Draft

North Carolina's Air Quality Management Process (AQMP) Conceptual Model

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BACKGROUND

EPA is working with three pilot areas to integrate non-traditional planning into air quality management: (1) Illinois and Missouri; (2) New York; and (3) North Carolina. Many state, local and tribal governments are moving away from single-pollutant planning towards multi-pollutant strategies that address future air quality needs. EPA's AQMP Project is an effort that encourages state and local governments to create a comprehensive air quality planning process that will provide a more efficient pollution control process. Air quality management plans address air quality concerns and goals such as nonattainment and maintenance of criteria pollutant standards, sector-based emissions, regional haze, visibility, ecosystem health, and risk reductions of Hazardous Air Pollutants. These plans may consider other issues such as land-use, transportation, energy and climate change. The goal is to integrate the requirements of the current SIP process into a more comprehensive plan for air quality in a manner consistent with the 2004 NAS report, "Air Quality Management in the United States," and the 2007 Clean Air Act Advisory Committee recommendations. The goal is also to develop a process that will be more efficient than the current air management process and produce the same, if not more environmental benefits.

Overview

The overall purpose of the AQMP pilot project is to define the process by which an integrated air planning process will be developed in North Carolina, including the implementation steps and timeline for such a process. North Carolina will strive to develop a process under which the various air quality issues of the state can be addressed.

The fundamental characteristics of the North Carolina AQMP Pilot Project are: (1) it comprehensively covers all pollutants affecting the State; (2) it covers all of the State, both non-attainment and attainment areas with regard to the NAAQS pollutants; (3) it involves partnerships with local elected officials, business and industry, environmental groups, the general public and any other interested groups; (4) and the technical steps needed to develop AQMP's are an ongoing pre-planned set of actions that will recur on an established schedule. The technical steps include: emission inventory development, assessments of growth including population, vehicle use, and energy use, meteorological modeling, air quality modeling, control strategy assessments and periodic reports of results of the analyses. The NCDAQ is currently developing a comprehensive multi-pollutant implementation plan that will be completed in December 2009.

State implementation plans (SIPs) have traditionally focused on the need to respond to a non-attainment situation when there is a revision to a NAAQS. This is not the most effective approach to SIP development because the current process is burdensome on both staff and resources due to the amount of work necessary to satisfactorily complete statutory requirements within the specified deadlines. Such a "surgical" response for a portion of a State that is designated as non-attainment may still be required unless there is a Clean Air Act change. The North Carolina AQMP is a continuous process whereby ongoing technical work is done under a comprehensive, statewide plan that is designed to address multiple pollutants instead of the current SIP process, which is not the most effective, that is done on a pollutant-by-pollutant basis. A comprehensive, statewide air quality management process provides a holistic approach designed to mitigate multiple pollutants. Employing control strategies with co-benefits of addressing multiple pollutants results in an effective and efficient method to address air quality issues. Adhering to a continuous process schedule (see Appendix A) has many advantages because it supports ongoing refinement and enhancement of technical analyses for improved accuracy and robustness. Our collaborative efforts with VISTAS have established a framework for modeling multi-pollutants; therefore, transitioning from modeling a single pollutant to modeling for multi-pollutants will require minimal effort. It also encourages stakeholders to be a part of the entire process that promotes greater input and involvement. The advantage of a continuous AQMP is having the groundwork for the air quality technical analyses, stakeholder involvement and policies already established, so when SIPs are due, they are incorporated into the ongoing process. Additionally, a State is better able to respond to various legislative inquiries when such technical information and evaluation are readily available.

Air Quality Issues in North Carolina

North Carolina has geographical characteristics that also influence air quality. These geographical regions include the Coastal Plain, Piedmont and Appalachian Mountains. The coastal plain is influenced by the coastal front and sea breeze that occurs due to daytime heating over land. As the air over land warms, a gradient is formed between the cooler air over the ocean. This gradient forms a circulation that causes winds to blow consistently inland, effectively mixing the atmosphere and cleaning the air. The opposite occurs overnight, where air over water is warmer than air over land and an offshore breeze occurs. By continuously circulating air, the atmosphere is kept clean relative to the central portions of the state.

The Piedmont region, however, is less affected by climatology than by population density. Major population centers exist within the central portion of the state. As such, poorer air quality is expected due to an increase in anthropogenic emissions, which lead to increases in ozone and particulate matter (primary and secondary). Typically, the Piedmont region is dominated by southwesterly flow, with the main cleaning component being synoptic scale frontal boundaries.

Air quality in the Appalachian Mountains is most often degraded during the overnight hours. This pattern is different from normal pollutant profiles as ozone formation occurs during daylight hours. Because the highest ozone levels typically occur overnight, it can be concluded that transport is the main cause rather than local formation.

Appendix B contains maps displaying the location of stationary sources and highway networks across the seven regional areas in North Carolina. The stationary sources' emissions are shown in tons per year. As shown in the maps, North Carolina has several major highways that traverse through the larger metropolitan areas across the State, specifically through the Piedmont Crescent. There are also electric generating utilities operating within these areas. As indicated by the maps, the resulting emissions in these areas are significant. In addition, there are electric generating utilities in the Asheville and Wilmington areas but the emissions are not as significant in these areas.

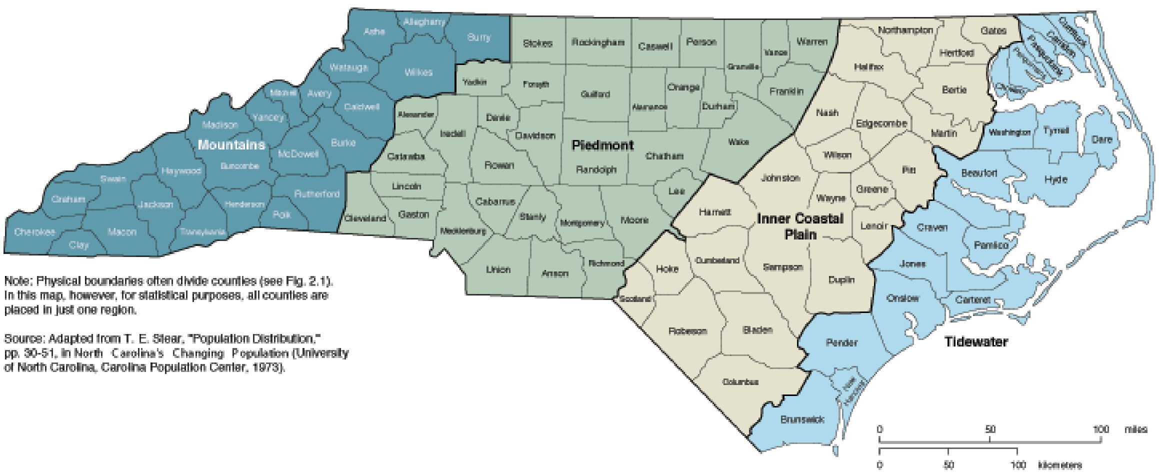


Figure 1.1 – Map of the Mountain, Piedmont and Coastal Regions Across North Carolina

Pollutants of Concern

As North Carolina develops the AQMP pilot project, one of the most critical elements will be the process to identify control strategies across multiple pollutants and addressing multiple air quality objectives. The first step in this process is to identify the pollutants of concern in North Carolina. The significant criteria pollutants of concern across the State are fine particulate matter ($PM_{2.5}$) and ozone (O_3). Regional haze is also of concern in the Class I areas (Great Smoky Mountains National Park, Joyce Kilmer-Slickrock Wilderness Area, Linville Gorge Wilderness Area, Shining Rock Wilderness Area and Swanquarter Wildlife Refuge) in North Carolina. North Carolina currently has one area, Metrolina, in nonattainment for the 1997 8-hour ozone NAAQS. There are three other areas in maintenance for the 1997 8-hour ozone NAAQS, the Triangle, Rocky Mount (Nash and Edgecombe Counties) and the Great Smoky Mountains National Park (Swain and Haywood Counties). Also, there were several areas that participated in the Early Action Compact process – the Triad (Alamance, Caswell, Davidson, Davie Forsyth, Guilford, Randolph and Rockingham Counties), Fayetteville, the Mountains (Buncombe, Haywood, Henderson, Madison and Transylvania Counties) and the Unifour area (Alexander, Burke, Caldwell and Catawba Counties), all of which attained the 1997 8-hour ozone standard early and are in attainment.

Ozone

Ozone forms through the reaction of NOx and VOC emissions. Nitrogen oxides are emitted from the utilities, combustion processes and motor vehicles. Volatile organic compounds are emitted from many industrial solvents as well as the various hydrocarbons (HC) that are evaporated from the gasoline used by motor vehicles or emitted through the tailpipe following combustion. Additionally, VOCs are emitted by natural sources such as trees and crops. Due to the generally warm and moist climate of North Carolina, vegetation abounds in many forms. The emissions from natural sources, such as vegetation, are referred to as biogenic emissions and account for approximately 85% (based on 2002 annual emissions) of the total VOC emissions in North Carolina. This results in North Carolina being a NOx limited environment, which means that reductions in NOx emissions will have the greatest impact on reducing ozone formation in North Carolina.

North Carolina's most populous metropolitan regions are located in the central portions of the State (Piedmont). The three largest cities (Charlotte, Greensboro and Raleigh) form a partial crescent extending from the southwest to the northeast. This combination of metropolitan regions is often referred to as the Piedmont Crescent. A network of interstate and intrastate highways interconnects these three largest cities and further extends into adjoining states in a general southwest to northeast pattern. The mobile-based NOx emissions follow these highway networks with the highest emissions occurring in or near the city centers. The industrial point sources with both anthropogenic NOx and VOC emissions are also generally located in close proximity to the cities and the major road networks. Finally, North Carolina's largest NOx point sources are electric generating facilities, which are spatially scattered around the State but are most heavily concentrated near the Piedmont Crescent. By combining each of the major emission source categories (biogenic source VOC emissions and mobile sources (highway and non-road) and electric generating facilities NOx emissions), the highest concentrations of precursor pollutants for ozone formation are focused throughout the Piedmont Crescent.

In March 2008, the USEPA strengthened its NAAQS for ozone from 0.08 parts per million to 0.075 parts per million. North Carolina is in the process of evaluating how many areas across the State violate the revised standard. The following figure shows the 2006-2008 design values for the recommended NC nonattainment boundaries for the revised 8-hour ozone NAAQS.

