$PM_{2.5}$ Designation Response Technical Support Document

1. Introduction

The purpose of this document is to provide the technical background to support information and data that is cited in our $PM_{2.5}$ designation response letter. This document includes information relating to $PM_{2.5}$ concentration trends in North Carolina, trajectory analyses, the EPA L-Factor analysis, commuting patterns and emissions data. The information included in this document originates from several places, including monitoring data, emissions data, work performed at the North Carolina Division of Air Quality and EPA's own work. North Carolina believes that the technical information below strongly supports designating only Catawba and Davidson Counties non-attainment, without the addition of surrounding counties.

As North Carolina stated in its letter to EPA, preliminary $PM_{2.5}$ data for 2004 shows that the monitors in Davidson and Catawba Counties continue to show a downward trend in $PM_{2.5}$ concentrations. North Carolina anticipates the downward trend to continue as a result of emissions reductions due to implementation of the Clean Smokestacks Act, NOx SIP call rules, federal heavy-duty engine standards and new fuel standards. North Carolina is also anticipating needed reductions from upwind out-of-state sources from the proposed Clean Air Interstate Rule, North Carolina's section 126 petition and other initiatives. As stated in the letter, North Carolina intends to provide EPA with a rolling twelve-quarter average of $PM_{2.5}$ from October 1, 2001 through September 30, 2004 for all sites within North Carolina by November 5, 2004. North Carolina will also provide EPA with the twelve-month average PM2.5 concentrations from across the state for 2002 – 2004, where the 4^{th}-quarter 2004 average will be replaced by the highest 4^{th}-quarter average from the last several years. The current twelve-quarter rolling average (third quarter 2001 through second quarter 2004) shows a $PM_{2.5}$ concentration of 15.095 $\mu g/m^3$ for the Hickory monitor in Catawba County and 15.489 $\mu g/m^3$ for the Lexington monitor in Davidson County. These values are lower than the current design values (15.5 $\mu g/m^3$ for Hickory and 15.8 $\mu g/m^3$ for Lexington based on 2001-2003 data) for those two monitors and North Carolina expects the downward trend in $PM_{2.5}$ to continue at these sites. North Carolina believes that there is an excellent chance that the Hickory monitor in Catawba County will attain the $PM_{2.5}$ standard using complete data for 2002-2004.

As discussed in North Carolina's Section 126 petition, broader data indicate a substantial connection between out-of-state sources and $PM_{2.5}$ levels across North Carolina. NC DAQ collected from EPA's Acid Rain Program SO_2 emissions data for utilities in the following eight states: Georgia, Kentucky, North Carolina, Ohio, South Carolina, Tennessee, Virginia and West Virginia. The data show a decreasing trend in SO_2 emissions across the region. The most significant absolute reductions occurred in Kentucky, Ohio, Tennessee and West Virginia. Smaller reductions occurred in South Carolina. EGU emissions of SO_2 actually increased slightly in Georgia and Virginia. Significantly, emissions in North Carolina were fairly steady over this period (although North Carolina expects decreases as the Clean Smokestacks Act is implemented), whereas total regional emissions dropped from about 4.5 million tons in 1999 to about

3.9 million tons in 2002. The following table indicates the SO_2 emissions from utilities in and near North Carolina for the specified years.

State	1999	2000	2001	2002
Georgia	512,226	518,752	489,634	512,494
Kentucky	678,801	586,909	537,667	484,129
North Carolina	457,943	453,442	449,656	462,993
Ohio	1,308,935	1,209,358	1,124,155	1,132,067
South Carolina	214,651	200,176	198,954	199,118
Tennessee	443,478	424,973	356,608	333,576
Virginia	225,739	214,232	217,435	230,846
West Virginia	694,516	593,315	498,056	507,106
Total	4,536,290	4,201,157	3,872,166	3,862,329

During the same period, average annual $PM_{2.5}$ concentrations in North Carolina for the entire $PM_{2.5}$ monitoring network has shown a downward trend from 2000 to 2002. The average annual concentrations for all sites from 1999 to 2002 are:

Year	Annual Concentration
1999	15.16 μg/m^3
2000	15.30
2001	13.51
2002	13.17

This trend supports the conclusion that out-of-state SO_2 reductions contribute to decreases in $PM_{2.5}$ levels in North Carolina. These data are particularly persuasive with regard to sources in Kentucky, Ohio, Tennessee and West Virginia. Emissions data for sources in the other states named in this petition regarding $PM_{2.5}$ show a similar trend.

The cause of the recent decreases in SO_2 emissions from out-of-state upwind utilities within the region is unclear. It is possible that this trend is the result of the Acid Rain Program, but nonregulatory causes may also explain the trend at least in part. If SO_2 emissions continue to decrease across the region, North Carolina expects its in-state $PM_{2.5}$ levels to drop as well. The relief sought by our Section 126 petition will ensure that both of these trends continue.

2. Hickory-Morganton-Lenoir

A. Ambient Data Analysis

North Carolina has examined the distribution of $PM_{2.5}$ concentrations based on the value of the observed concentration and temporally on monthly basis. Figure 1 shows the distribution of 24-hr average $PM_{2.5}$ concentrations at the Hickory monitor in Catawba County for 2000-2003. The distribution shows that over 70% of the 24-hr average $PM_{2.5}$ concentrations occur between 0.1 and 20.0 μg/m^3, while nearly 95% of the concentrations are less than 30.0 μg/m^3. Only a very few of the 24-hr average concentrations are above 30.0 μg/m^3. Figure 2 shows a similar graph as Figure 1 except for only 2003 data. Using only 2003 data, 50% of the $PM_{2.5}$ concentrations are below 15.1 μg/m^3 and almost 80% of the $PM_{2.5}$ concentrations are 20.0 μg/m^3 or less. Note that only a handful of concentrations occurred above 30.0 μg/m^3. This analysis supports the downward trend in $PM_{2.5}$ concentrations observed in Catawba County.

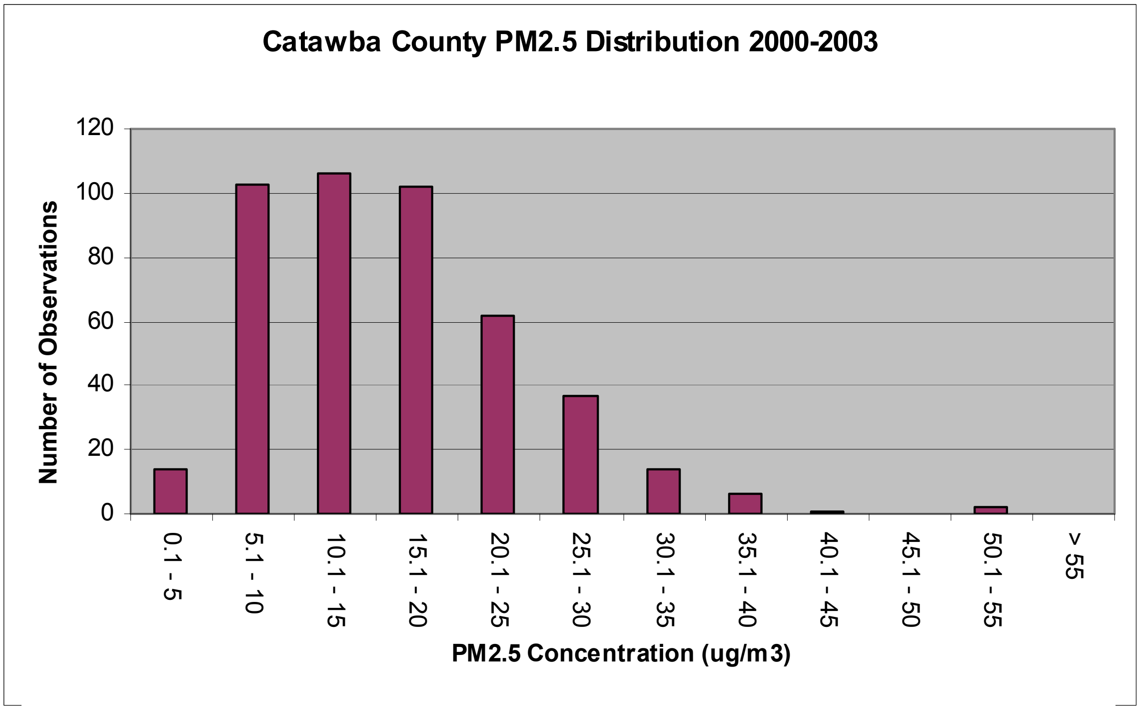


FIGURE 1. $PM_{2.5}$ concentration distribution for the Hickory FRM monitor in Catawba County for 2000 – 2003. The $PM_{2.5}$ concentration (μg/m3) is shown along the x-axis while the number of observations is shown along the y-axis.

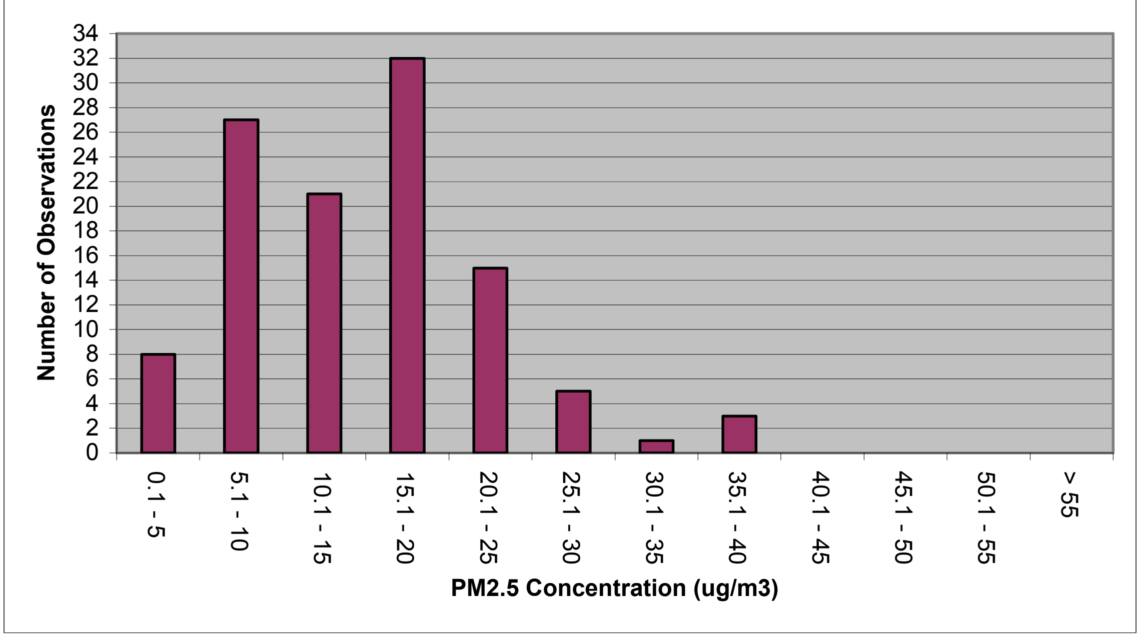


FIGURE 2. $PM_{2.5}$ concentration distribution for the Hickory FRM monitor in Catawba County for 2003 only. The $PM_{2.5}$ concentration (μg/m3) is shown along the x-axis while the number of observations is shown along the y-axis.

A temporal analysis of $PM_{2.5}$ concentration data from the past five years shows that for the Hickory area $PM_{2.5}$ concentrations are highest during the summer months. Figure 3 shows the monthly average $PM_{2.5}$ concentration for the Hickory monitor for 1999 – 2003. Note that $PM_{2.5}$ concentrations are consistently higher during the summer months, particularly May – August, and are the only months when $PM_{2.5}$ concentrations average significantly above 15.0 $\mu g/m^3$. For the remaining months of the year, average $PM_{2.5}$ concentrations are either below or very close to 15.0 $\mu g/m^3$. Therefore, it stands to reason that addressing the factors that affect $PM_{2.5}$ concentrations during the summer months when $PM_{2.5}$ concentrations are the highest is necessary bring the annual standard below 15.0 $\mu g/m^3$.

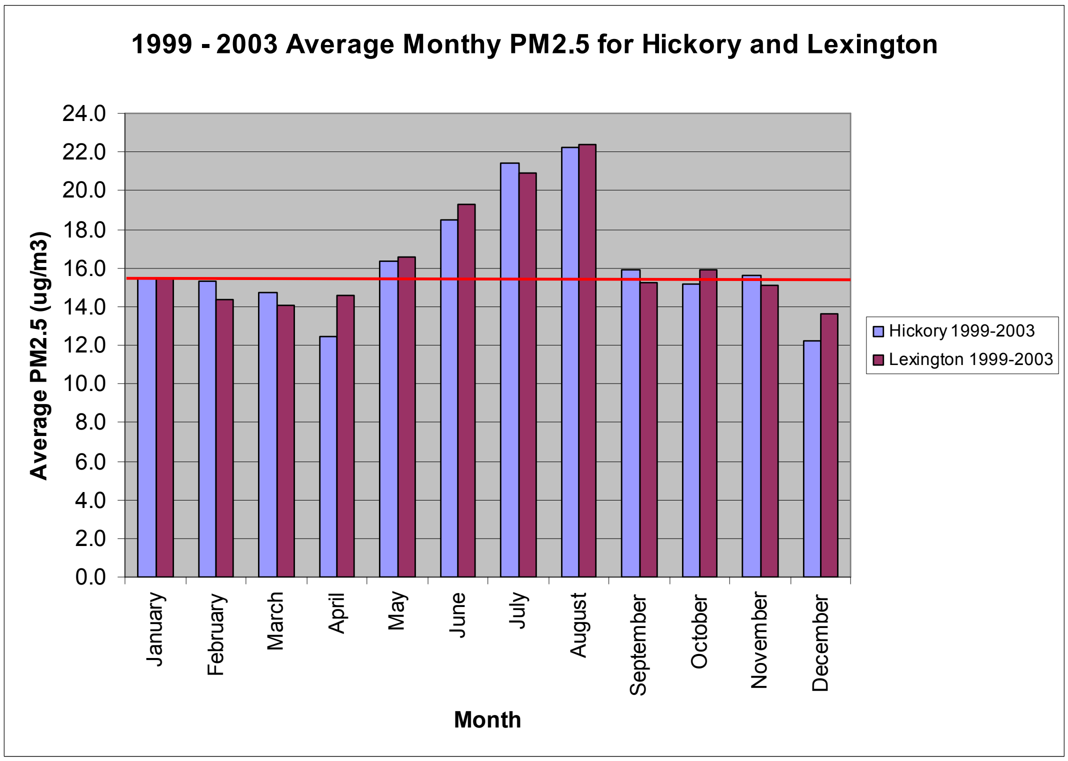


FIGURE 3. The monthly average $PM_{2.5}$ concentration from 1999 – 2003 is shown above for both the Hickory monitor in Catawba County (blue) and the Lexington Monitor in Davidson County (dark red). Note the significantly higher $PM_{2.5}$ concentrations for both monitors during summer months of May through August.

B. Meteorological Analysis

The data presented in the previous section highlighted the seasonal nature of $PM_{2.5}$ concentrations, and how concentrations of fine particles are highest during the months of May – August. Climatologically, the predominant wind direction during those months is from the Southwest as a high-pressure system located off the eastern Seaboard is the dominant summertime meteorological pattern for North Carolina.

C. L-Factor Analysis

EPA has presented with a ranking of counties within each MSA that incorporates an analysis of emissions within each county adjusted by an urban – rural weighting factor. North Carolina reiterates the overwhelming ranking of Catawba County over both Caldwell and Burke Counties in the L-Factor analysis. Catawba County's cumulative L-Factor score is nearly 60, while Burke and Caldwell Counties rank much lower at less than 20 each. Catawba County is clearly the dominant source county of emissions in the Hickory region. North Carolina believes that in an area such as Hickory, a lower cut-point for the L-Factor analysis is appropriate given the concentrated nature of the emissions in Catawba County and much lower emissions in surrounding counties such as Burke and Caldwell and the marginal nature of the violation.

The majority of emissions in Burke and Caldwell counties are mobile emissions, and as such will be addressed by federal rules such as the heavy-duty engine standards and new low-sulfur fuels. Also, Burke and Caldwell Counties will be implementing Inspection/Maintenance programs in 2005 that will also help reduce mobile emissions. There will be little to no additional benefit to designating Burke and Caldwell Counties non-attainment, and will only burden counties that are already part of an EAC for ozone.

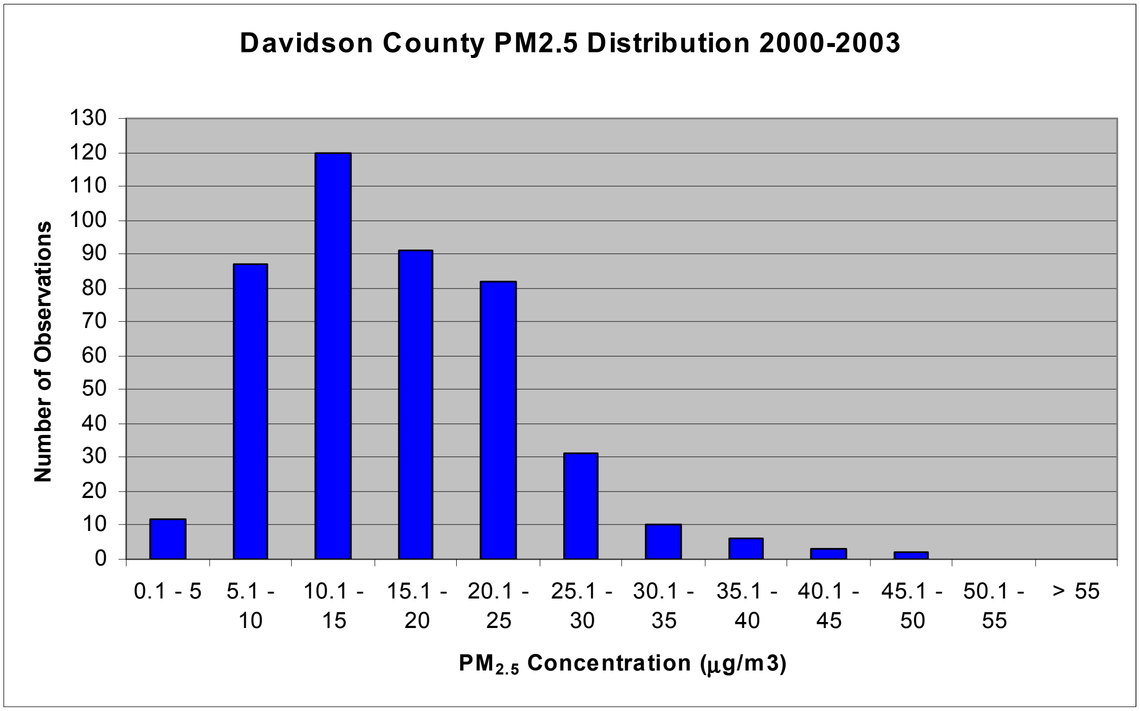
2. Greensboro/Winston-Salem/High Point

A. Ambient Data Analysis

A similar analysis of $PM_{2.5}$ concentration data as was done for the Hickory monitor was also performed for the Lexington monitor in Davidson County. The results of this analysis are presented in Figures 4 and 5. For 2000-2003, almost 70% of the concentrations occur below 20.0 $\mu g/m^3$ and nearly 87% of the concentrations occur below 25.0 $\mu g/m^3$. Focusing only on 2003, 75% of the concentrations occur below 20.0 $\mu g/m^3$ and over 90% of the concentrations fall below 25.0 $\mu g/m^3$. Again, a very small percentage (less than 5%) of the concentrations are above 30.0 µg/m3. As with the Hickory monitor, the data supports a downward trend in the $PM_{2.5}$ concentrations in Davidson County. North Carolina is focused on continuing the downward trend in $PM_{2.5}$ in these areas and across the entire state through the implementation of the North Carolina Clean Air Bill and the Clean Smokestacks Act. As discussed in North Carolina's Section 126 petition, there is a need for further emissions reductions from utilities in other States in order for our State to successfully attain and maintain the PM2.5 standard. Therefore, North Carolina encourages EPA to finalize the Clean Air Interstate Rule, as well as appropriately address the State's Section 126 petition.

A temporal analysis of the $PM_{2.5}$ concentrations at the Lexington monitor show similar behavior to that observed in Hickory, with the highest concentrations occurring during the summer months of May – August. The above analysis shows that the majority of $PM_{2.5}$ concentrations occur below or just above the annual standard of 15 $\mu g/m^3$. North

Carolina is confident that emissions controls that have recently been implemented and new controls that will be implemented in the next few years will continue to reduce $PM_{2.5}$ concentrations across the state.



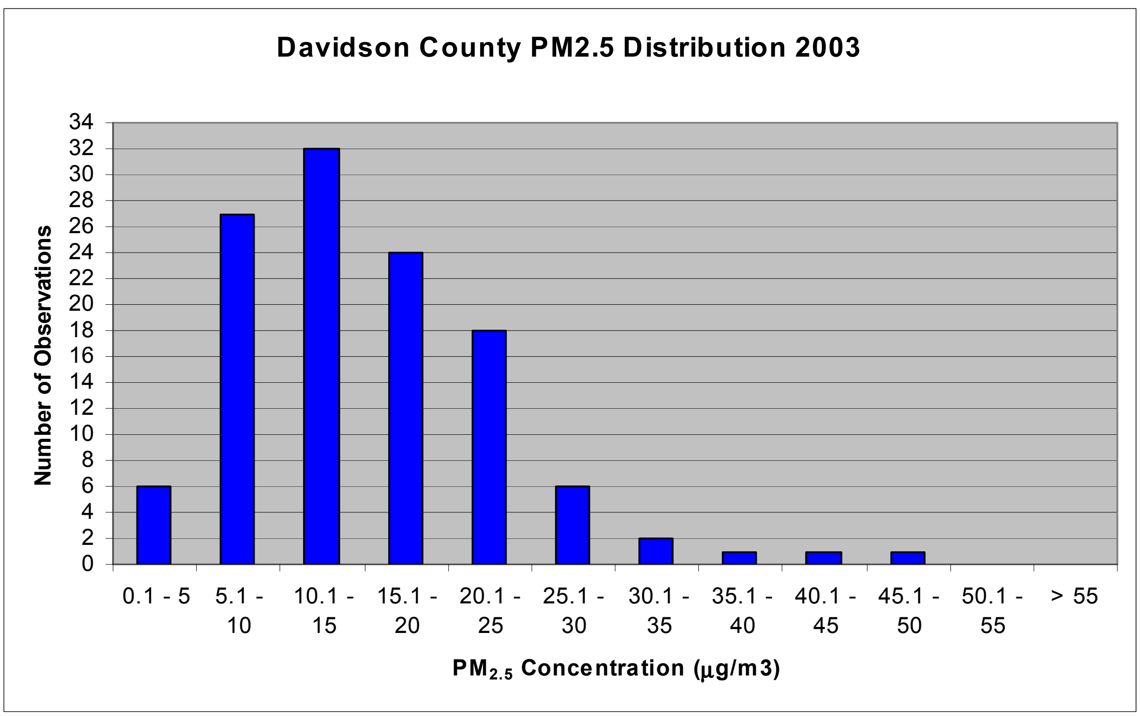


FIGURE 5. $PM_{2.5}$ concentration distribution for the Lexington FRM monitor in Davidson County for 2003 only. The $PM_{2.5}$ concentration (µg/m3) is shown along the x-axis while the number of observations is shown along the y-axis.

FIGURE 4. $PM_{2.5}$ concentration distribution for the Lexington FRM monitor in Davidson County for 2000-2003. The $PM_{2.5}$ concentration (µg/m3) is shown along the x-axis while the number of observations is shown along the y-axis.

B. Meteorological Analysis

The Lexington monitor in Davidson County is located to the south and west of the Belews Creek power plant in Stokes County. The forward trajectory analysis originating from the Belews Creek power plant suggests that the overall impact of the Belews Creek power plant on the Lexington monitor is rather limited (Appendix A). Of the 55 days analyzed, on only 7 of the days did the forward trajectory from Belews Creek pass near or over the Lexington monitor. North Carolina believes that overall impact of Belews Creek on Davidson County is not sufficient to include Stokes County in the non-attainment boundary.

Belews Creek has already installed and will continue to install significant emissions controls as part of the Clean Smokestacks Act (CSA) that will dramatically reduce NOx and SO_2 emissions. As a result of the new controls, NOx emissions will decrease from 43,567 tons per year to 7,022 (over 80%) by the end of 2004 and SO_2 emissions will decrease from 103,138 tons per year to 10,805 tons per year (nearly 90%) by 2008. These are significant reductions that will be implemented as part of CSA. Therefore, in the near future on days when the wind direction is favorable for Belews Creek to potentially impact Davidson County and other downwind areas, SO_2 and other emissions will be much lower than they are currently. North Carolina is providing the full Clean Smokestacks Act compliance schedule based on the information submitted by the two utilities in March 2004 (Appendix B). North Carolina continues to believe that this progressive legislation should be a factor in EPA's final decision on the PM2.5 nonattainment boundaries.

C. L-Factor Analysis

The L-Factor analysis performed by EPA ranks Stokes, Guilford, Davidson, Forsyth and Randolph Counties within the top 80% of the cumulative score. Obviously, the reason for Stokes being on the top of the ranking is due to the presence of the Belews Creek power plant in the county. However, as has been discussed previously, Belews Creek has already installed significant NOx emissions controls and will install significant SO2 emissions controls over the next several years as part of the CSA. As a result, Stokes County will rank much lower in the L-Factor analysis since it is a very rural county with little mobile or area emissions and few point sources other than Belews Creek.

The dominant source of emissions in Guilford County is from the mobile sector, and therefore are low-level emissions that would be expected to impact a local area monitor more than a monitor in another county. Based on the North Carolina 2002 annual emissions for the Triad, low-level (area, mobile and non-road) emissions account for 92% of the total county SO_2 emissions, where mobile SO_2 emissions alone account for 58% of the total SO_2 emissions in Guilford County. Low-level emissions account for over 99% of the total county NOx emissions, where mobile NOx emissions alone account for 92% of the total county NOx emissions in Guilford County.

An analysis of the Triad MSA commuting patterns shows that over 90% of the Guilford County workforce works within Guilford County, while less than 1.5% of the commuting population commutes into Davidson County (Table 1). However, the $PM_{2.5}$ monitor in Guilford County is a full microgram under the standard. Guilford County is also climatologically downwind of Davidson County during the summer months when PM2.5 concentrations are highest. Therefore, it stands to reason that the mobile sector emissions from Guilford County, which is the dominant source sector, do not significantly impact $PM_{2.5}$ concentrations in Davidson County. North Carolina believes that designating Guilford County non-attainment will do very little to reduce $PM_{2.5}$ concentrations in Davidson County.

TABLE 1. Shown below are the commuter county of residence, commuter workplace county and the percent of the Triad MSA commuting into that county for Guilford County.

Residence County	Workplace County	Commuter Count	% of MSA
Guilford Co. NC	Alamance Co. NC	4050	2.0%
Guilford Co. NC	Davidson Co. NC	2982	1.4%
Guilford Co. NC	Davie Co. NC	67	0.0%
Guilford Co. NC	Forsyth Co. NC	7636	3.7%
Guilford Co. NC	Guilford Co. NC	187150	90.9%
Guilford Co. NC	Randolph Co. NC	3984	1.9%
Guilford Co. NC	Stokes Co. NC	68	0.0%
Guilford Co. NC	Yadkin Co. NC	45	0.0%

Similar to Guilford County, the majority of emissions in Randolph County are from the mobile sector, with very few point sources, and therefore would be expected to have a greater impact on the local area. Based on the North Carolina 2002 annual emissions for the Triad, low-level emissions account for 92% of the total county SO_2 emissions, where mobile SO_2 emissions alone account for 62% of the total SO_2 emissions in Randolph County. Low-level emissions account for 99.5% of the total county NOx emissions, where mobile NOx emissions alone account for 95% of the total county NOx emissions.

The analysis of the commuting patterns in Randolph County shows that over 61% of the total Triad MSA commuting population stays within Randolph County, while over 32% of the commuting population commutes into Guilford County (Table 2). Only 4.2% of the commuting population in Randolph County commutes into Davidson County. Randolph County is also climatologically downwind of Davidson County, especially during the summer months when $PM_{2.5}$ concentrations in Davidson County are the highest. North Carolina believes that designating Randolph County non-attainment will do little to reduce $PM_{2.5}$ concentrations in Davidson County, since Randolph County

TABLE 2. Shown below are the commuter county of residence, commuter workplace county and the percent of the Triad MSA commuting into that county for Randolph County.

Residence County	Workplace County	Commuter Count	% of MSA
Randolph Co. NC	Alamance Co. NC	578	0.9%
Randolph Co. NC	Davidson Co. NC	2607	4.2%
Randolph Co. NC	Davie Co. NC	11	0.0%
Randolph Co. NC	Forsyth Co. NC	694	1.1%
Randolph Co. NC	Guilford Co. NC	20278	32.3%
Randolph Co. NC	Randolph Co. NC	38637	61.5%
Randolph Co. NC	Stokes Co. NC	10	0.0%

contains very few point sources and the majority of the traffic stays within the county or commutes into Guilford County.

Forsyth County contains a significant amount of mobile sector emissions. As was the case with both Guilford and Randolph Counties, the large majority of commuters within the Triad MSA stay within the county. Over 83% of the commuters stay within Forsyth County, while 11.5% of the commuters travel into Guilford County and less than 3.0% of the commuting population works in Davidson County. As was the case with Guilford County, despite the large commuter population that remains in the County, the $PM_{2.5}$ monitor in Forsyth County is under the annual standard.

TABLE 3. Shown below are the commuter county of residence, commuter workplace county and the percent of the Triad MSA commuting into that county for Forsyth County.

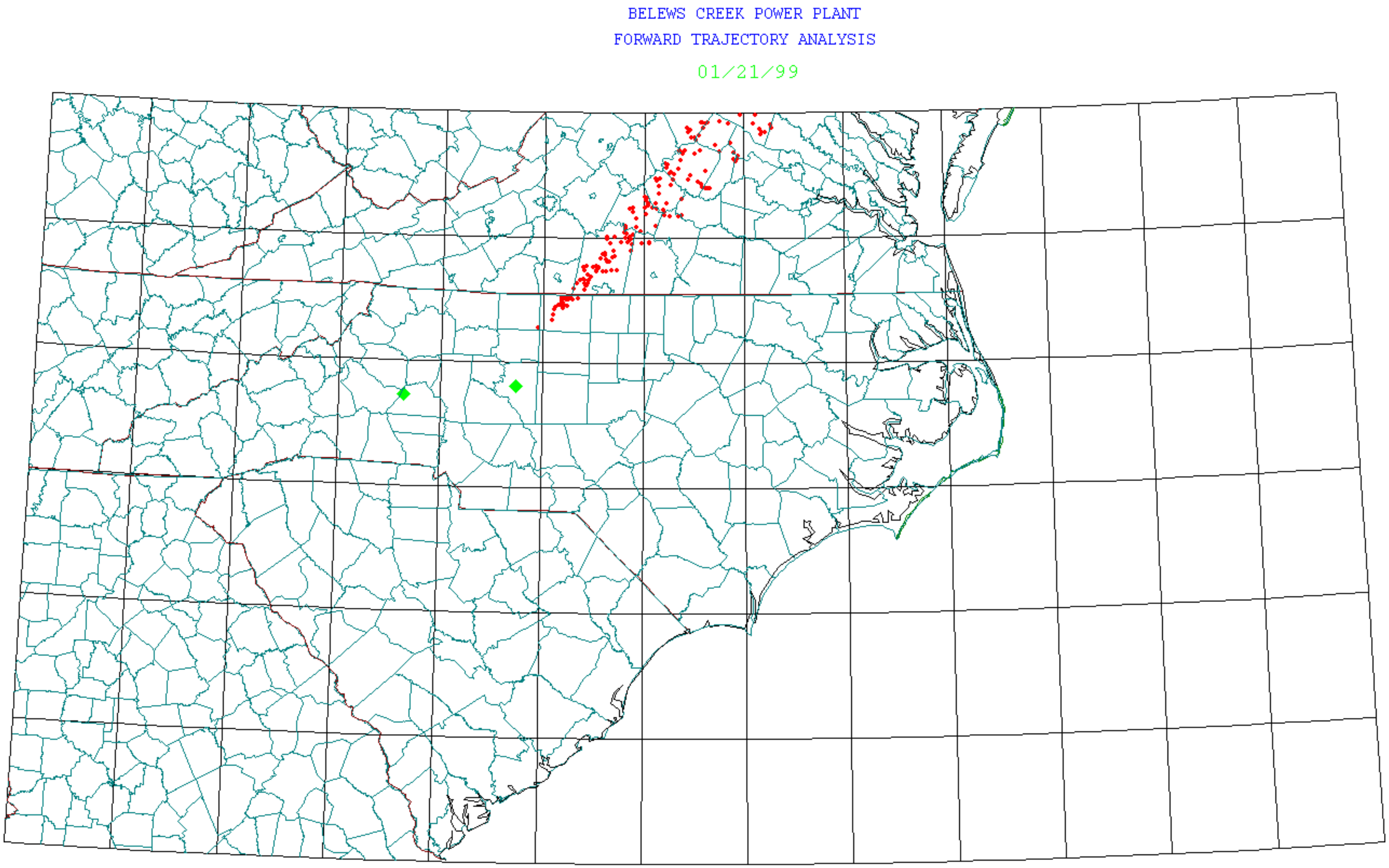
Residence County	Workplace County	Commuter Count	% of MSA
Forsyth Co. NC	Alamance Co. NC	287	0.2%
Forsyth Co. NC	Davidson Co. NC	4136	2.9%
Forsyth Co. NC	Davie Co. NC	902	0.6%
Forsyth Co. NC	Forsyth Co. NC	119233	83.2%
Forsyth Co. NC	Guilford Co. NC	16515	11.5%
Forsyth Co. NC	Randolph Co. NC	392	0.3%
Forsyth Co. NC	Stokes Co. NC	1165	0.8%
Forsyth Co. NC	Yadkin Co. NC	663	0.5%

The analyses above support North Carolina's belief that the emissions from the commuting traffic within Guilford, Randolph and Forsyth Counties do not significantly impact $PM_{2.5}$ concentrations in Davidson County. North Carolina continues to see no advantage to designating these counties non-attainment. Stokes County should also be classified as attainment given the significant emissions controls that will be installed on the Belews Creek power plant. As stated in the letter, if EPA will not classify the entire Stokes County area as attainment, North Carolina recommends that only the Sauratown township where Belews Creek is located be designated non-attainment.

