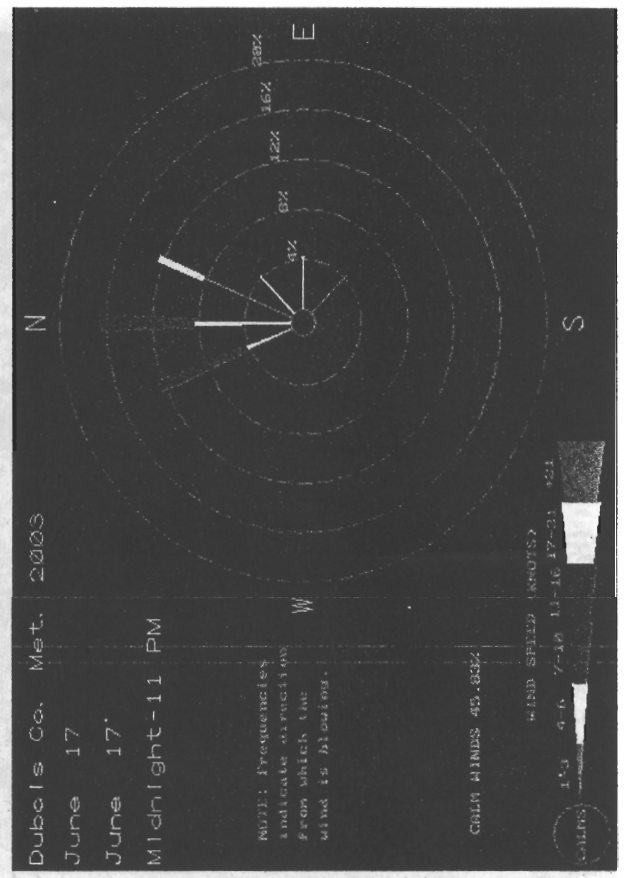
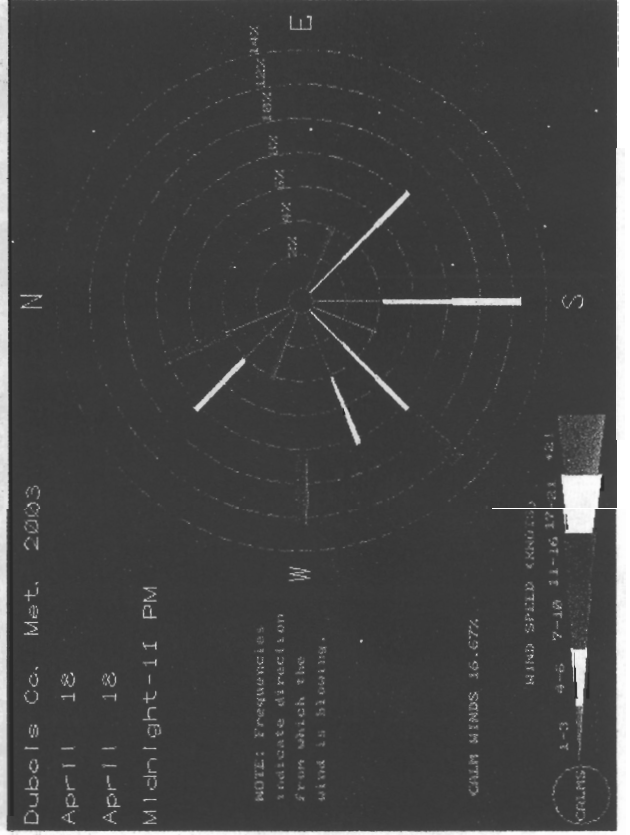
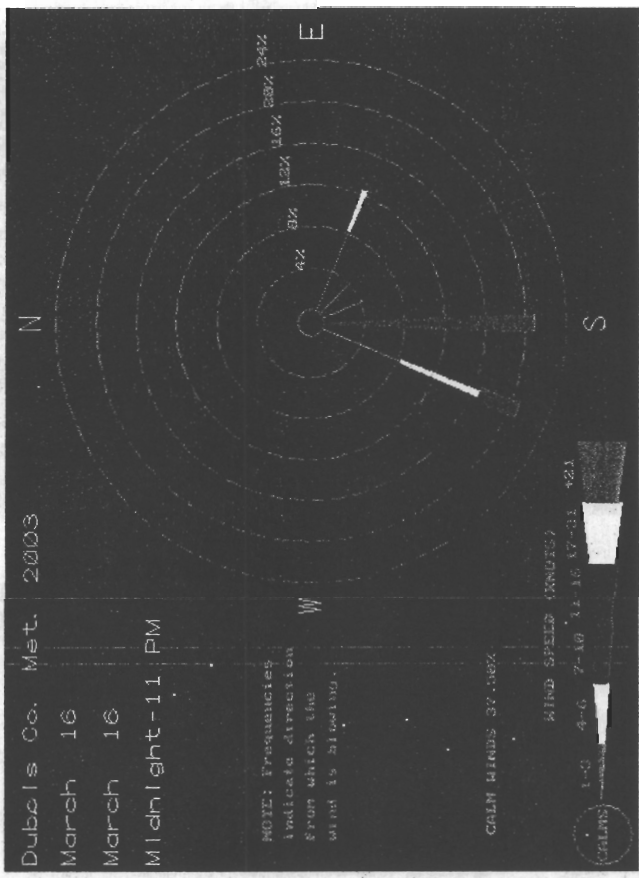