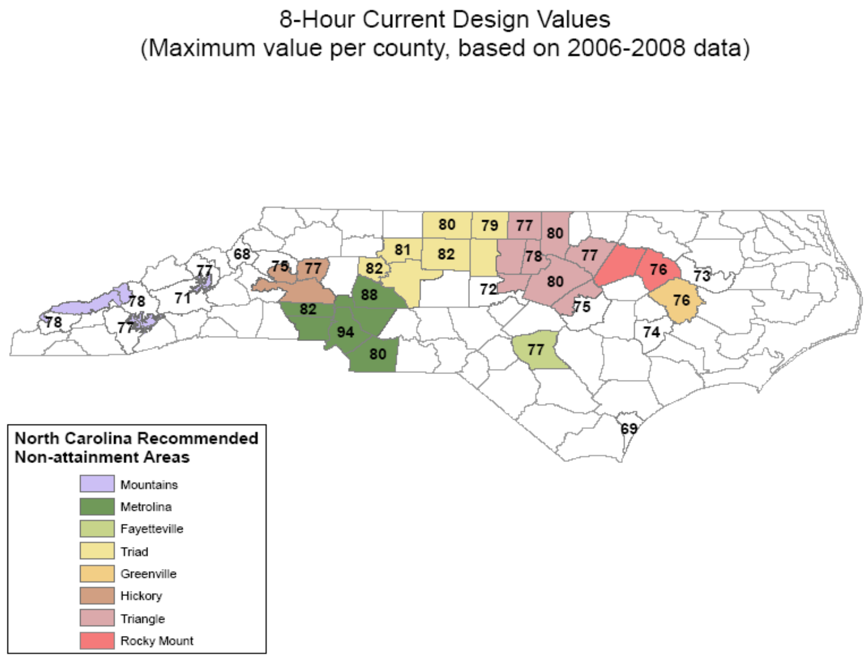


Figure 1.2 – 2006-2008 Design Values for the Proposed NC Nonattainment Areas for the Revised 8-hour Ozone NAAQS

<u>Particulate Matter</u>

$PM_{2.5}$ can be either gaseous or solid particles formed in the atmosphere via complex reactions. As previously stated, $PM_{2.5}$ is another significant pollutant of concern in North Carolina. High $PM_{2.5}$ concentrations have been a concern in several of our urban areas - Catawba, Guilford and Davidson Counties. However, the 2006-2008 data shows that all of the monitors in NC have come into compliance with both the annual and daily $PM_{2.5}$ standards, 15.0 $\mu g/m^3$ and 35 $\mu g/m^3$ respectively.

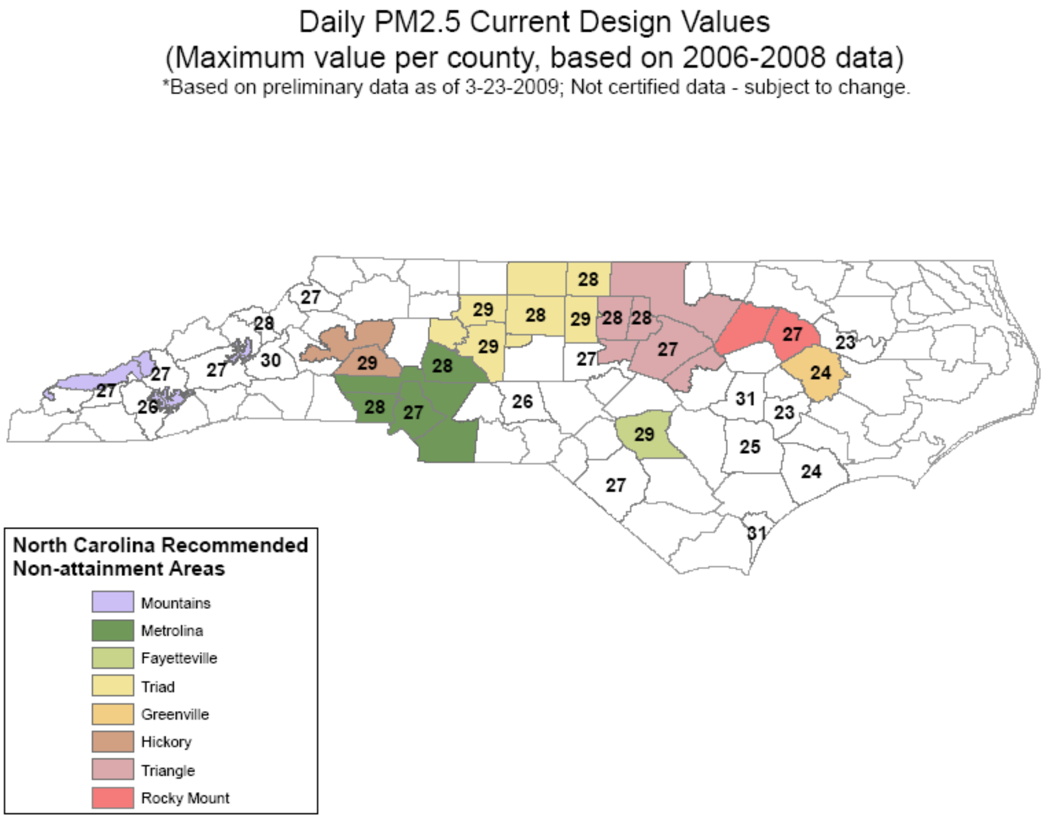


Figure 1.3 – 2006-2008 Design Values for the Daily $PM_{2.5}$ NAAQS Nonattainment Areas

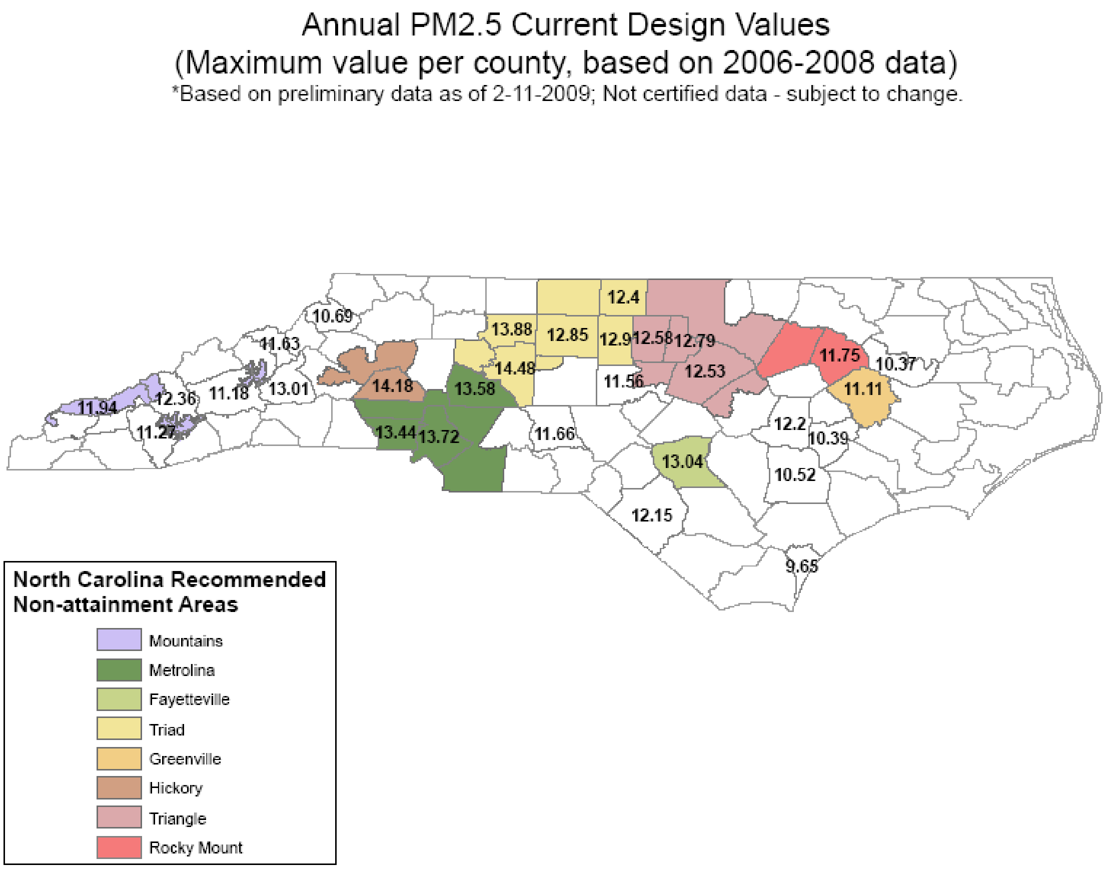


Figure 1.4 – 2006-2008 Design Values for the Annual $PM_{2.5}$ NAAQS Nonattainment Areas

While the monitors in the State currently attain the $PM_{2.5}$ standards, the NCDAQ will continue evaluating the ambient data and modeling to determine necessary steps in the event the standards are revised again. In addition, the DC Circuit Court recently remanded the $PM_{2.5}$ NAAQS to the USEPA for reconsideration of levels of the annual and secondary standards. Such reconsideration could result in tighter standards in the future. There are currently two monitors, one in Hickory (Catawba County) and one in the Triad (Davidson County), which are close to the $PM_{2.5}$ NAAQS.

In addition to the monitoring of total $PM_{2.5}$ mass as discussed above, NCDAQ also operates several speciated sites across the State. Figure 1.5 shows the results from the analysis of the speciated or Chemical Speciation Network (CSN) filters, which is the average of all of the NCDAQ monitors across the State. The results for 2006 show sulfates (SO_4) and organic carbon (OC) as the main contributors to $PM_{2.5}$, with 26% and 28%, respectively; ammonium (NH_4) contributes 10%; nitrates (NO_3) contribute 6%; elemental carbon (EC) is approximately 4%; and crustal material is 3% of the total $PM_{2.5}$ mass. The "other" portion of the $PM_{2.5}$ that accounts for 23% of the mass can be attributed to water (H_2O), sea salts and other trace materials captured with the CSN monitors.

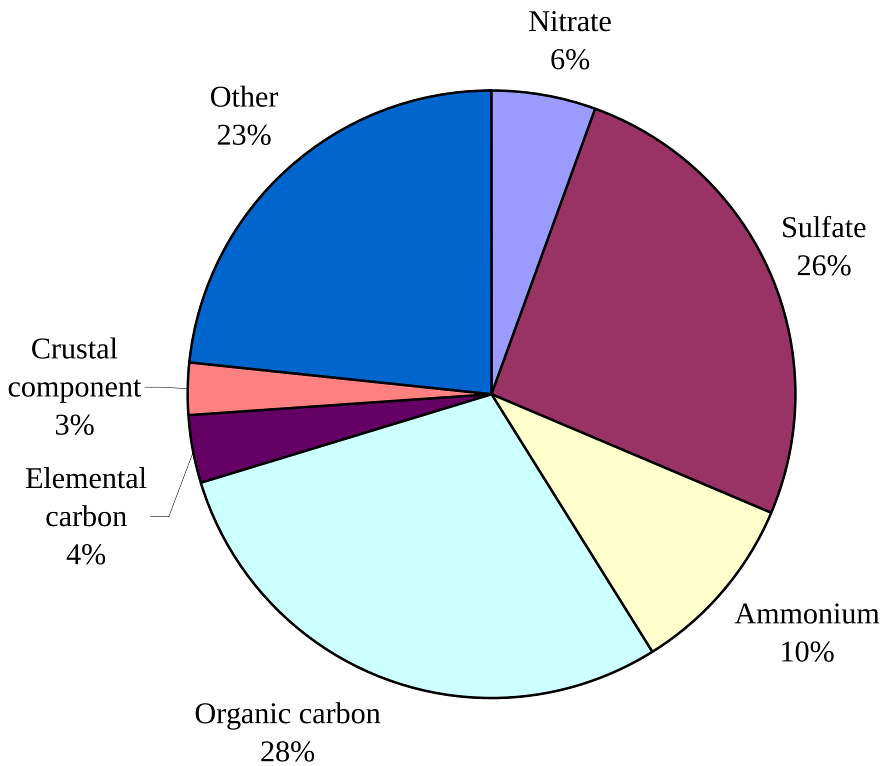


Figure 1.5 – North Carolina $PM_{2.5}$ Speciation for 2006

The percentages of species contribution fluctuate throughout the year with the most significant changes to SO_4 and NO_3. Sulfates are more pronounced during the summertime or warm season months than during the wintertime and NO_3 fluctuates from almost undetectable in the summertime to as much as ten percent in the winter. Ammonium and particle bound water are less dominant than SO_4 and OC and are reasonably consistent throughout the year. Elemental carbon and crustal material are less prevalent throughout the year. Ammonium nitrate is almost undetectable in the summertime and contributes as much as ten percent during the wintertime.