North Carolina has also been provided with an analysis of $PM_{2.5}$ concentration and its relationship to population density in the Triad area. The analysis shows that there is a much better correlation between $PM_{2.5}$ concentrations and population density in the Triad area when the Lexington monitor in Davidson County is not included in the correlation. Put simply, the Lexington monitor does not behave the same as surrounding monitors when considering the population around the monitoring site. The analysis suggests that the higher concentrations of $PM_{2.5}$ in Davidson County are the result of local factors rather than broader regional factors and therefore the addition of counties beyond just Davidson County will not help the monitor attain the standard. This analysis is included in Appendix C. The lack of a consistent relationship between population density and $PM_{2.5}$ concentrations in the Triad calls into question the validity of EPA's own L-Factor analysis, which is based on the premise that $PM_{2.5}$ concentrations are directly correlated to local (county) emissions.

Appendix A – Trajectory Analysis

- The following are 24-hr long forward trajectories originating at the Belews Creek power plant (36.28°N, -80.06°W) in Stokes County, NC run every hour on days when the PM2.5 concentration at the Lexington Monitor (35.81°N, -80.26°W) in Davidson County was high.
- The forward trajectories were run every hour starting at 00 UTC (7 PM EST the previous day) through 23 UTC (6 PM the same day) for 24 hours (resulting in 24 individual trajectories) for each day. The result is a "plume like" representation of the potential impact of emissions originating from Belews Creek.
- The use of multiple trajectories starting throughout the day versus one trajectory starting at one particular hour of the day results in a better representation of the potential dispersion of the power plant emissions.
- Red dots represent the trajectory path (hourly) and the green diamonds represent the locations of the Lexington FRM PM2.5 monitor in Davidson County and the Hickory FRM PM2.5 monitor in Catawba County.
- The monitored PM2.5 concentrations for both the Lexington and Hickory monitors along with the date monitored is shown for each day.
- On several days when concentration data from the Lexington monitor was unavailable, concentration data from the Hickory monitor was used.