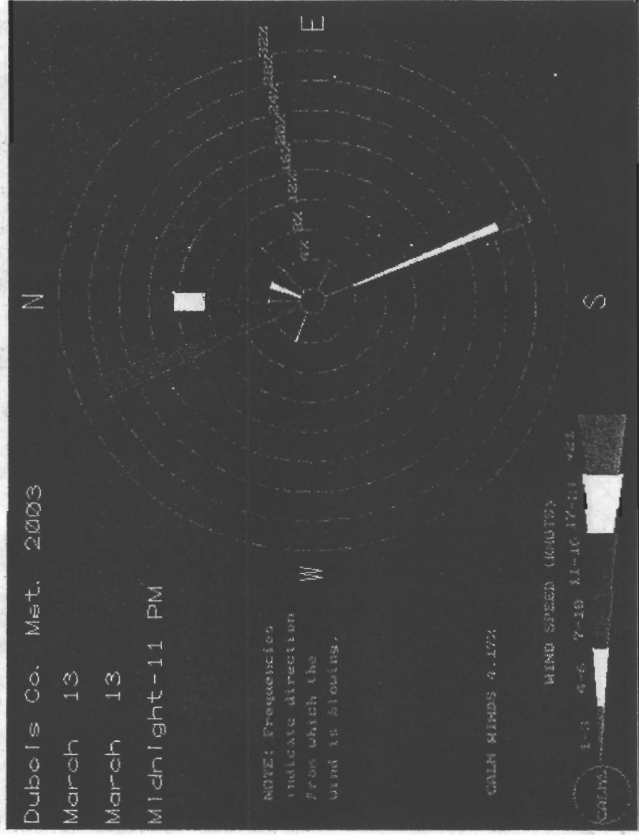


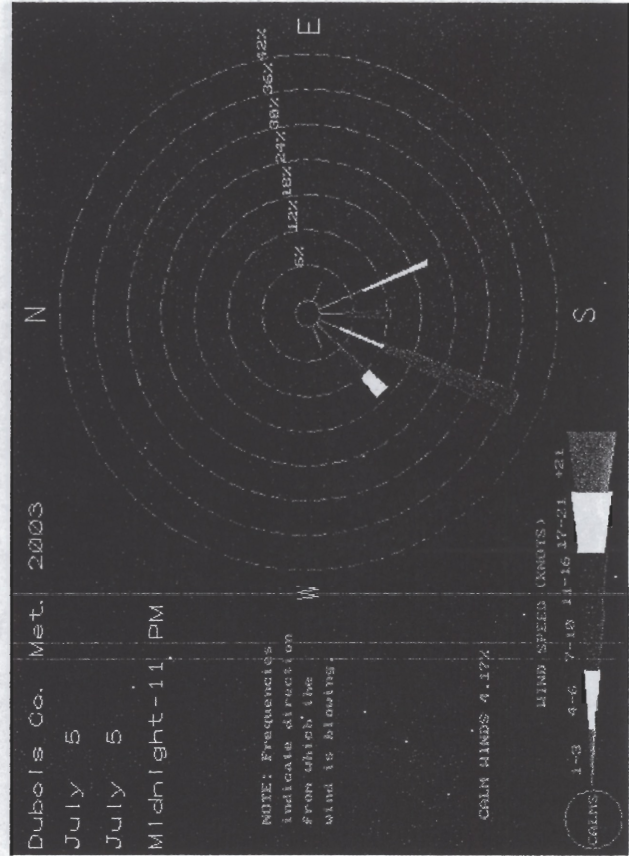
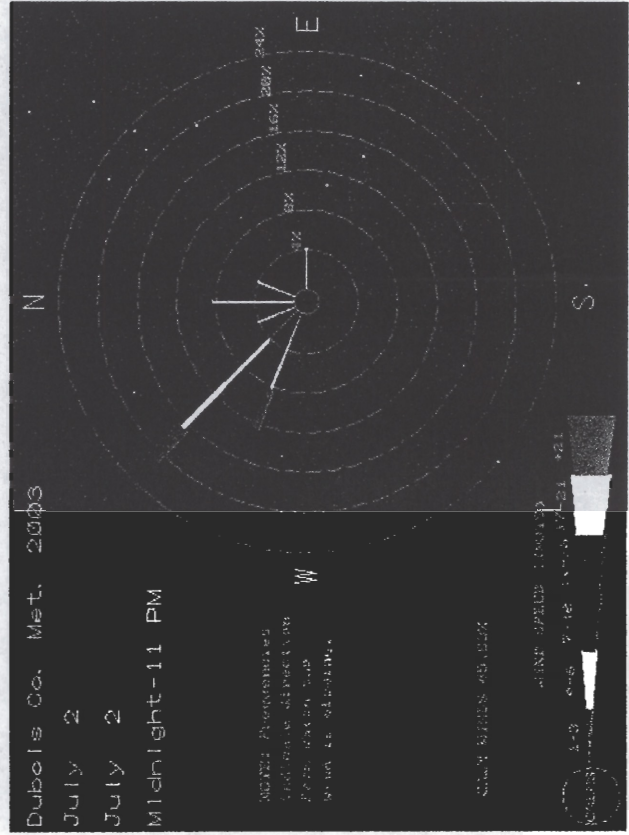
