# Protecting Air Quality

## GIS tools increase efficiency and accuracy

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The Clean Air Act forms the framework for all efforts leading to the protection of air quality. The mission of the Bureau of Air Quality (BAQ) at the South Carolina Department of Health and Environmental Control (SCDHEC) is to "conserve and enhance air resources and ensure that ambient air quality is maintained at the highest level."

### Projects/Applications at BAQ

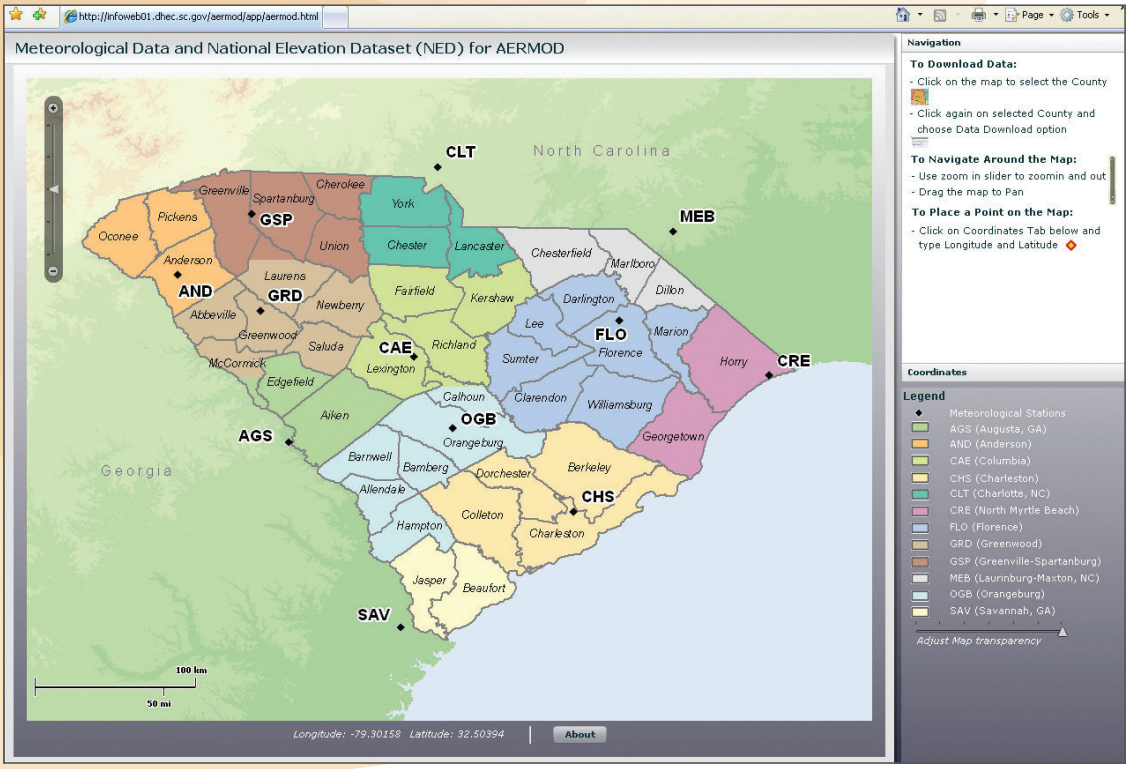
BAQ protects air quality through regulating emission sources, planning, education, and the implementation of various air quality programs. GIS has become an important tool to assist in environmental decision making at BAQ.

### South Carolina Ozone Nonattainment Boundary

Ground-level ozone is an air pollutant formed by chemical reactions between oxides of nitrogen (NO*x*) and volatile organic compounds (VOC) in the presence of sunlight. The ozone season in South Carolina begins on April 1 and lasts through October 31 of each year.

BAQ has developed an extensive ambient air quality monitoring network for ozone and other pollutants. In operation since 1959, the ambient monitoring network is used to establish general or background information in rural areas, determine the effects of NO*x* and/or VOC emissions from specific sources on ozone formation, monitor pollutant concentrations in suburban and urban areas, and ascertain interstate and intrastate transport of pollutants. In 2008, there were 16 ozone monitors strategically located throughout the state that had at least three years of quality assured data. These monitors were located in accordance with United States Environmental Protection Agency (EPA) monitor siting guidance. Ozone concentrations are measured 24 hours per day, and 8-hour moving averages are calculated. The maximum 8-hour average is reported each day.