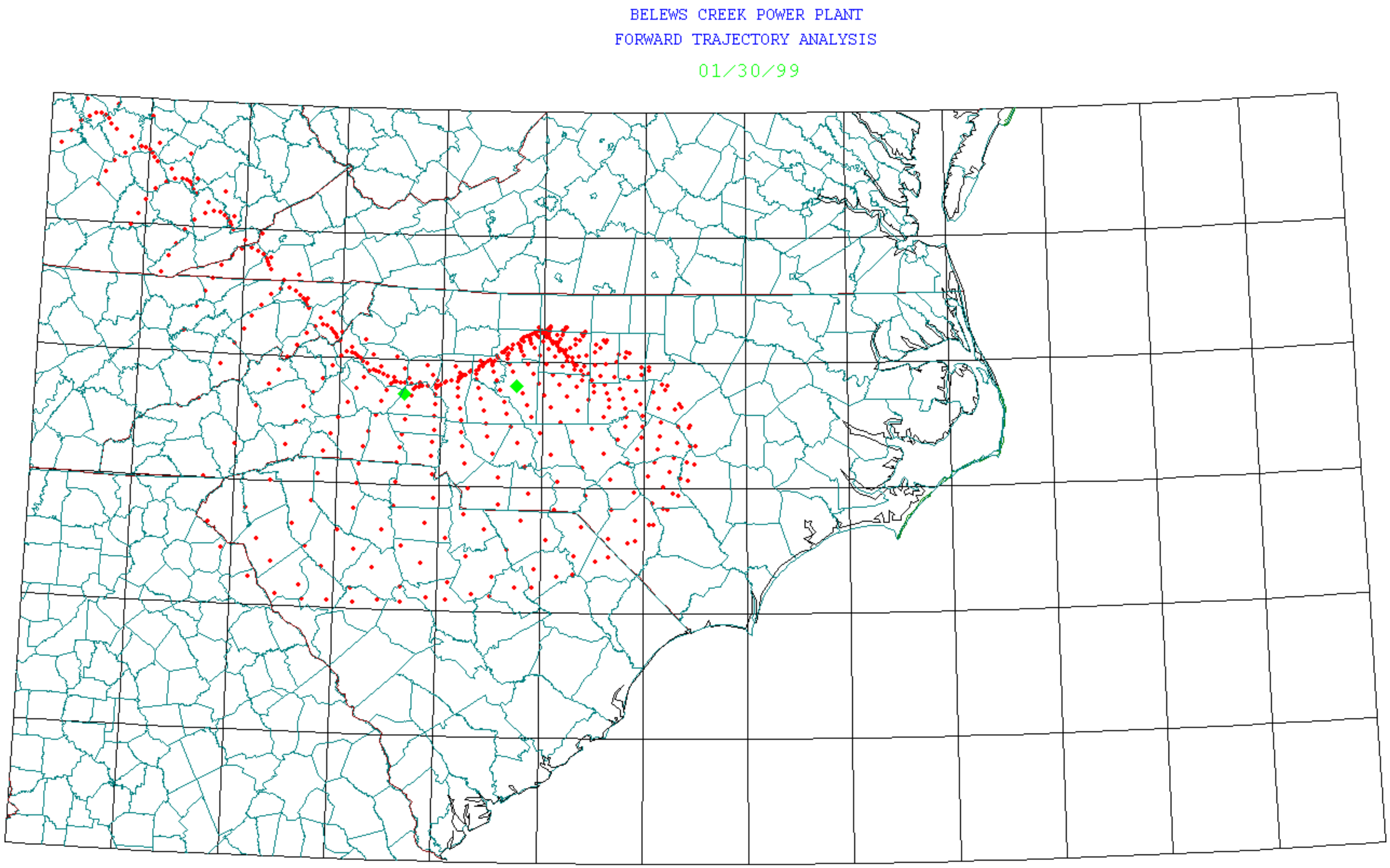


Source: **Belews Creek Power Plant**

Date:**01/21/1999**

Concentration @ Hickory: **41.0 μg/m³**

Concentration @ Lexington: **31.0 μg/m³**

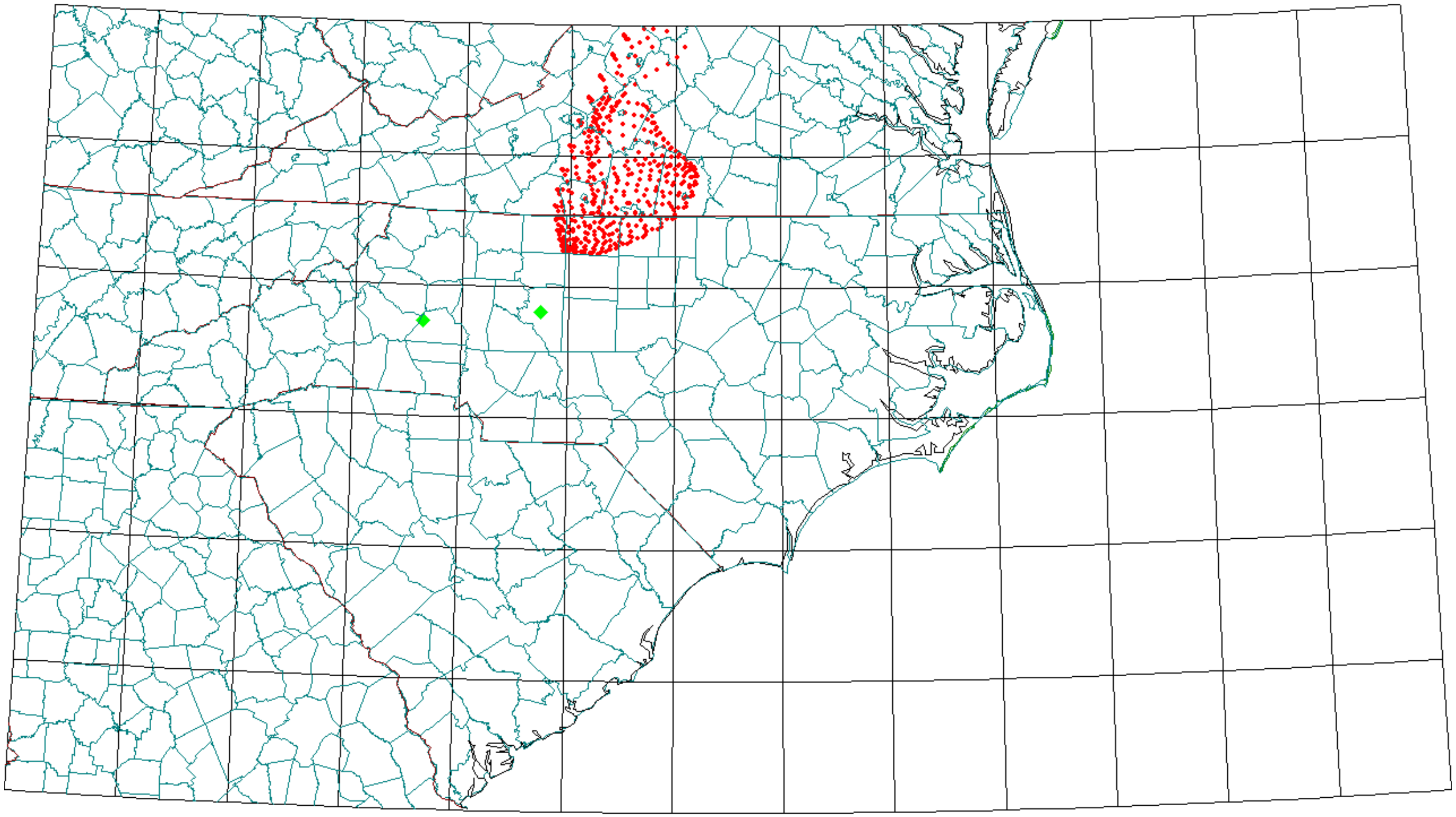


Source: **Belews Creek Power Plant**

Date:**01/30/1999**

Concentration @ Hickory: **28.9 μg/m³**

Concentration @ Lexington: **23.0 μg/m³**

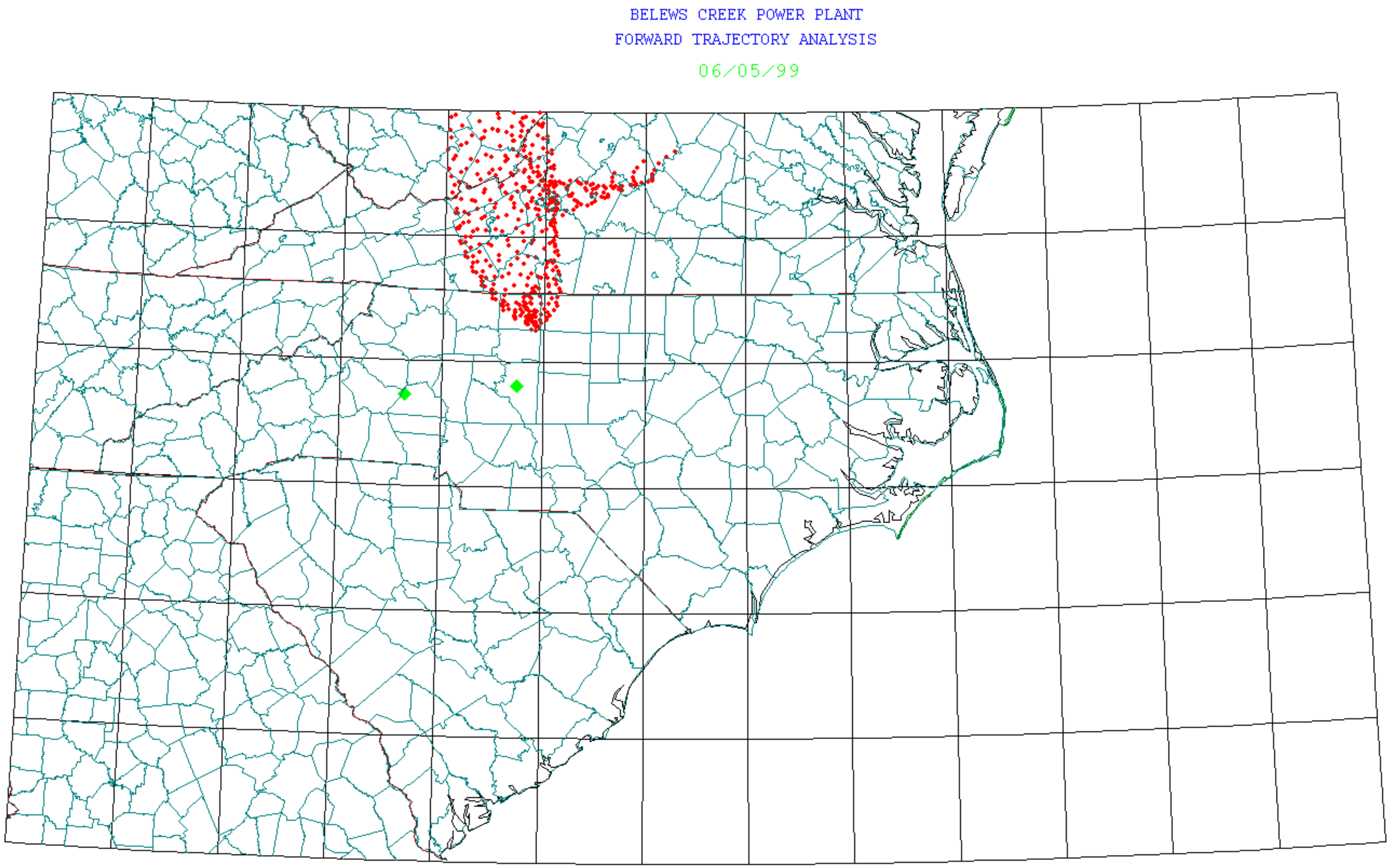


Source: **Belews Creek Power Plant**

Date:**05/30/1999**

Concentration @ Hickory:**25.0 μg/m³**

Concentration @ Lexington: **29.1 μg/m³**

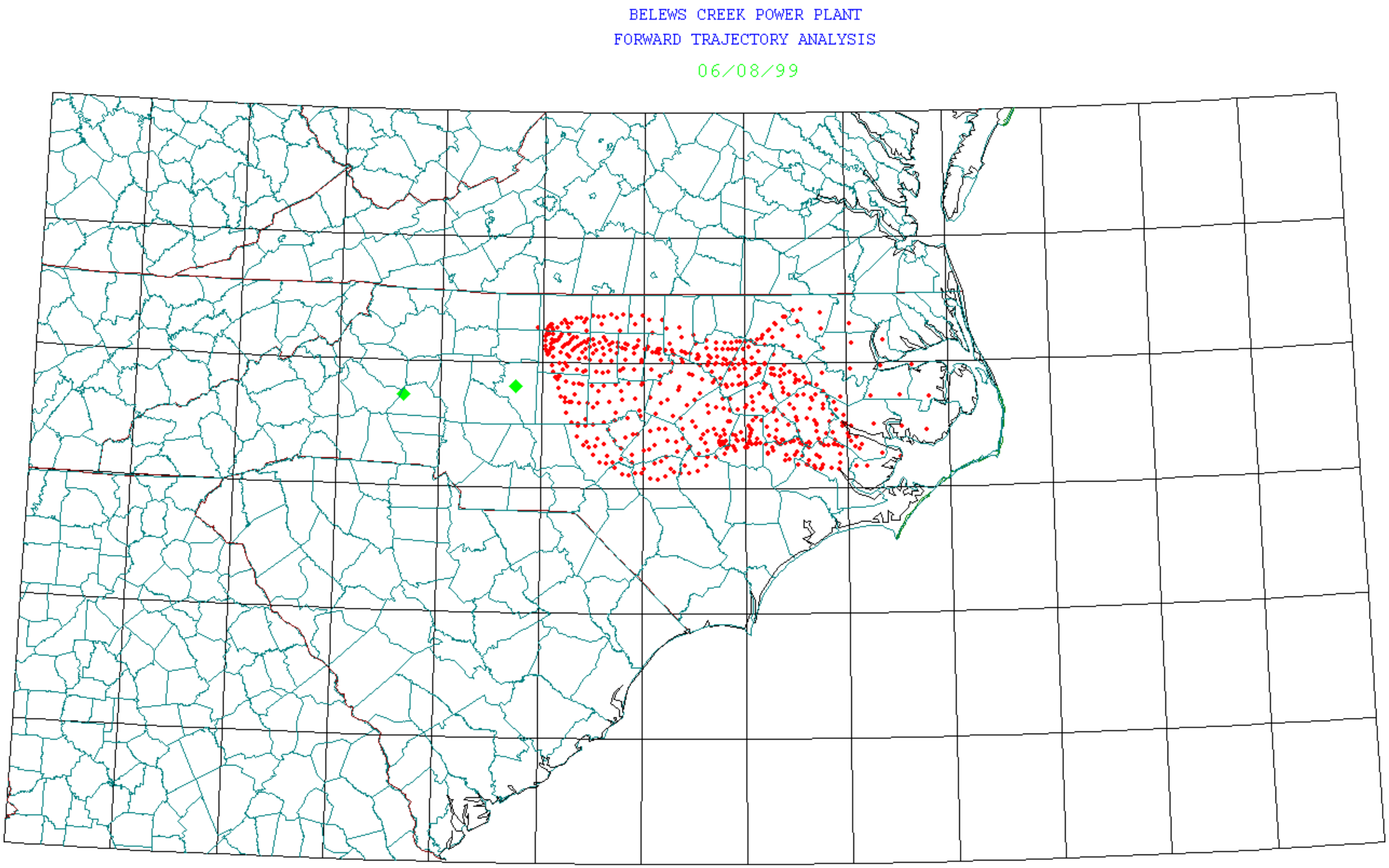


Source: **Belews Creek Power Plant**

Date:**06/05/1999**

Concentration @ Hickory: **33.2 μg/m³**

Concentration @ Lexington: **23.7 μg/m³**

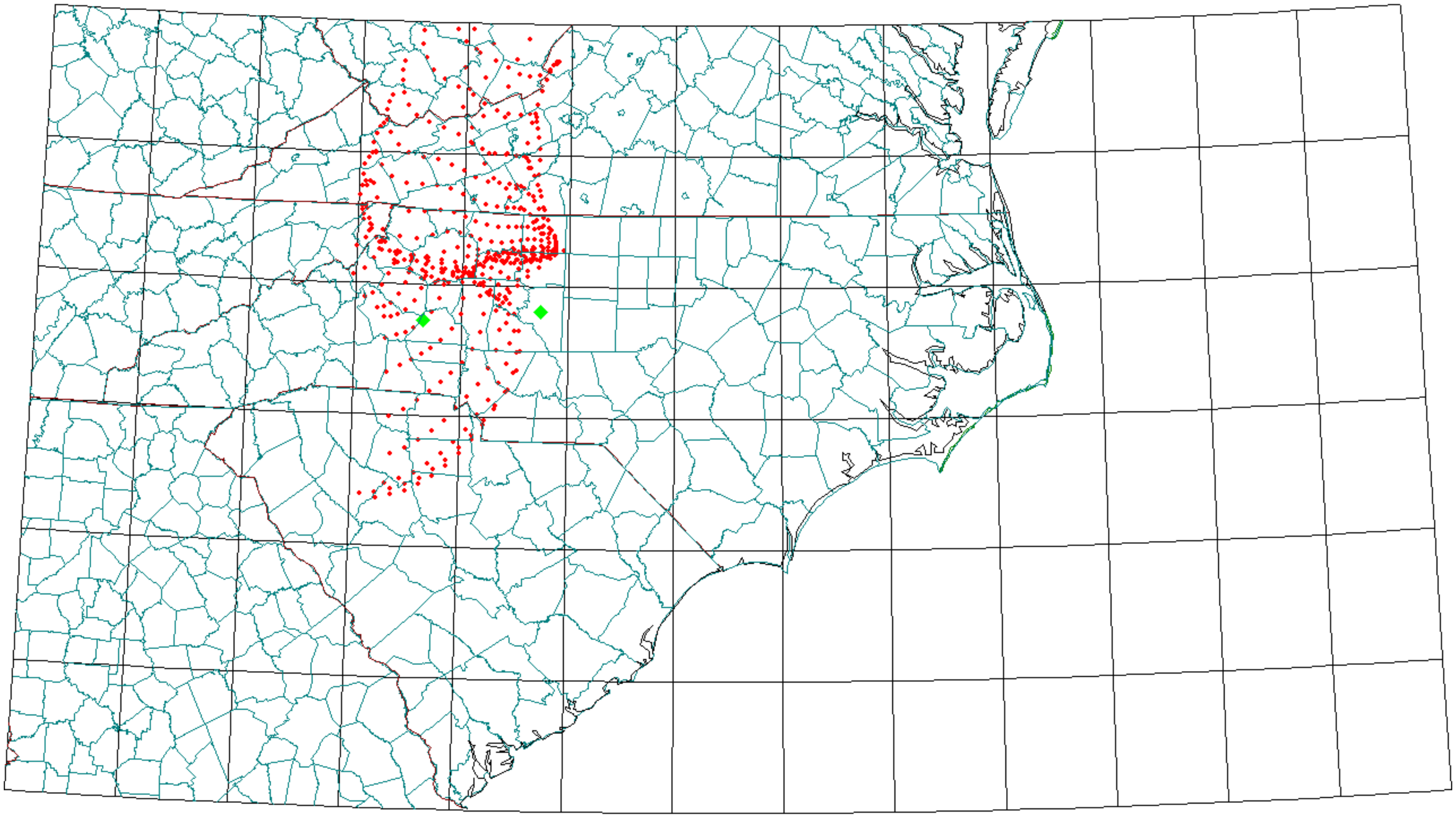


Source: **Belews Creek Power Plant**

Date:**06/08/1999**

Concentration @ Hickory: **31.7 μg/m³**

Concentration @ Lexington: **Missing**

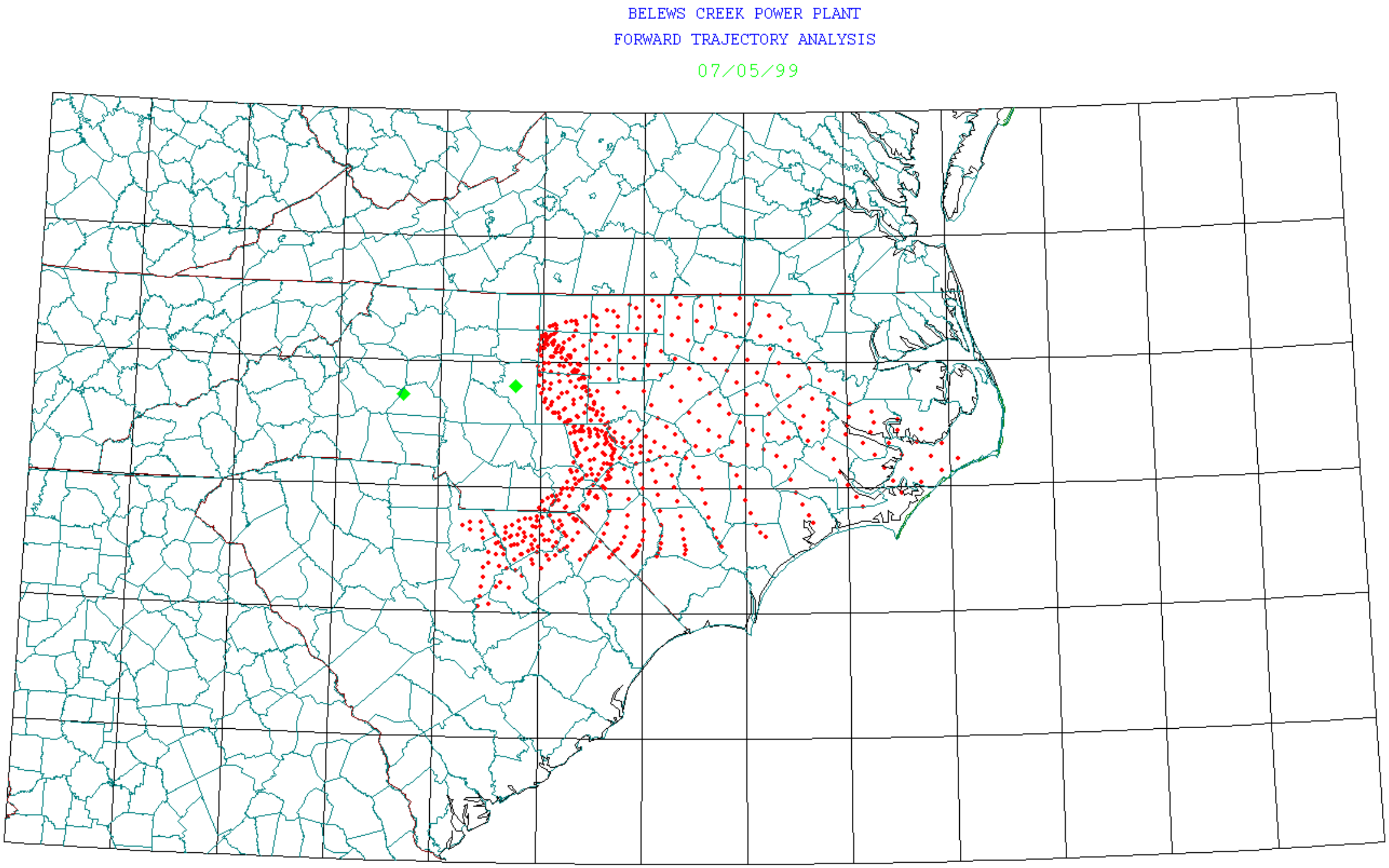


Source: **Belews Creek Power Plant**

Date:**06/11/1999**

Concentration @ Hickory: **Missing**

Concentration @ Lexington: **29.8 μg/m^3**

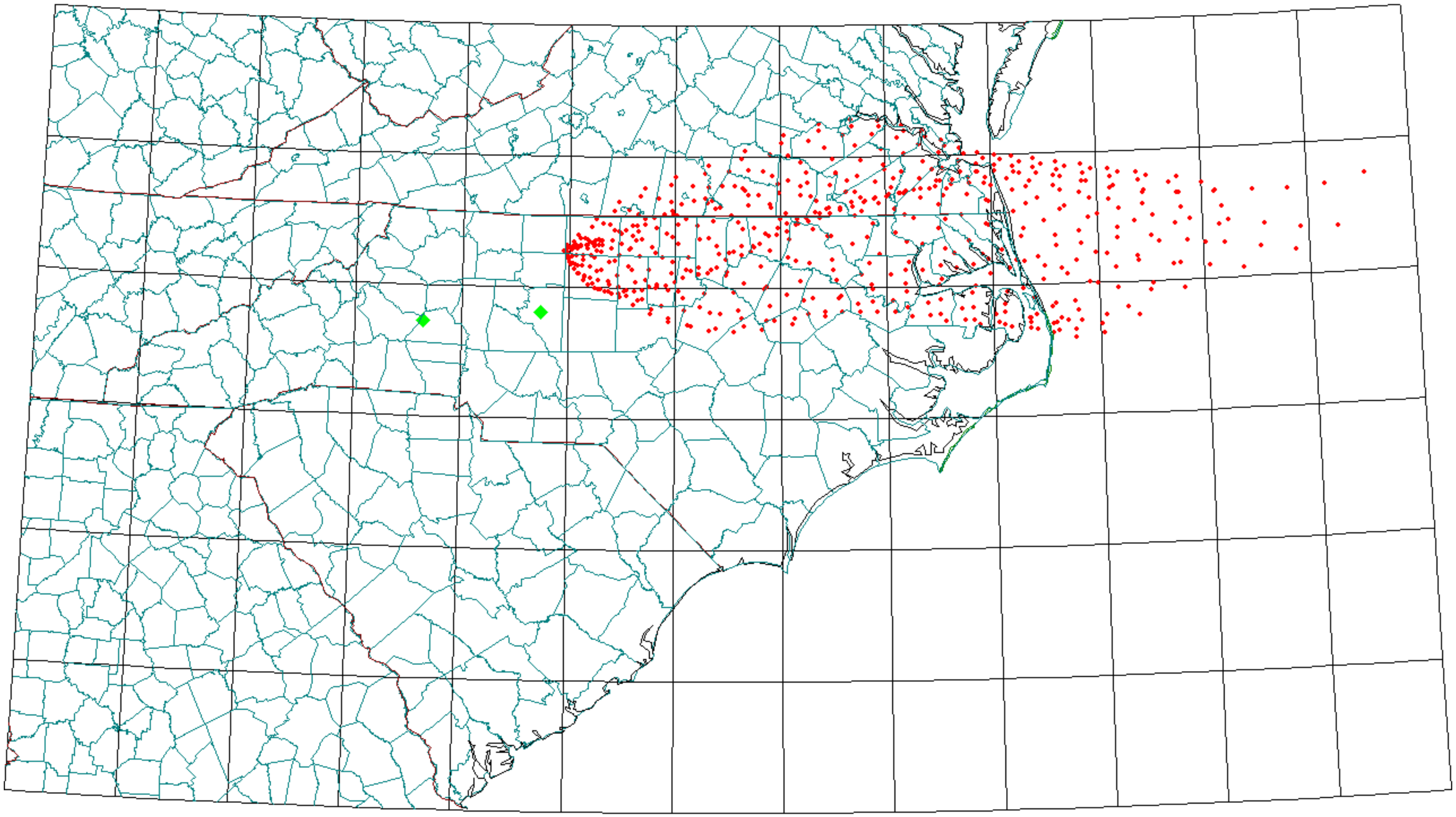


Source: **Belews Creek Power Plant**

Date:**07/05/1999**

Concentration @ Hickory: **28.2 μg/m³**

Concentration @ Lexington: **36.6 μg/m³**

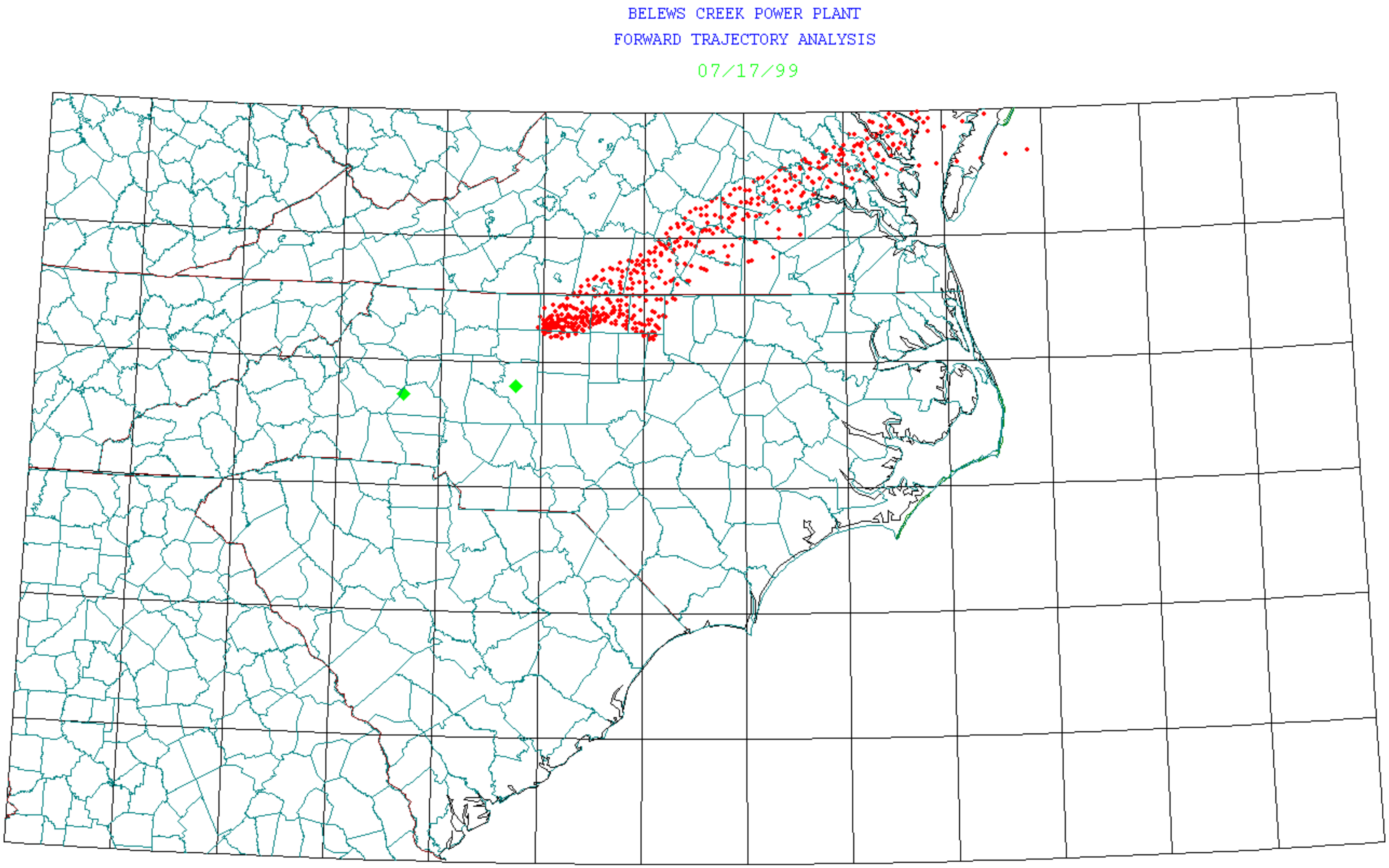


Source: **Belews Creek Power Plant**

Date:**07/08/1999**

Concentration @ Hickory:**24.6 μg/m³**

Concentration @ Lexington: **28.4 μg/m³**

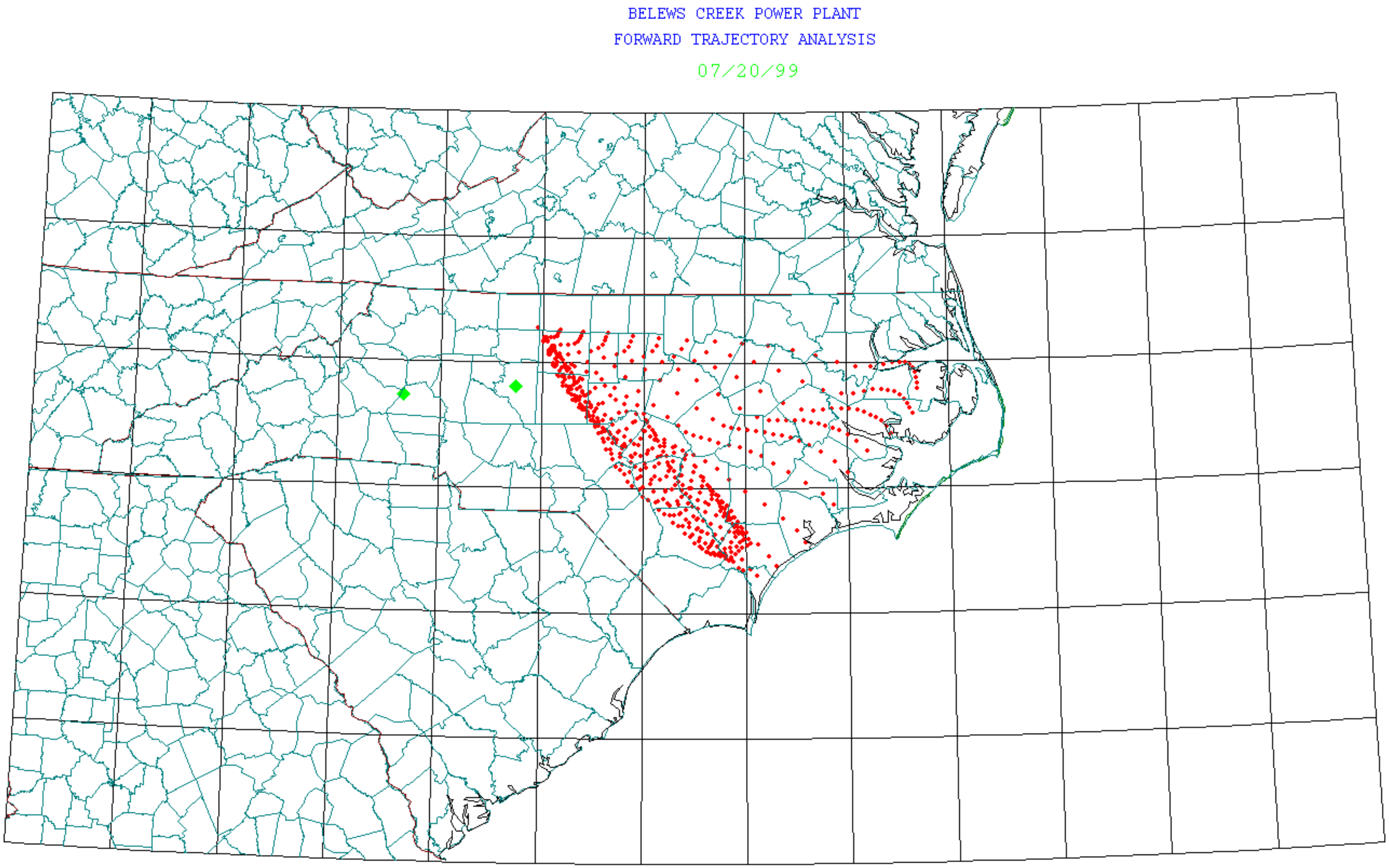


Source: **Belews Creek Power Plant**

Date:**07/17/1999**

Concentration @ Hickory: **32.3 μg/m³**

Concentration @ Lexington: **38.9 μg/m³**

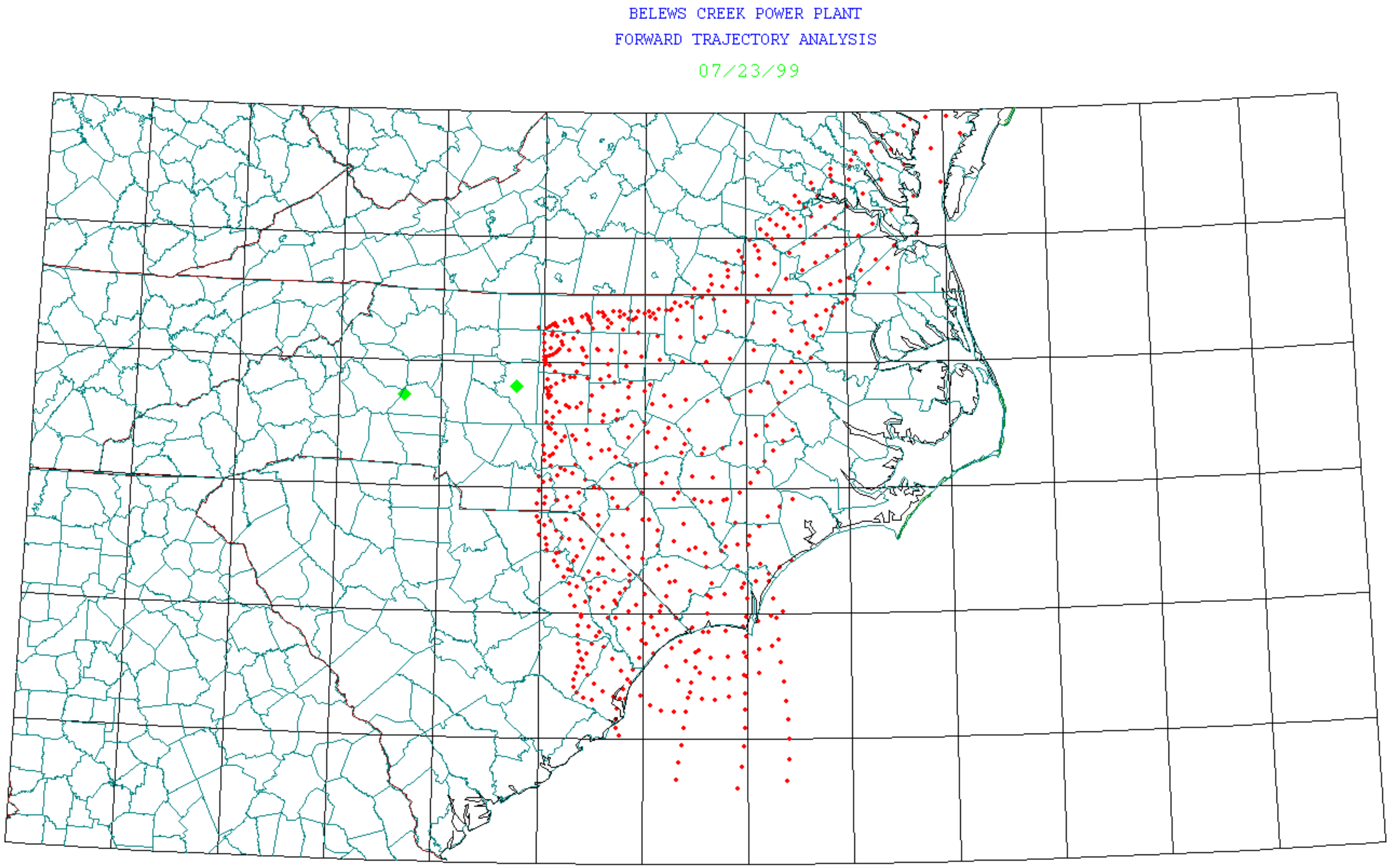


Source: **Belews Creek Power Plant**

Date:**07/20/1999**

Concentration @ Hickory: **30.9 μg/m³**

Concentration @ Lexington: **30.6 μg/m³**

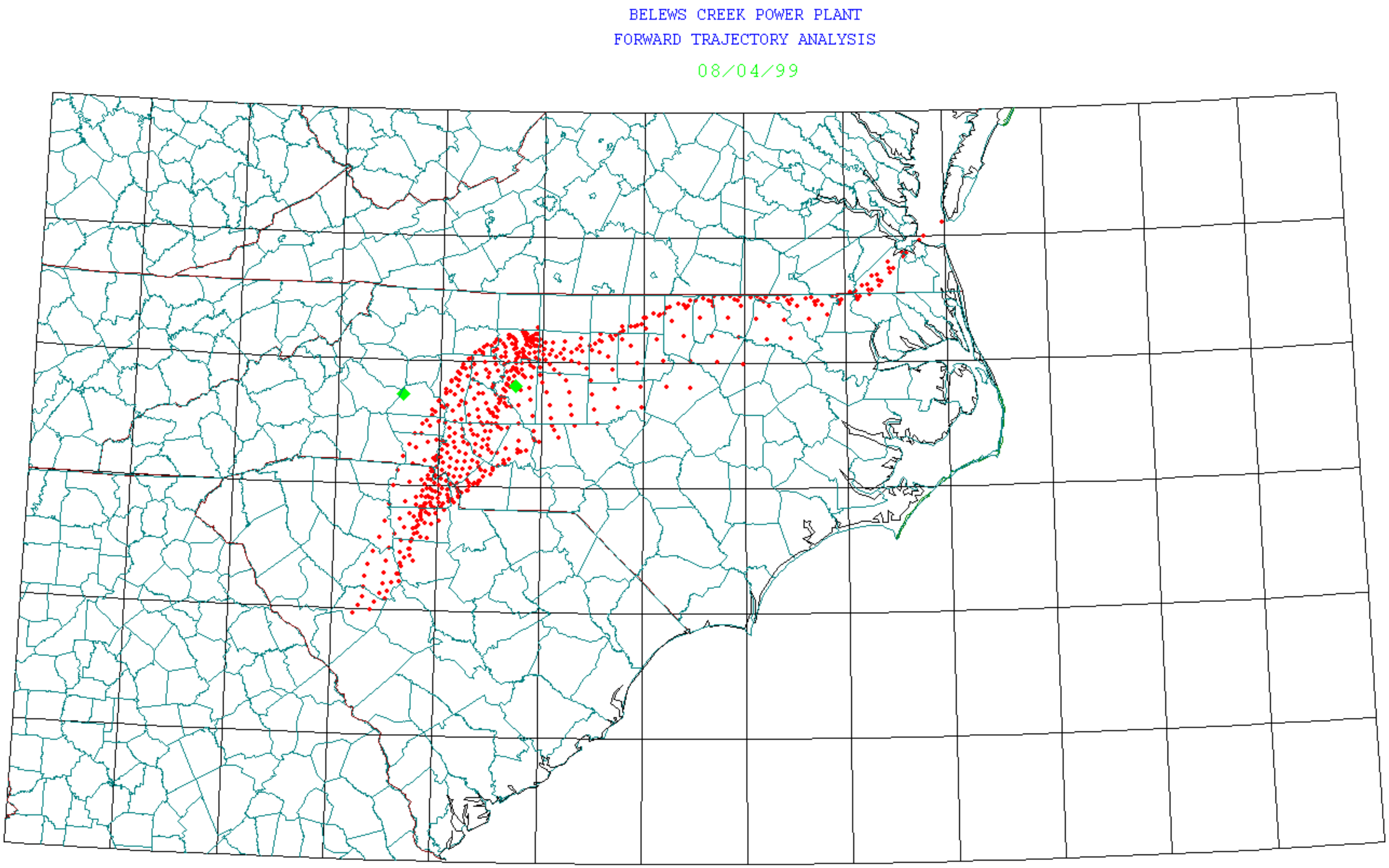


Source: **Belews Creek Power Plant**

Date:**07/23/1999**

Concentration @ Hickory: **36.1 μg/m³**

Concentration @ Lexington: **40.5 μg/m³**

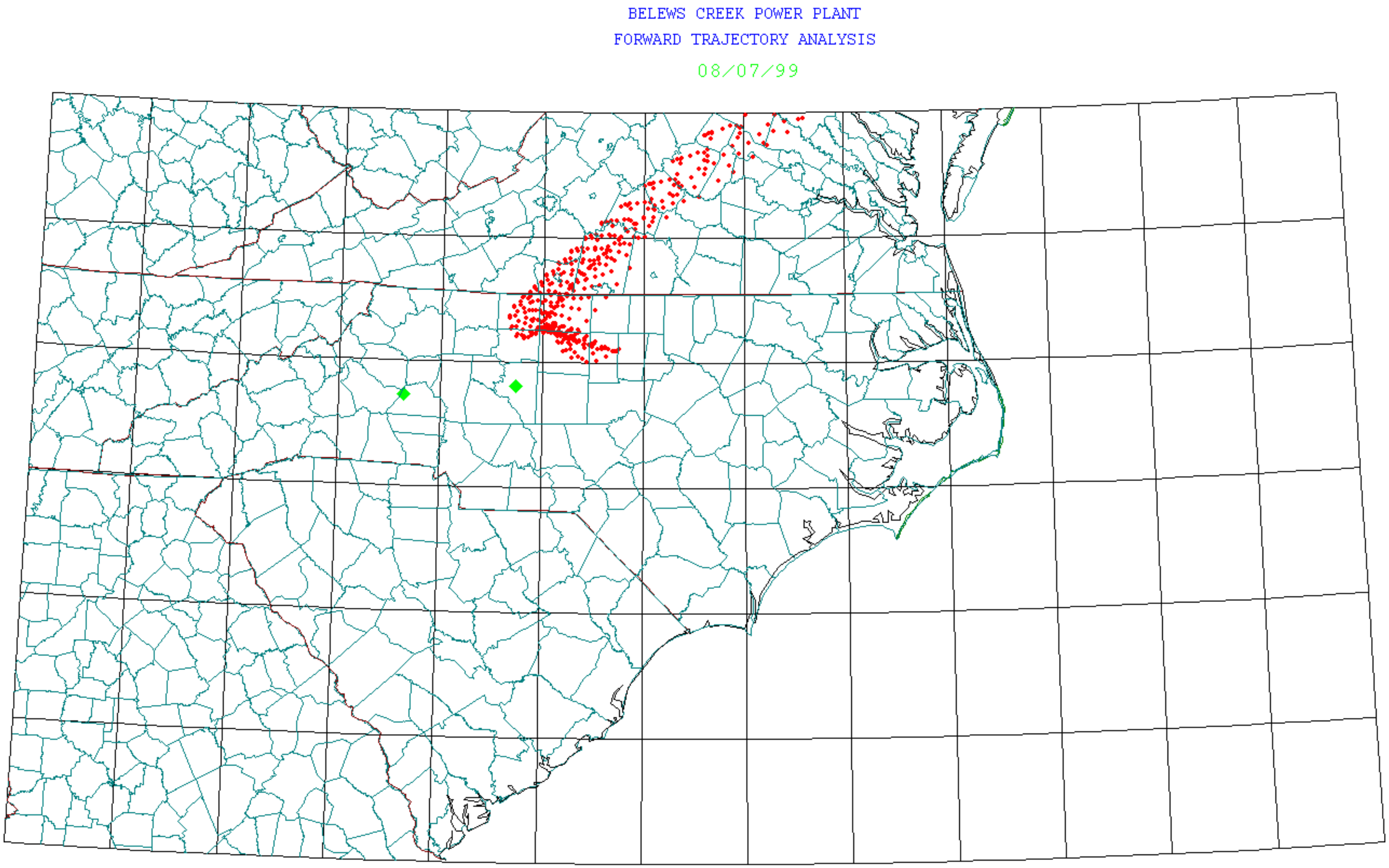


Source: **Belews Creek Power Plant**

Date:**08/04/1999**

Concentration @ Hickory: **28.1 μg/m³**

Concentration @ Lexington: **24.8 μg/m³**

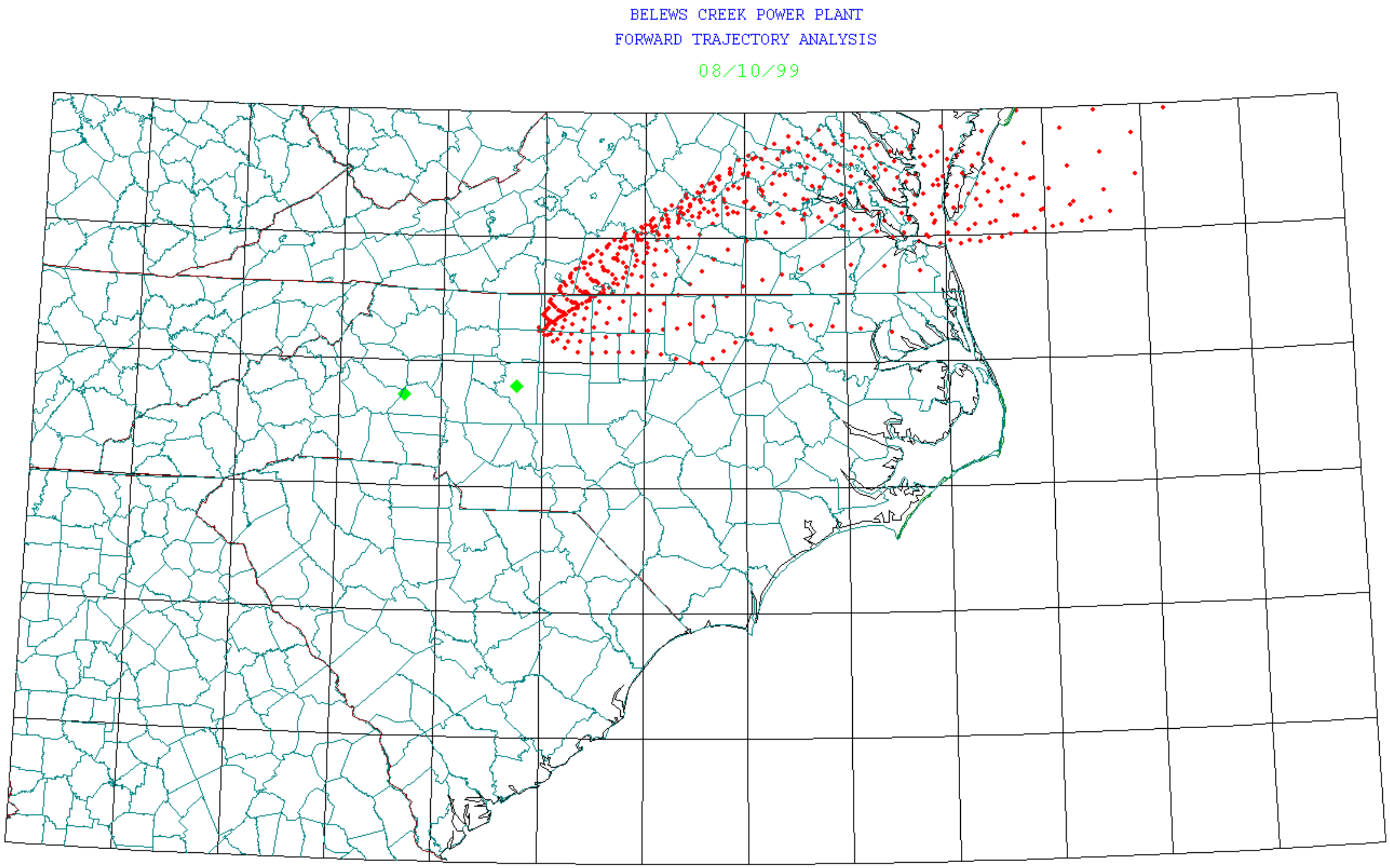


Source: **Belews Creek Power Plant**

Date:**08/07/1999**

Concentration @ Hickory: **33.1 μg/m³**

Concentration @ Lexington: **33.8 μg/m³**

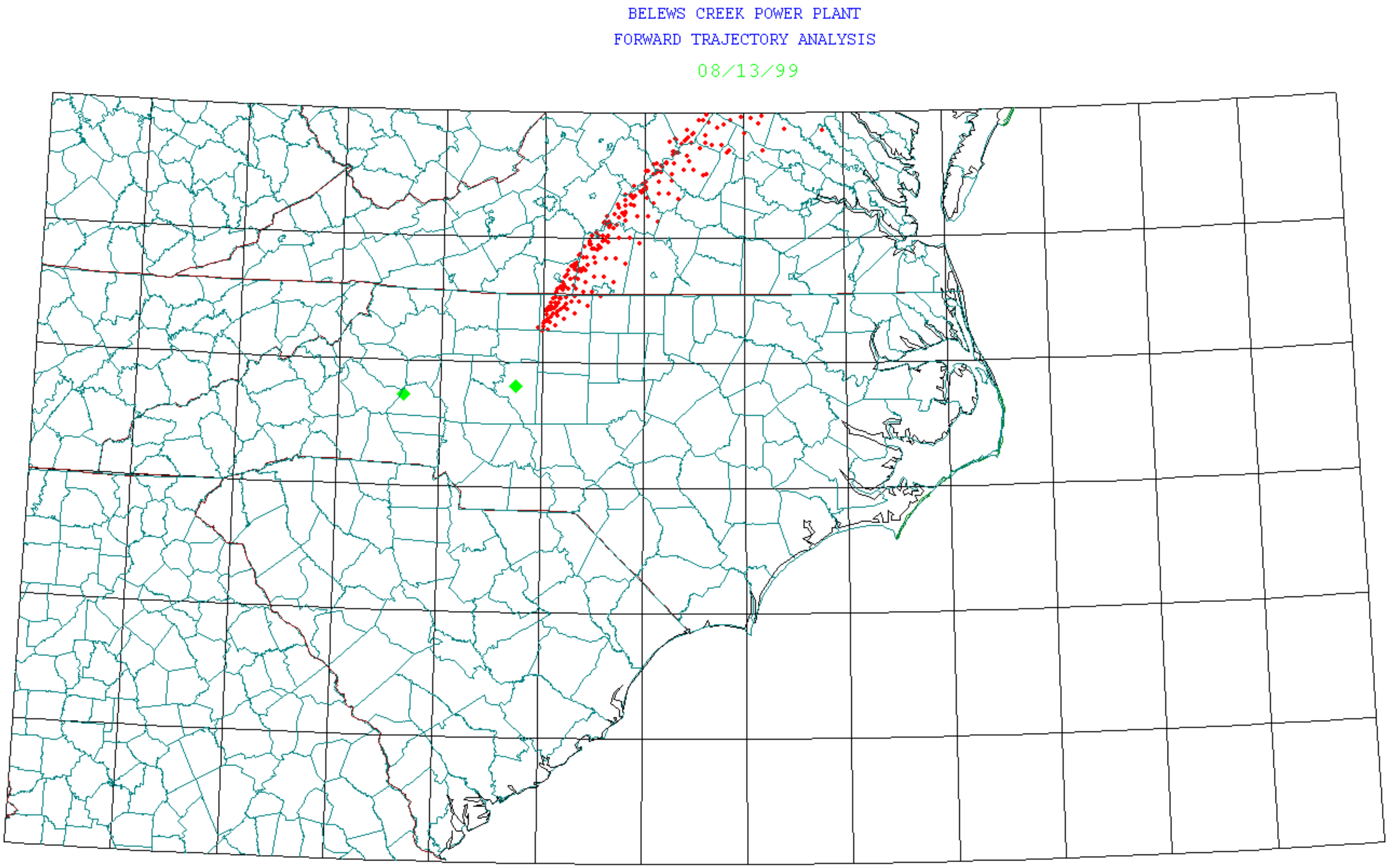


Source: **Belews Creek Power Plant**

Date:**08/10/1999**

Concentration @ Hickory: **28.4 μg/m^3**

Concentration @ Lexington: **24.3 μg/m^3**

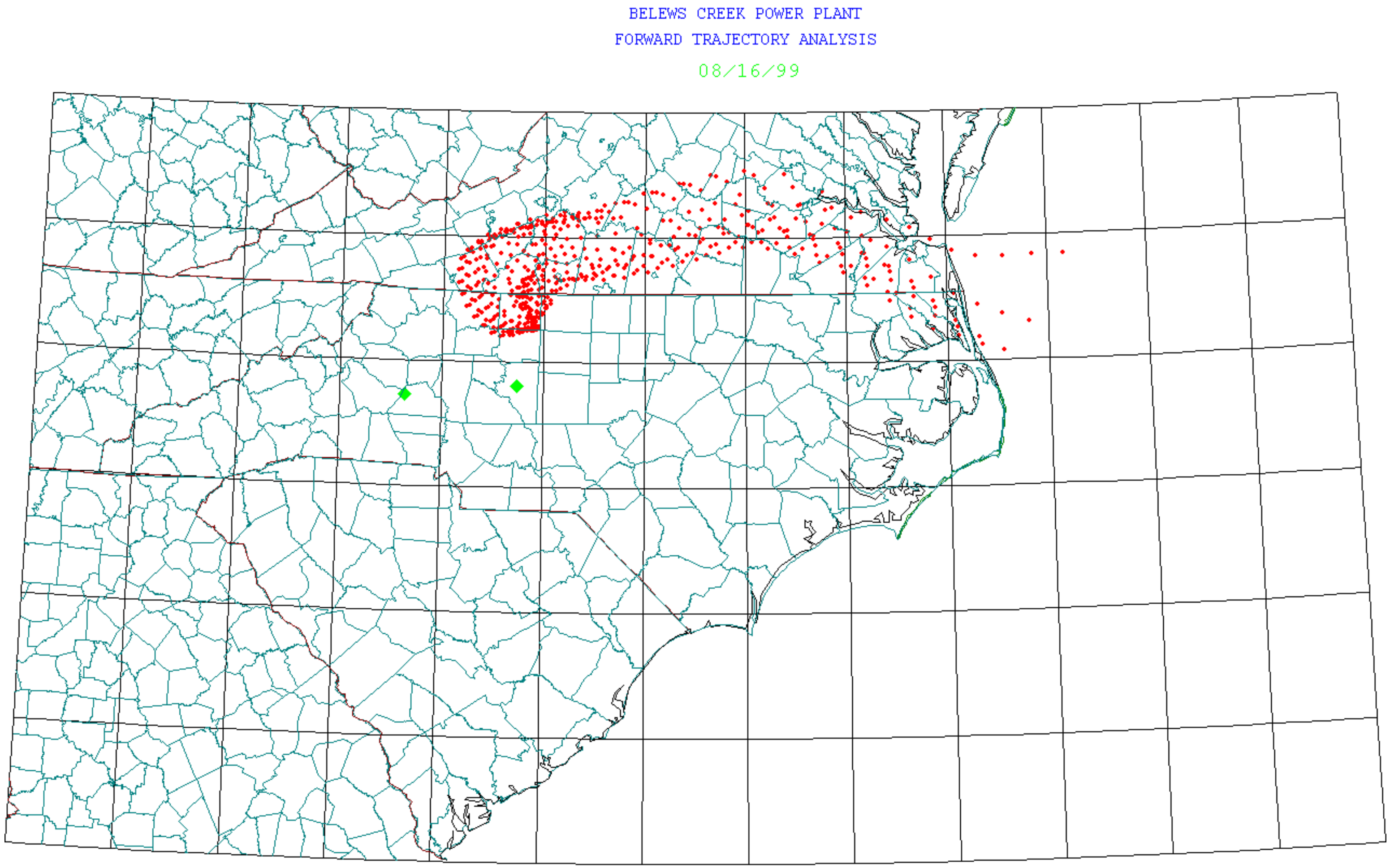


Source: **Belews Creek Power Plant**

Date:**08/13/1999**

Concentration @ Hickory: **31.0 μg/m³**

Concentration @ Lexington: **44.8 μg/m³**

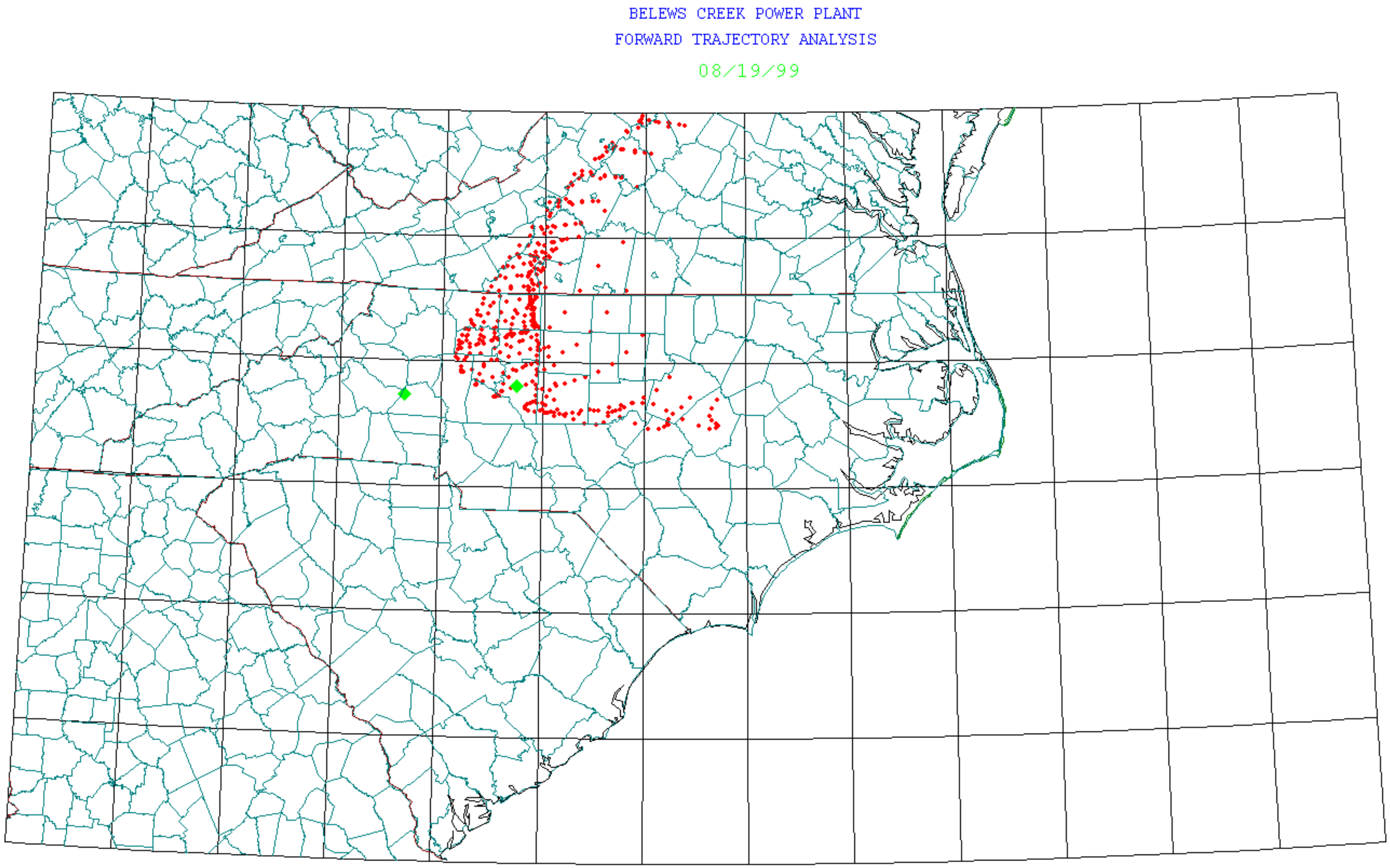


Source: **Belews Creek Power Plant**

Date:**08/16/1999**

Concentration @ Hickory: **31.1 μg/m³**

Concentration @ Lexington: **30.1 μg/m³**

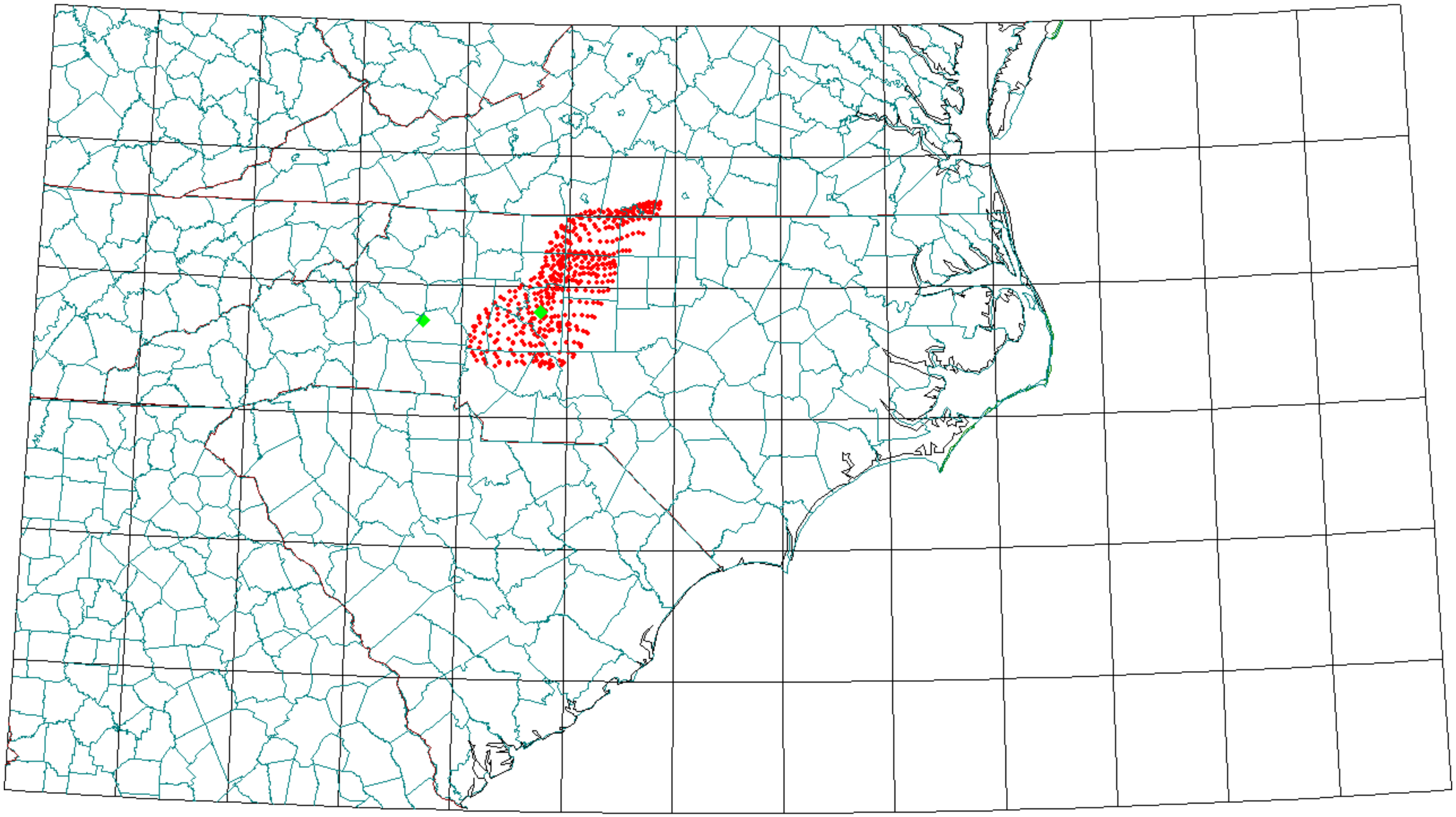


Source: **Belews Creek Power Plant**

Date:**08/19/1999**

Concentration @ Hickory: **29.6 μg/m³**

Concentration @ Lexington: **31.1 μg/m³**

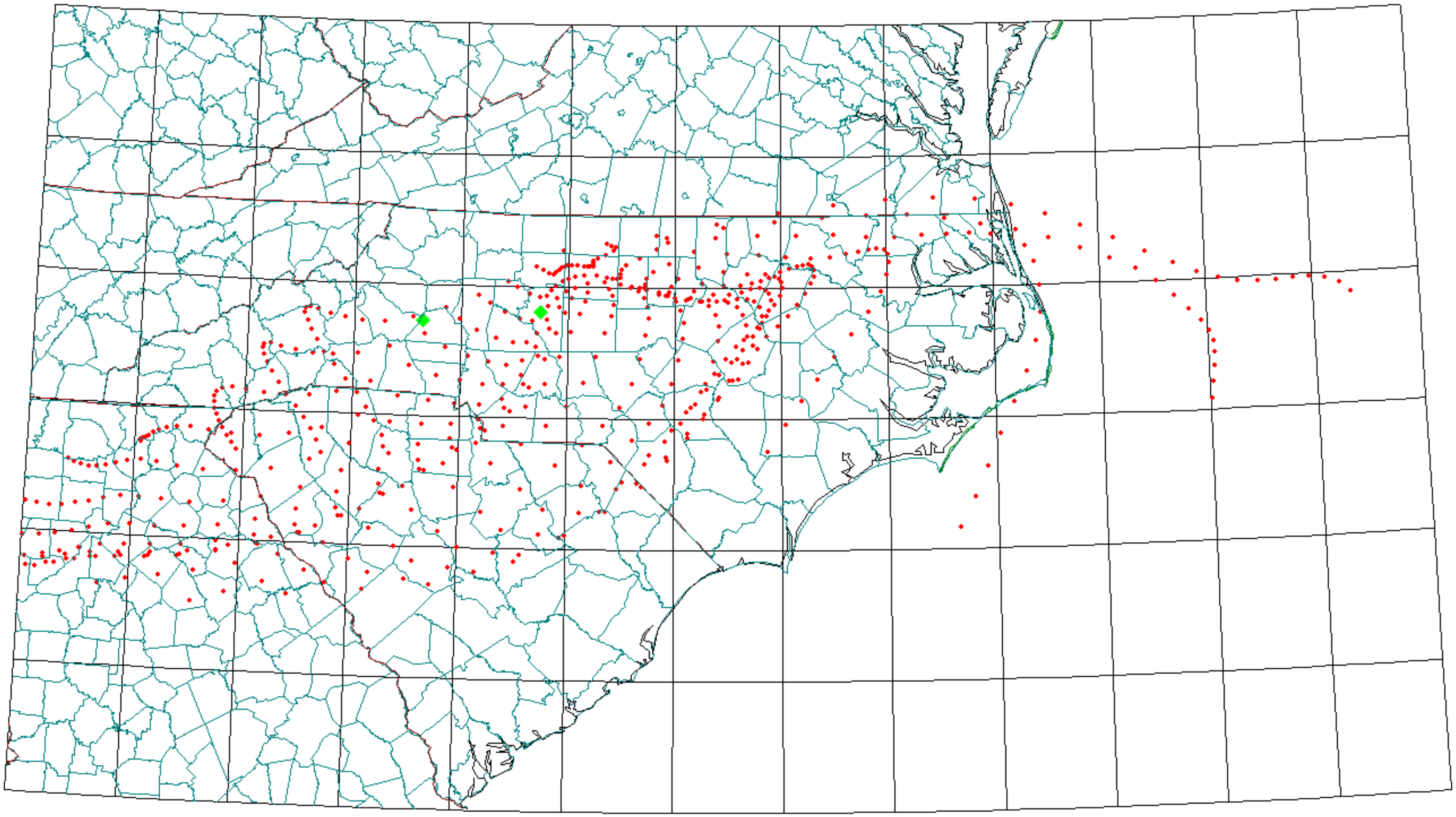


Source: **Belews Creek Power Plant**

Date:**08/28/1999**

Concentration @ Hickory:**Missing**

Concentration @ Lexington: **32.1 μg/m^3**