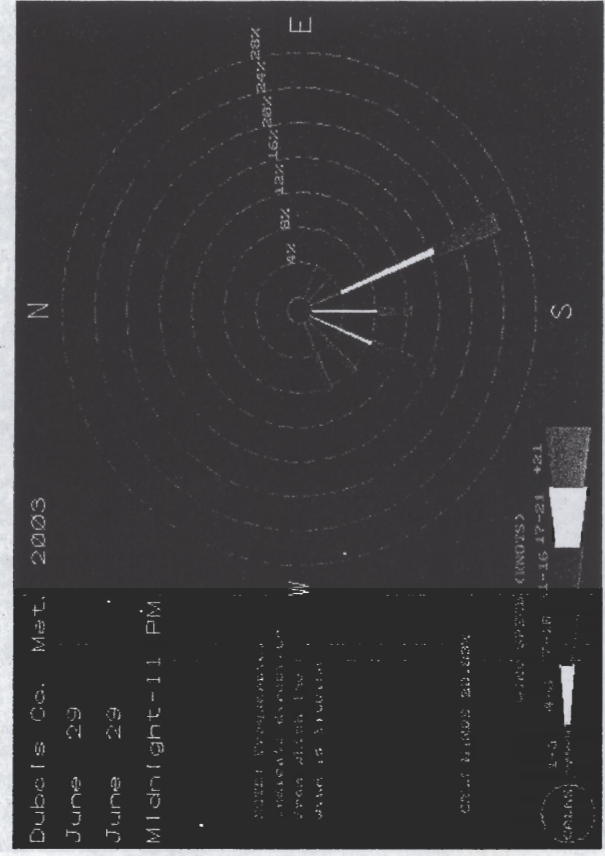
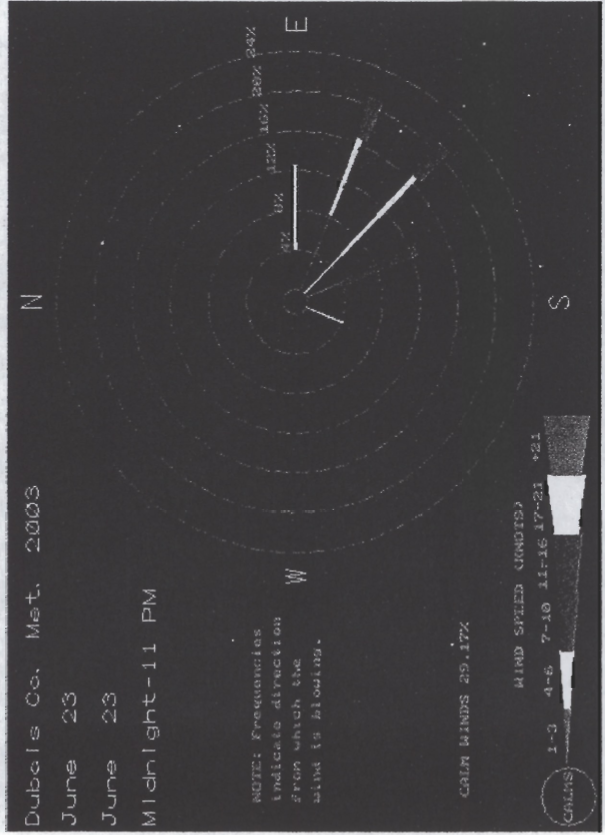


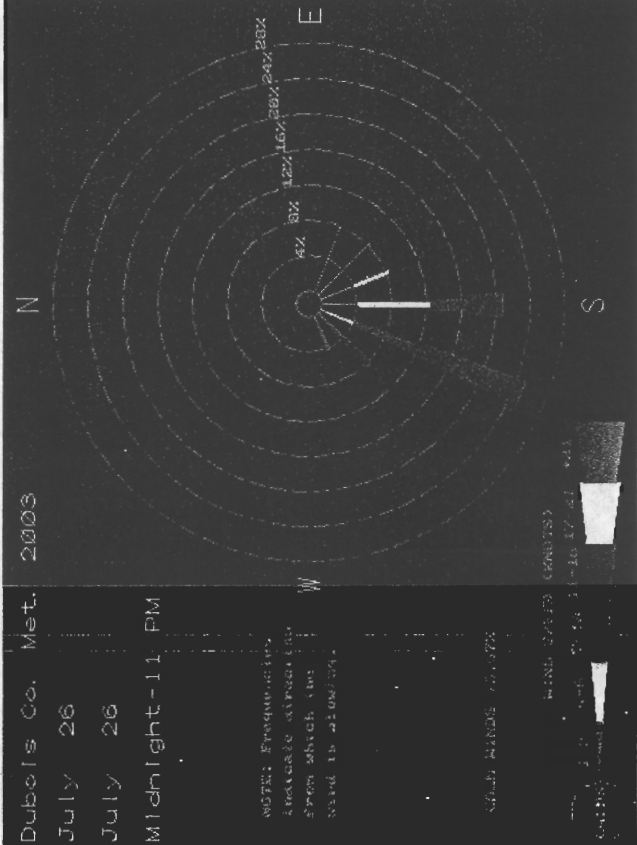