In March 2008, based on scientific evidence and human health studies, the EPA lowered the ozone standard to 0.075 parts per million (ppm). Areas where ozone levels violate national ambient air quality standards may be designated as nonattainment areas. BAQ was required to submit new nonattainment boundary recommendations to EPA. The factors considered in the recommendation designation of the new nonattainment boundaries were

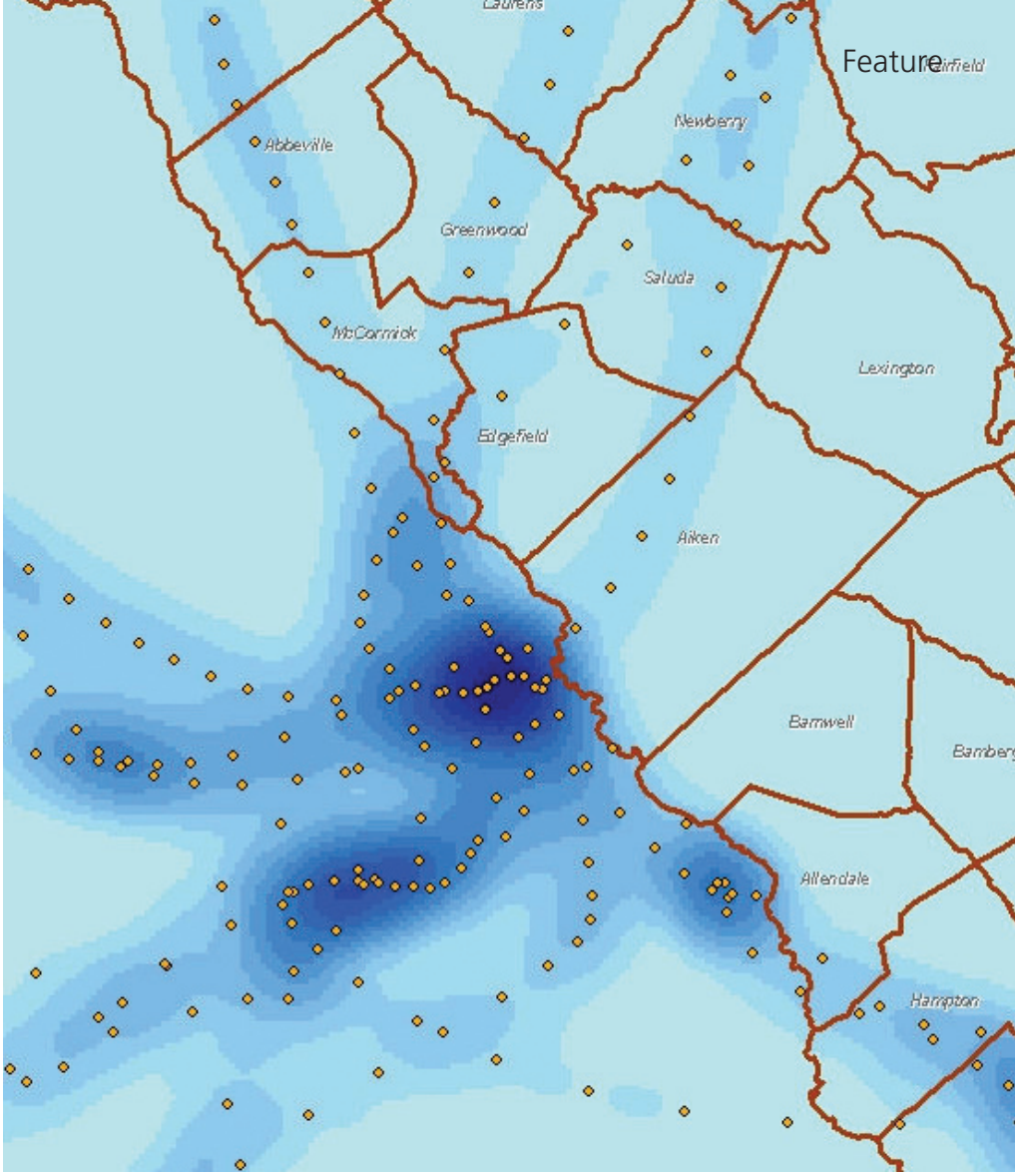



*The AERMOD mapping application allows site visitors to download meteorological and National Elevation Dataset data.*