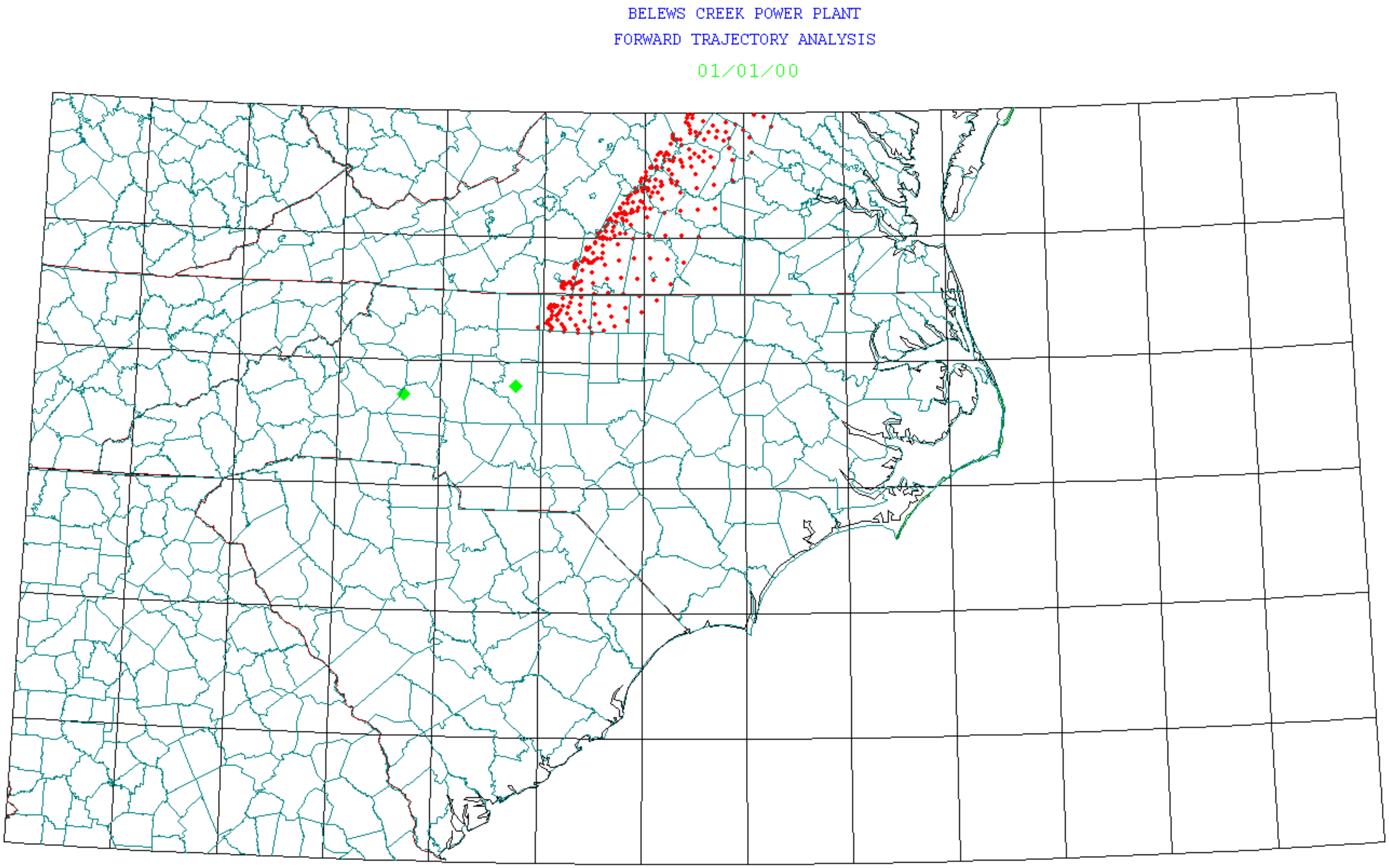


Source: **Belews Creek Power Plant**

Date:**11/11/1999**

Concentration @ Hickory:**21.9 μg/m³**

Concentration @ Lexington: **31.8 μg/m³**

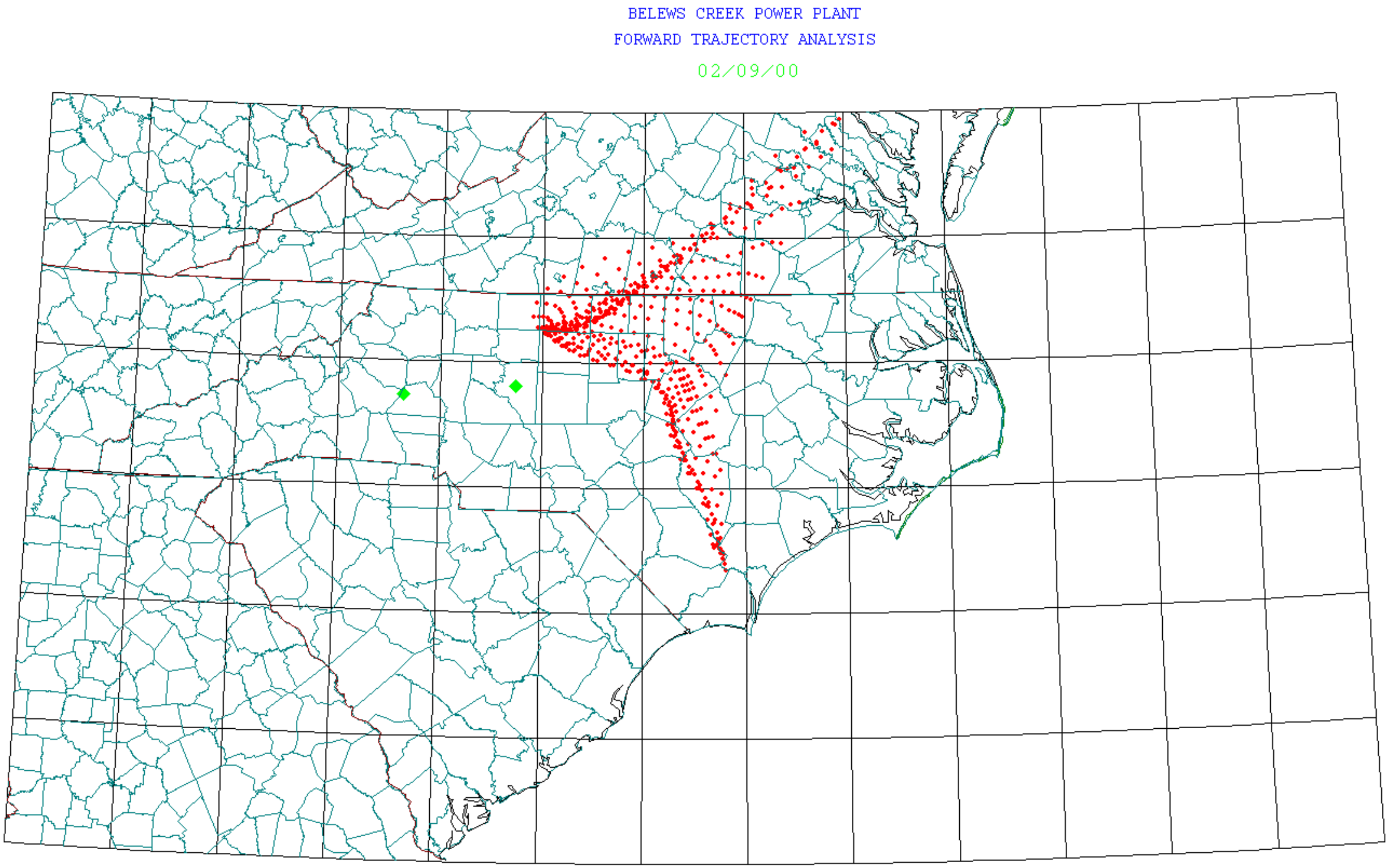


Source: **Belews Creek Power Plant**

Date: **01/01/2000**

Concentration @ Hickory: **33.0 μg/m³**

Concentration @ Lexington: **46.8 μg/m³**

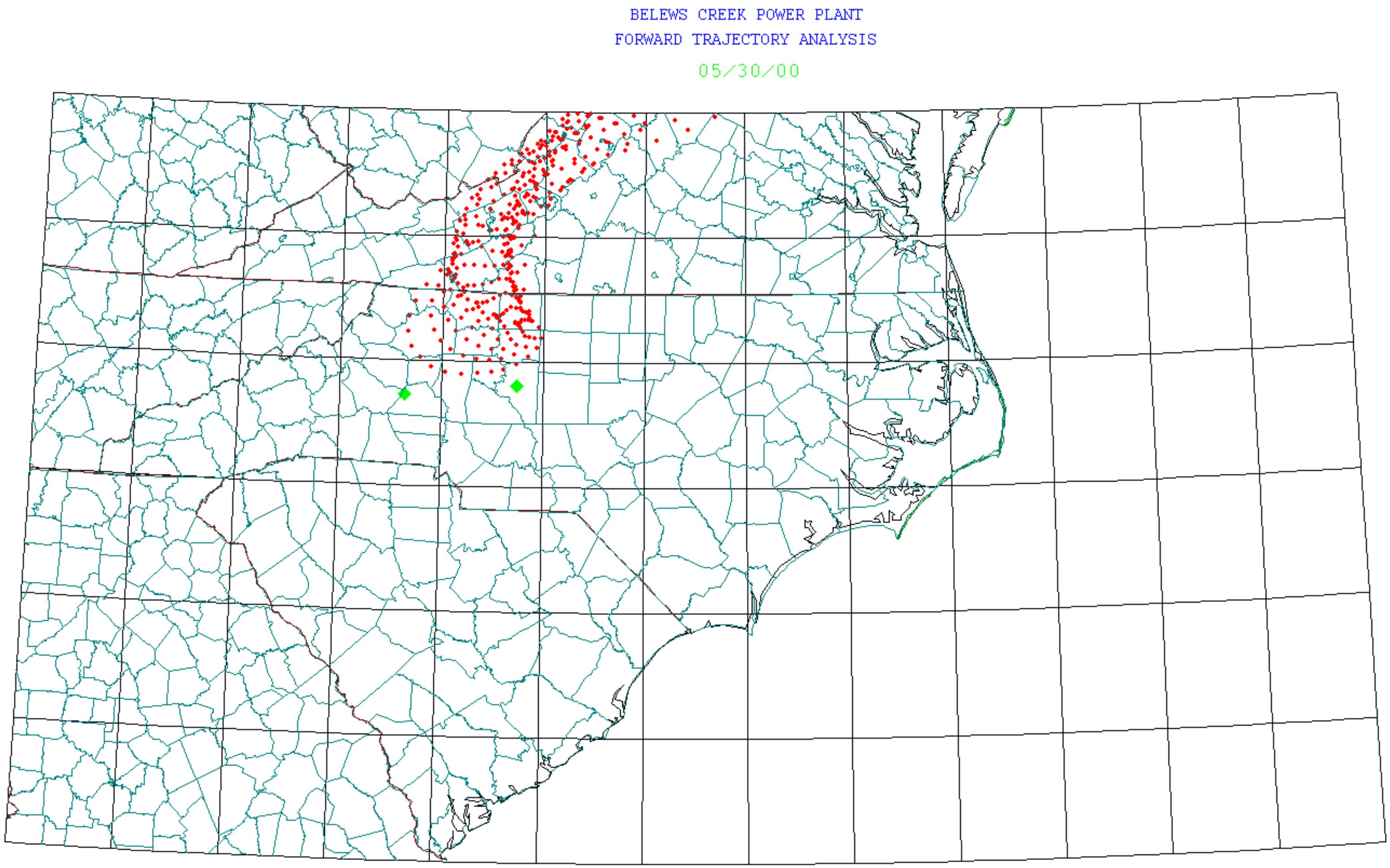


Source: **Belews Creek Power Plant**

Date:**02/09/2000**

Concentration @ Hickory: **33.5 μg/m³**

Concentration @ Lexington: **29.4 μg/m³**

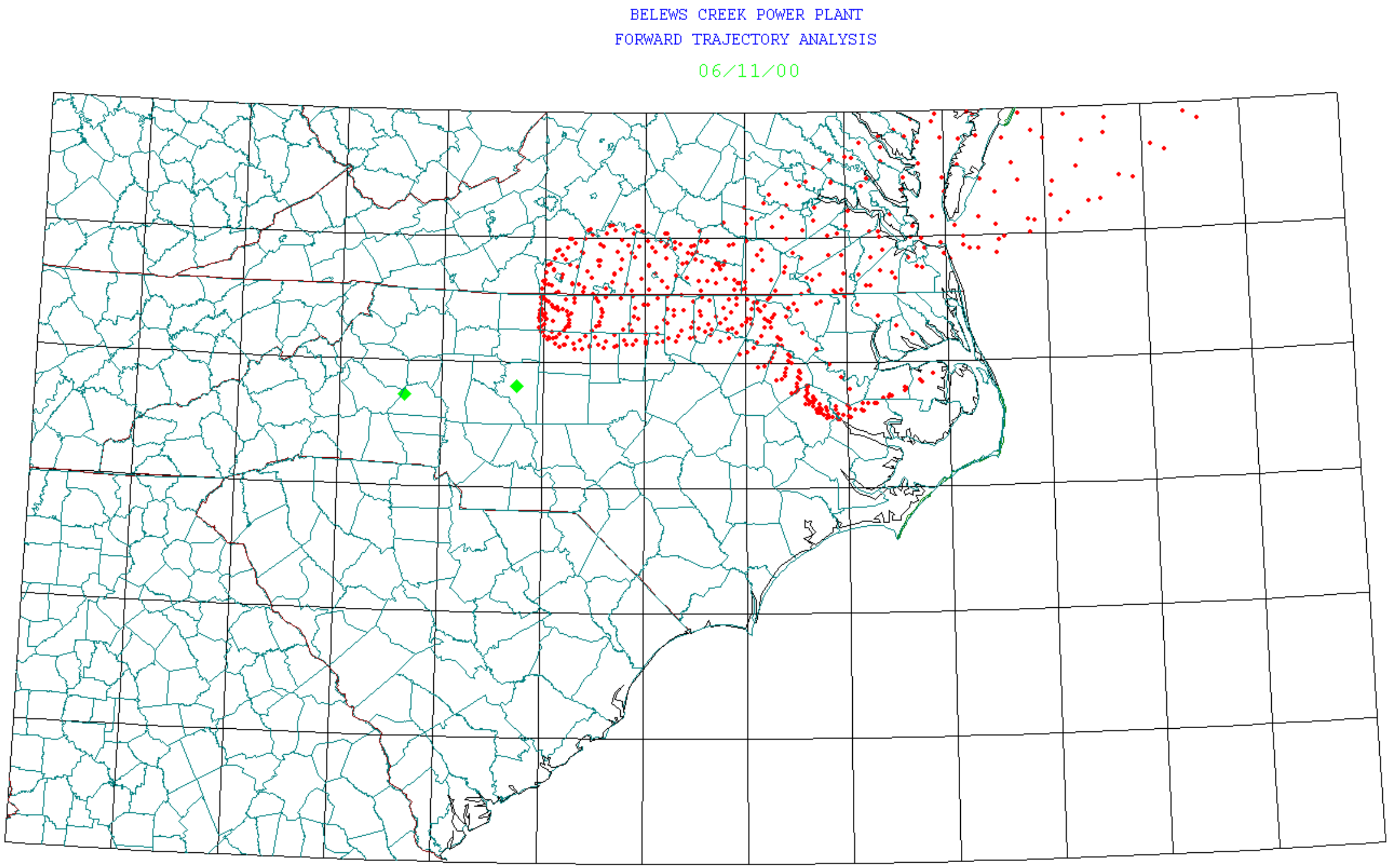


Source: **Belews Creek Power Plant**

Date: **05/30/2000**

Concentration @ Hickory: **30.8 μg/m³**

Concentration @ Lexington: **8.3 μg/m³**

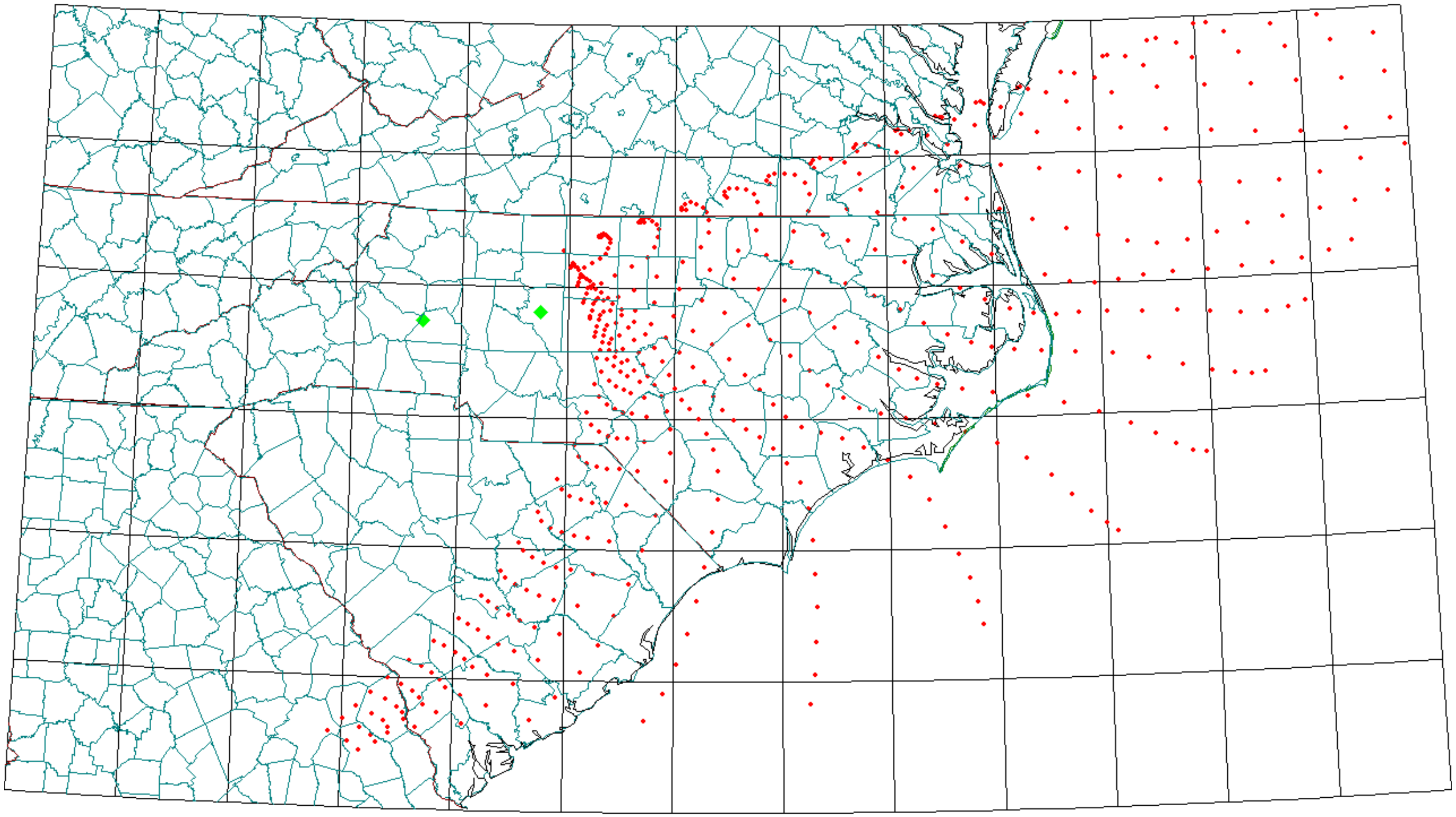


Source: **Belews Creek Power Plant**

Date:**06/11/2000**

Concentration @ Hickory: **28.2 μg/m³**

Concentration @ Lexington: **24.9 μg/m³**

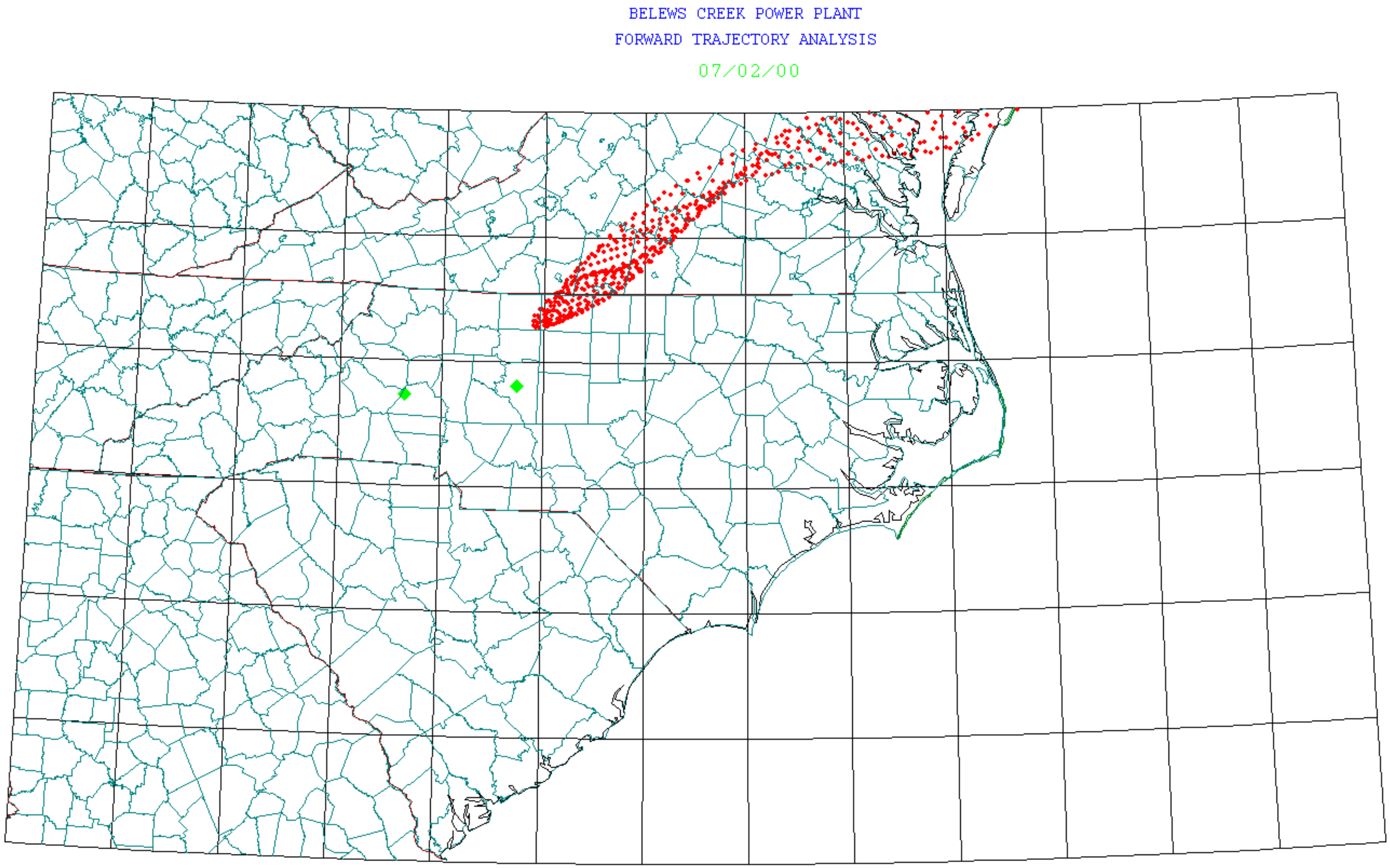


Source: **Belews Creek Power Plant**

Date: **06/29/2000**

Concentration @ Hickory:**12.0 µg/m³**

Concentration @ Lexington: **34.1 µg/m³**

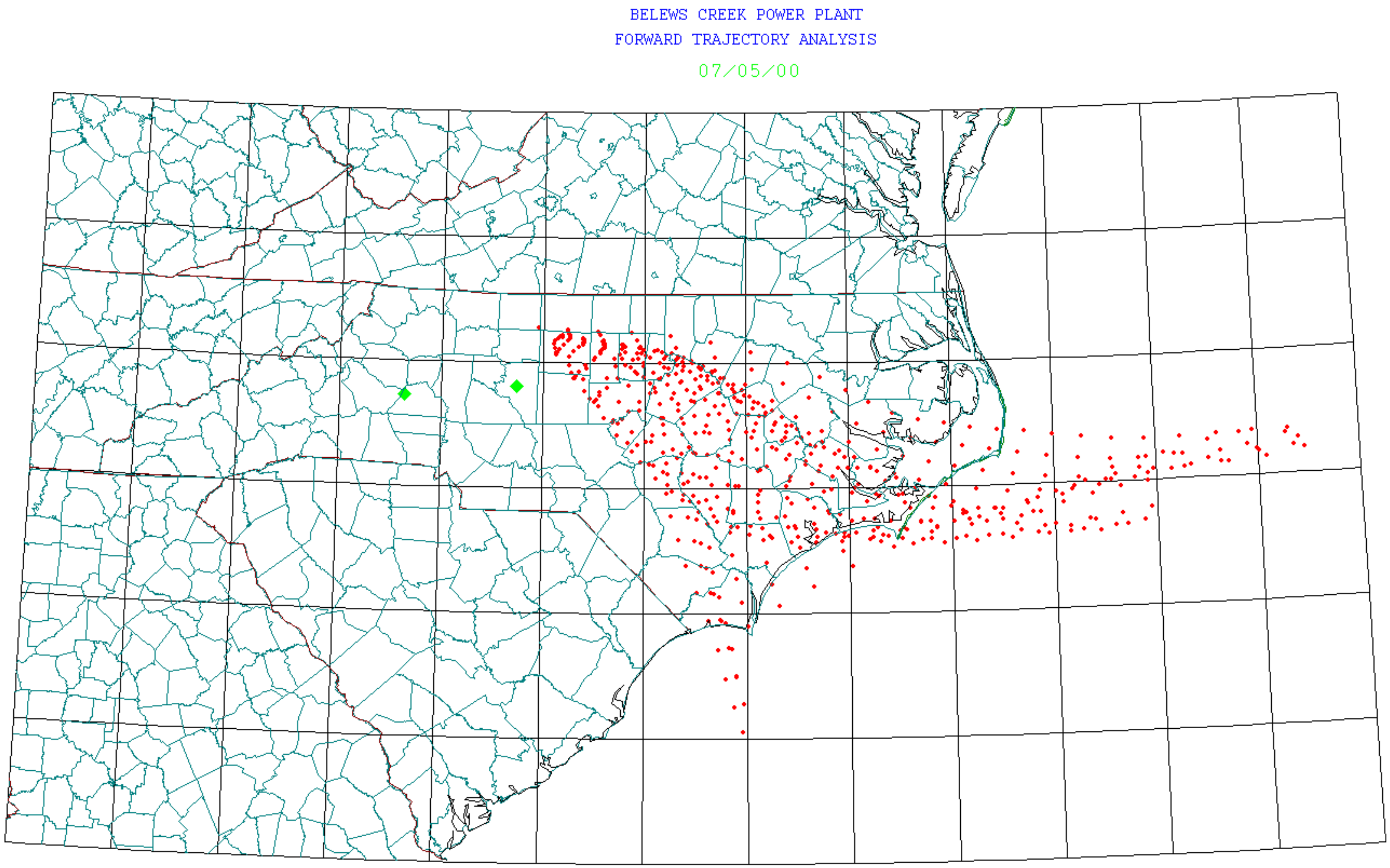


Source: **Belews Creek Power Plant**

Date:**07/02/2000**

Concentration @ Hickory: **29.4 μg/m³**

Concentration @ Lexington: **32.7 μg/m³**

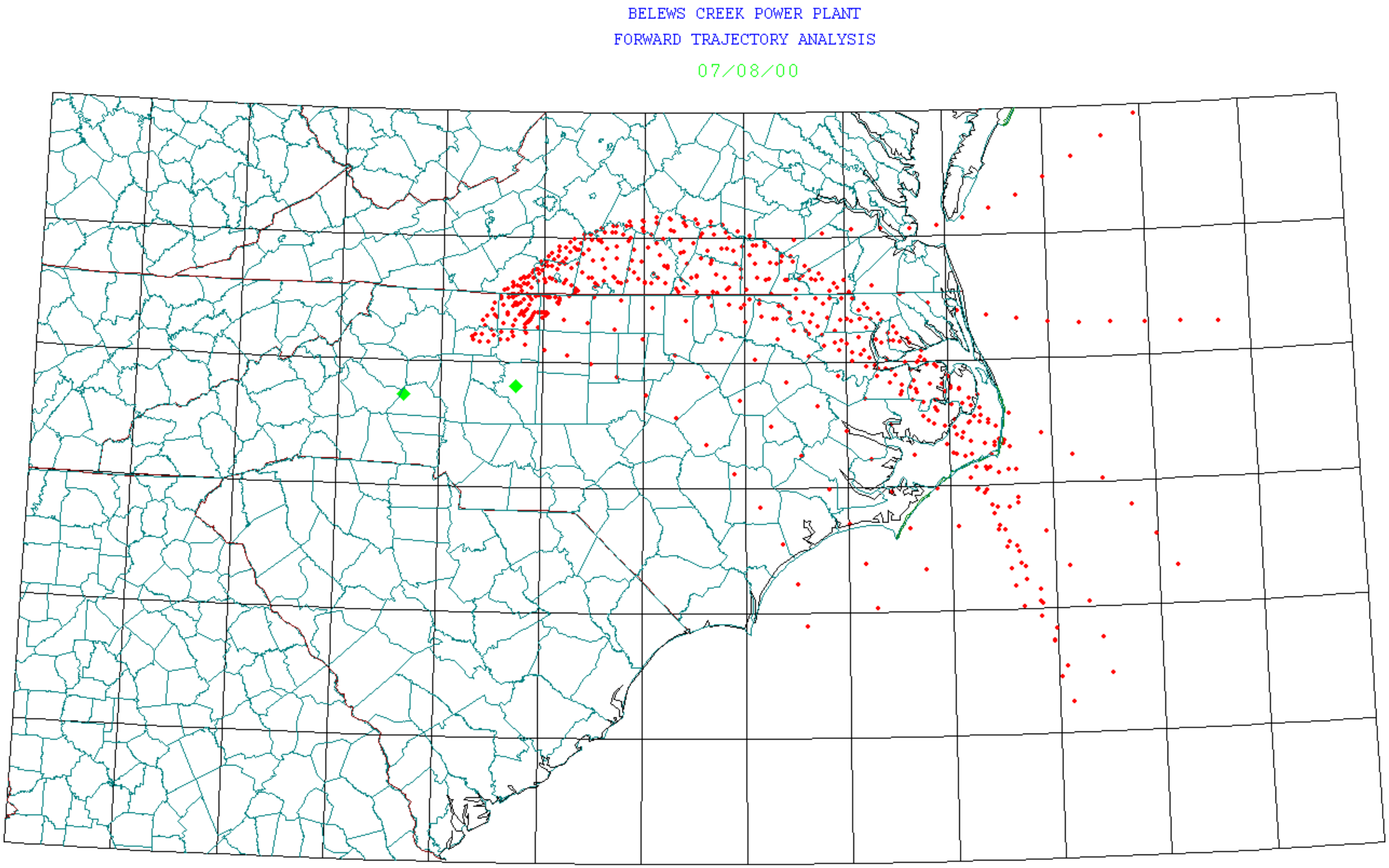


Source: **Belews Creek Power Plant**

Date:**07/05/2000**

Concentration @ Hickory: **29.1 μg/m³**

Concentration @ Lexington: **20.6 μg/m³**

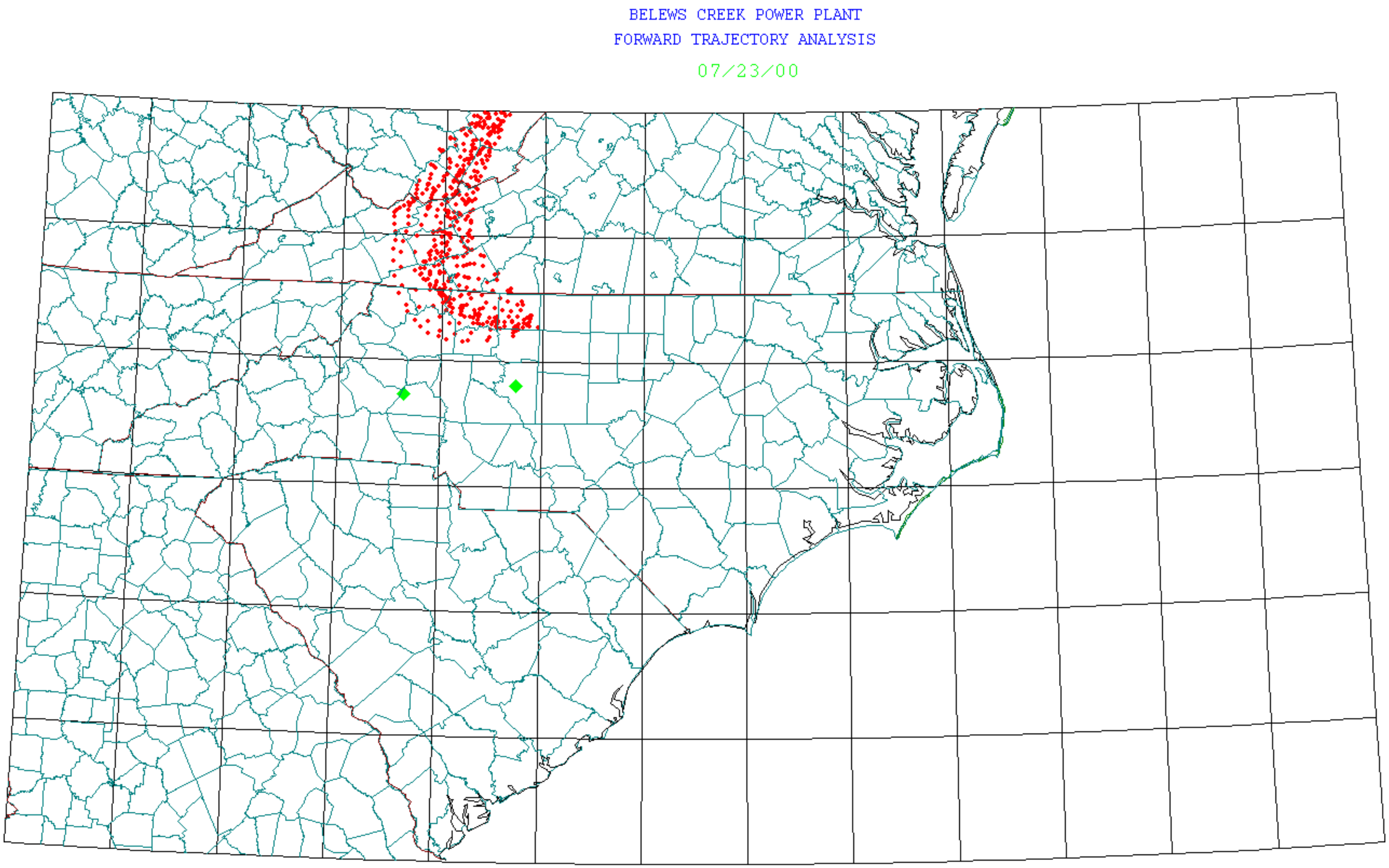


Source: **Belews Creek Power Plant**

Date:**07/08/2000**

Concentration @ Hickory: **32.7 μg/m³**

Concentration @ Lexington: **27.8 μg/m³**

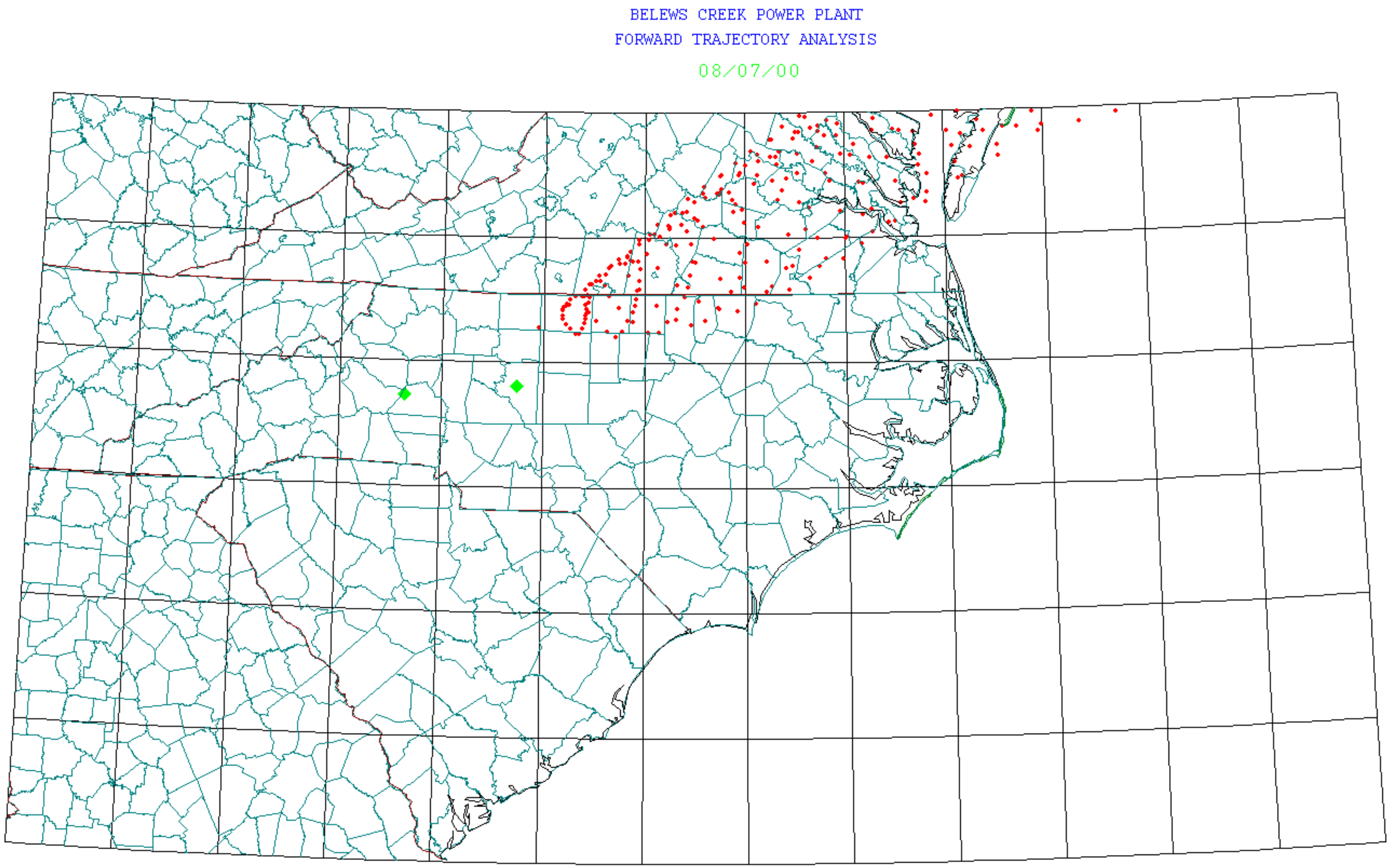


Source: **Belews Creek Power Plant**

Date:**07/23/2000**

Concentration @ Hickory: **30.6 μg/m³**

Concentration @ Lexington: **Missing**

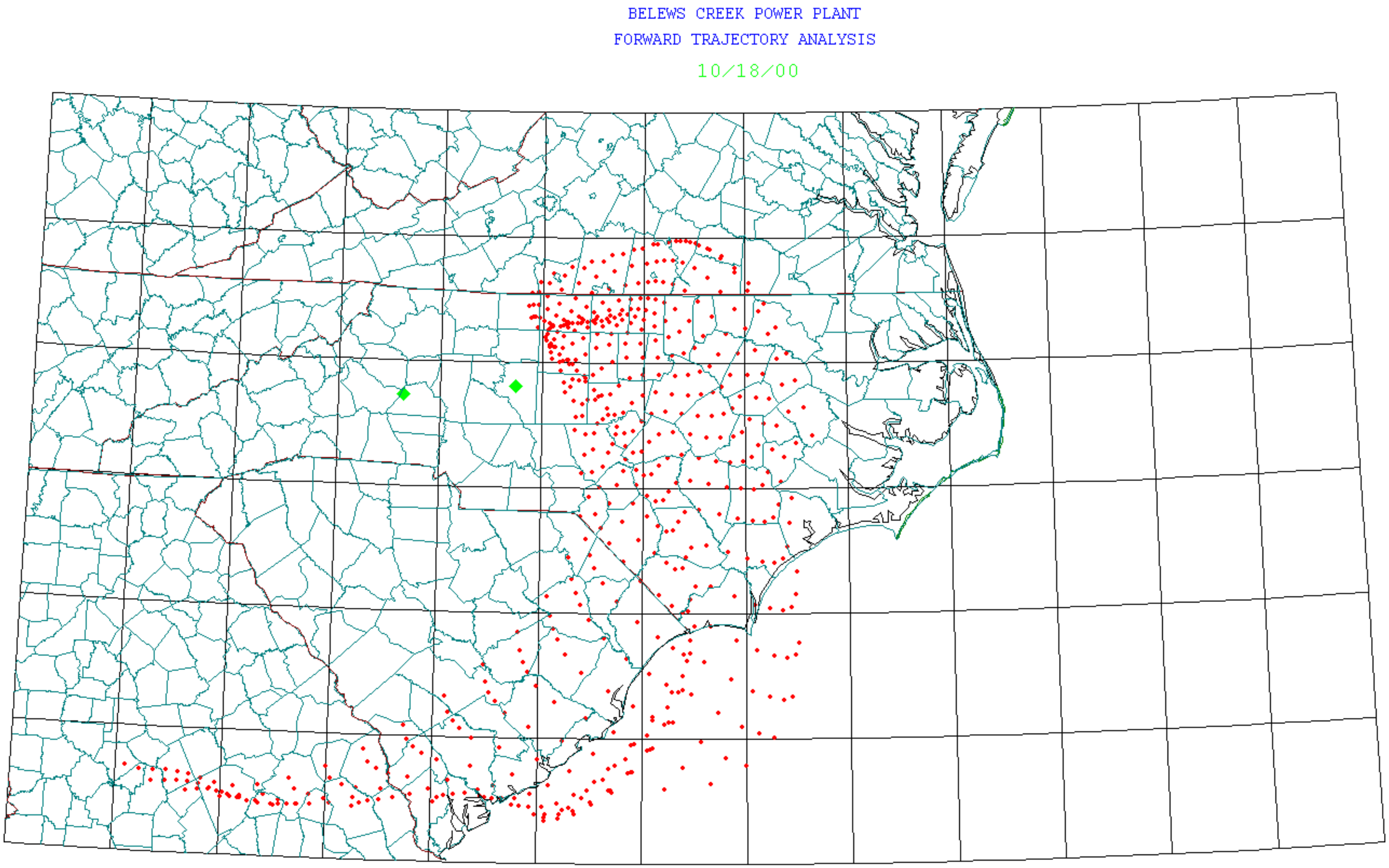


Source: **Belews Creek Power Plant**

Date:**08/07/2000**

Concentration @ Hickory: **34.2 μg/m³**

Concentration @ Lexington: **Missing**

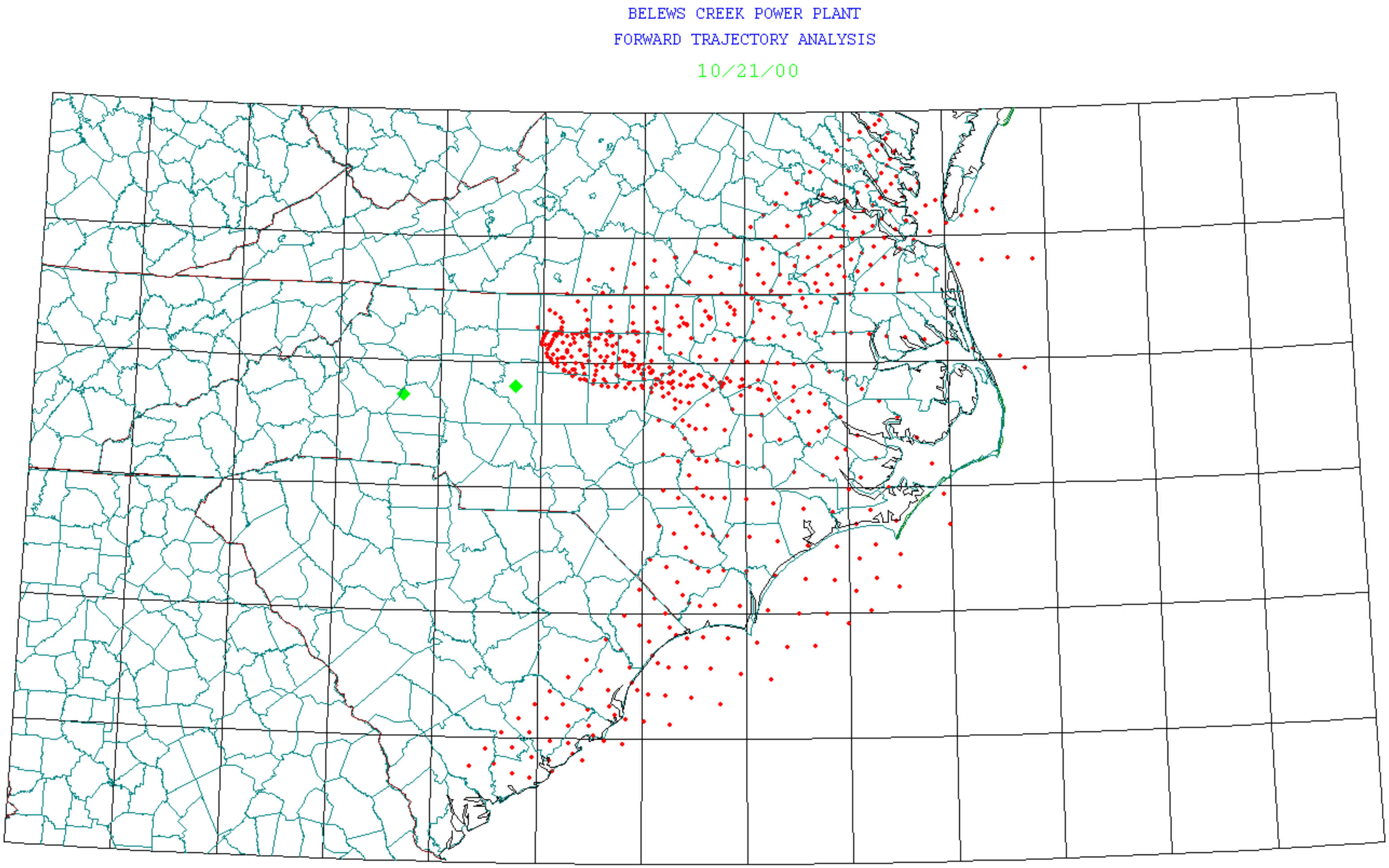


Source: **Belews Creek Power Plant**

Date:**10/18/2000**

Concentration @ Hickory: **28.2 μg/m³**

Concentration @ Lexington: **28.0 μg/m³**

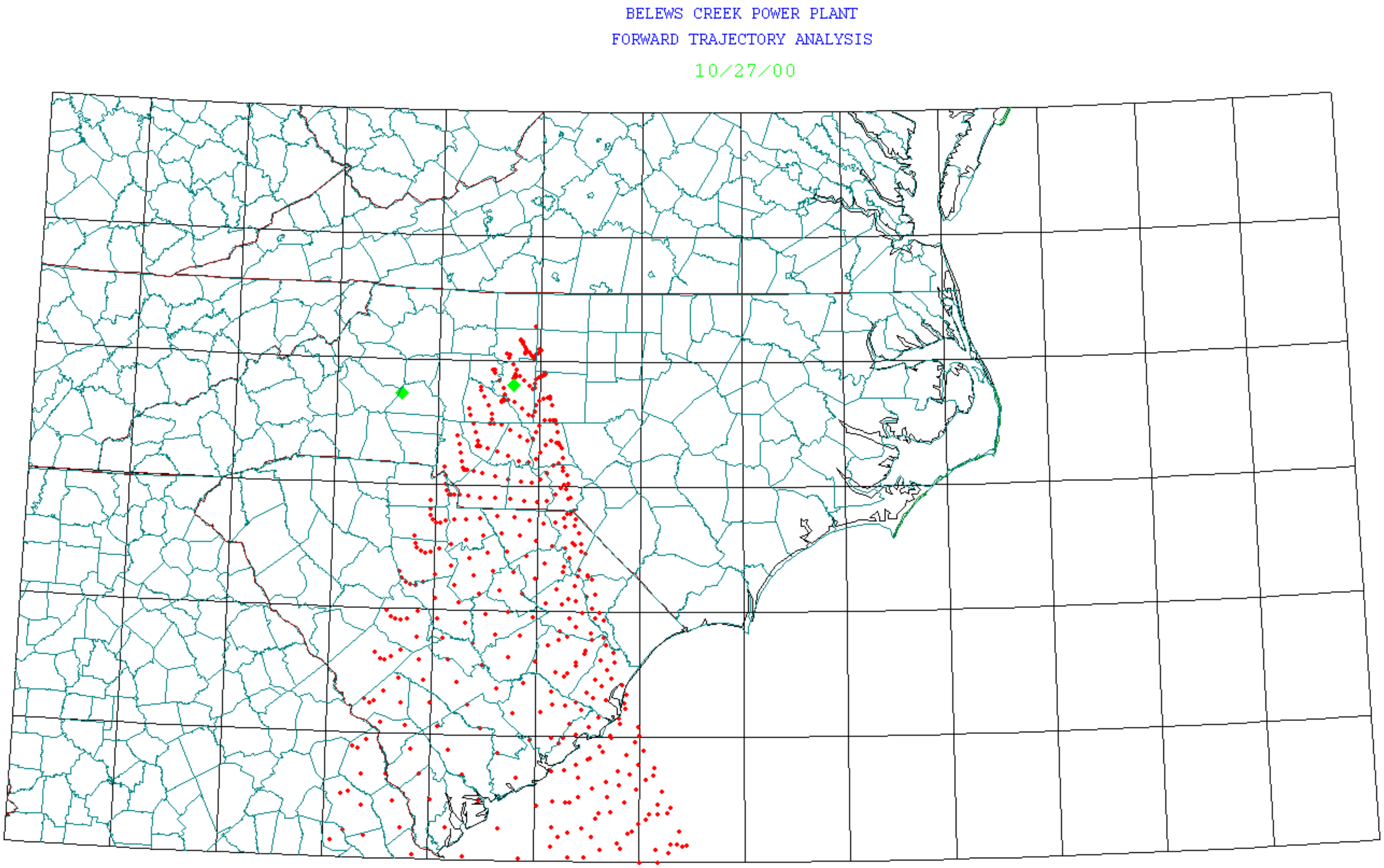


Source: **Belews Creek Power Plant**

Date:**10/21/2000**

Concentration @ Hickory: **38.0 µg/m³**

Concentration @ Lexington: **37.7 µg/m³**

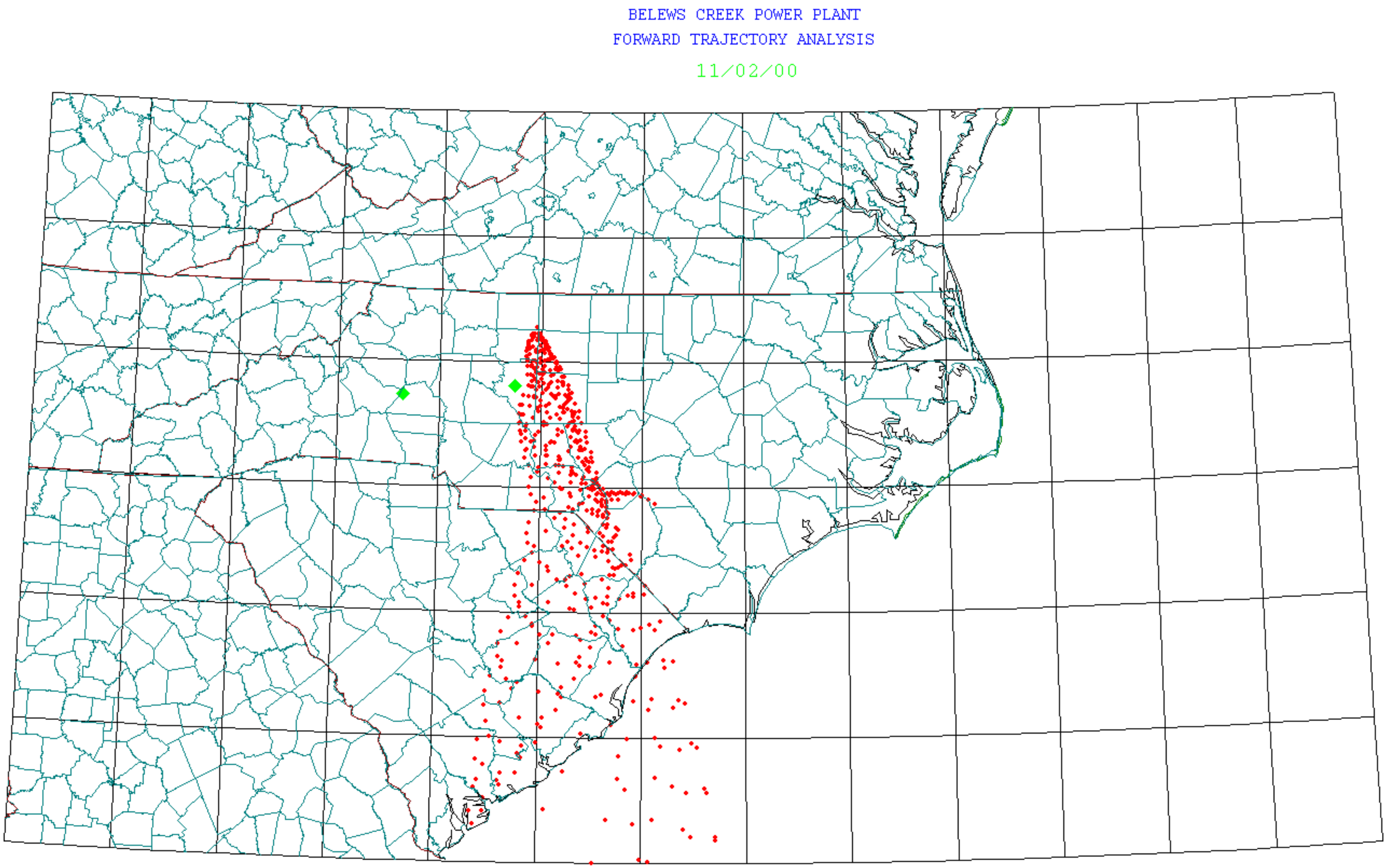


Source: **Belews Creek Power Plant**

Date:**10/27/2000**

Concentration @ Hickory: **36.7 μg/m³**

Concentration @ Lexington: **31.1 μg/m³**

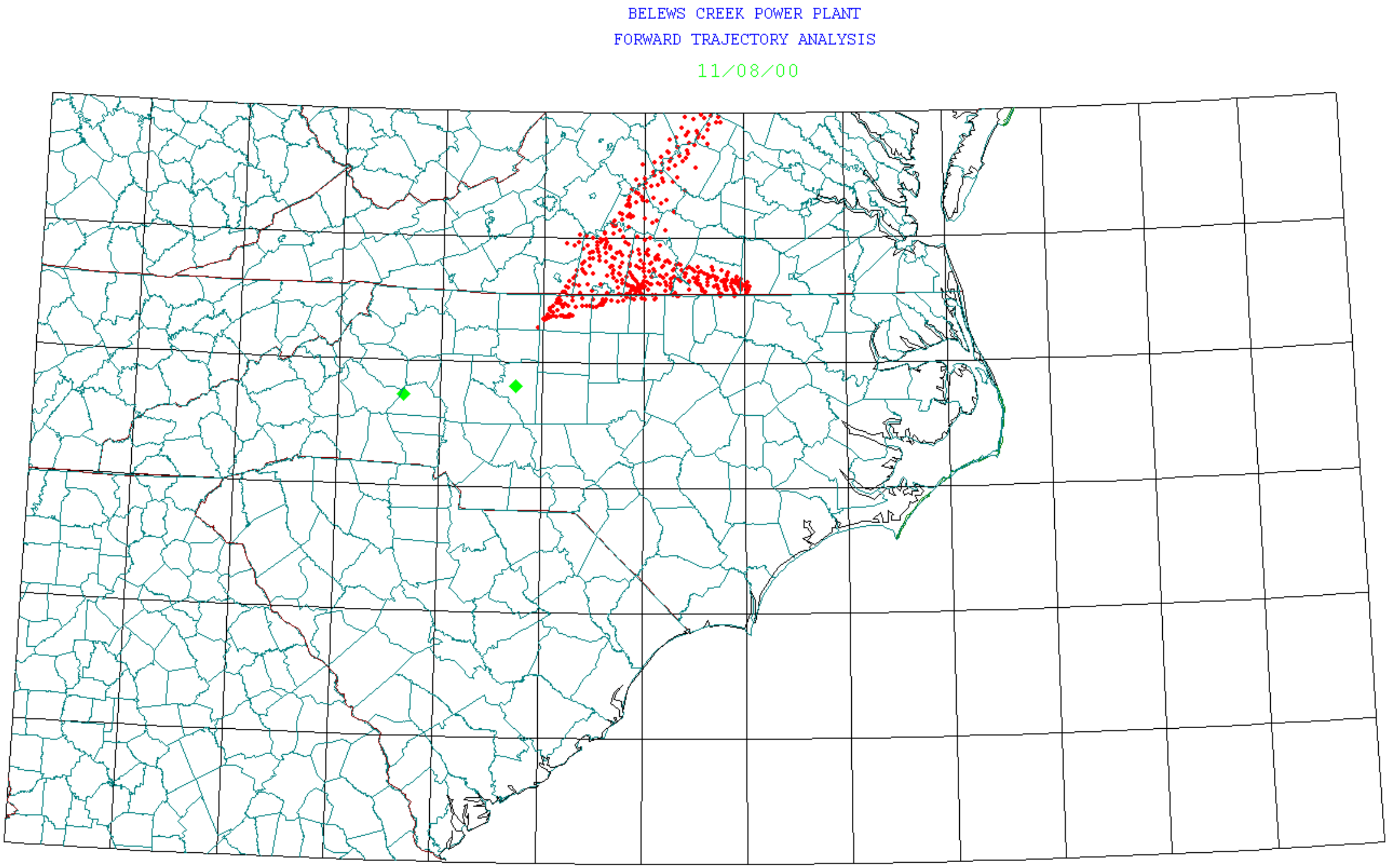


Source: **Belews Creek Power Plant**

Date:**11/02/2000**

Concentration @ Hickory: **54.7 μg/m³**

Concentration @ Lexington: **27.7 μg/m³**

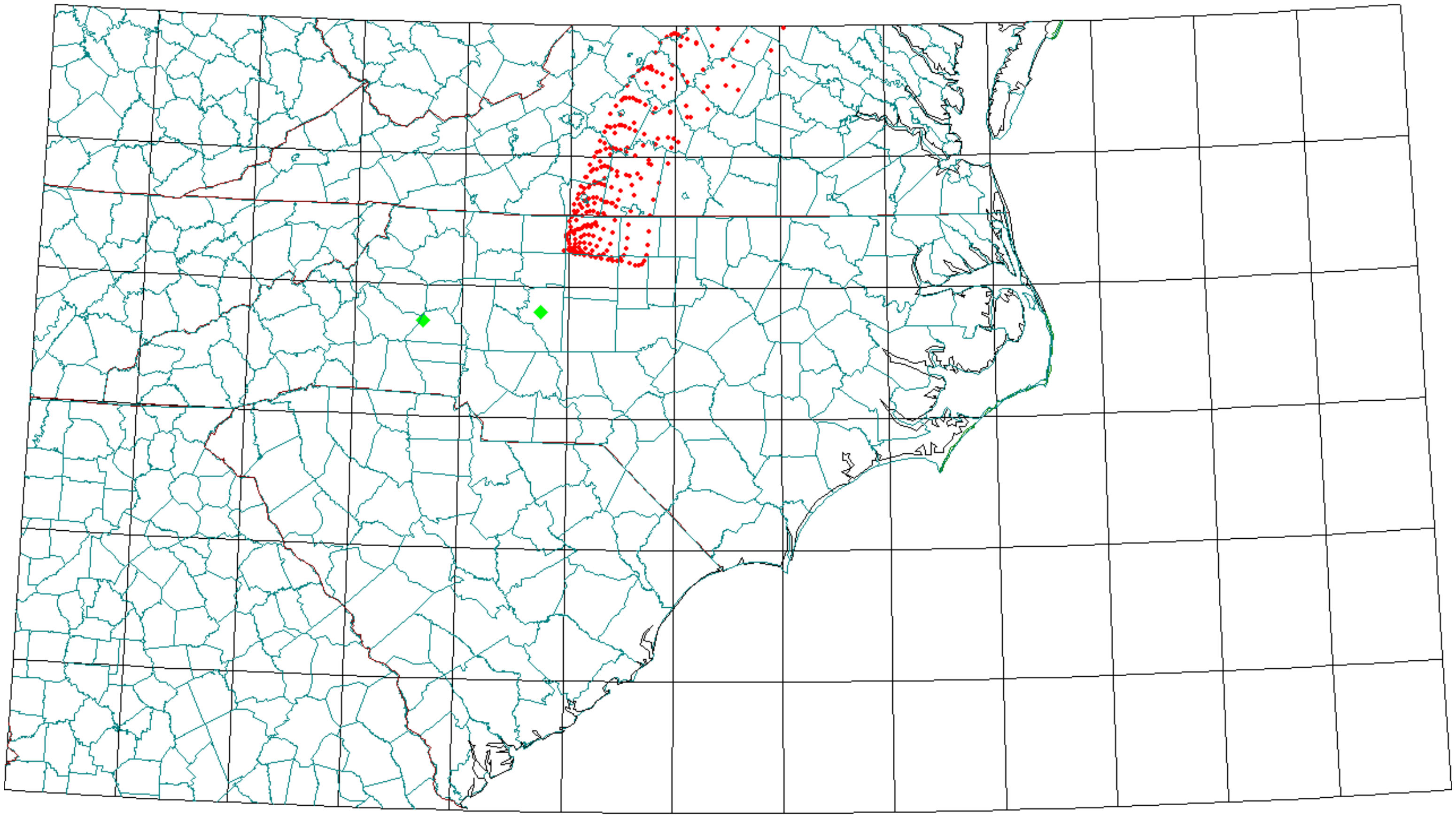


Source: **Belews Creek Power Plant**

Date:**11/08/2000**

Concentration @ Hickory: **50.1 μg/m³**

Concentration @ Lexington: **30.7 μg/m³**

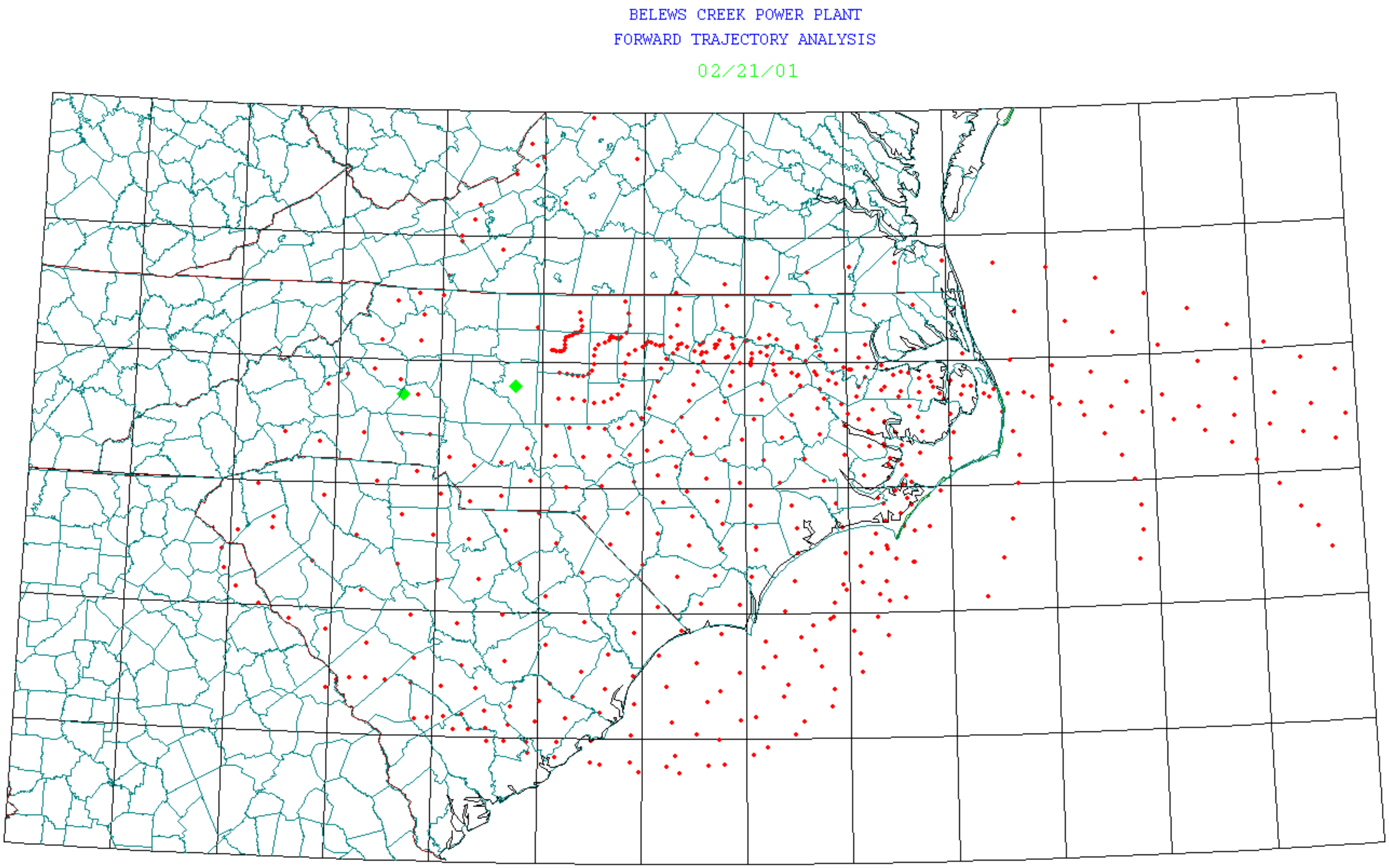


Source: **Belews Creek Power Plant**

Date:**12/11/2000**

Concentration @ Hickory:**26.2 μg/m³**

Concentration @ Lexington: **38.7 μg/m³**

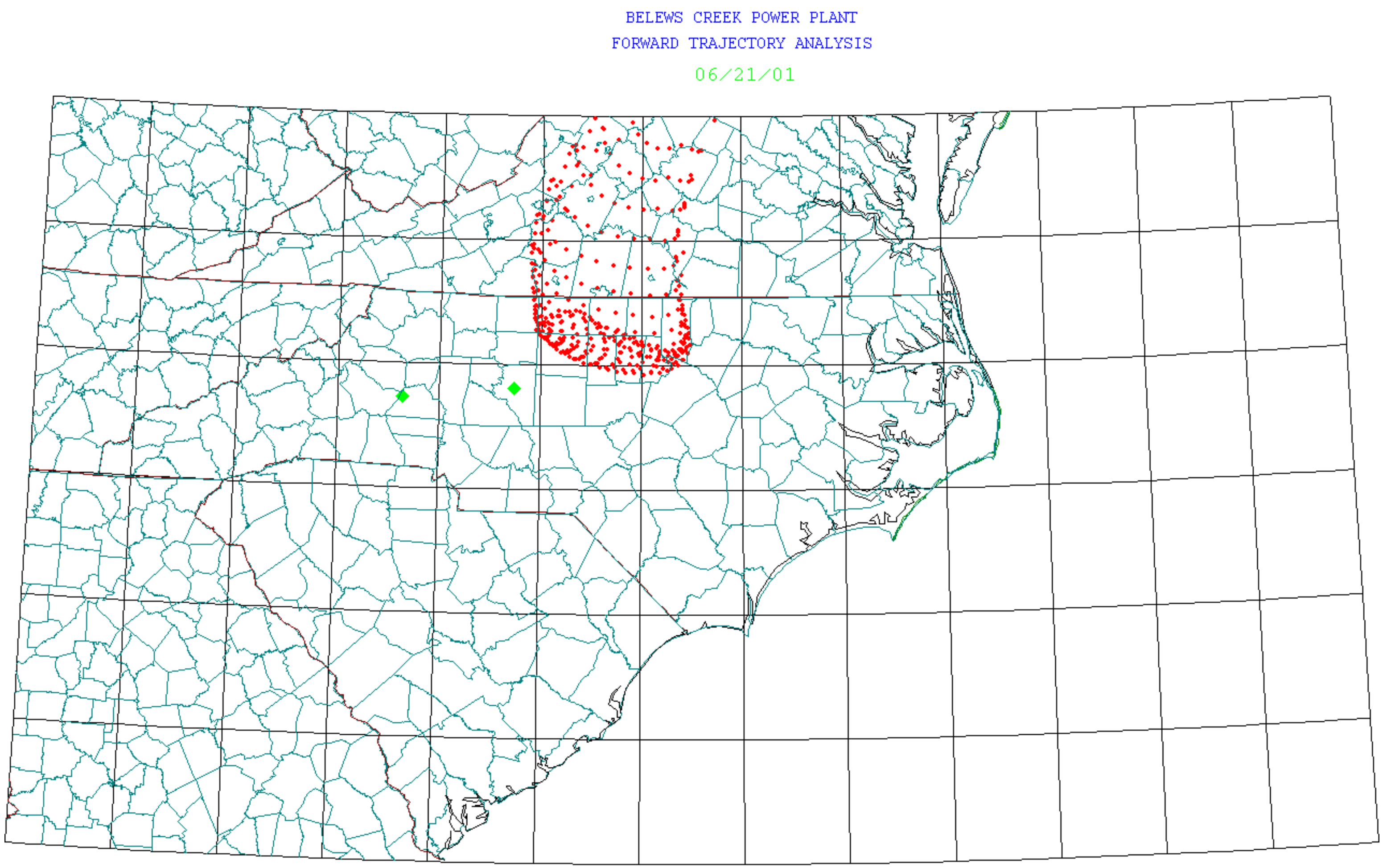


Source: **Belews Creek Power Plant**

Date:**02/21/2001**

Concentration @ Hickory: **32.8 μg/m³**

Concentration @ Lexington: **24.5 μg/m³**