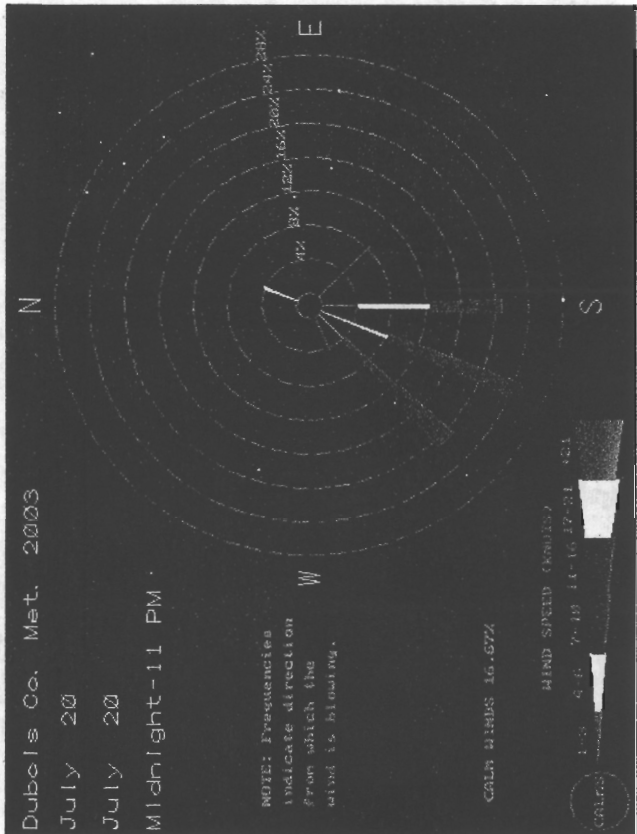
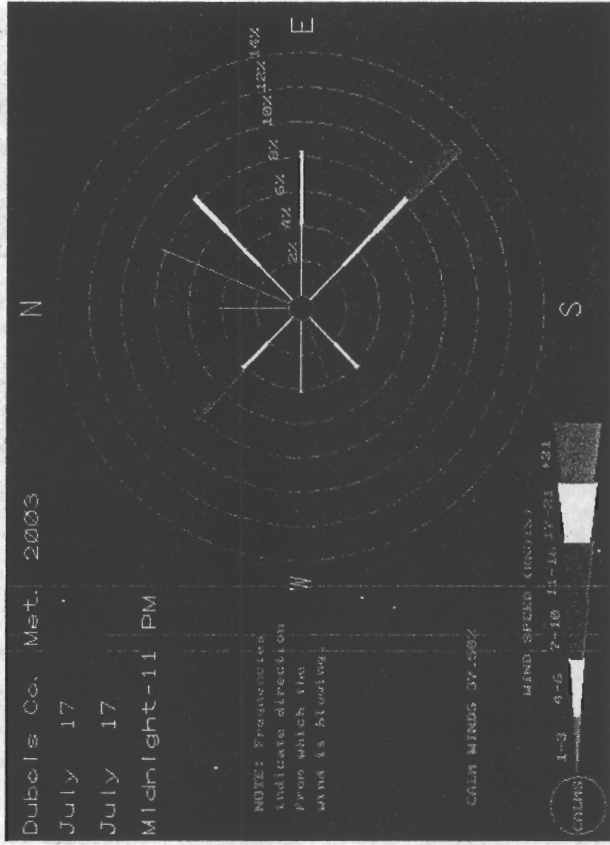
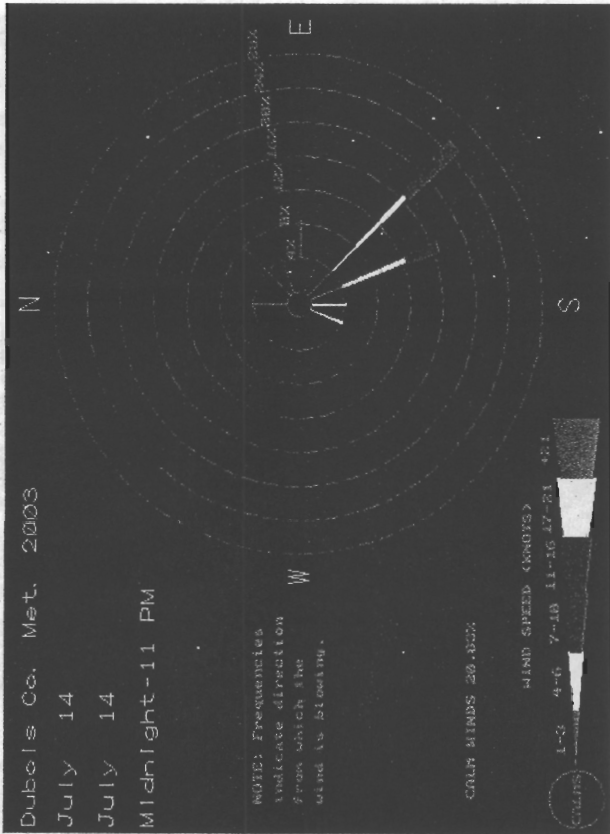