Organic carbon is a major contributor to $PM_{2.5}$ mass. There are varied source contributions to carbon mass, which are mobile sources and emissions from fires. However, there is not a clear understanding of the relative contributions to organic carbon due to the uncertainty in emissions profiles for those sources. NCDAQ has funded two separate studies with the goal to better understand the organic carbon component of the $PM_{2.5}$ total mass, one with Georgia Institute of Technology and one with University of Wisconsin. Since those studies were completed, there have been more source apportionment activities conducted throughout the United States. One core component integral to the results of the source apportionment work is the assumption of the source profiles used in the analysis. As part of this AQMP, the NCDAQ is working with

USEPA and Sonoma Technology, Inc. to evaluate and improve the accuracy of emissions profiles used for source attributions of ambient measurements and atmosphere chemical transport modeling. Particulate carbon has proven difficult to adequately model so a better understanding of carbon and which emission sources are controllable versus uncontrollable are needed. NCDAQ knows that controlling carbon from anthropogenic sources of carbon will likely be more effective in reducing $PM_{2.5}$ emissions in urban areas. In addition, carbon from gas and diesel engines is a relatively small contribution in rural areas, but a larger contributor in urban areas. Through these efforts, NCDAQ expects to gain insight on which source sectors contribute the most to the organic carbon portion of $PM_{2.5}$ total mass, so that the most effective control strategies can be devised to address future violations of the $PM_{2.5}$ standards.

Sulfate particles are formed in the atmosphere from SO_2 emissions. The largest sources of SO_2 emissions come from electric generating units and industrial point sources, specifically coal-fired utilities, industrial boilers and other combustion sources. Through the implementation of the Clean Smokestacks Act (CSA) in North Carolina and the Clean Air Interstate Rule throughout the eastern United States, the emissions of SO_2 are expected to decrease by approximately seventy percent. Due to the implementation schedule of the CSA, significant reductions in SO_2 have already occurred. NCDAQ observed a reduction in the design values between 2005-2007 and 2006-2008 by as much as 1 microgram/m^3 at some monitors. This reduction in $PM_{2.5}$ total mass seems to correlate well with the reduction in SO_2 emissions in the state and region. Industrial and natural sources contribute to NH_4 emissions and nitrogen oxides from combustion sources contribute to NO_3.

Regional Haze

Another air quality concern is regional haze. Regional haze is caused by natural and manmade sources emitting fine particles and their precursors, often transported over large distances and across state borders. Regional haze is an issue because it degrades the visibility in our Class I areas. Figure 1.6 below illustrates the location of the Class I areas in North Carolina.

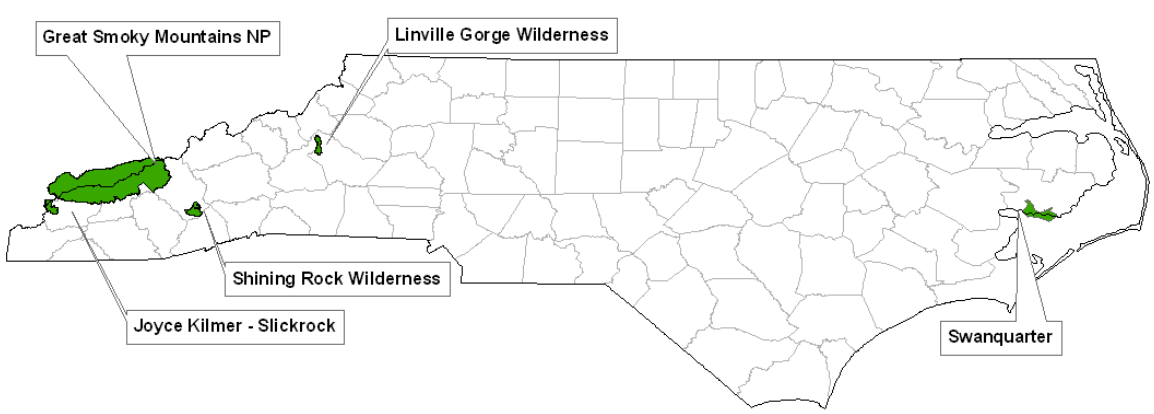


Figure 1.6 – Map of North Carolina's Class I Areas

Regional haze is particularly a concern in the western part of North Carolina, where all but one of our Class I areas are located. In the southeastern portion of the United States, the most important sources of haze-forming emissions are coal-fired power plants, industrial boilers and other combustion sources, mobile source emissions, area source emissions, fires and wind blown dust. Sulfates are the largest contributor to regional haze. Particulate organic matter (POM) is the second most important contributor to fine particle mass and light extinction at the North Carolina Class I areas. Elemental carbon is a minor contributor to visibility. Elemental carbon levels are higher at urban monitors than at the Class I areas and suggest controls of fossil fuel combustion sources would be more effective to reduce $PM_{2.5}$ in urban areas than to improve visibility in Class I areas. Ammonium nitrate, NH_4NO_3, is formed in the atmosphere by reaction of NH_3 and NOx. At elevated temperatures nitric acid remains in gaseous form, for this reason, particle nitrate levels are very low in the summer and a minor contributor to visibility impairment. Particle nitrate concentrations are higher on winter days and are more important for the coastal Class I site where a higher percentage of worst days can occur on winter days. The peak hazy days occur in the summer under stagnant weather conditions with high relative humidity, high temperatures, and low wind speeds. The 20% best visibility days at the Southern Appalachian sites can occur at any time of year. At Swanquarter and other coastal sites, the 20% worst and best visibility days are distributed throughout the year. Ammonium nitrate formation is limited by NH_3 concentrations, which suggest that for winter days, controlling NH_3 sources would be more effective in reducing ammonium nitrate levels than controlling NOx. Soil fine particles are minor contributors to visibility impairment on most days; therefore, no control strategies are needed for fine soil at this time. Figures 1.7 and 1.8 displays the average light extinction for the 20% haziest days and 20% clearest days, respectively.

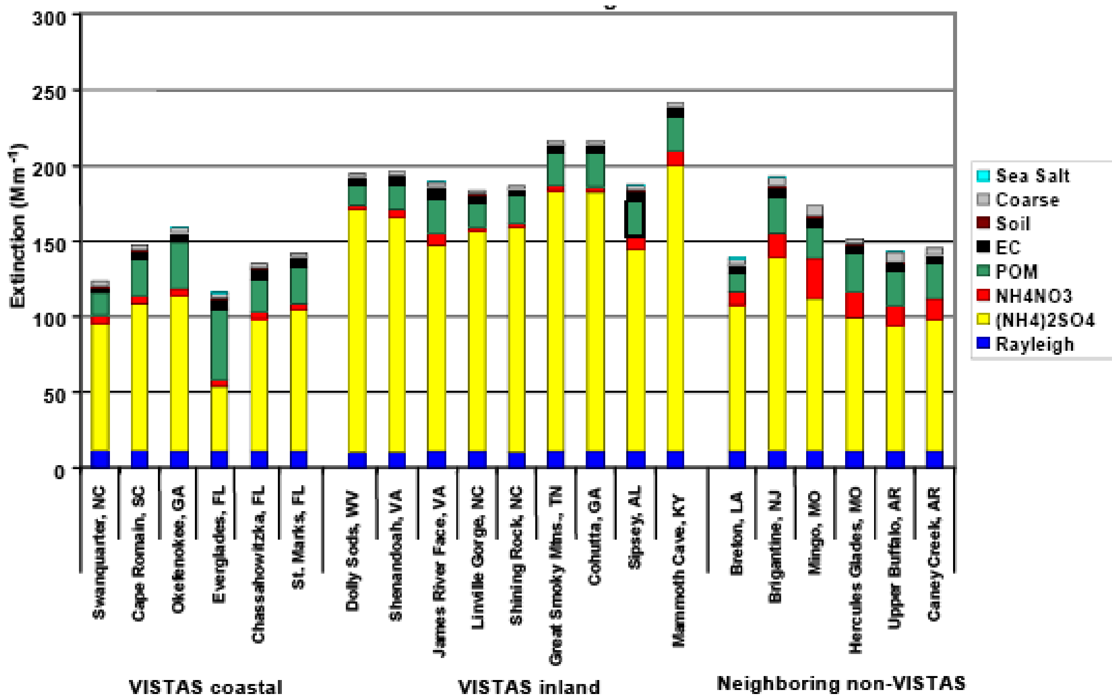


Figure 1.7 - Average light extinction for the 20% Haziest Days in 2000-2004 at VISTAS and neighboring Class I areas using new IMPROVE equation

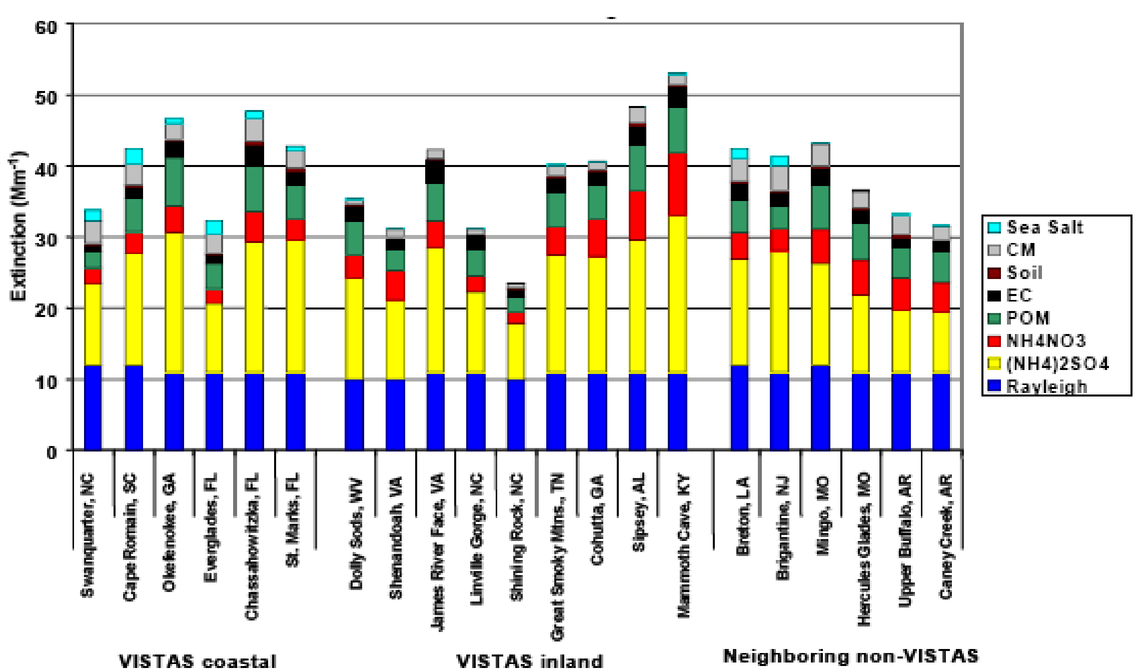


Figure 1.8 - Average light extinction for the 20% Clearest Days in 2000-2004 at VISTAS and neighboring Class I areas using new IMPROVE equation

Toxics

Mercury is the primary toxic of concern in North Carolina. The largest source of mercury is from coal-fired power plants. Other toxics of potential concern are benzene and arsenic. Mobile sources are the predominant contributor of benzene and industrial combustion sources of arsenic.