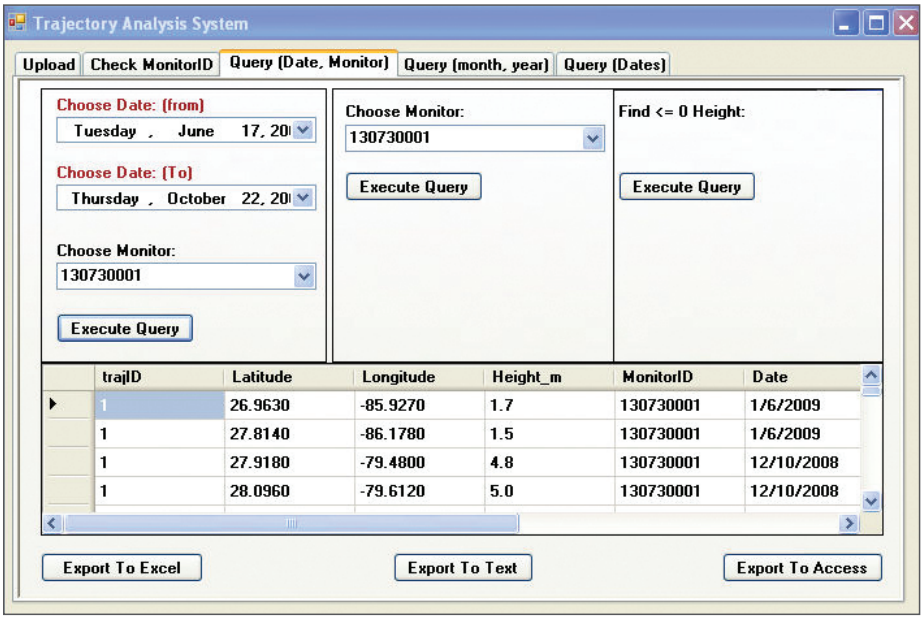
- Air quality data
- Emissions data
- Population density and degree of urbanization
- Traffic and commuting patterns
- Meteorology

The process of designating areas that meet or do not meet these standards is very resource intensive. It would not have been possible to accomplish this task without the use of GIS. BAQ uses ESRI ArcGIS 9.3 desktop and server products for performing spatial analysis, modeling, managing spatial data, creating maps, and disseminating the geographic information via Web services.

The data layers used in nonattainment boundary designation were acquired from a number of sources. South Carolina state agencies maintain GIS database repositories and provide data via Web services or data download option. BAQ maintains Microsoft SQL Server and Oracle databases of air quality and emissions inventory data. The locations of all ambient air monitoring stations were acquired as GPS coordinates that were differentially corrected.




*A trajectory density map of the Aiken area shows high ozone days.*




*Trajectory Analysis System allows users to load trajectories into a Microsoft SQL Server database and query the data.*

Facilities in South Carolina must obtain operating permits based on the quantity of the pollutants to be emitted. The locations of permitted facilities are provided as either GPS coordinates or mapped using county orthophotos or 1:24,000-scale National Aerial Photography Program (NAPP) digital orthophoto quarter quadrangles (DOQQs). For areas containing an ozone monitoring station that showed an exceedance, that area and the neighboring counties were carefully evaluated using the nonattainment criteria. U.S. Census data from the American Community Survey (ACS) was helpful in analyzing the population to determine the degree of urbanization and understand commuting patterns.