Dubois County Wind Rose Analysis - 2003

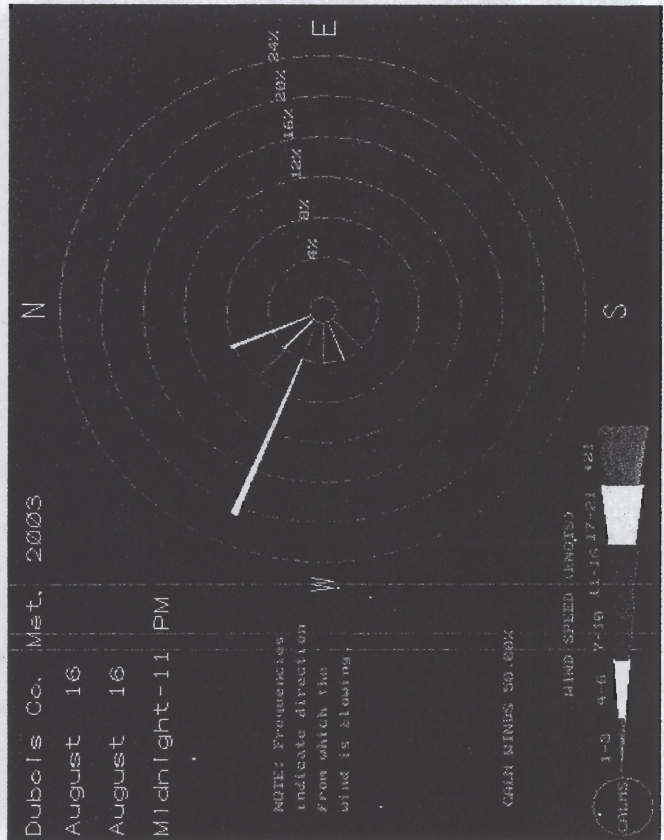
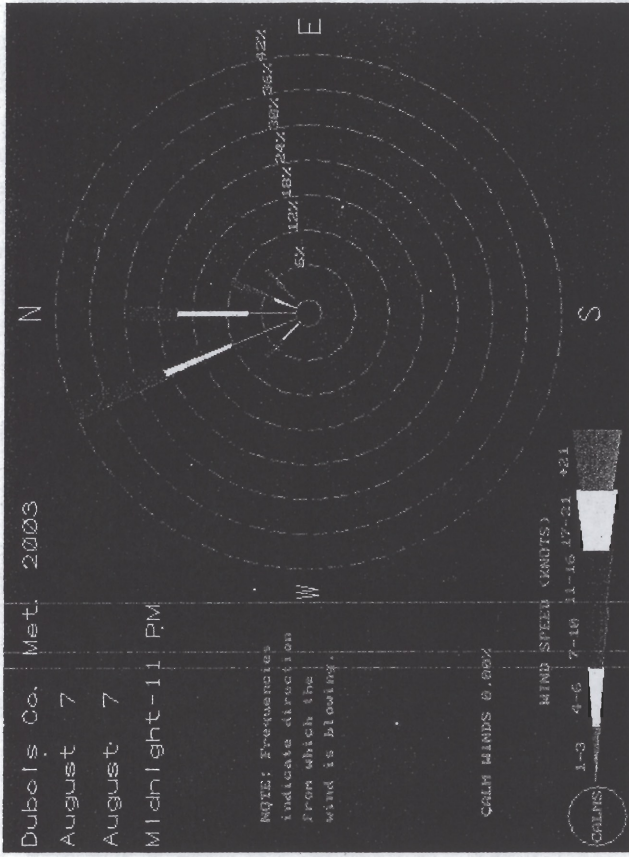
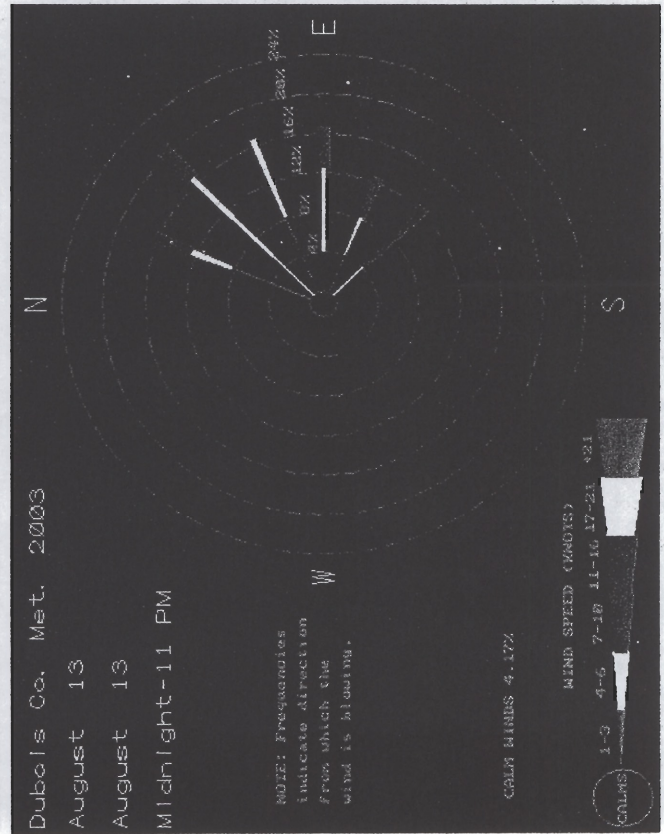