Greenhouse Gases

Greenhouse gases (GHG) will be addressed in the pilot project to the extent that measures can be undertaken to reduce GHG emissions. To address GHG, North Carolina is in the process of approving the Annual Emissions Reporting Rule that requires facilities that have a Title V permit to include GHG emissions to their annual emissions inventory. The GHG being reported are carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). North Carolina is in the initial phase of addressing GHG and including what kind of control programs may be most effective are just beginning to be evaluated.

Other Criteria Pollutants

Although the AQMP is a comprehensive plan focusing on multi-pollutant solutions, due to statutory requirements, North Carolina will address what control programs are necessary to attain the 2008 8-hour ozone standard, as well as those measures necessary to maintain both the daily and annual $PM_{2.5}$ standard. As shown in Table 1.1, there are monitoring sites across the state that violate- the ozone and $PM_{2.5}$ NAAQS. North Carolina is attaining the NAAQS for CO, NO_2, PM_{10}, and SO_2 so they will not be the primary focus of the AQMP, but the projected emissions and air quality information will be evaluated to ensure that the State will continue to maintain these standards. North Carolina does not yet monitor for lead, but the State expects to address the new monitoring requirements for lead on the required timeline. In addition, NCDAQ has completed a preliminary evaluation of the surrogate data for lead, and believes that the State will be in attainment of the new lead standard.

Table 1.1 – Summary of Maximum 2006 Pollutant Levels Across North Carolina

Pollutant	Highest Pollutant Value	Primary Standard Level	Averaging Time
CO	3.0	9.0 ppm	8-hour
NO_2	0.0133	0.053 ppm	Annual (Arithmetic Mean)
PM_{10}	43	150 μg/m^3	24-hour
$PM_{2.5}$	15.16	15.0 μg/m^3	Annual (Arithmetic Mean)
	36.5	35 μg/m^3	24-hour
SO_2	0.0052	0.03 ppm	Annual (Arithmetic Mean)
	0.032	0.14 ppm	24-hour
Ozone	0.093	0.075 ppm	8-hour

Note: The following table lists the maximum pollutant level and not the design values that are used to demonstrate attainment.

To the extent that North Carolina discovers attainment or maintenance issues with other criteria pollutant NAAQS, the pilot project will address how those pollutants can be incorporated into the process. The overall pilot project will address how these emissions can be reduced using multi-pollutant control strategies.

Developing a Multi-Pollutant Emissions Inventory

The measures the NCDAQ will take toward development of a multi-pollutant emissions inventory involves several steps. The CMAQ air quality model will be used to estimate future ozone, particulate matter, regional haze and nitrogen deposition emissions. CMAQ developers are currently in the process of beta testing a mercury deposition module and as soon as this module is available, the NCDAQ will explore this as an option for modeling mercury deposition. The CMAQ air quality model currently does not have the capabilities to model GHG; therefore, other models are needed to address GHG. The Clean Air and Climate Protection Software, developed by ICLEI, is a software package that we will use to develop GHG emissions inventories for the stationary source sector as well local control strategies. In addition, the USEPA is in the process of developing a new mobile model, MOVES, which encompasses both the on-road and nonroad source sectors. MOVES has a component that addresses GHG, GREET. The new MOVES mobile model will be used to generate criteria pollutants, toxic and GHG emissions for the on-road and nonroad source sectors. The NCDAQ is currently working with Title V sources to obtain information regarding their toxic and GHG emissions so the NCDAQ can use this data to develop an emissions inventory. We currently use the Carnegie Mellon University ammonia emissions model to generate an ammonia emissions inventory for various source sectors. Lastly, future emissions forecasting will include criteria air pollutants, toxics and GHG. The NCDAQ plans on utilizing all of these tools to develop a comprehensive, multi-pollutant emissions inventory.

Impacts of Meteorology on Ozone, $PM_{2.5}$ and Regional Haze

Ozone

Periods of elevated ozone formation are typically found in slow-moving, high-pressure weather systems. These systems are characterized by sinking air, which upon sinking works to create a pronounced thermal inversion (temperature increasing with altitude). As this inversion becomes stronger, vertical mixing of the atmosphere is hindered, allowing sufficient conditions for ozone precursors (NOx and VOCs) to react accordingly. Because stagnant air, decreased cloud formation and warm temperatures often identify these systems, major ozone formation occurs during the hot summer season. However, as the ozone standard has changed through the years, the definition of peak ozone season has changed in North Carolina. For example, with the one hour standard of 0.12 ppm, the peak ozone season was June through August, while the 8-hour average of 0.08 ppm standard resulted in the peak ozone season being extended to include May and September, and the new 8-hour standard of 0.075 ppm, may result again in the peak ozone season being extended to cover more months of the year,

Generally, ozone formation is hindered when incoming ultraviolet radiation is restricted, because ozone formation is a photochemical process. The lack of ultraviolet rays is generally caused by cloud formations associated with frontal boundaries and low-pressure systems.

$PM_{2.5}$

The impact of meteorological variables on fine particulate is a little less straightforward. Particles can be formed two ways: (1) Direct release into the atmosphere and (2) Secondary formation due to atmospheric processes. Typically, periods of elevated particle pollution involve high-pressure systems similar to those mentioned previously. In any case, a well-mixed atmosphere is typically much cleaner. As high-pressure systems remain stagnant, particles can remain over an area for an extended period of time.

However, because particles can also serve as condensation nuclei, formation can occur when a higher relative humidity is achieved. As atmospheric moisture content increases, so does the moisture’s ability to condense on a particle (nuclei). Particles are removed from the atmosphere in two ways: (1) deposit onto surfaces (dry deposition) or (2) removal through incorporation into cloud droplets during precipitation (wet deposition). It follows naturally that periods where particles decrease are during rain events. The highest daily values of $PM_{2.5}$ tend to occur in the summer months, and the lowest values in the winter months.

Regional Haze

Regional haze is defined as impaired visibility caused by one or more atmospheric pollutants that contribute to what is known as light extinction. One of the primary pollutants associated with regional haze is particulate matter (fine and coarse). Particulate matter less than 10 μm in diameter contributes to light scattering. Elevated levels of particulates are typically seen in similar stagnant high-pressure systems noted above. Regional haze will be at its highest during warm, relatively moist, calm weather conditions. The problem, meteorologically, is mitigated during periods of turbulent weather (low-pressure systems). The worst visibility impairment tends to occur in the summer months, and the periods of best visibility tend to occur in the winter.

Technical Tools

The technical tools that are intended for use at this point in the development of the technical products to support an air quality management plan include:

i. MM-5 or WRF meteorological model
ii. SMOKE emissions model for preparing emissions to be used in an air quality model
iii. MOBILE6.2 or MOVES on-road mobile emission factor model
iv. NONROAD or MOVES nonroad emission factor model
v. CMAQ, CAM-x, or WRFCHEM are all potential candidates for the air quality model
vi. IPM or similar model for projecting future emissions from the utility sector
vii. GEOSCHEM or similar model to provide international transport information will be used to better understand international issues and ascertain the role of NC with respect to these issues.
viii. BENMAP or similar model to show exposure and risk associated with various control strategies.
ix. AirControlNET or similar tool will be used to evaluate possible control strategies.
x. EGAS growth factor model or similar tool
xi. EDMS emissions model for aircraft, or similar tool
xii. Accepted GHG emissions protocols
xiii. PAVE and GIS are visualization tools used to display emissions output.

The NCDAQ is also using Dr. Ivar Tombach's recommendations as outlined in his technical paper, *Recommendations for Modeling of Meteorology, Emissions, and Air Quality to Support State Regulatory Decisions for Ozone, Fine Particles, and Regional Haze, January 21, 2009*, as guidance for developing a multi-pollutant modeling strategy. As a result, the NCDAQ will evaluate some of the current modeling tools and features available to determine their effectiveness for multi-pollutant modeling. The following briefly illustrates some of the tools, modeling parameters and approaches under consideration:

- Update to the most recent version of CMAQ or CAMx,
- Use a grid scale of 4 km or less when modeling urban areas and complex terrain,
- Implement the new downscaling approach that has been developed for calculating GEOS-Chem boundary conditions,
- Become familiar with the WRF model and explore whether its use would improve air quality simulations,
- Become familiar with the different source apportionment tools provided in CMAQ and evaluate which ones would be most useful for future development of emission control strategies,
- Evaluate what information will be needed for air pollution management decisions and which analytical approaches would be most useful for supporting those decisions (hybrid apportionment approach),
- Become familiar with the MEGAN biogenic emissions model and the CONCEPT emissions model and evaluate whether they are useful modeling tools, and
- Review the current state of ammonium models.

Potential Control Strategies

Since the early 1990's, North Carolina has implemented numerous control strategies to address ozone, carbon monoxide and later particulate matter and regional haze. As the standards continue to be strengthened, the number of control measures available for adoption at the State level decline. Therefore, many future measures will need to be more local in nature. The NCDAQ will continue to evaluate what can be done on a statewide basis, but more efforts will need to occur at a local, nonattainment level. One core challenge will be to work effectively with local governments to identify and adopt appropriate local measures that will provide the most benefit for their communities. A critical element of the process will be how the trade-offs will be addressed. One potential way is to utilize a tool such as BENMAP and take the exposure and risk into account when one pollutant will be improved, but another will be degraded.

For ozone, it is likely that North Carolina will need to continue to address NOx emission reductions since North Carolina is a NOx limited area. The main issue will be identifying control measures that have not already been implemented that will provide multi-pollutant solutions.

For $PM_{2.5}$, the State will need to assess whether further SO_2 reductions are feasible, and what potential controls are available to address the organic carbon contribution to the total $PM_{2.5}$ mass. Another precursor pollutant of concern for controlling $PM_{2.5}$ levels is NH_4. The most intense NH_3 emissions are in the eastern part of the State because of the large concentration of animal operations in that area. One question that may need to be answered is whether cost effective controls exist to reduce NH_3 emissions from these animal operations, particularly swine operations that utilize the lagoon system for treating waste and the extent to which control of these emissions is necessary or beneficial. One potential co-benefit of reducing NH_3 is the likelihood of reducing CH_4, which results in GHG benefits. Appendix C contains maps displaying the various permitted animal operations across the State.

Similar to $PM_{2.5}$, improving regional haze will begin with reducing SO_2 emissions since sulfates, the largest contributor to regional haze, are formed from SO_2. NH_4 emissions and direct $PM_{2.5}$ are also important to regional haze so focusing on reducing these emissions will have a multi-pollutant benefit of addressing both regional haze and $PM_{2.5}$.

For the mercury investigation, the issue of hotspots is being evaluated by conducting an assessment of mercury deposition both before and after installation of scrubbers at the larger power plants.