Since motor vehicle emissions are a significant contributor to ozone formation, the daily vehicle miles traveled were collected by the South Carolina Department

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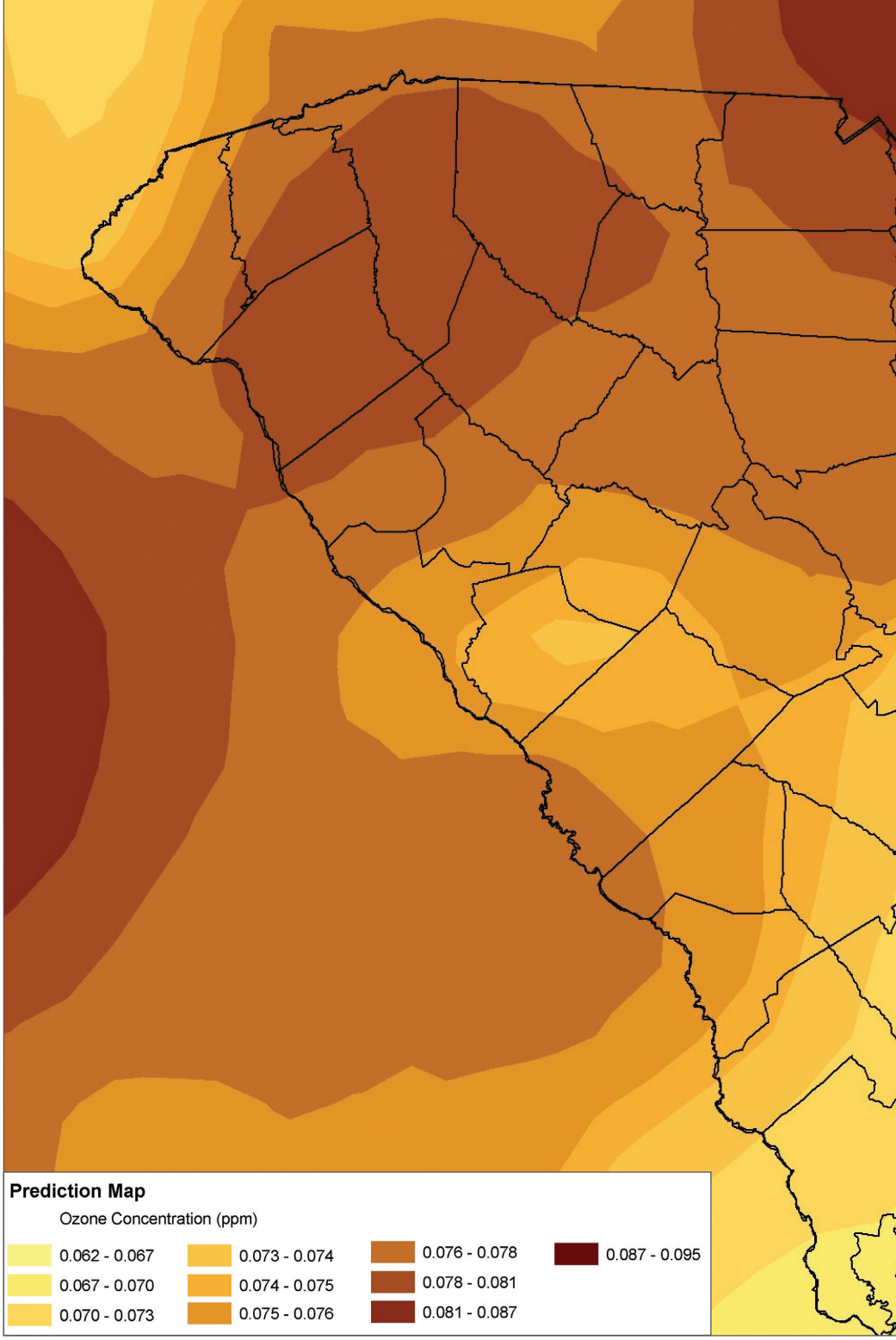
of Transportation, and traffic counts were calculated for each area. ACS data helped in understanding driving patterns and estimating the percentage of people who use public transportation. Major emission sources with VOC and NO*x* quantities were mapped to understanding how they may have contributed to ozone exceedance in each area. Wind roses were created for the ozone season to look at the dominant wind direction. Based on the existing data and analysis, five nonattainment ozone boundaries were delineated.

### Interactive Map for AERMOD Modeling

AERMOD is a steady-state plume model that is used to predict pollutant concentrations at selected downwind receptor locations. The model was developed by the American Meteorological Society (AMS) and EPA. Facilities applying for an air permit in South Carolina must demonstrate compliance with applicable air quality standards. AERMOD is the current EPA-recommended refined model to be used for this purpose.