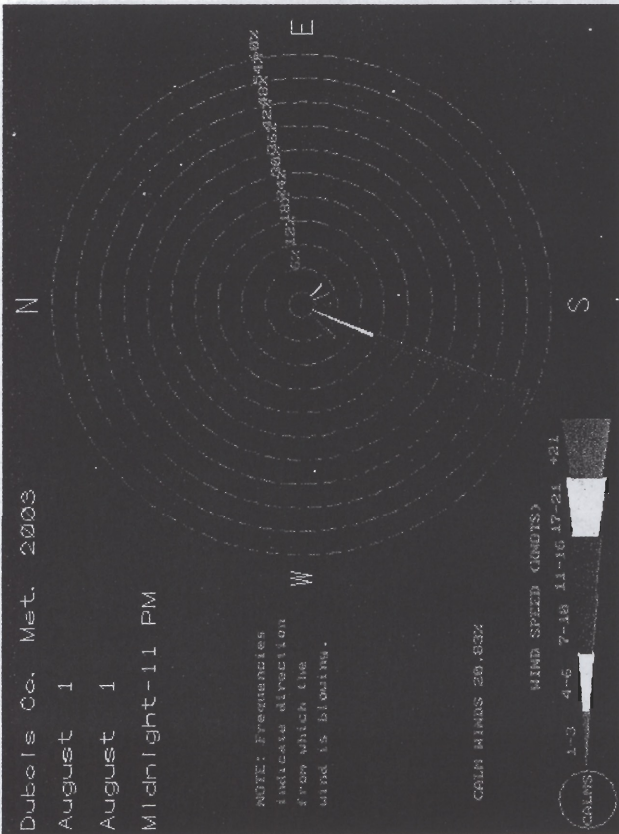
Wind Speed and Wind Direction on Days where PM2.5 readings were $\geq 