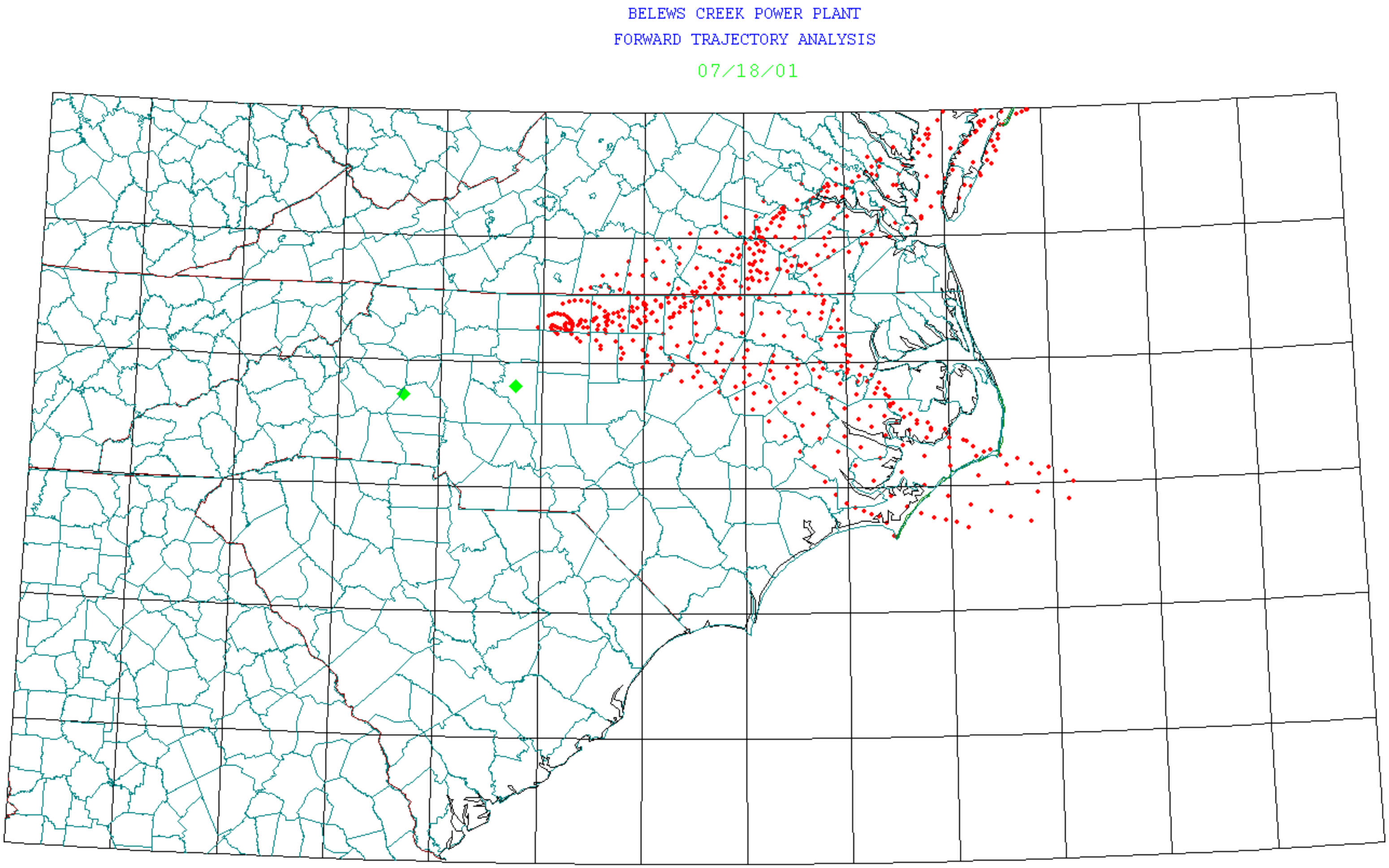


Source: **Belews Creek Power Plant**

Date:**06/21/2001**

Concentration @ Hickory: **28.4 μg/m³**

Concentration @ Lexington: **39.2 μg/m³**

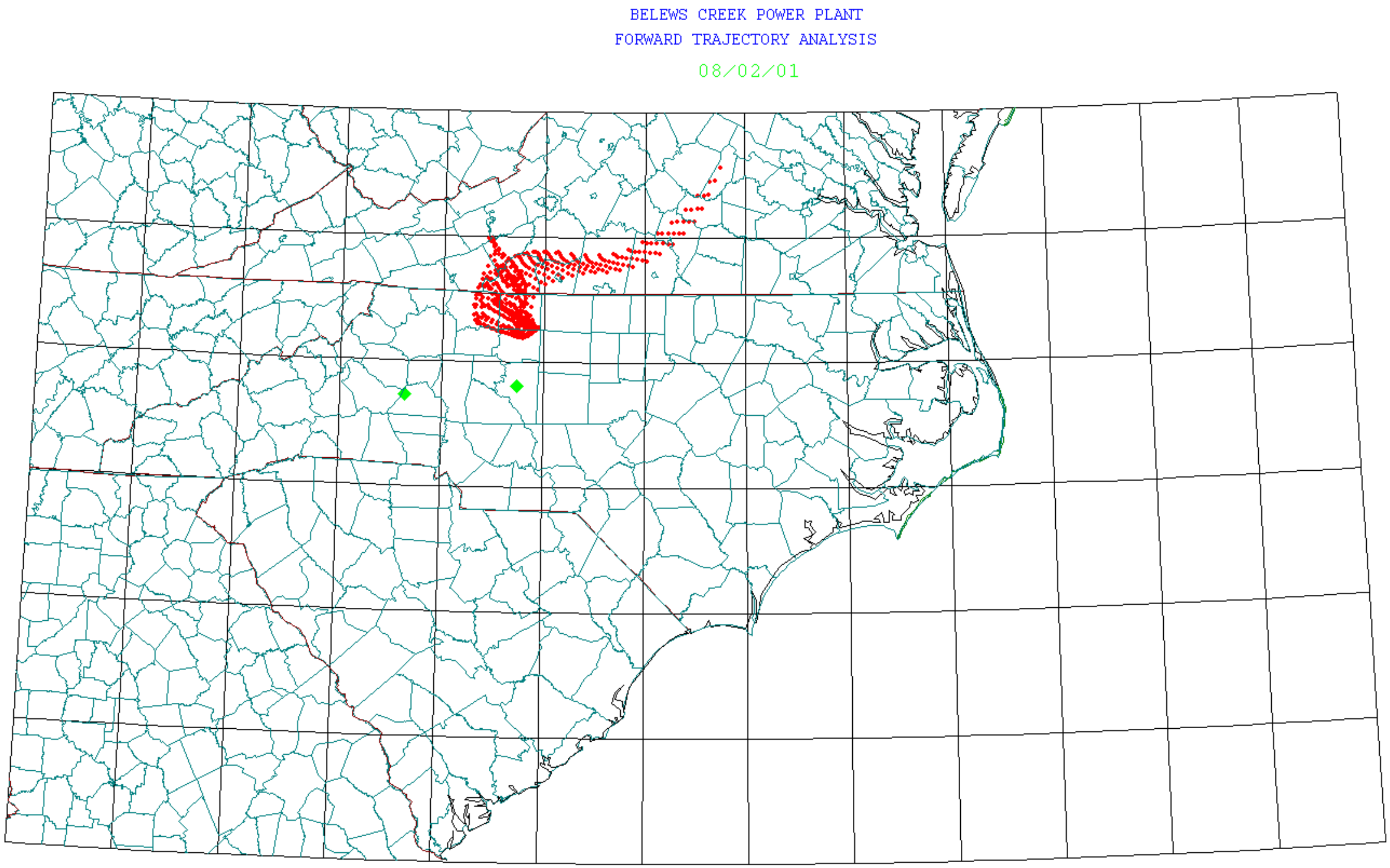


Source: **Belews Creek Power Plant**

Date:**07/18/2001**

Concentration @ Hickory: **40.0 μg/m³**

Concentration @ Lexington: **41.6 μg/m³**

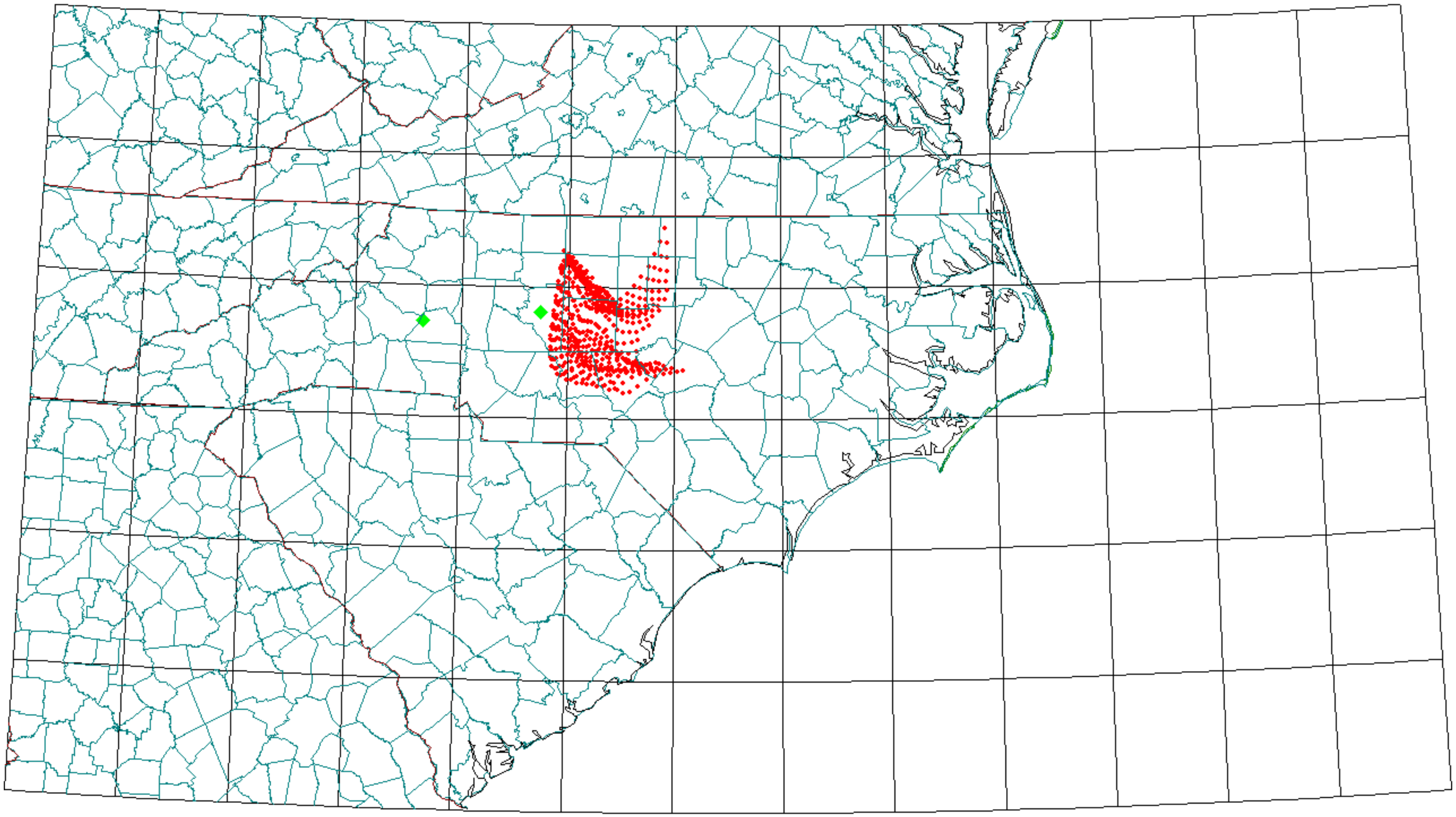


Source: **Belews Creek Power Plant**

Date:**08/02/2001**

Concentration @ Hickory: **29.3 μg/m³**

Concentration @ Lexington: **13.0 μg/m³**

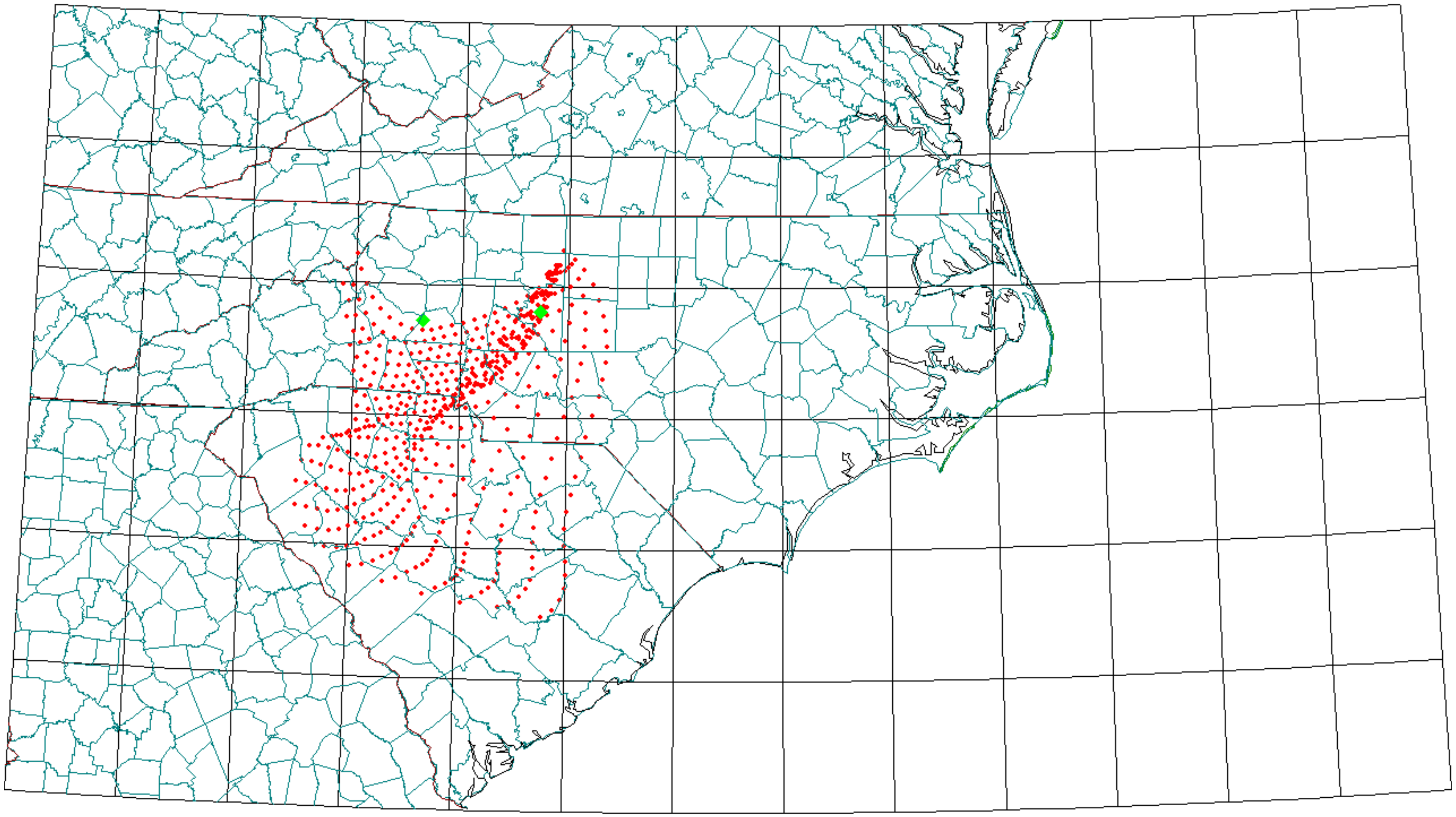


Source: **Belews Creek Power Plant**

Date:**08/08/2001**

Concentration @ Hickory:**24.4 μg/m³**

Concentration @ Lexington: **37.7 μg/m³**

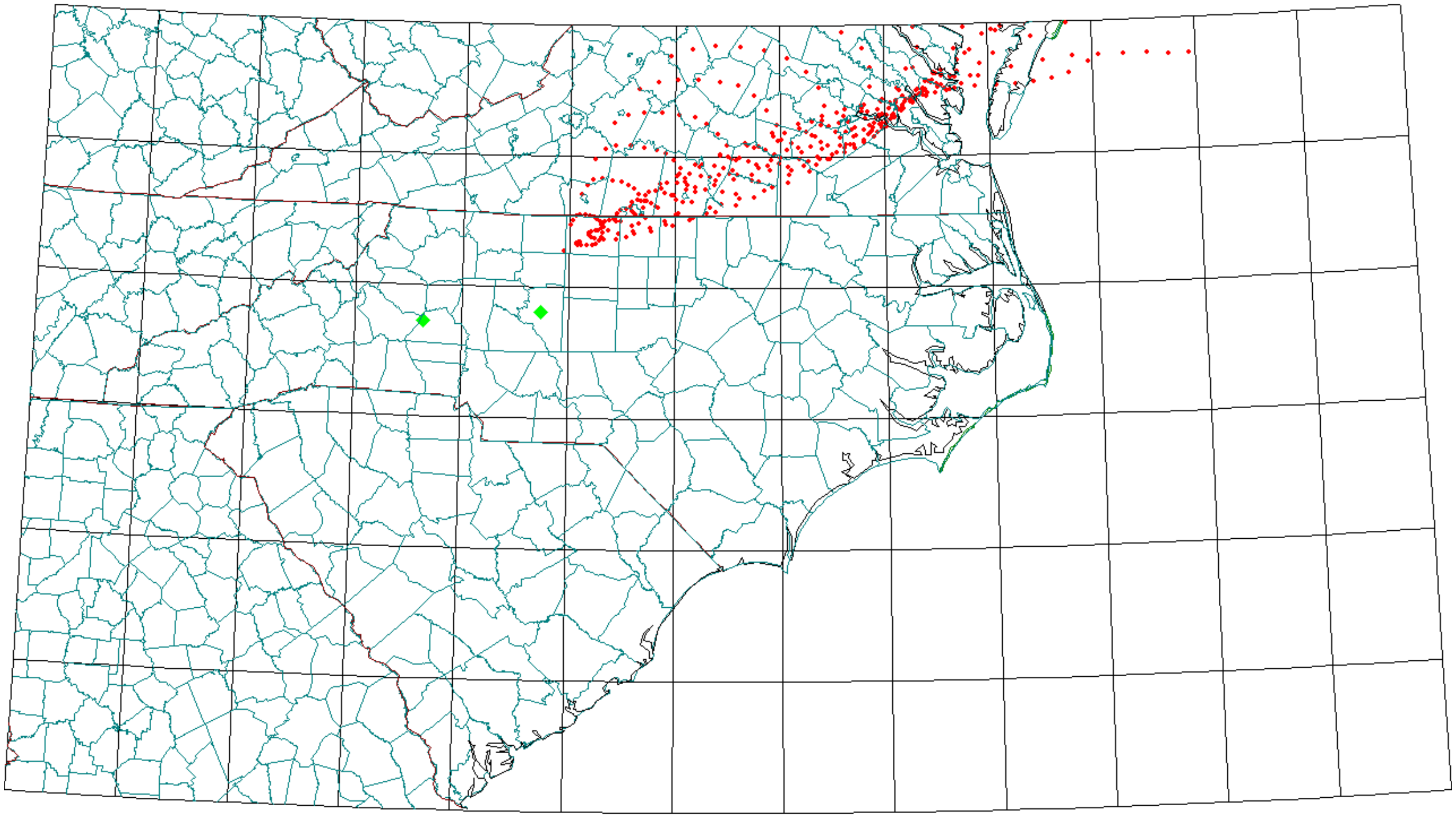


Source: **Belews Creek Power Plant**

Date:**08/14/2001**

Concentration @ Hickory:**25.7 μg/m³**

Concentration @ Lexington: **29.0 μg/m³**

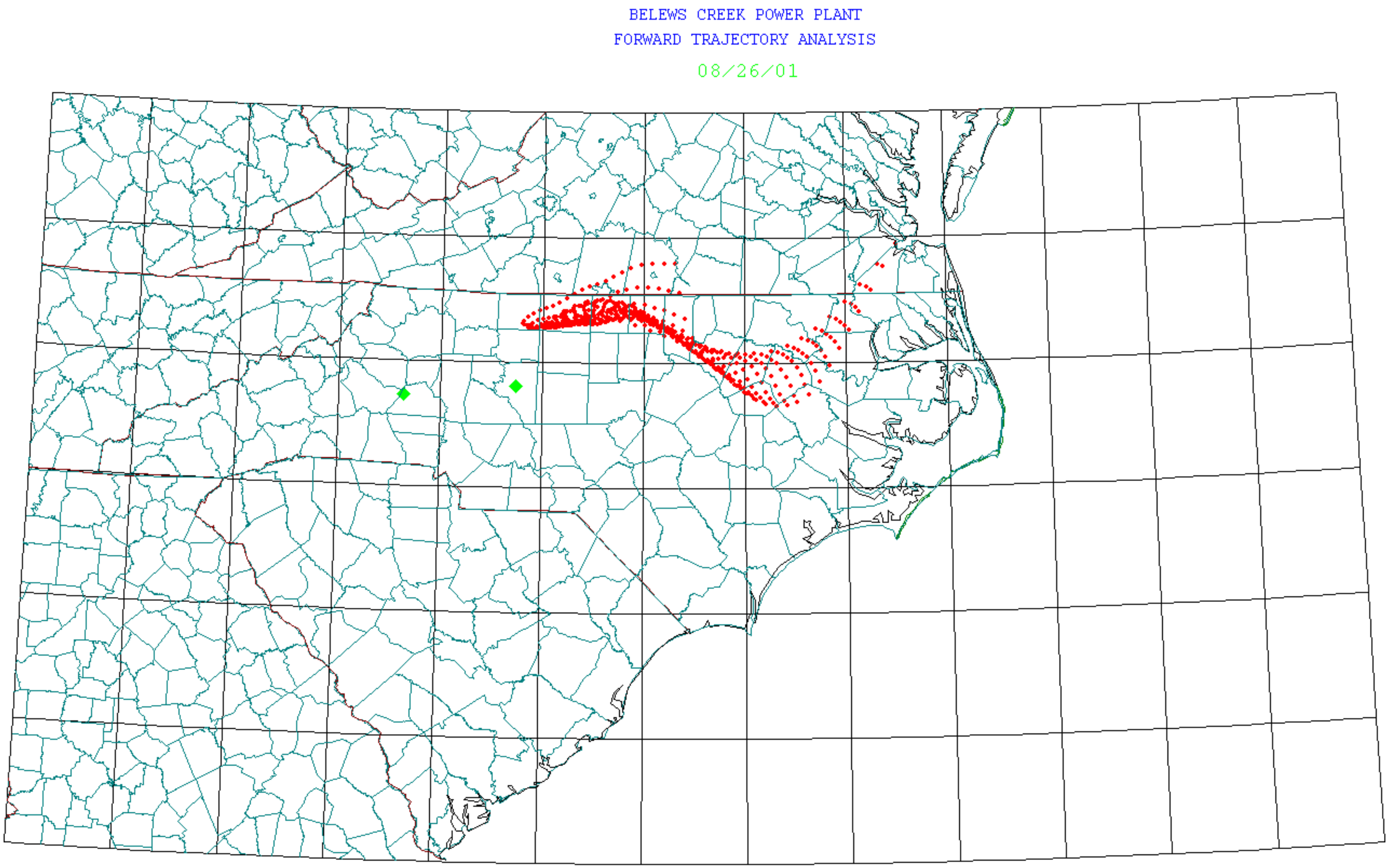


Source: **Belews Creek Power Plant**

Date:**08/17/2001**

Concentration @ Hickory:**26.5 μg/m³**

Concentration @ Lexington: **27.9 μg/m³**

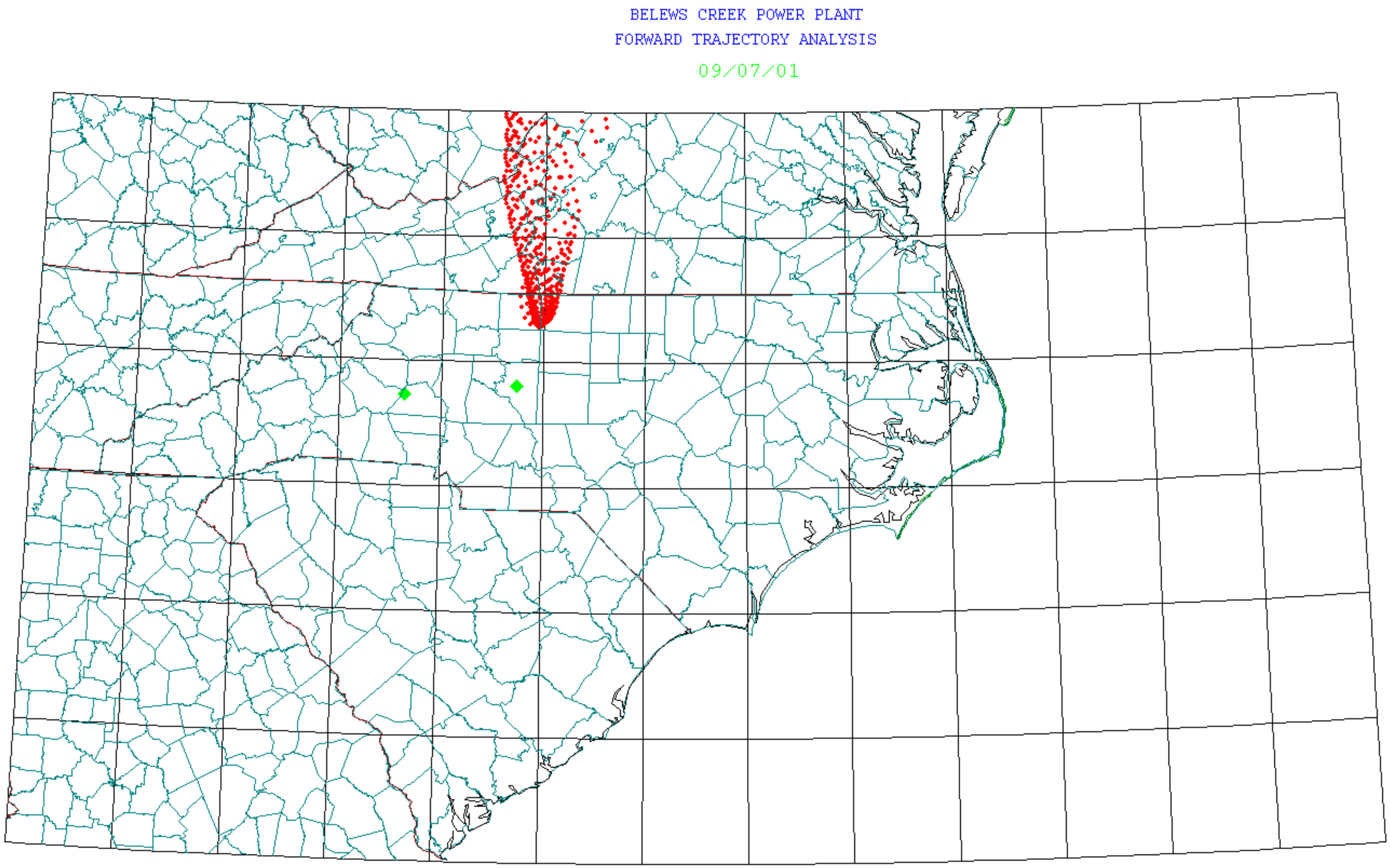


Source: **Belews Creek Power Plant**

Date:**08/26/2001**

Concentration @ Hickory: **32.0 μg/m³**

Concentration @ Lexington: **27.6 μg/m³**



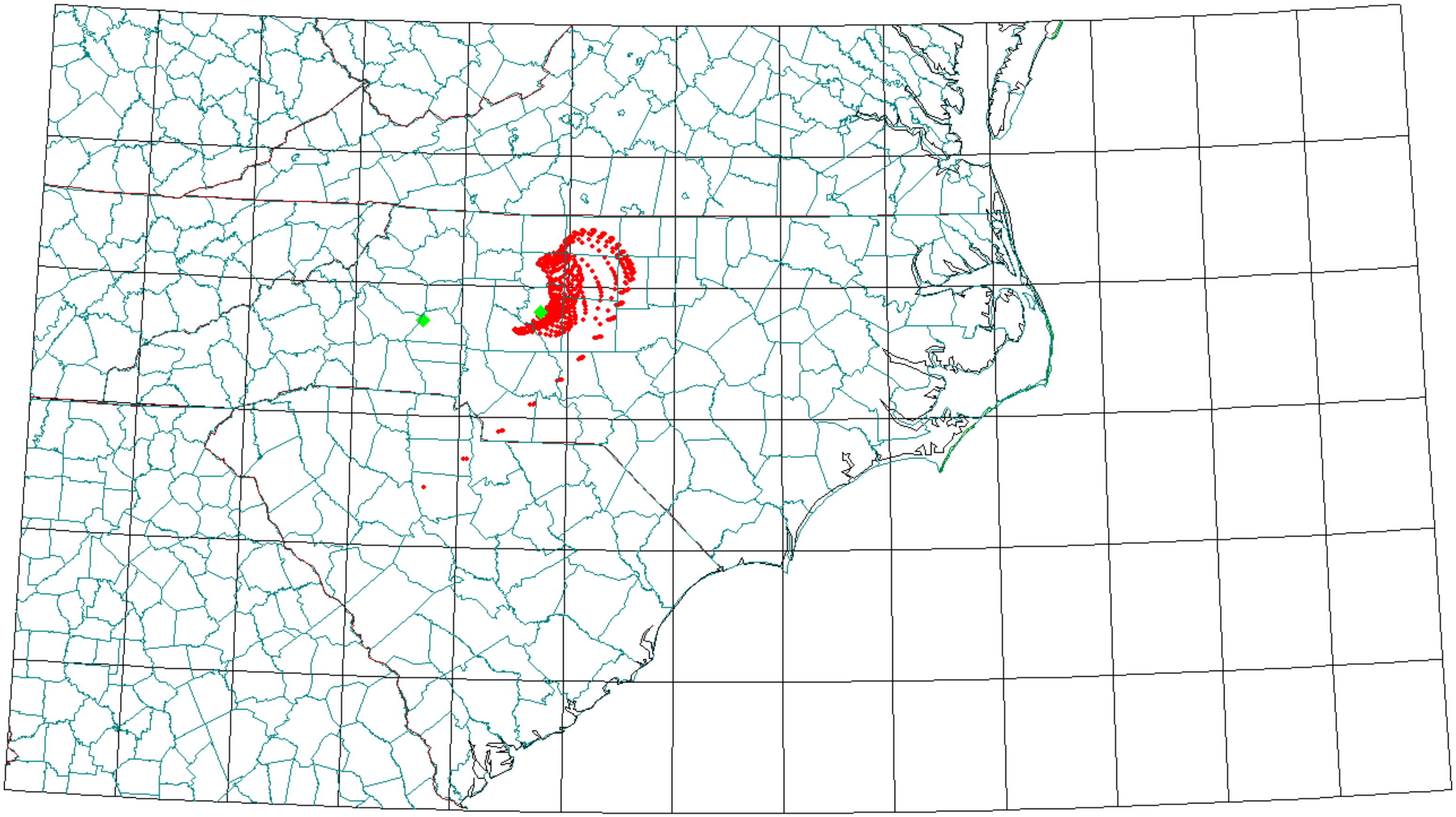
Source: **Belews Creek Power Plant**

Date:**09/07/2001**

Concentration @ Hickory: **30.2 μg/m³**

Concentration @ Lexington: **22.0 μg/m³**

BELEWS CREEK POWER PLANT
FORWARD TRAJECTORY ANALYSIS
09/13/01

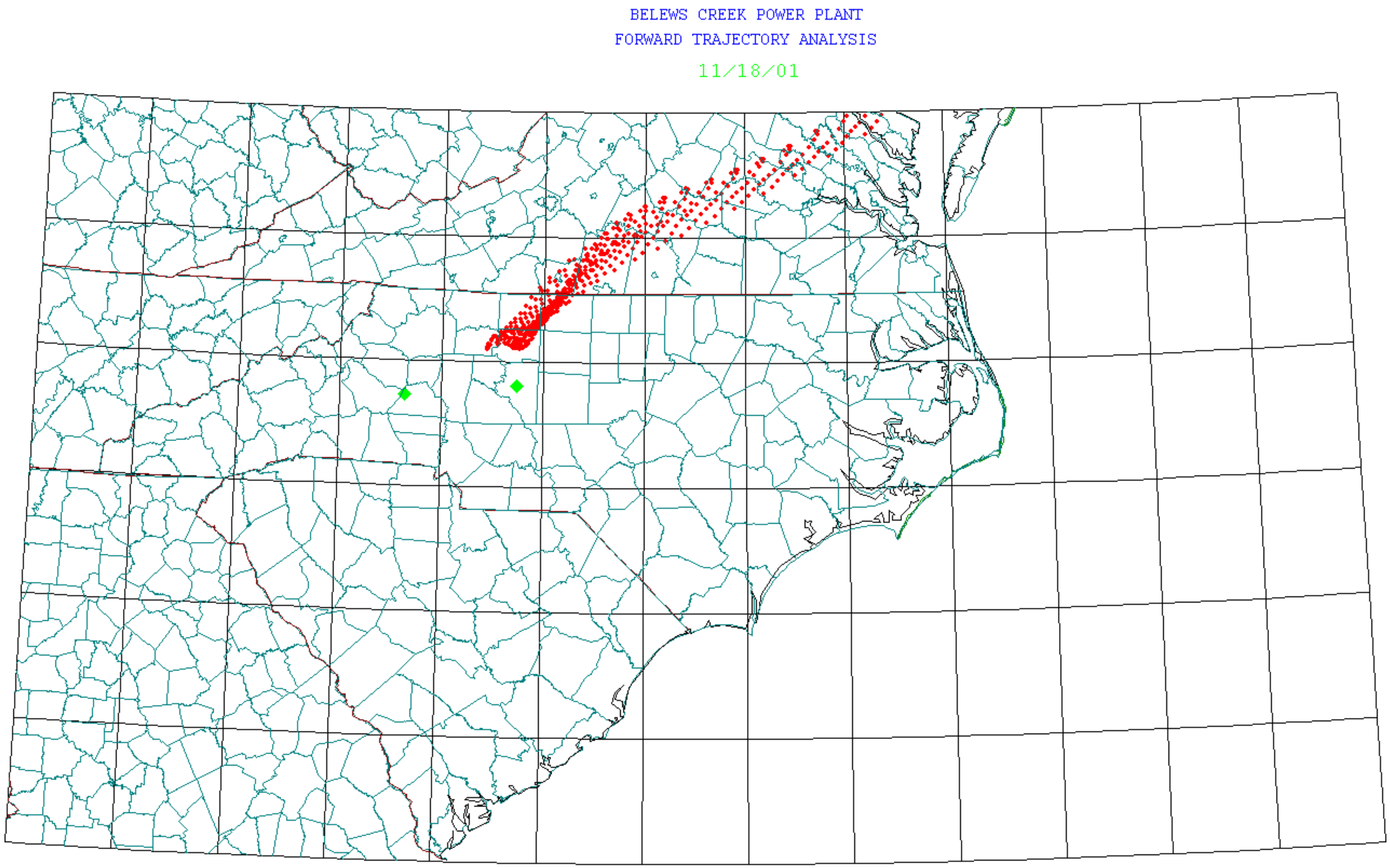


Source: **Belews Creek Power Plant**

Date:**09/13/2001**

Concentration @ Hickory: **30.4 μg/m³**

Concentration @ Lexington: **24.3 μg/m³**

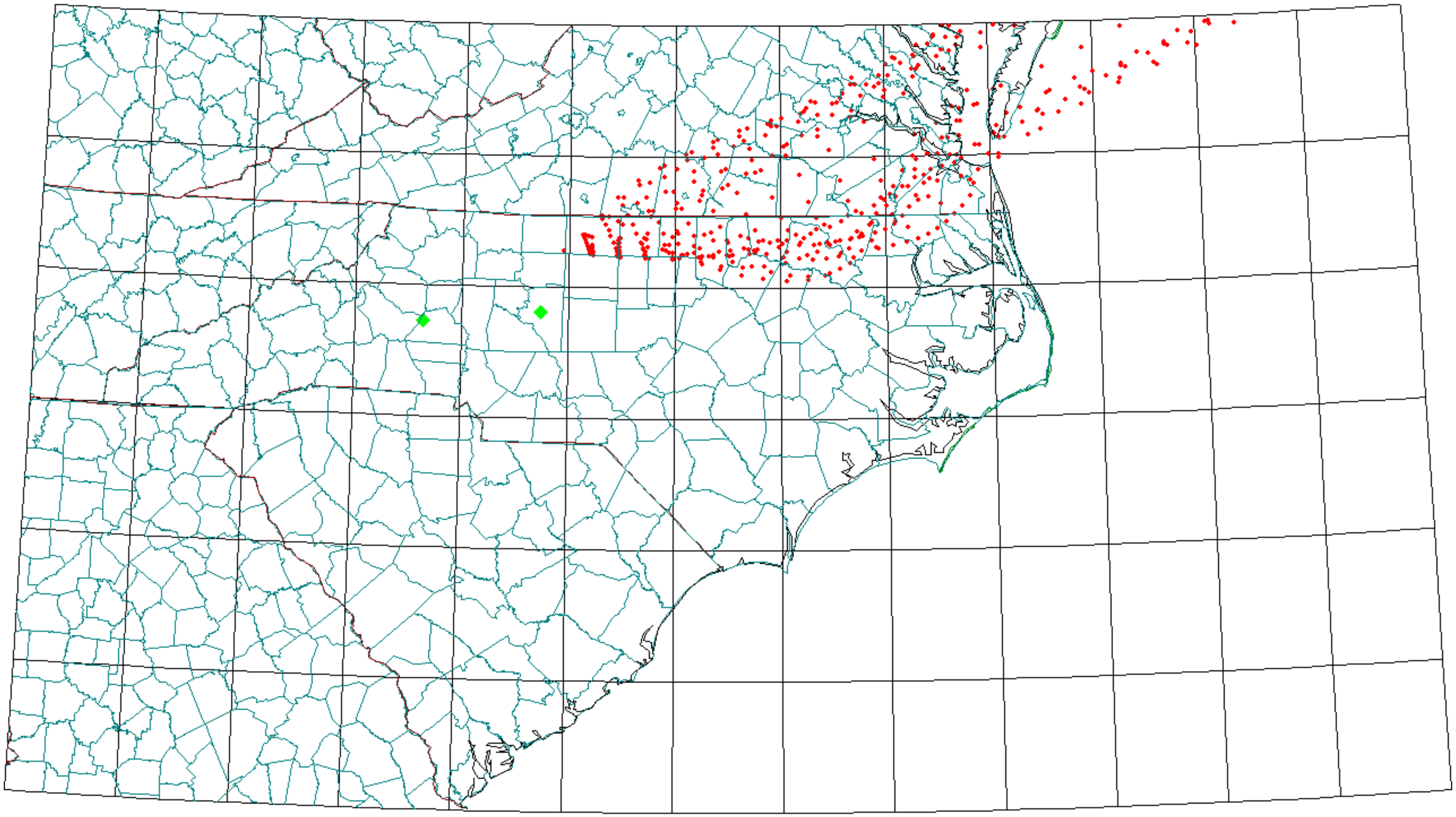


Source: **Belews Creek Power Plant**

Date:**11/18/2001**

Concentration @ Hickory: **28.1 μg/m³**

Concentration @ Lexington: **22.4 μg/m³**

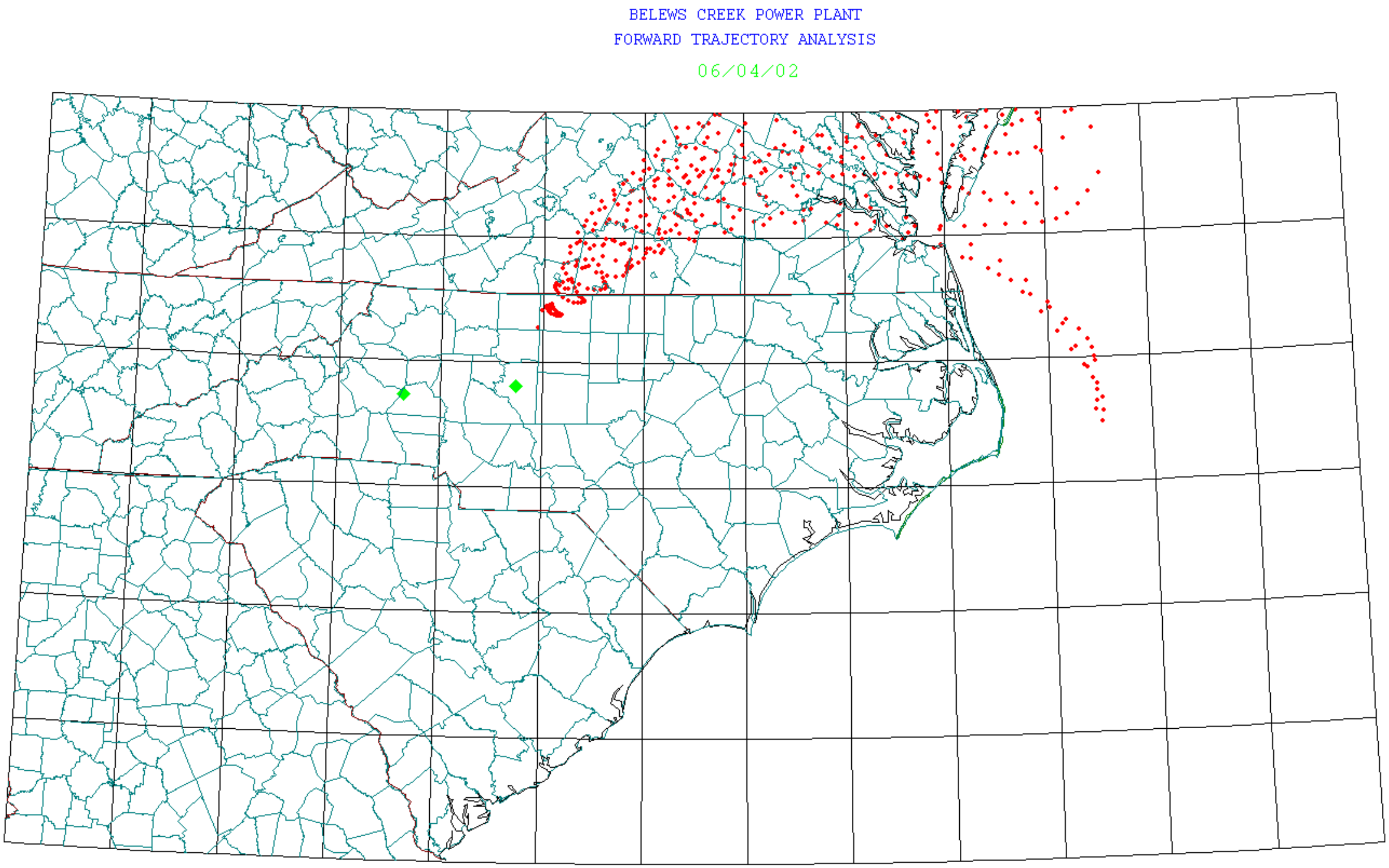


Source: **Belews Creek Power Plant**

Date:**01/05/2002**

Concentration @ Hickory:**22.3 μg/m³**

Concentration @ Lexington: **28.5 μg/m³**

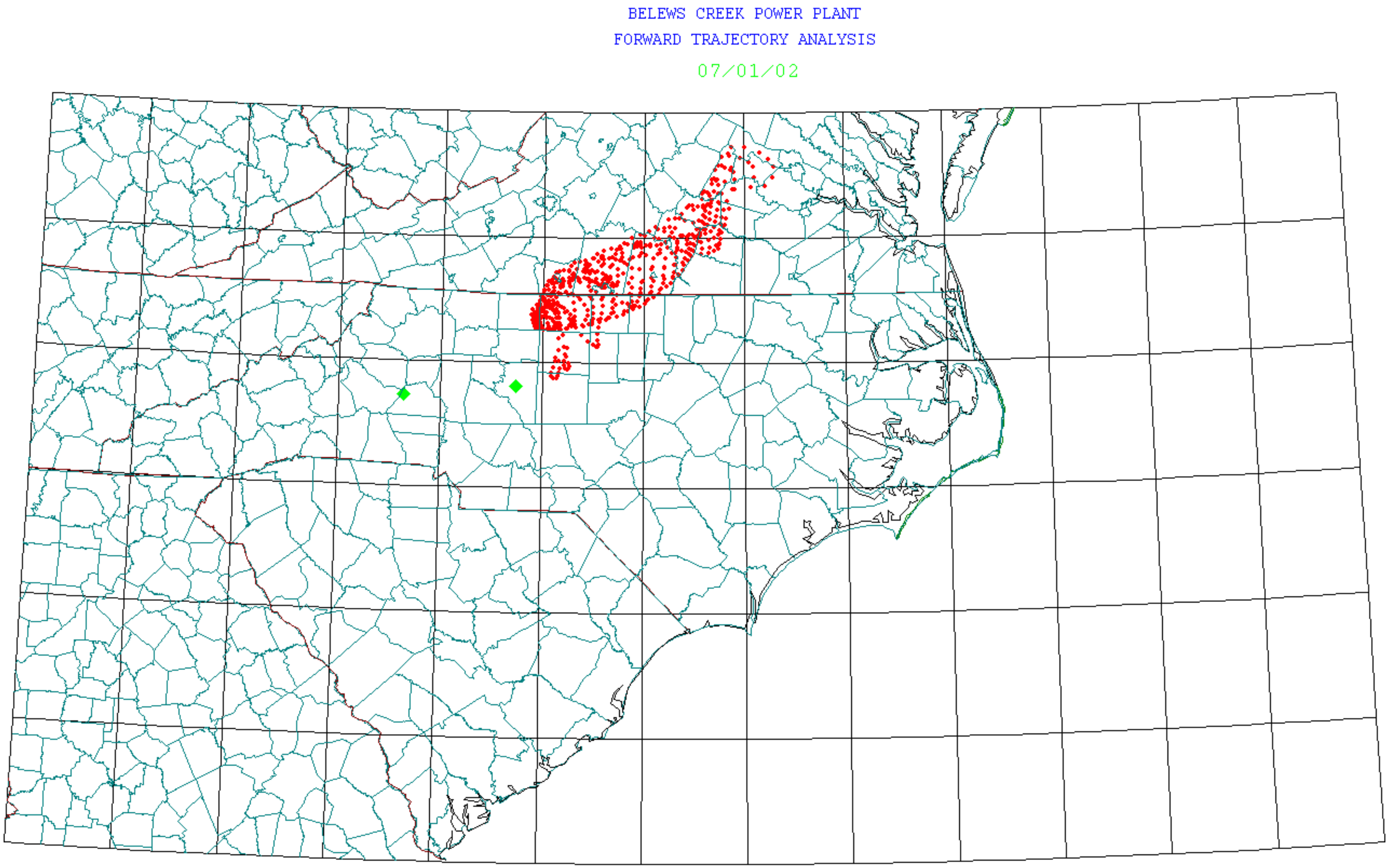


Source: **Belews Creek Power Plant**

Date:**06/04/2002**

Concentration @ Hickory: **29.0 μg/m³**

Concentration @ Lexington: **26.4 μg/m³**



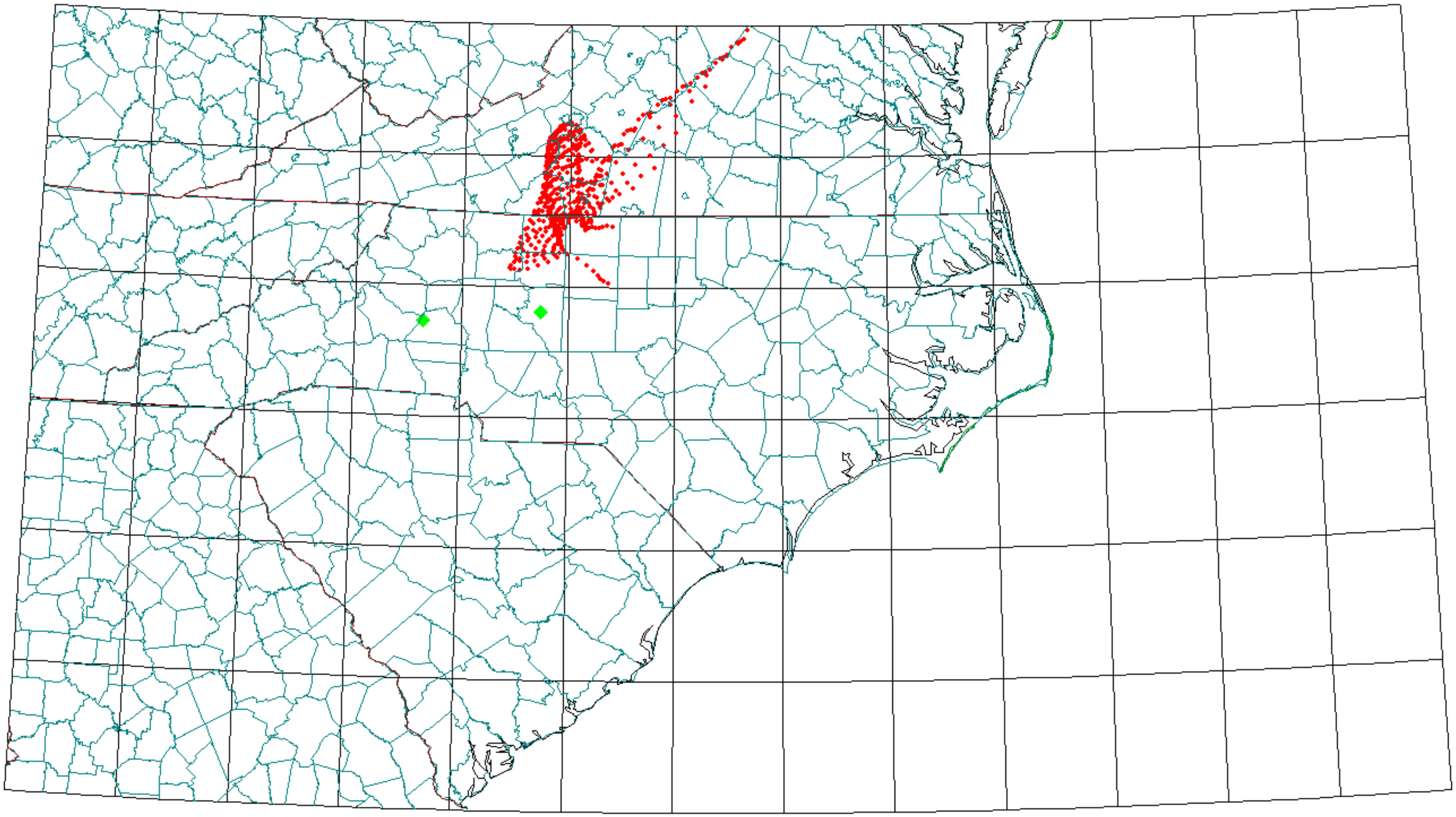
Source: **Belews Creek Power Plant**

Date:**07/01/2002**

Concentration @ Hickory: **33.5 μg/m³**

Concentration @ Lexington: **31.1 μg/m³**

BELEWS CREEK POWER PLANT
FORWARD TRAJECTORY ANALYSIS
07/07/02

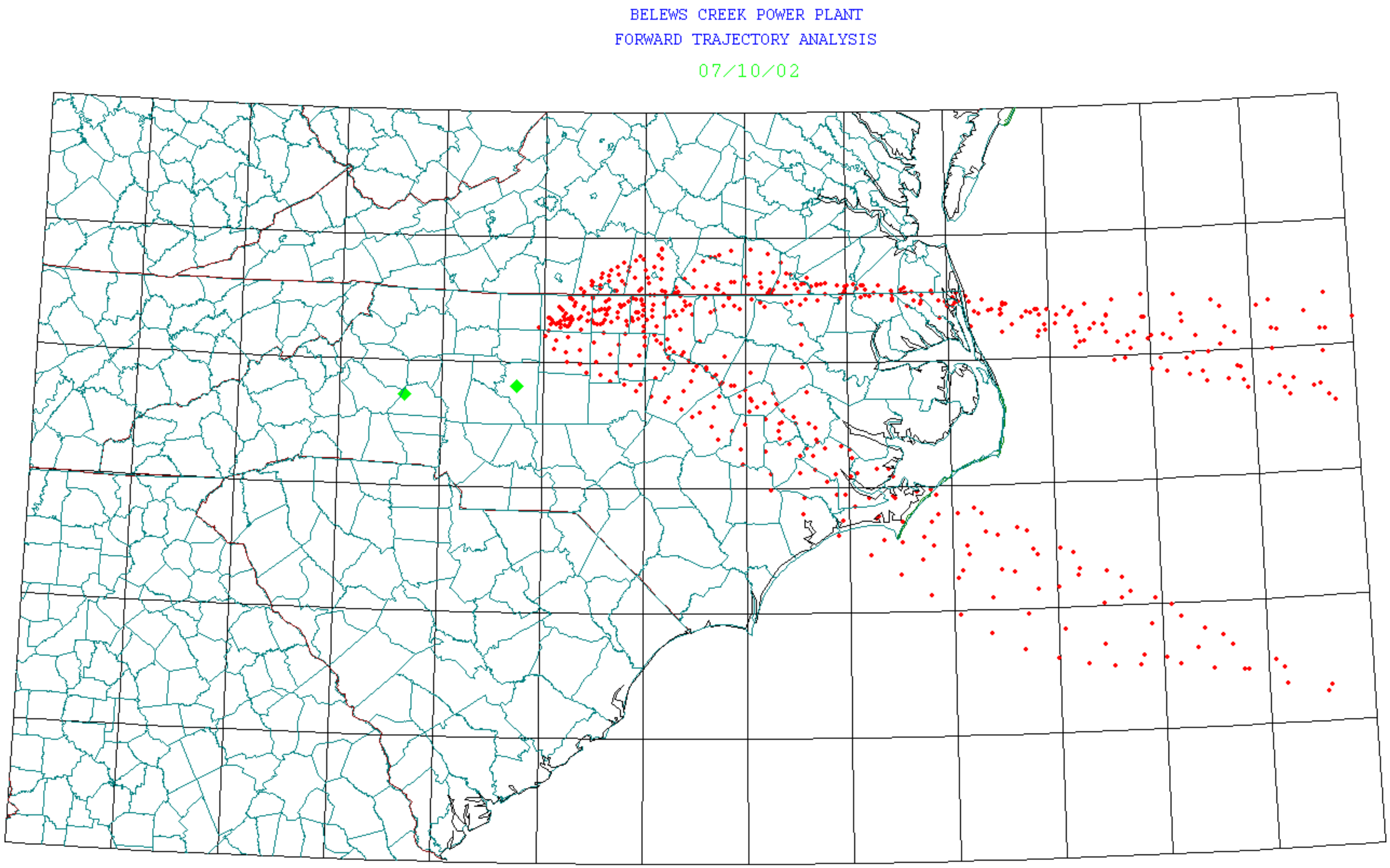


Source: **Belews Creek Power Plant**

Date:**07/07/2002**

Concentration @ Hickory: **28.3 µg/m³**

Concentration @ Lexington: **21.1 µg/m³**

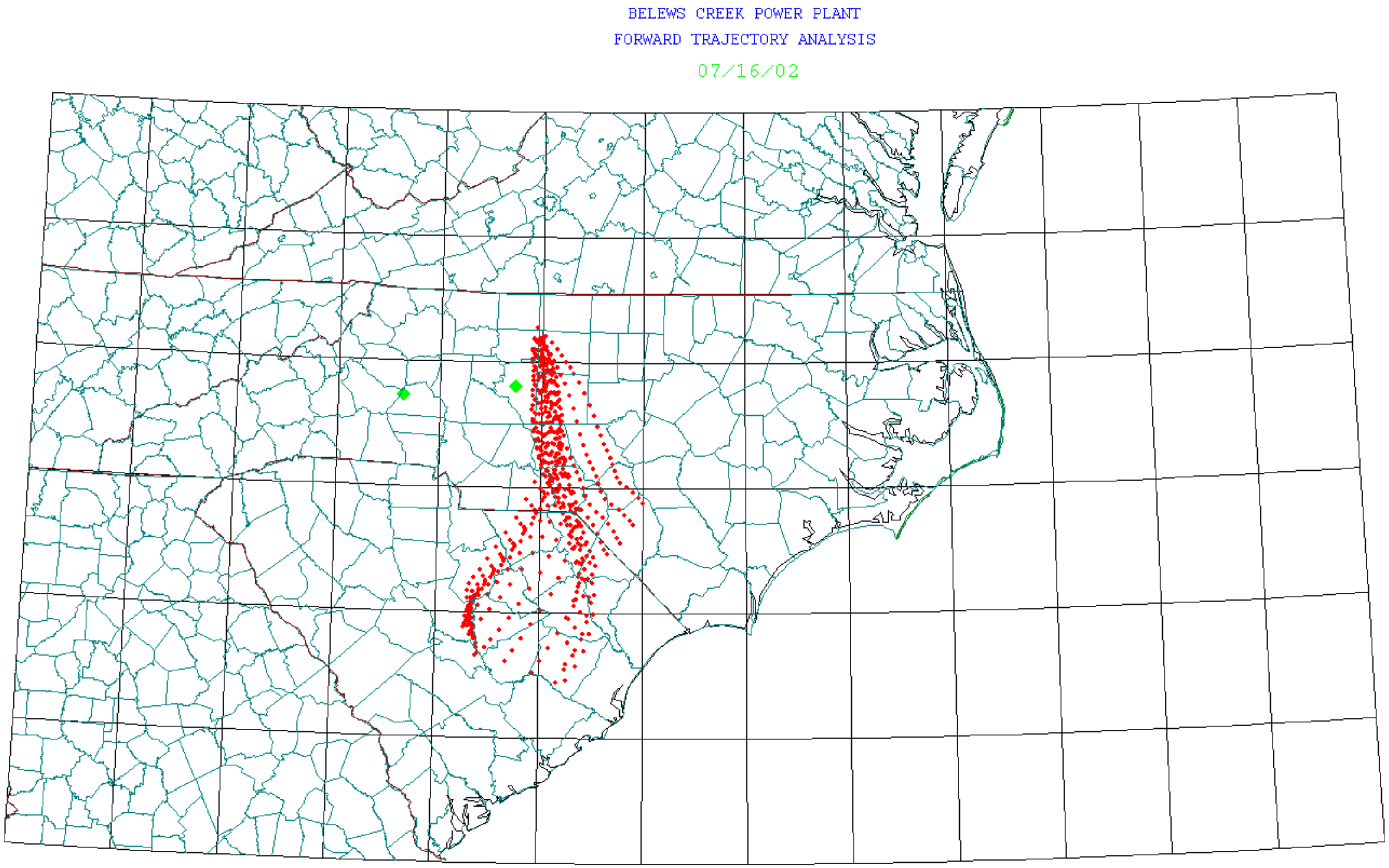


Source: **Belews Creek Power Plant**

Date:**07/10/2002**

Concentration @ Hickory: **27.8 μg/m³**

Concentration @ Lexington: **25.8 μg/m³**

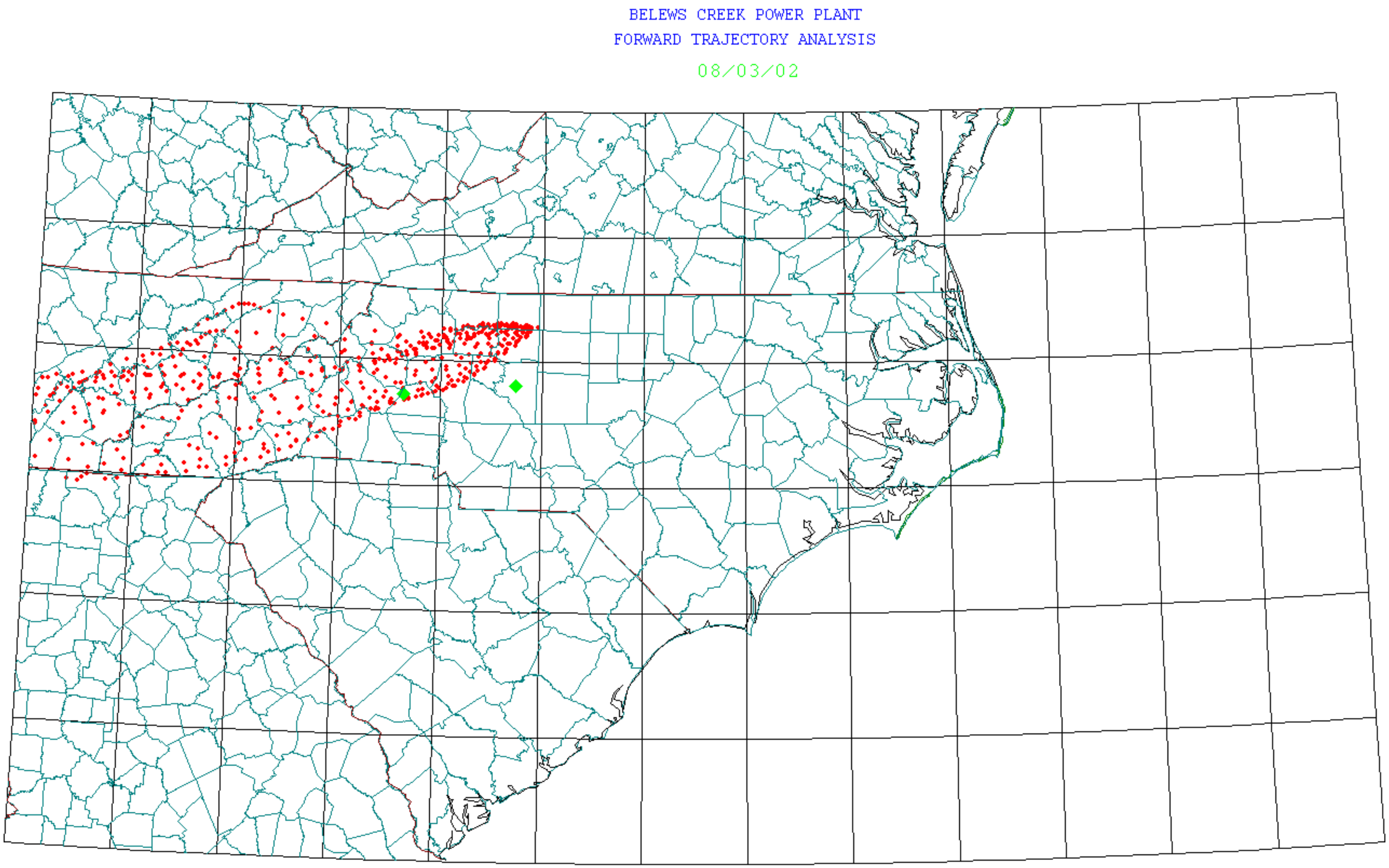


Source: **Belews Creek Power Plant**

Date:**07/16/2002**

Concentration @ Hickory: **33.5 µg/m³**

Concentration @ Lexington: **33.1 µg/m³**

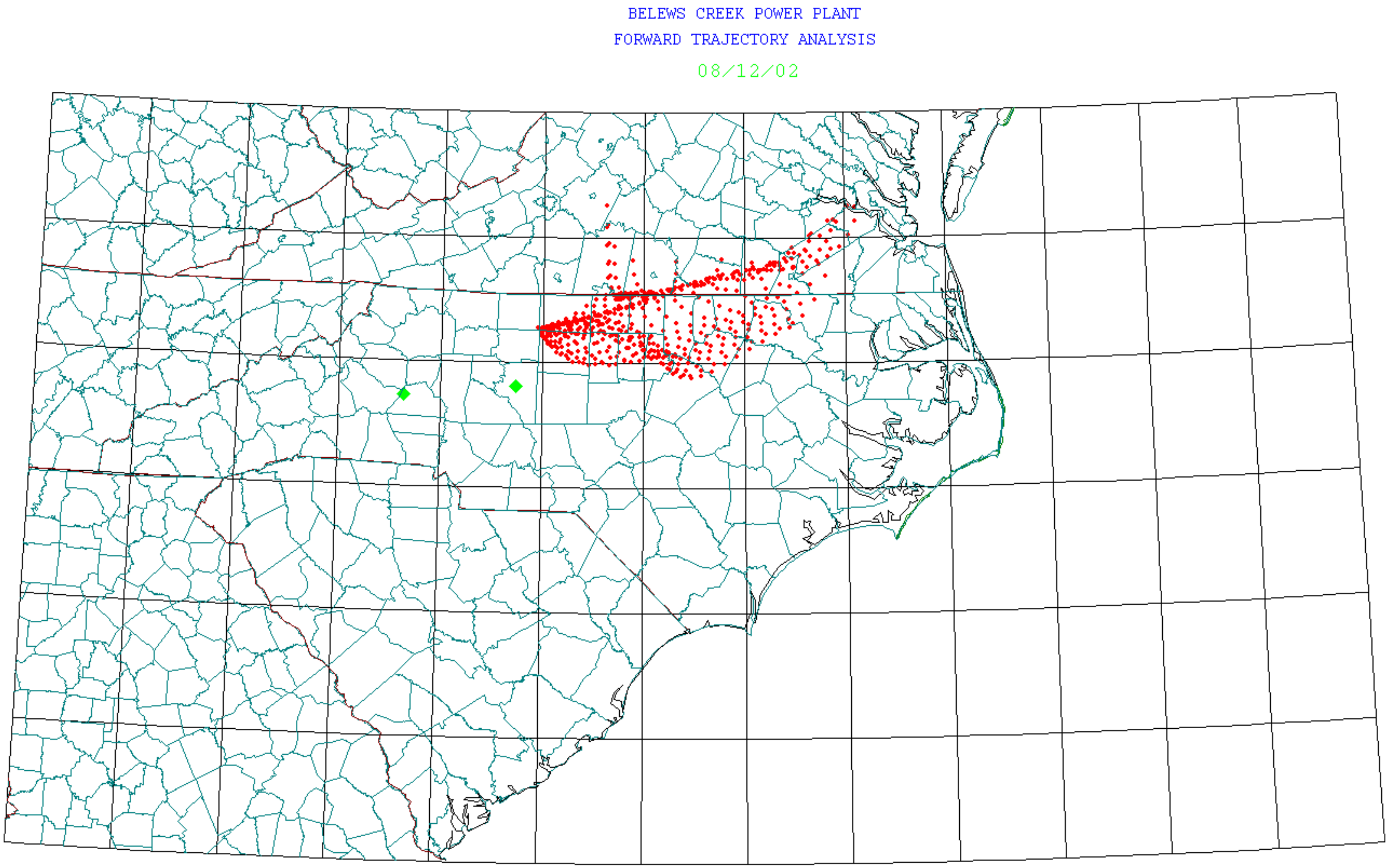


Source: **Belews Creek Power Plant**

Date:**08/03/2002**

Concentration @ Hickory: **30.0 μg/m³**

Concentration @ Lexington: **19.5 μg/m³**

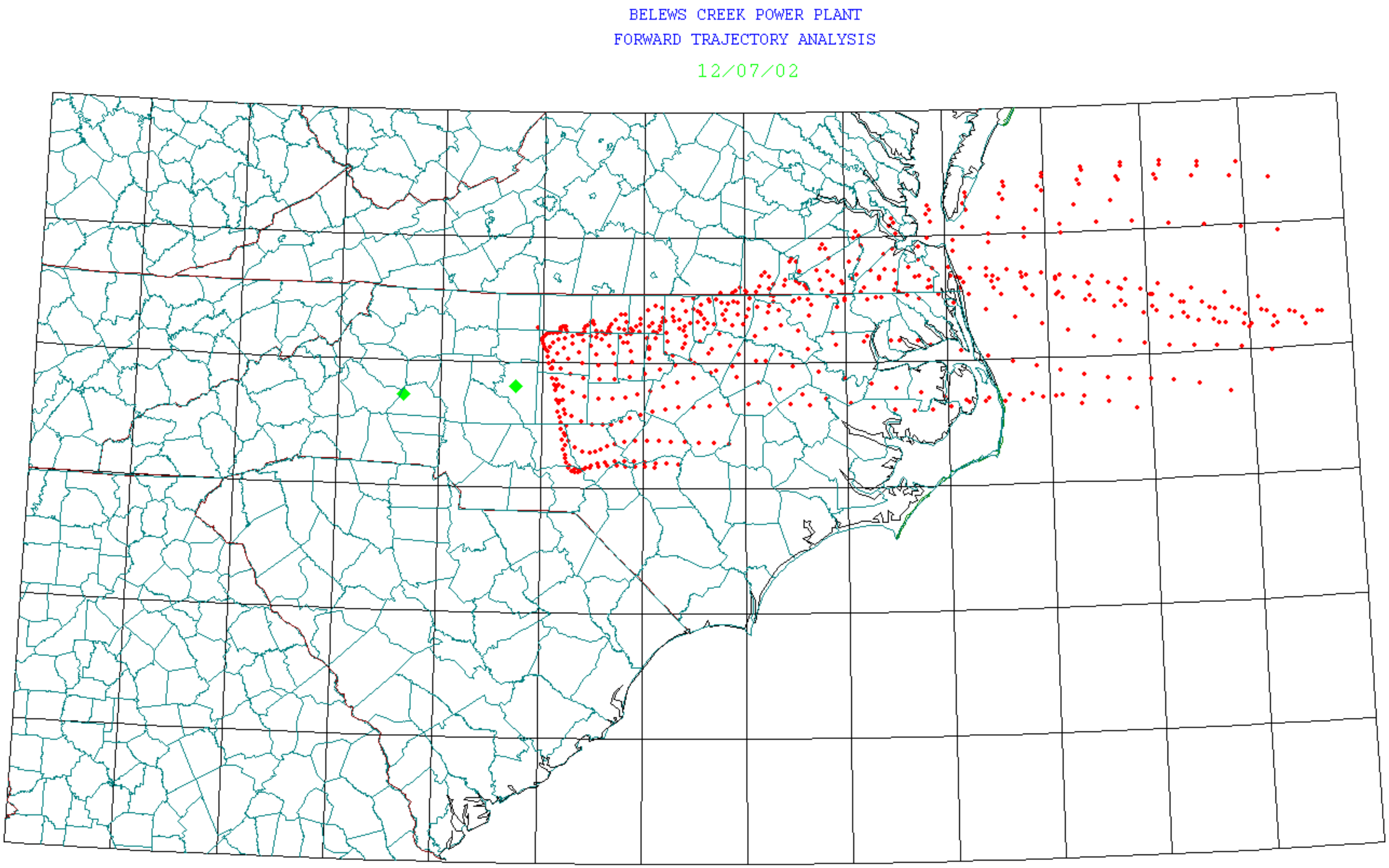