AERMOD contains two input data preprocessors that are part of the regulatory modeling system: AERMET and AERMAP. AERMET processes meteorological (surface and upper-air) characteristics data. Its output is input directly into AERMOD. AERMAP processes digital terrain data and requires as input either National Elevation Dataset (NED) or digital elevation model (DEM) data. The terrain data is used primarily to establish the elevations of the model receptors and the topography in the modeling domain.

To make the modeling process more efficient, BAQ developed an application that allows users to download AERMET and NED data from the BAQ Web site through an interactive map. Data can be obtained for each county. The mapping application was created using the ArcGIS API for Flex. Flex was chosen because it gives the user rich interactivity and has a robust development environment. The application can be viewed at infoweb01.dhec.sc.gov/aermod/app/aermod.html.

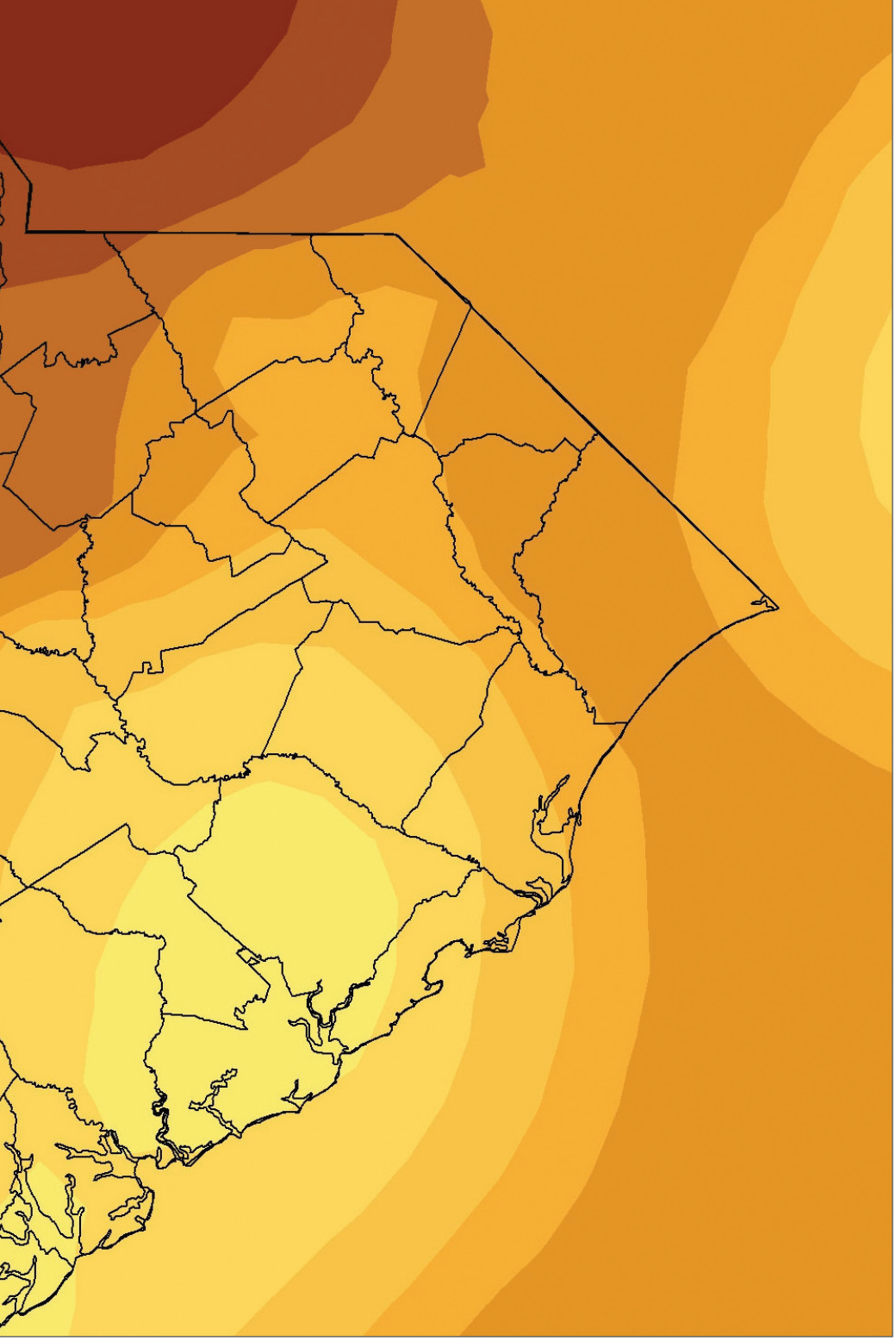



### Trajectory Analysis

A trajectory is a three-dimensional view of the path an air parcel travels based on meteorological data. To understand air movement, trajectories are created and analyzed for every 8-hour ozone exceedance day. Trajectories are created using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model from the National Oceanic and Atmospheric Administration (NOAA). Detailed information regarding the trajectory model can be found on the NOAA Web site at www.arl.noaa.gov/ready/hysplit4.html.

Output files from the model contain the longitude and latitude for a parcel of air. Frequently, back trajectories are analyzed because they provide clues about the origin of air masses and assist in determining possible meteorological conditions during elevated ozone episodes. Each trajectory runs back in time for a 36-hour time period. The Trajectory Analysis System and ArcGIS tools were created by BAQ to aid the analysis process. Trajectory Analysis System is a simple .NET application that is used to load the trajectory output files from the model to a Microsoft SQL Server database. The data can be queried by locations, date range, height, and hour and displayed in ArcGIS to be analyzed further.

Back trajectories were queried for days when the maximum 8-hour ozone concentration exceeded 0.075 ppm at the Jackson (Aiken County) ozone monitoring station through



*An ozone prediction map shows predicted ozone concentration.*

the years 2006–2008. The 300-meter and 500-meter back trajectories showed transport just south of the Atlanta area, eastward into the central Savannah River area of South Carolina. Exceedances of the 8-hour ozone standard occurred across the Atlanta area on May 2 and May 3, 2007. Ozone precursors from the Atlanta area moved into the central Savannah River area on May 3, 2007, and this, combined with meteorologic conditions, resulted in an ozone exceedance at the Jackson site.