20 \mu\text{g}/\text{m}^3$

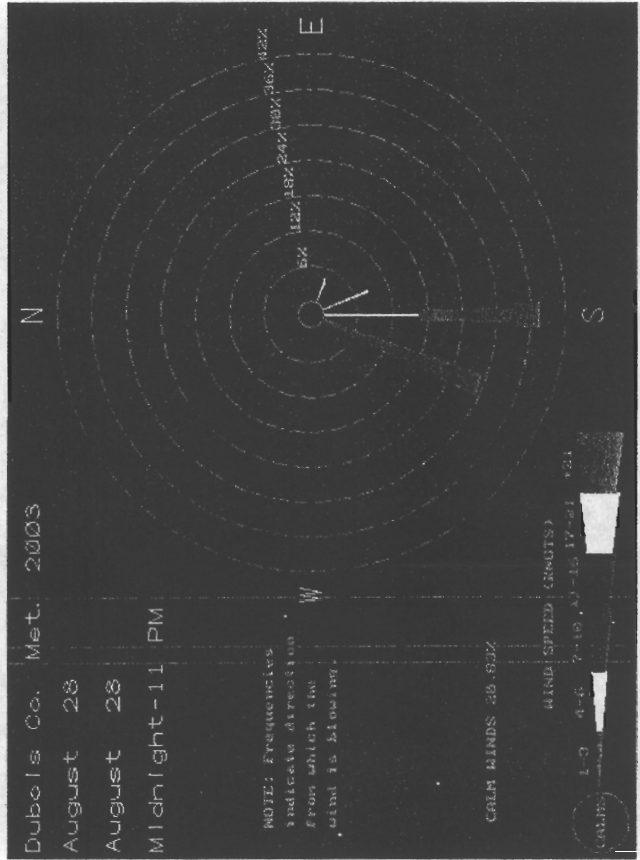
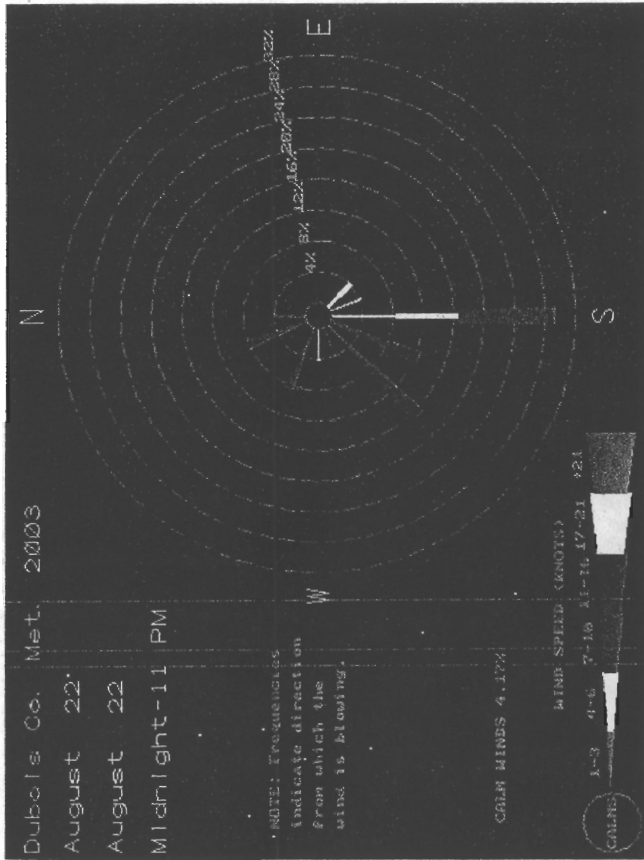