North Carolina has passed several rules to address these air quality issues. A landmark rulemaking in the State is the NOx SIP Call Rule, which is designed to reduce NOx emission form large stationary combustion sources. Passing the Clean Smokestacks Act was another monumental pathway to improving air quality in North Carolina. The Clean Smokestacks Act is a beneficial control strategy with far reaching co-benefits. The Clean Smokestacks Act requires coal-fired power plants to reduce their NOx and SO_2 emissions, with significant mercury co-benefits when a selective catalytic reduction unit and a wet scrubber are installed on a coal-fired boiler. Additionally, the Clean Air Interstate Rule addresses NOx and SO_2 emissions by placing a cap on SO_2 and NOx emissions from stationary sources. The reductions of SO_2 from these programs provide co-benefits of potentially reducing $PM_{2.5}$ and improving regional haze. An issue to explore is whether the co-benefit from controlling emissions from coal-fired power plants is sufficient to address the mercury deposition in the State. Reducing NOx, SO_2 and mercury deposition will benefit many of North Carolina's ecosystems. One of the co-benefits of controlling mercury deposition is to reduce mercury because it is harmful to the fisheries across the entire State. Decreasing SO_2 and NOx emissions, respectively, will reduce acid deposition that is detrimental to the mountain streams in the western part of the State and reduce nitrogen deposition, which is harmful to the estuaries in the eastern part of the State.

Another potential State program intended to reduce NOx and $PM_{2.5}$ emissions is the anti-idling rule. The anti-idling rule will reduce NOx and $PM_{2.5}$ emissions from heavy-duty trucks (both diesel and gasoline) through reducing unnecessary idling. As with the Clean Smokestacks Act, this program will have co-benefits of reducing both ozone precursors and particulate matter.

The open burning rule has been in place since 1971. The open burning ban was a rule, adopted in June 2004, is aimed at reducing emissions that contribute to ozone and particle pollution when the air quality is expected to be poor. The ban is triggered when either the NCDAQ or local air programs forecast a code orange, red or worse ozone conditions for a particular metropolitan area. The Piedmont and Triad areas are subject to the open burning ban that is intended to reduce $PM_{2.5}$ in these areas.

Other potential programs (focusing on the Piedmont and Triad areas) intended to reduce $PM_{2.5}$ include a woodstove change-out program, a burn it right campaign and diesel retrofit initiatives. These programs will also benefit our Class I areas in the western part of the State affected by regional haze due to the decrease in particulate matter. Such programs may be implemented if they are determined to be effective multi-pollutant strategies.

Reducing emissions from the transportation sector is more of a challenge because the reductions will have to be initiated by local programs. Federal and state control measures that have yielded the most reductions have already been implemented. Further local strategies are needed such as diesel retrofits, transportation control measures, expanding transit systems and promoting fuel efficiency. Such measures individually do not have a huge impact, but collectively they have the potential to produce significant reductions.

The primary sources of GHG are transportation and the utilities. Energy efficiency and conservation are emphasized as the most effective control strategies in the Climate Action Plan Advisory Group's recommendations to mitigate GHG in these source sectors. Appendix D summarizes the policy recommendations from the Climate Action Plan Advisory Group presented to the NCDAQ as potential mitigation options for reducing GHG in NC. Many of these measures will also benefit the efforts to reduce criteria pollutants because they will result in reductions in NOx and SO_2. Additionally, implementing conservation efforts in the utilities sector also provides co-benefits for regional haze due to the reductions in SO_2.

The NCDAQ will develop policies and programs to implement these measures as well as the criteria for prioritizing them based upon air quality and public health concerns. The biggest challenges facing North Carolina are attaining the 8-hour ozone NAAQS, maintaining the annual $PM_{2.5}$ NAAQS, improving visibility in the Class I areas, reducing mercury deposition, and beginning to reduce greenhouse gases. A common pollutant for $PM_{2.5}$ and regional haze is SO_2, specifically from coal-fired power plants. Mercury, also emitted primarily from coal-fired power plants, is the largest toxic concern in the State because of its adverse effect on fisheries across the State. NOx is predominantly emitted from the mobile sources sector, the largest contributor of NOx; therefore reducing NOx emissions from this source sector is imperative to reducing ozone.

North Carolina has developed several regulations to address these air quality issues that are beneficial because of their potential as a multi-pollutant control strategy. The Clean Smokestacks Act is a control strategy that reduces SO_2, which is the primary contributor to both $PM_{2.5}$ emissions and regional haze. In addition to controlling SO_2 emissions, the Clean Smokestacks Act controls NOx and mercury, which provide additional co-benefits of addressing ozone and mercury deposition. The initiatives, conservation and energy efficiency, recommended to mitigate GHG in the transportation and stationary source sectors focus on reducing NOx and SO_2 emissions that will also benefit the efforts to reduce ozone, $PM_{2.5}$ emissions and regional haze. Energy efficiency measures will also provide co-benefits of reducing toxics. Although, there are other State programs, the

Clean Smokestacks act in conjunction with the GHG mitigation efforts, are clearly the two programs that could potentially provide the most co-benefits when addressing the most important air quality issues in North Carolina.

Control Strategy Assessment

The measures that will be used to gauge improvement in air quality or success of the air quality management process will include environmental indicators, such as number of exceedance days per year by area, levels of exceedances when they do occur, and the change in the design value for the criteria pollutants. For the greenhouse gas initiatives, the emission reductions will be tracked via the greenhouse gas climate registry that is currently being established in the State. The climate registry is a mechanism for industry in the State to report their greenhouse gas emissions. For the mercury study, the change in mercury deposition will be tracked. Another indicator of success will be the impact on the actual process, i.e., how the resources of the State are impacted. This metric is harder to track than the environmental indicators. It is not clear yet what measures will be used to assess this aspect of the process. Another tool to gauge the effectiveness of various programs is using graphical display programs such as PAVE, which is used to display air quality modeling output. Bar graphs and pie charts are also useful in showing emission trends across various source sectors, time periods, pollutants, etc. Programs to reduce emissions are constantly evolving. The programs the NCDAQ develops to address air quality issues will be provided upon completion of the AQMP pilot project.

In order to evaluate these programs, the NCDAQ will strategically assess the programs based on various parameters. This information will be also shared with stakeholders to use as a guide to evaluate program effectiveness. Table 1.2 below specifies the parameters that will be used for the strategic assessment. As the pilot project progresses, the table will be populated based on technical analysis and input from stakeholders that will be used as a tool for stakeholders and NCDAQ staff to utilize to determine which control strategies yield the most co-benefits and should be implemented.

Table 1.2 – Parameters for Strategic Assessment

Control Strategy	Pollutants Reduced	Emission Reduction	EJ Issues	Smart Growth	Cost Benefit	Degradation Issues	Implementation Concerns
Heavy Duty Engine OBD Program	NOx, $PM_{2.5}$		N/A	N/A		None Known	

Stakeholder Involvement

The North Carolina AQMP pilot project will address certain air quality issues to illustrate how the technical work would fit into a broader AQMP. This comprehensive process will have challenges, such as how to balance between various pollutants and strategies when certain control measures could result in improvements in one pollutant and degradation in another. Another challenge is ensuring that all stakeholders are part of the process. Stakeholders will include, but are not limited to, federal partners, other State agencies, local air quality agencies, local and State elected officials, environmental groups, regulated community, rural and metropolitan planning organizations, local and State transportation partners and the general public.

To adequately address a multi-pollutant process, stakeholders' involvement becomes far reaching. A broader range of organizations and agencies, i.e., State Energy Office, Toxics Protection Branch, etc., have to be included in the process. The challenge is ensuring the right players are involved and complete integration of individual groups such that everyone is working toward the same goal without pursuing individual agendas of the organization they are representing.

The stakeholder process should be continuous and ongoing to prevent interruption of the technical work that is transpiring on a regular schedule. This is specifically a challenge given the number of pollutants and the geographic scope of the North Carolina AQMP pilot project. The NC DAQ will provide technical data and analysis as well as tools so stakeholders can be fully engaged in the decision making process.

The NCDAQ recognizes that stakeholder involvement is an integral part of the AQMP. Their input is invaluable to meet the challenges of multi-pollutant strategies. Stakeholders will support a variety of roles during the AQMP. Stakeholders can provide data on local initiatives to mitigate air pollution as well as provide feedback on potential control measures. Another task of stakeholders is to provide emissions data used to create profiles in emissions inventory development, which is a key component to developing an emissions inventory as accurately as possible. Local stakeholders will play an important role in implementing local control strategies, especially in the mobile source sector because federal and state control measures have been exhausted in this sector. Areas of particular concern are Metrolina (Charlotte metropolitan area), the Triad (Greensboro-Winston Salem-High Point metropolitan area), the Triangle (Raleigh-Durham-Chapel Hill metropolitan area) and the Mountains (western portion of the state). One of the challenges of working with local officials will be to champion control measures that do not yield large emissions reductions but are imperative for these areas to improve air quality.

Stakeholder involvement with neighboring states is also an essential component of the stakeholder process. Many of the North Carolina's neighboring states have similar air quality issues. Regional planning and cooperation is key to successfully addressing air quality issues. Collaborative efforts such as VISTAS focuses on a regional technical analysis versus individual state efforts resulting in significant cost savings and a superior technical product. Regional collaboration also provides additional resources and expertise to support these efforts.

The stakeholder involvement will be intensive and time consuming. Elected officials at all levels will need to be engaged in the effort at various times. Other implementing agencies such as the Department of Transportation, the State Energy Office, the Division of Forest Resources, local air agencies and staff in the local governments across the State will need to be consulted with on a regular basis. The environmental groups, regulated community and general public will need routine briefings on the efforts involved in developing an air quality management plan. A communication strategy will be developed to propose the schedule for meetings, briefings and other communication efforts. A list serve will be developed such that interested parties across the State can subscribe and receive routine updates as well.

The NCDAQ currently conducts monthly stakeholder meetings, the State Interagency Consultation Meetings (SICM), whose primary focus is mobile related issues and serves as a forum for various local, state and federal agencies to disseminate information. In addition to the SICM, the NCDAQ has another stakeholder group, the Outside Involvement Committee (OIC), which consists of the public, private industry and environmental groups. The OIC meets quarterly and is a conduit for exchanging information on all subject matter related to air quality. The NCDAQ can utilize the foundation already established through the SICM and OIC to involve stakeholders in the AQMP. For other stakeholders such as elected officials, meetings could be conducted on an annual basis or a time frame agreed upon by all parties. As an extension of the stakeholder process, the local communities are needed to effectively address the two air quality issues that will take the support of the local communities to solve, attaining the 2008 8-hour ozone standard and achieving greenhouse gas emission reductions. Both issues will require local initiatives and help from the local communities to help with the educational effort as to why personal action is important. Certain areas have ongoing committees that meet on varying schedules, for example, the Unifour Air Quality Committee. Such committees exist in Asheville, Fayetteville, Metrolina, the Triad and the Triangle. The NCDAQ will collaborate with these local committees as a means of information exchange during the AQMP process. As the stakeholders process evolves, the process will serve as a forum for various areas to strategize, share methodologies used to quantify emission benefits and engage in problem solving sessions. Also, local programs and municipalities are the catalysts for implementing these control strategies because the State does not have the authority to implement such programs.