## Ambient Air Monitoring Network Assessment

BAQ is mandated by EPA to perform air monitoring network assessment every five years. The assessment determines if the new monitoring sites are needed and whether some of the existing sites can be terminated. The current assessment is in progress and has to be submitted to EPA in 2010.

There are many steps involved in performing network assessment. With the use of ArcGIS, site-by-site analyses were completed and the individual monitors ranked based on the number of parameters monitored at each site, measured concentrations, and the population and area served. Population and area served were represented by Thiessen polygons. Ranking gave insight into the importance of each monitoring site. Site-by-site analyses don't evaluate the entire network, and each monitoring site is scored independently from the others.

To understand the overall network and determine the deficiencies, further analyses were performed to examine the phenomena that influence high pollutant concentrations. The ArcGIS Geostatistical Analyst extension provides interpolation methods for producing surfaces based on the data samples. Kriging was used to produce the two raster surfaces—a map of predicted ozone values and a map of standard errors associated with ozone predicted values. Prediction standard error, distance to roads, population, NO*x* emissions, and VOC emissions grids were input to the weighted overlay analysis.

The rasters were reclassified to a common scale of 1 to 10 (with 1 being the least suitable and 10 being the most suitable location for placing new monitors). Each raster was assigned percentage weights. The weighted overlay allows the user to look at the areas with the lowest suitability and where the uncertainty of the network is the greatest and place new monitors if needed. The model was built with ModelBuilder to ensure that the whole process could easily be repeated.

## Conclusion

GIS and the tools developed by BAQ increased productivity and led to greater efficiency and accuracy. It became easy to query and analyze millions of records and display only relevant information. Since GIS has become an integral part of the BAQ's daily operations, it is possible to make informed decisions and provide better services for the public.

## About the Author

Elzbieta Covington is a GIS manager at the Bureau of Air Quality at the South Carolina Department of Health and Environmental Control. She came to the department in 2006 after working for 12 years at Earth Sciences and Resources Institute at the University of South Carolina.