Source: **Belews Creek Power Plant**

Date:**08/12/2002**

Concentration @ Hickory: **40.7 μg/m³**

Concentration @ Lexington: **36.9 μg/m³**



Source: **Belews Creek Power Plant**

Date:**12/07/2002**

Concentration @ Hickory: **29.2 μg/m³**

Concentration @ Lexington: **43.7 μg/m³ (flagged)**

Appendix B – CSA Implementation Schedule

- Clean Smokestakes Act implementation schedule for North Carolina Duke Power Company power plants
- Schedules for Allen, Belews Creek, Buck, Cliffside, Dan River, Marshall and River Bend power plants
- SO_2 and NO_x future rates
- Information taken from the Environmental Review Commission Report submitted June 1, 2004

Expected Duke Power Company Compliance Plan for NC Clean Air Plan
(Exhibit A)

NO_x							
				2007 Compliance		2009 Compliance	
Facility	Unit	Technology	Operational Date	Expected Rate #/MMBTUs	Tons	Expected Rate #/MMBTUs	Tons
Allen	1	SNCR	2003	0.17	715	0.17	650
Allen	2	SNCR	2007	0.19	703	0.17	829
Allen	3	SNCR	2005	0.17	1,310	0.17	1,086
Allen	4	SNCR	2006	0.17	1,357	0.17	1,458
Allen	5	SNCR	2008	0.23	1,845	0.17	1,516
Belews Creek	1	SCR	2003	0.10	3,482	0.10	3,463
Belews Creek	2	SCR&Burners	2004	0.10	3,540	0.10	3,524
Buck	3	SNCR	2009	0.42	458	0.25	392
Buck	4	SNCR	2008	0.42	285	0.25	238
Buck	5	SNCR	2006	0.21	682	0.17	605
Buck	6	SNCR	2007	0.17	593	0.17	646
Cliffside	1	SNCR	2009	0.35	205	0.25	198
Cliffside	2	SNCR	2009	0.35	201	0.25	199
Cliffside	3	SNCR	2008	0.35	339	0.25	357
Cliffside	4	SNCR	2008	0.35	326	0.25	343
Cliffside	5	SCR	2002	0.07	1,179	0.07	1,225
Dan River	1	SNCR	2009	0.37	374	0.25	349
Dan River	2	SNCR	2009	0.37	410	0.25	378
Dan River	3	SNCR&Burners	2007	0.20	484	0.17	588
Marshall	1	SNCR	2007	0.20	2,107	0.18	2,145
Marshall	2	SNCR	2006	0.18	1,548	0.18	2,153
Marshall	3	SNCR	2005	0.17	3,457	0.17	2,915
Marshall	4	SNCR	2008	0.23	4,447	0.17	3,615
Riverbend	4	SNCR	2007	0.20	359	0.17	397
Riverbend	5	SNCR&Burners	2008	0.24	375	0.17	383
Riverbend	6	SNCR&Burners	2008	0.22	693	0.17	653
Riverbend	7	SNCR	2007	0.17	557	0.17	651
			Expected Total:		**32,032**		**30,956**
			Compliance Limit:		**35,000**		**31,000**

Technology
SNCR - Selective Non Catalytic Reduction.
SCR - Selective Catalytic Reduction

Expected Duke Power Company Compliance Plan for NC Clean Air Plan
(Exhibit B)

SO_2							
				2009 Compliance		2013 Compliance	
Facility	Unit	Technology	Operational Date	Expected Rate #/MMBTUs	Tons	Expected Rate #/MMBTUs	Tons
Allen	1	Scrubber	2011	1.55	5,931	0.15	707
Allen	2	Scrubber	2011	1.55	7,554	0.15	765
Allen	3	Scrubber	2011	1.55	9,905	0.15	1,183
Allen	4	Scrubber	2012	1.55	13,298	0.15	1,238
Allen	5	Scrubber	2012	1.55	13,819	0.15	1,361
Belews Creek	1	Scrubber	2008	0.15	5,355 } 10,805	0.15	5,255
Belews Creek	2	Scrubber	2008	0.15	5,450	0.15	5,331
Buck	3			1.40	2,195	1.40	2,172
Buck	4			1.40	1,333	1.40	1,322
Buck	5			1.40	4,981	1.40	5,093
Buck	6			1.40	5,322	1.40	5,716
Cliffside	1			1.70	1,344	1.70	1,328
Cliffside	2			1.70	1,356	1.70	1,400
Cliffside	3			1.70	2,426	1.70	2,495
Cliffside	4			1.70	2,329	1.70	2,451
Cliffside	5	Scrubber	2009	0.19	3,474	0.15	2,829
Dan River	1			1.40	1,953	1.40	1,949
Dan River	2			1.40	2,114	1.40	2,134
Dan River	3			1.40	4,841	1.40	4,843
Marshall	1	Scrubber	2007	0.15	1,787	0.15	1,776
Marshall	2	Scrubber	2007	0.15	1,794	0.15	1,781
Marshall	3	Scrubber	2006	0.15	2,572	0.15	3,122
Marshall	4	Scrubber	2006	0.15	3,190	0.15	3,147