Potential Roadblocks

The potential roadblocks in the air quality management plan effort include the statutory deadlines for the various criteria pollutants, the seeming lack of support by EPA for an early action compact process under the 2008 8-hour ozone standard, and the management of multiple objectives in a single plan. Another roadblock is the “moving target” in terms of meeting the USEPA guidance. For a structured AQMP effort to work, the USEPA would need to acknowledge that not all “state of the art” tools, information, recently released guidance, etc., can be used in the development of the technical analysis. There has to be an understanding that a future version of the technical analyses will address the developments that occur after a certain point in the planning process.

North Carolina will continue working closely with VISTAS and ASIP in order to obtain emission inventories from the surrounding States. Additionally, VISTAS is continuing to work closely with MANE-VU and MRPO to gather emissions inventories from outside the VISTAS region.

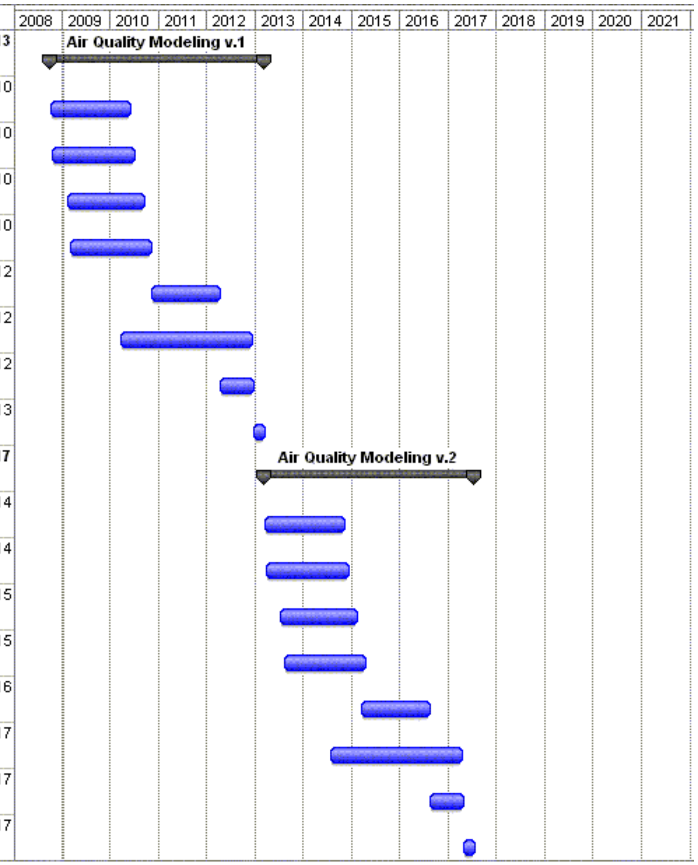
Another core challenge is making the AQMP process work in view of the various statutory timelines for State implementation plan submittals for NAAQS non-attainment and maintenance areas.

Over the next 6-9 months, two integral deliverables of the AQMP will be implemented, the communication strategy and the control strategy evaluation process as well as finalizing the schedule for the first AQMP report.

The final product that will be submitted in December will include a layout for carrying out this comprehensive air quality management process. The process will include a technical analysis timeline defining when the various technical products will be completed, a communications strategy identifying the stakeholders and the interaction schedule with the various stakeholders, a schedule for the development and completion of the first air quality management process report or plan, as well as the update schedule for future reports, and finally, an outline of the first iteration of the air quality management process.

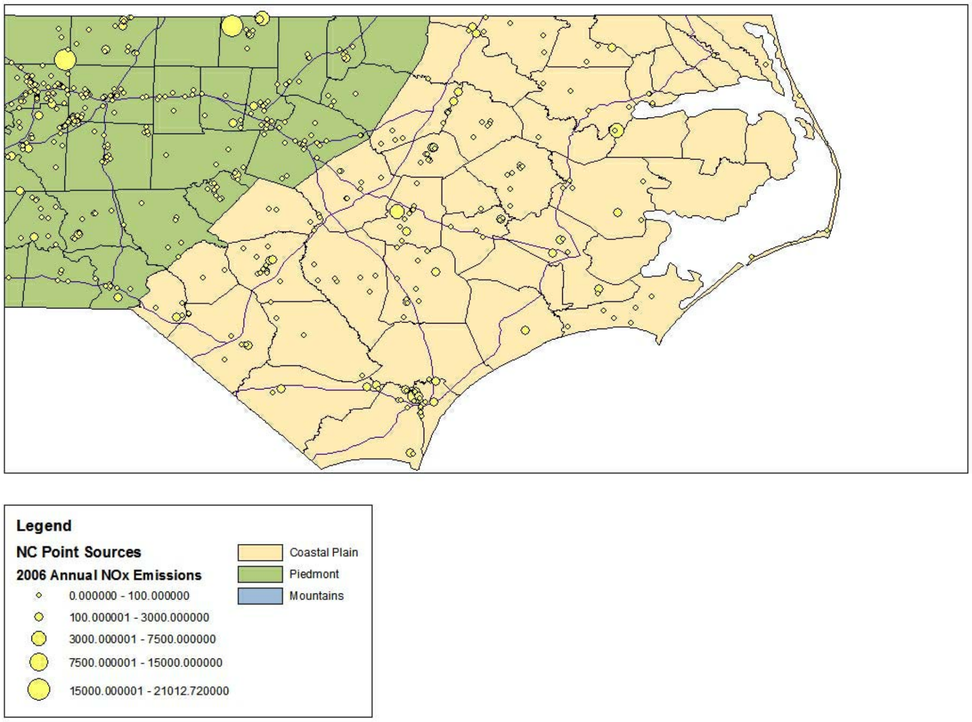
Appendix A – AQMP Timescale

ID		Task Name	Duration	Start	Finish
1		**Air Quality Modeling v.1**	**1151 days**	**Fri 10/3/08**	**Fri 3/1/13**
2		Meteorological Modeling	431 days	Fri 10/3/08	Fri 5/28/10
3		Emissions Inventory Development	448 days	Mon 10/13/08	Wed 6/30/10
4		Emissions Modelings	415 days	Mon 2/2/09	Fri 9/3/10
5		Air Quality Modeling	435 days	Mon 3/2/09	Fri 10/29/10
6		Control Strategy Development	369 days	Tue 11/2/10	Fri 3/30/12
7		Rulemaking	709 days	Tue 3/16/10	Fri 11/30/12
8		AQMP Documentation	185 days	Mon 4/2/12	Fri 12/14/12
9		Public Hearing Process	55 days	Mon 12/17/12	Fri 3/1/13
10		**Air Quality Modeling v.2**	**1133 days**	**Mon 3/4/13**	**Wed 7/5/17**
11		Meteorological Modeling	431 days	Mon 3/4/13	Mon 10/27/14
12		Emissions Inventory Development	448 days	Mon 3/18/13	Wed 12/3/14
13		Emissions Modelings	415 days	Mon 7/1/13	Fri 1/30/15
14		Air Quality Modeling	435 days	Mon 8/5/13	Fri 4/3/15
15		Control Strategy Development	369 days	Fri 3/6/15	Wed 8/3/16
16		Rulemaking	709 days	Mon 7/21/14	Thu 4/6/17
17		AQMP Documentation	185 days	Thu 8/4/16	Wed 4/19/17
18		Public Hearing Process	55 days	Thu 4/20/17	Wed 7/5/17

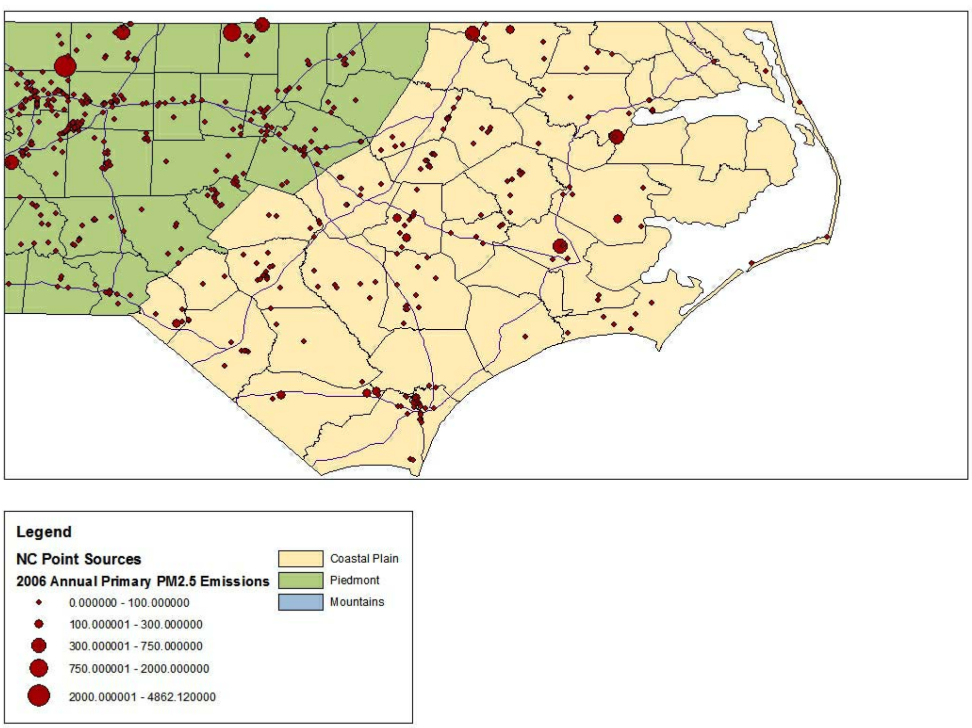


Appendix B – Maps of Point Source Emissions and Highway Networks per Region Across NC

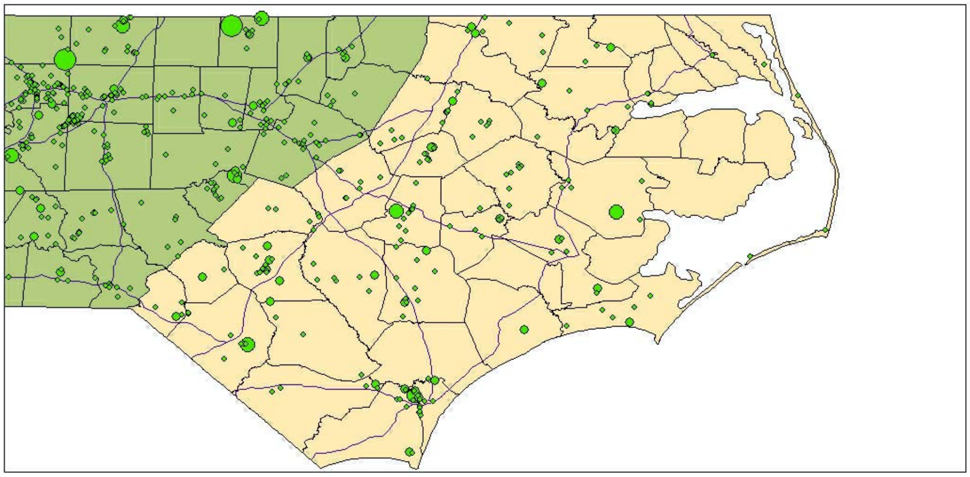
Coastal Region 2006 Annual NOx Emissions