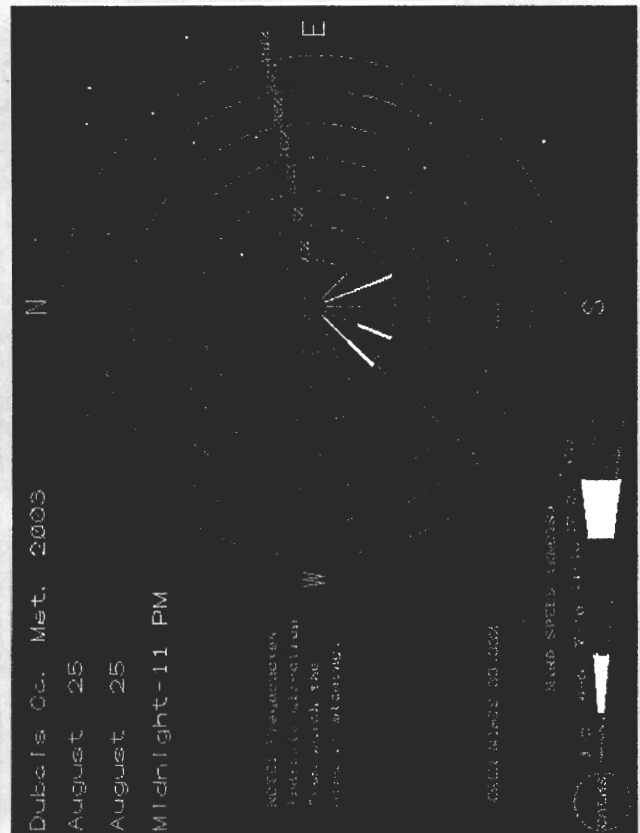
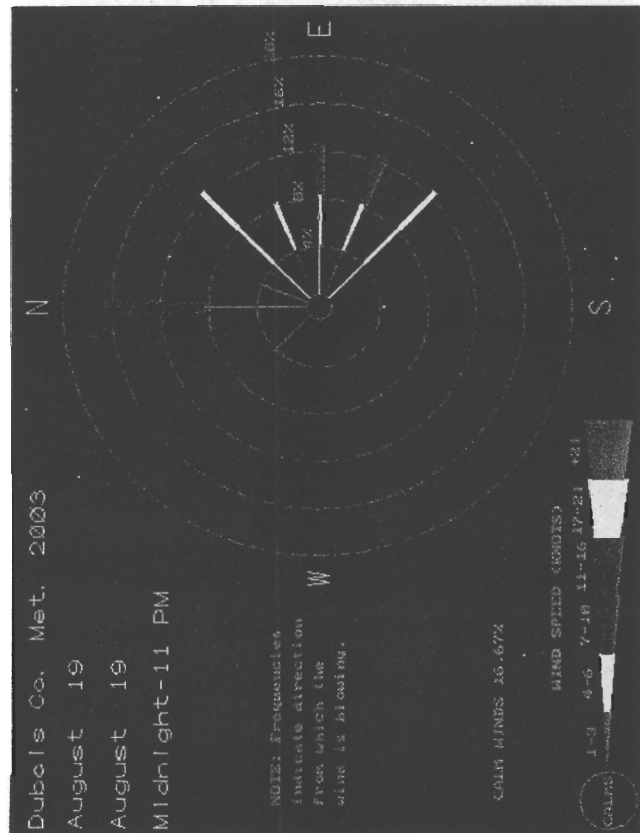












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