Riverbend	4			1.60	3,740	1.60	3,867
Riverbend	5			1.60	3,609	1.60	3,581
Riverbend	6			1.60	6,146	1.60	6,260
Riverbend	7			1.60	6,130	1.60	6,230
			Expected Total:		**123,947**		**79,339**
			Compliance Limit:		**150,000**		**80,000**

Appendix C – $PM_{2.5}$ / Population Density Correlation Analysis

* The following analysis is the work of Hoy Bohanon, with edits made by Wyat Appel.

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The information about the methodology is contained in two spreadsheets containing multiple sheets and some sheets containing large amounts of data. The sheets are generally labeled "**PM2.5 DESIGNATIONS DATA SPREADSHEET - 6/14/04.**"

The author assumes that data in these spreadsheets contains the best available data. It appears that EPA prejudged the data with a conclusion that nonattainment monitors must be influenced by 80% of the total emissions in immediately surrounding counties and in some cases such as the Triad counties that may be two or three counties distant. There was some attempt to make a correction for background by an "urban excess" calculation that applied weighting factors to emissions data. Some unknown algorithm created values for carbon and crustal which were then weighted and combined with SO2 and NOx to determine the weighted emissions score. Wind patterns are not considered.

The measured data that exist for the Triad and surrounding counties (as selected by EPA) is shown in the table below. Counties with missing data are omitted.

	COU	Design Values		Total Emissions, 2001 (tons)			
Sequence		'01-'03	Pop Density	PM	SO2	NOX	VOC
530	**Guilford**	**14.1**	**663**	**2,418**	**2,833**	**19,068**	**34,464**
531	**Davidson**	**15.8**	**274**	**1,951**	**1,398**	**11,281**	**14,970**
532	**Forsyth**	**14.6**	**768**	**1,559**	**5,885**	**14,552**	**20,679**
534	**Alamance**	**13.7**	**315**	**1,181**	**749**	**5,618**	**8,967**
538	Chatham	12.2	79	1,714	11,605	5,823	4,734
545	Orange	13.1	301	857	756	6,264	6,751
548	Montgomery	12.1	56	516	484	1,631	4,175
549	Caswell	13.3	55	483	199	1,071	1,622

An initial basic analysis of the measured data is to determine the independent and dependent variables, (or the potential causes and the effect) and then investigate whether there is a relationship. The effect (dependent variable) is $PM_{2.5}$ which is shown as Design

Values (DV). It may be influenced (independent variables) by population density (which is a surrogate for many emissions), PM, SO2, NOx, or VOC.

Examining the Population Density

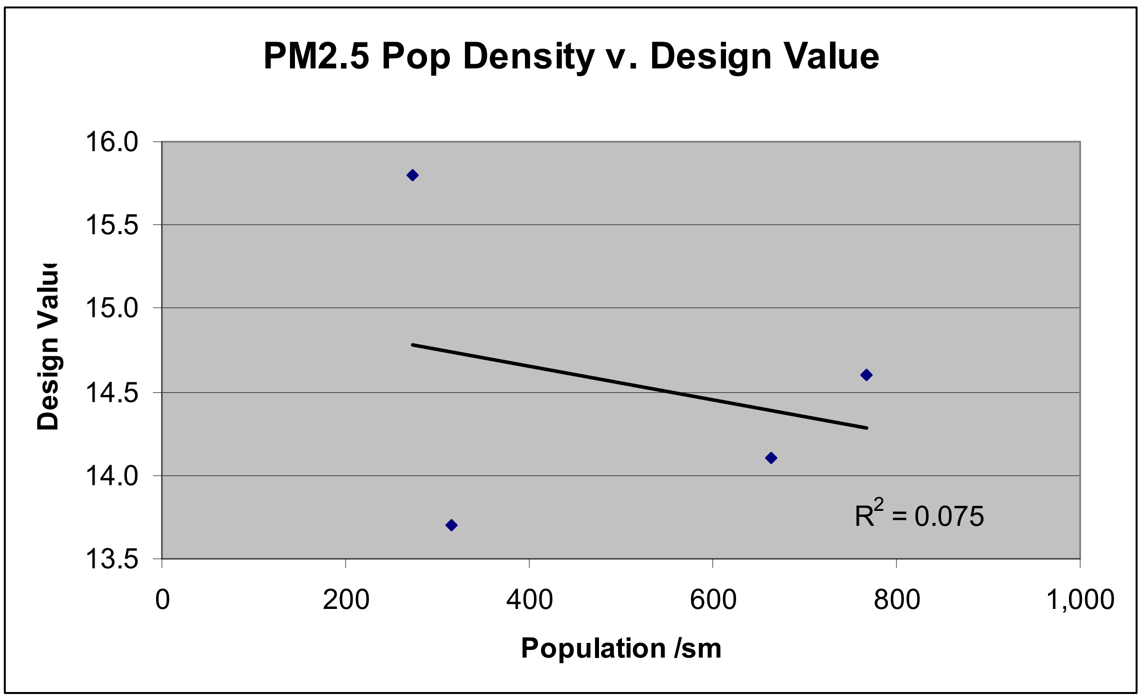
The data for the immediate Triad area is:

Triad

	Density	Design Value
Guilford	**663**	**14.1**
Forsyth	**768**	**14.6**
Alamance	**315**	**13.7**
Davidson	**274**	**15.8**

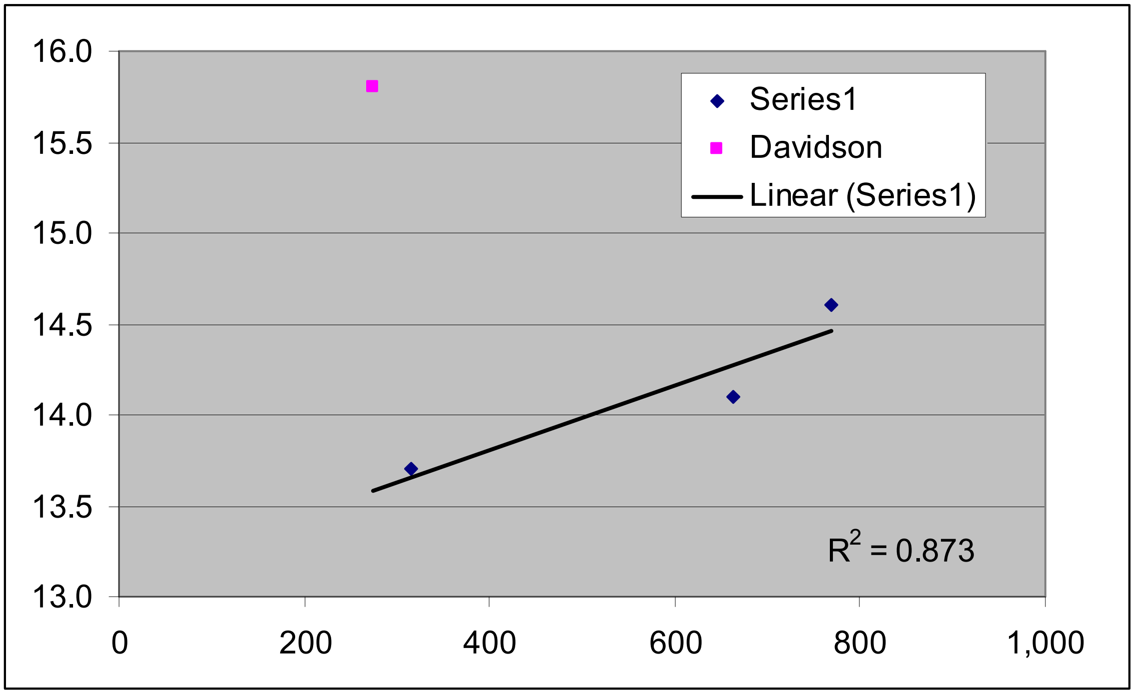
Where density is people / square mile and design value is PM2.5 in µg/m^3

Plotting the data gives



The added trend line shows that the correlation is negative. This means that higher population results in lower PM. This doesn't make sense. The correlation coefficient is very low.

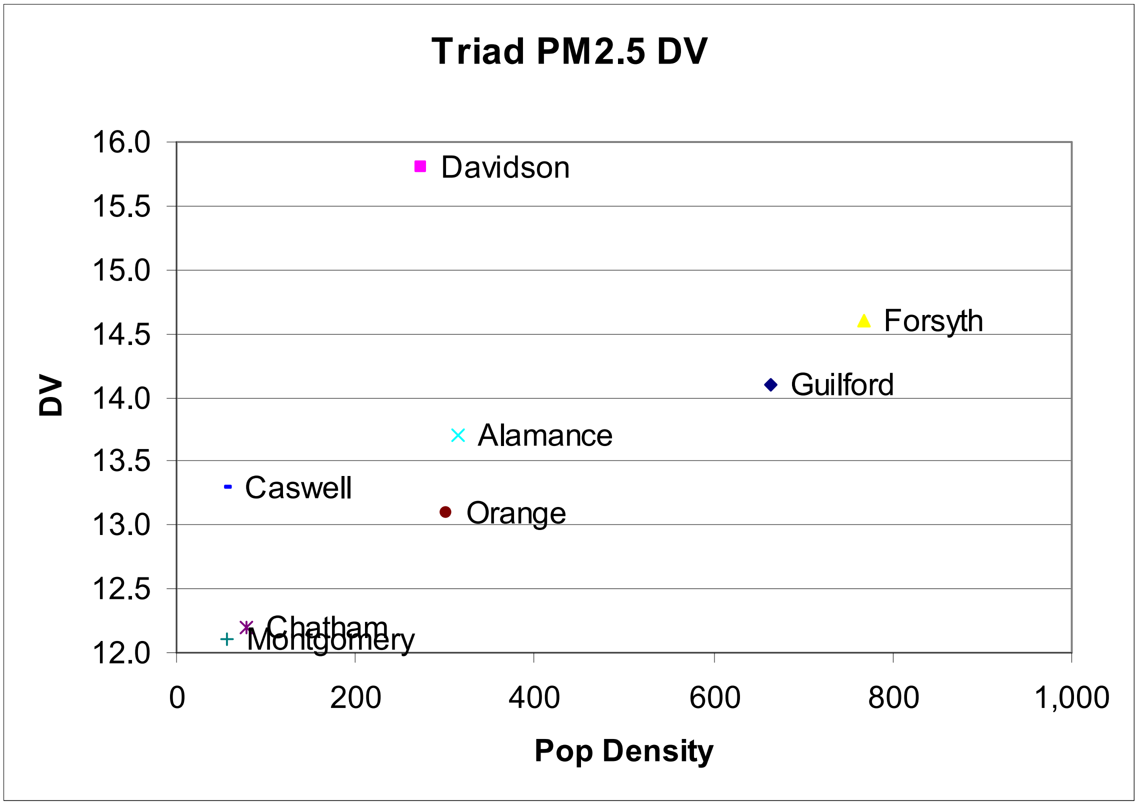
A trend line that excludes the Davidson County data point results in the following:

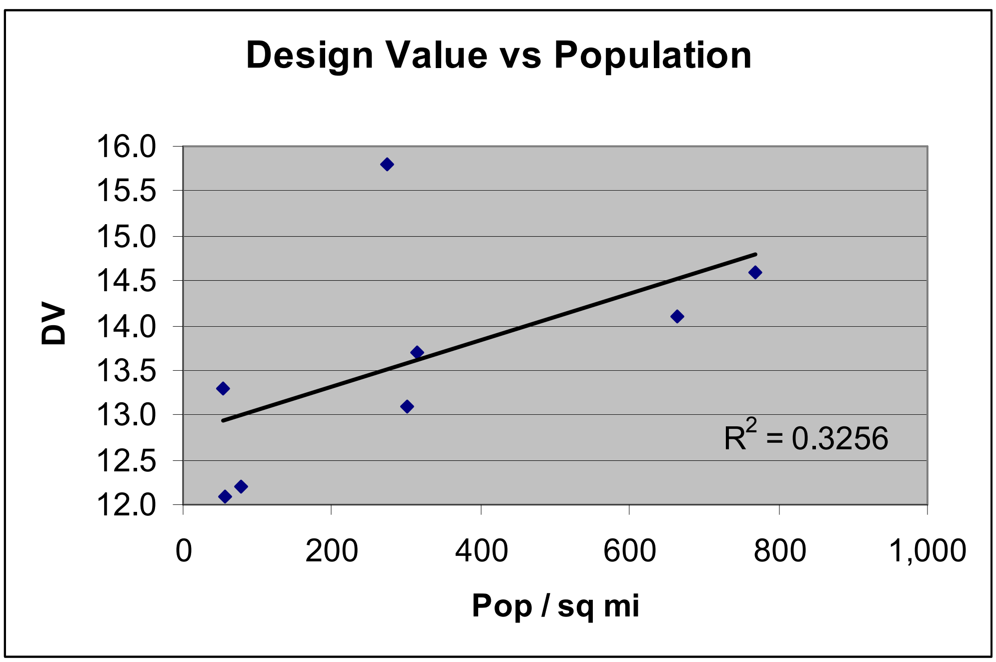


This is a better fit and the line shows that increasing population results in increased $PM_{2.5}$.