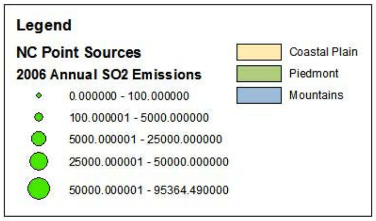


Coastal Region 2006 Annual $PM_{2.5}$ Emissions

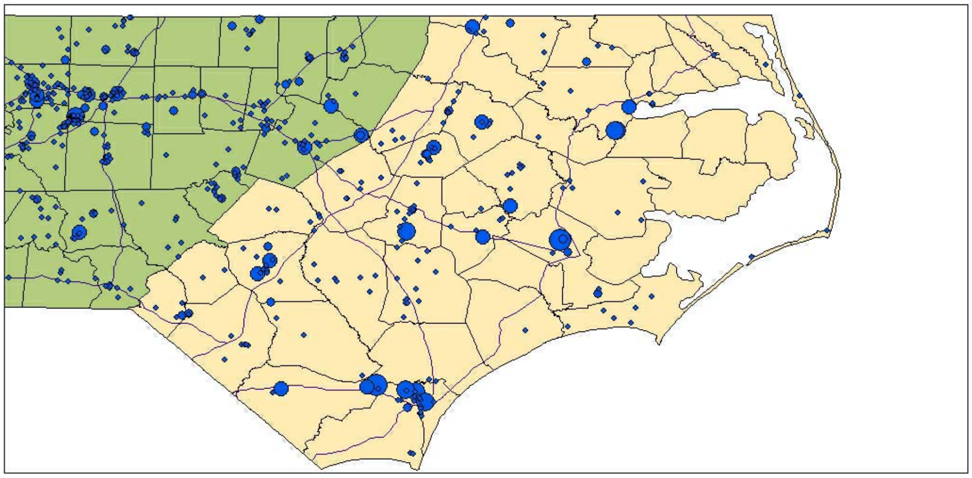


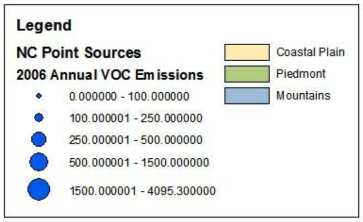
Coastal Region 2006 Annual SO_2 Emissions



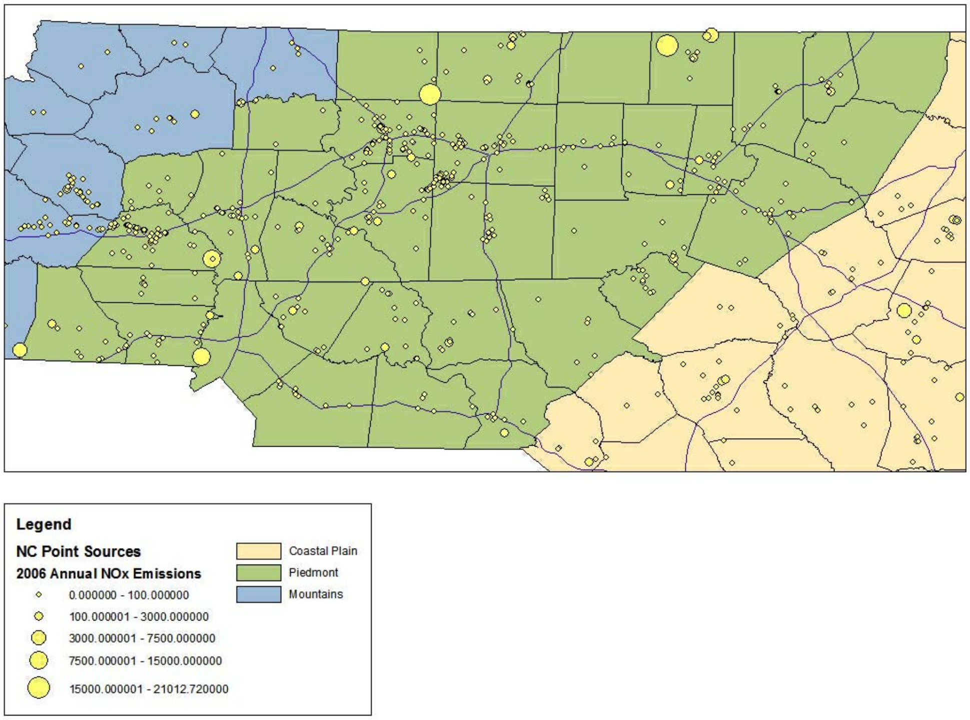


Coastal Region 2006 Annual VOC Emissions

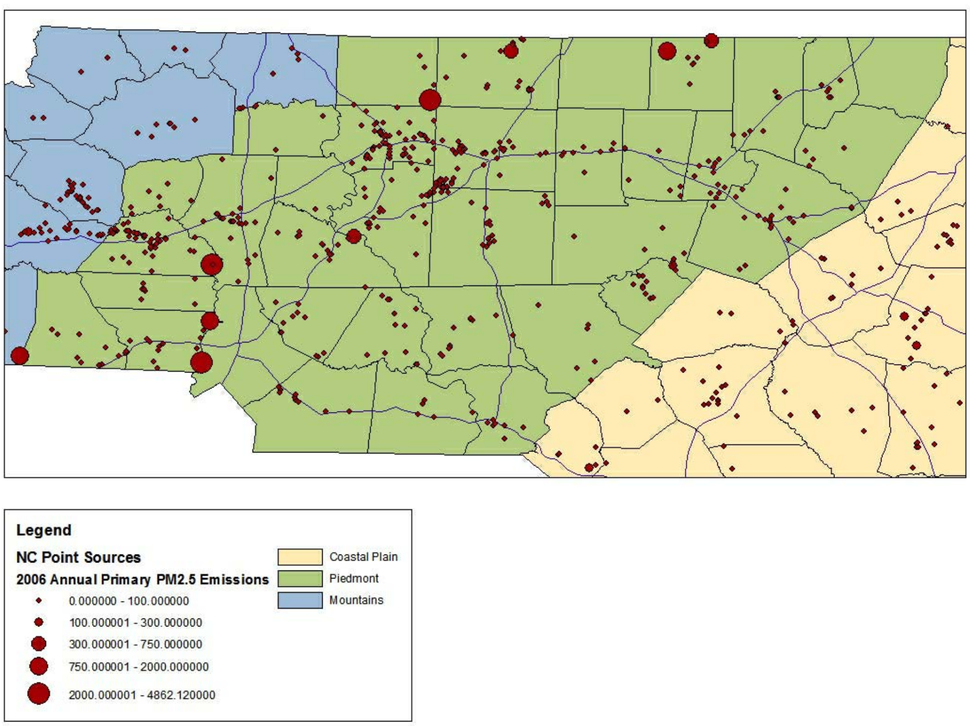




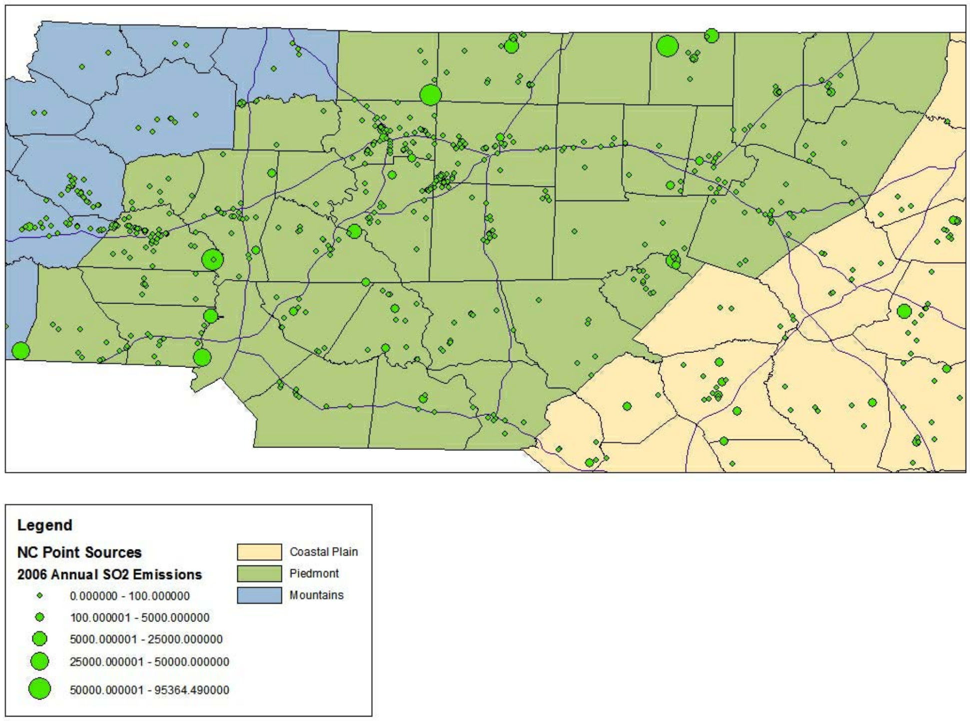
Piedmont Region 2006 Annual NOx Emissions



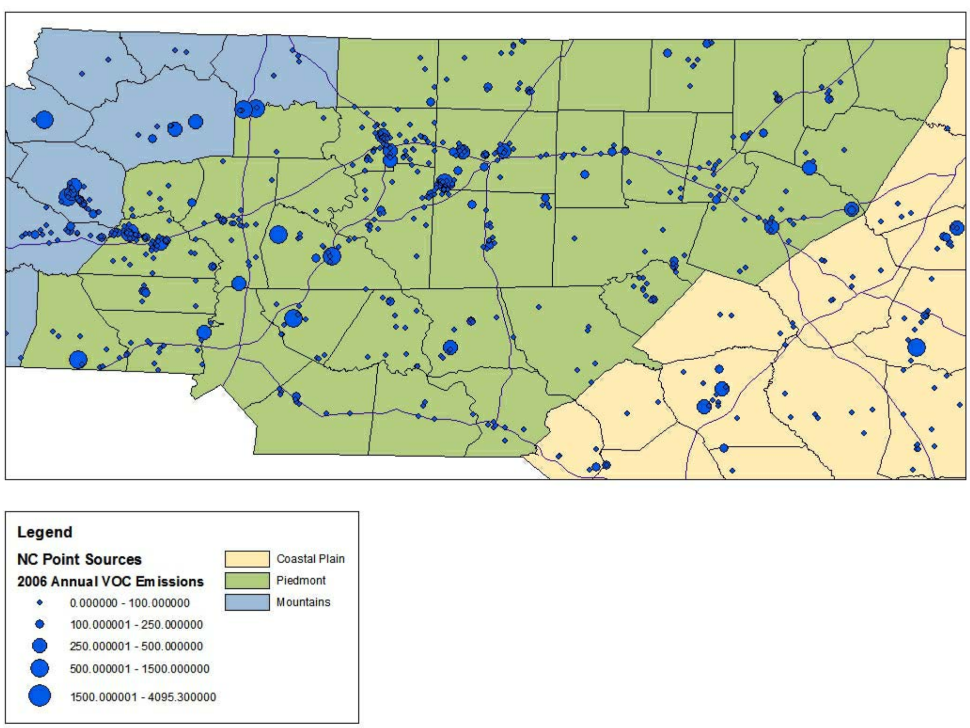
Piedmont Region 2006 Annual $PM_{2.5}$ Emissions