This look at the data leads to an obvious question. Is Davidson County different from the other counties in the area?
To make a more informed analysis, the other surrounding counties listed in the EPA spreadsheet should be added.

Triad+

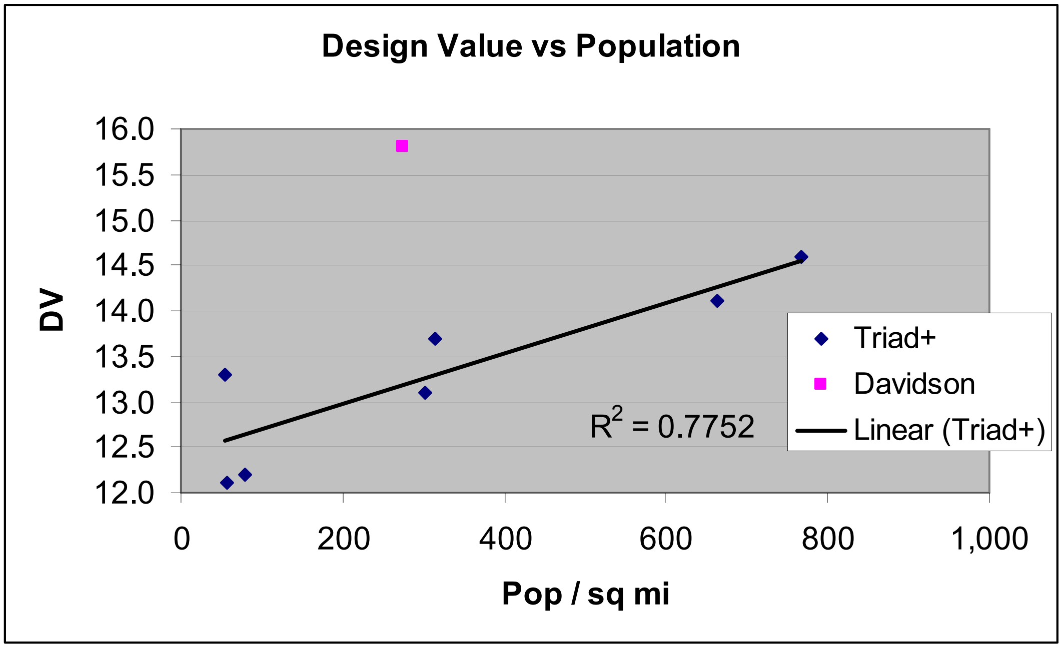
	Density	Design Value
Guilford	**663**	**14.1**
Forsyth	**768**	**14.6**
Alamance	**315**	**13.7**
Davidson	**274**	**15.8**
Chatham	79	12.2
Orange	301	13.1
Montgomery	56	12.1
Caswell	55	13.3





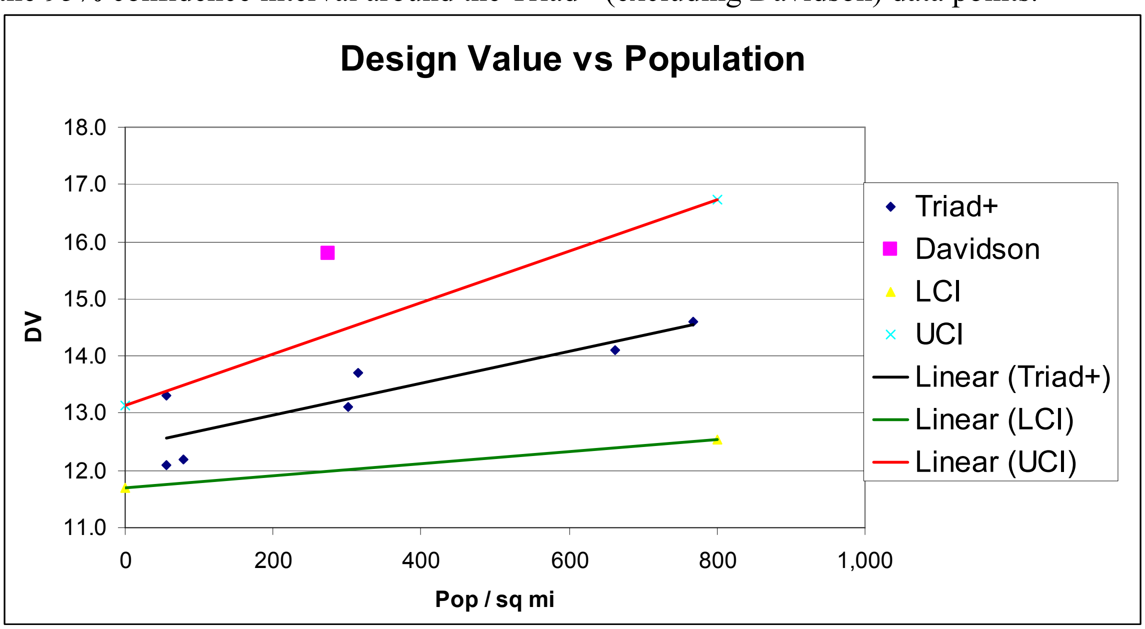
With the additional data, the regression line now shows increasing $PM_{2.5}$ with increasing population, but the fit isn't very good ($r^2 = 0.3$).

Excluding Davidson County from the regression results in the following:



The fit is much better. The intercept corresponds closely to what EPA used as the background value in its urban excess calculation. The intercept of the regression line (value where the population equals zero) is 12.4. In the urban excess calculation EPA appears to have used a value of 12.2 from James River Face, VA for a background (zero population) number for the Triad. The two numbers are quite close.

The question arises, is there something different about Davidson County? Is it an outlier in terms of the surrounding area? An initial determination can be made by determining the 95% confidence interval around the Triad+ (excluding Davidson) data points.



The Triad+ data set (not including Davidson) is bounded by a 95% upper confidence interval and a 95% lower confidence interval. Points within these intervals are statistically likely (with 95% confidence) to be a part of the same data set. Davidson County clearly falls outside of this data set.

One may logically conclude based upon the data, that the other counties exhibit an increased design value due to increased population (which appears to be a decent surrogate for increased cars, commerce, jobs, etc.).

One may also conclude that Davidson County is different from all other counties.

It is therefore appropriate to "single out" Davidson County and begin the process of determining what makes its PM2.5 concentration higher. It is inappropriate to include any of the other counties adjacent to or surrounding Davidson in a nonattainment designation. Their design values all attain the current standard and there is no evidence that the contribution to each other is significant. Their differences can be explained by the "local effect" of population. Davidson has some unexplained "local effect" making it unique among the counties in the Triad area of North Carolina.

Additional Analysis

One may ask whether or not the other possible input factors such as PM give similar results. Is there another measured component that closely correlates to the design values? The answer is no. The following table lists the R square values for the data set excluding Davidson County. Higher values indicate better correlation. Lower values indicate lack of correlation.

Component	R-square
Population density	0.77
PM	0.20
SO2	0.02
NOx	0.52
VOC	0.50

Could two factors be involved? The stepwise procedure for multiple linear regression is to add the next factor highest r-square factor to the analysis. A multiple linear regression using population density combined with NOx shows NOx to not be a significant factor. ($p=0.32$).