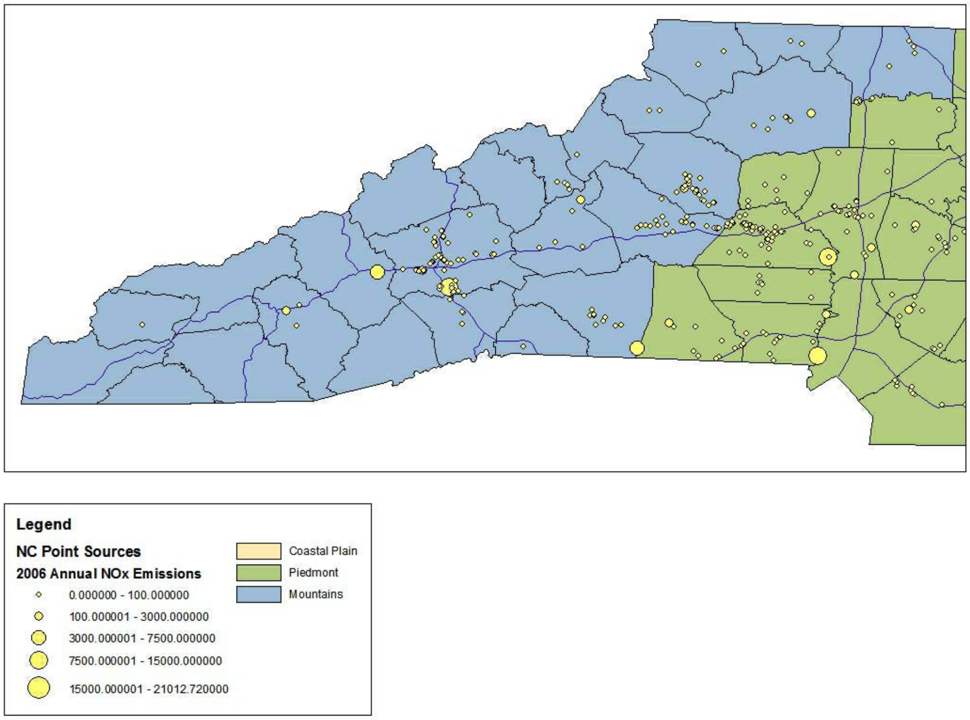
Piedmont Region 2006 Annual SO_2 Emissions



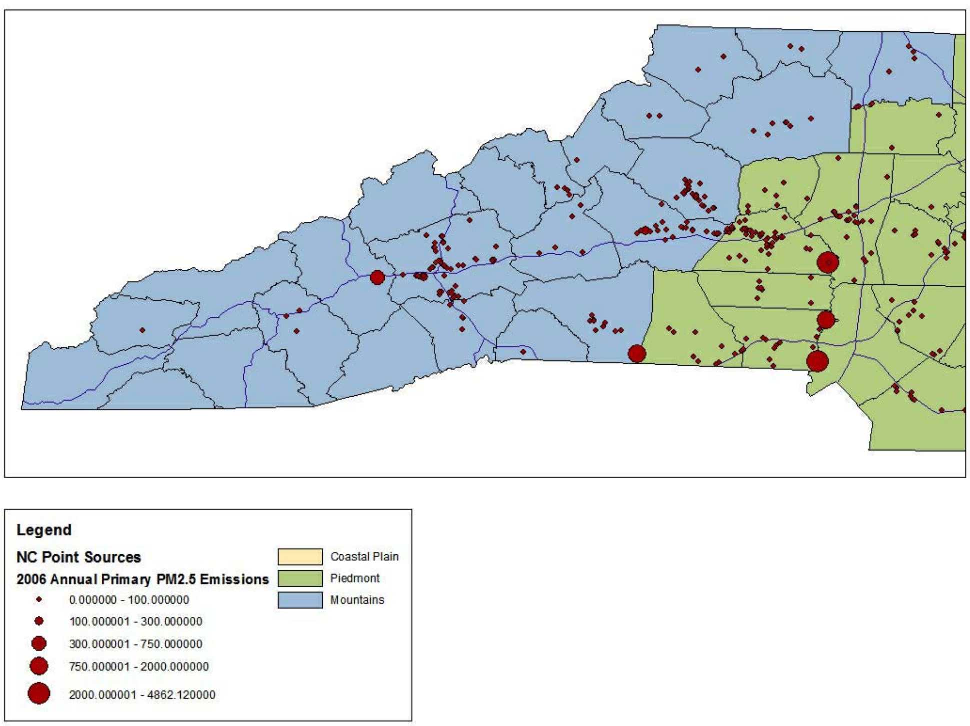
Piedmont Region 2006 Annual VOC Emissions



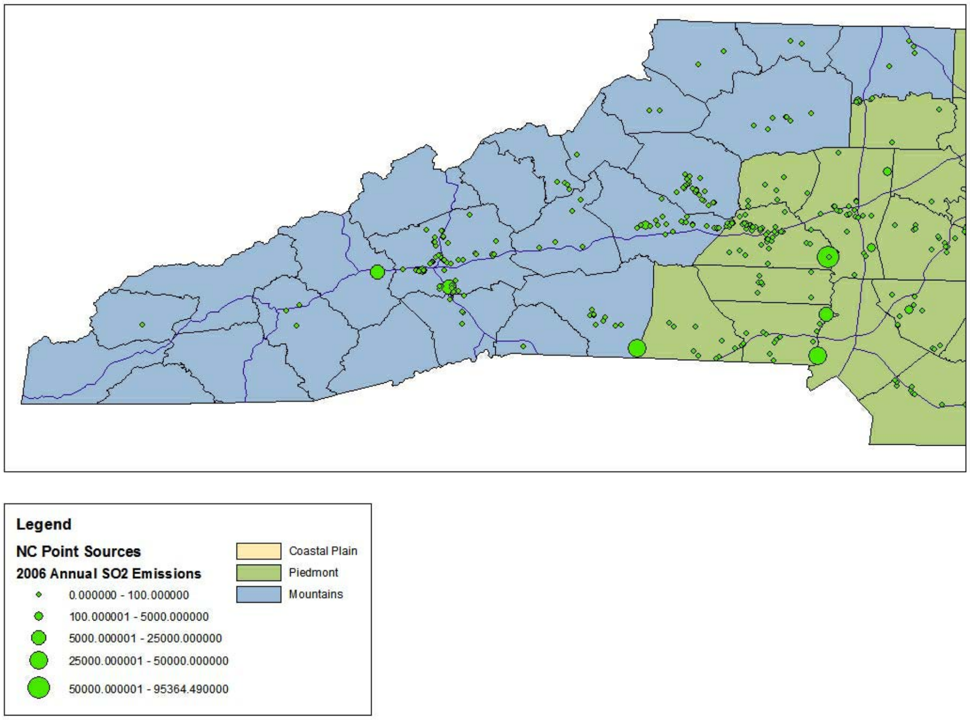
Mountains Region 2006 Annual NOx Emissions



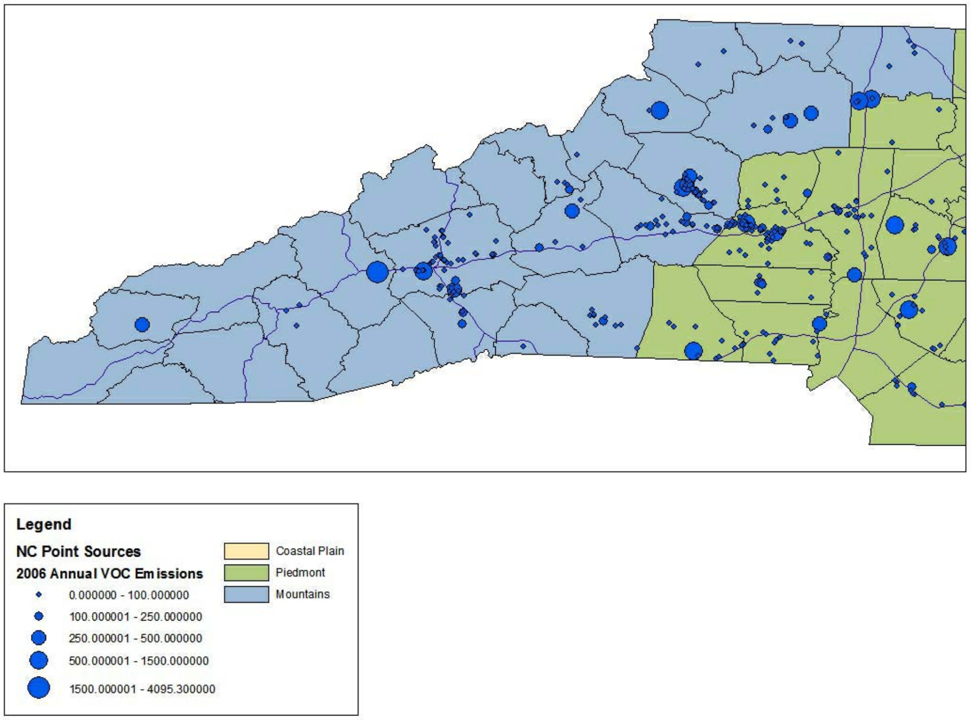
Mountains Region 2006 Annual $PM_{2.5}$ Emissions



Mountains Region 2006 Annual SO_2 Emissions

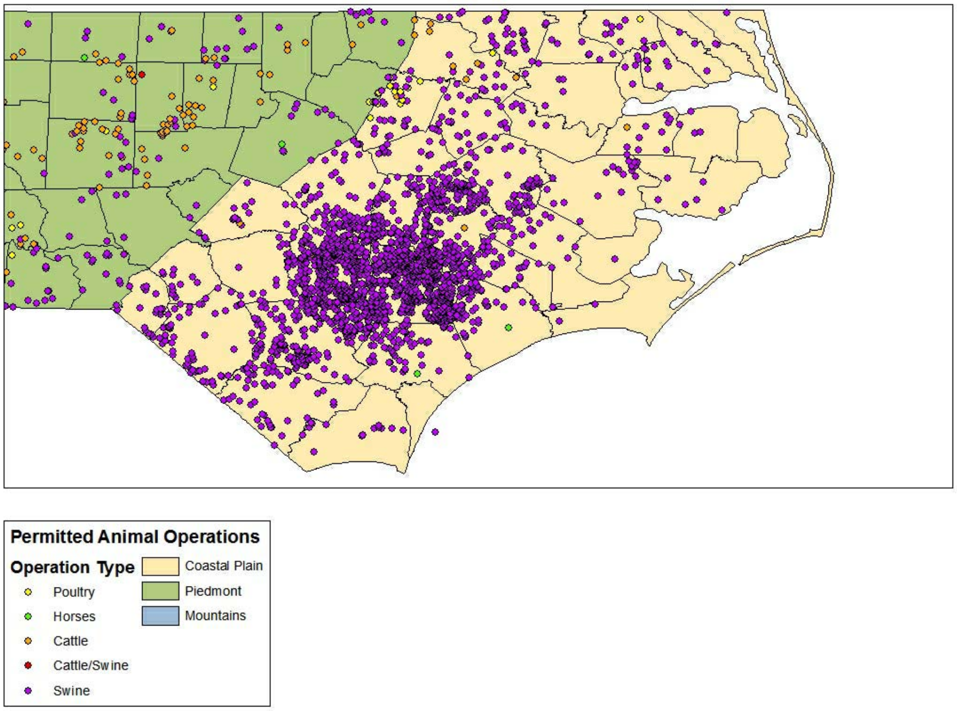


Mountains Region 2006 Annual VOC Emissions

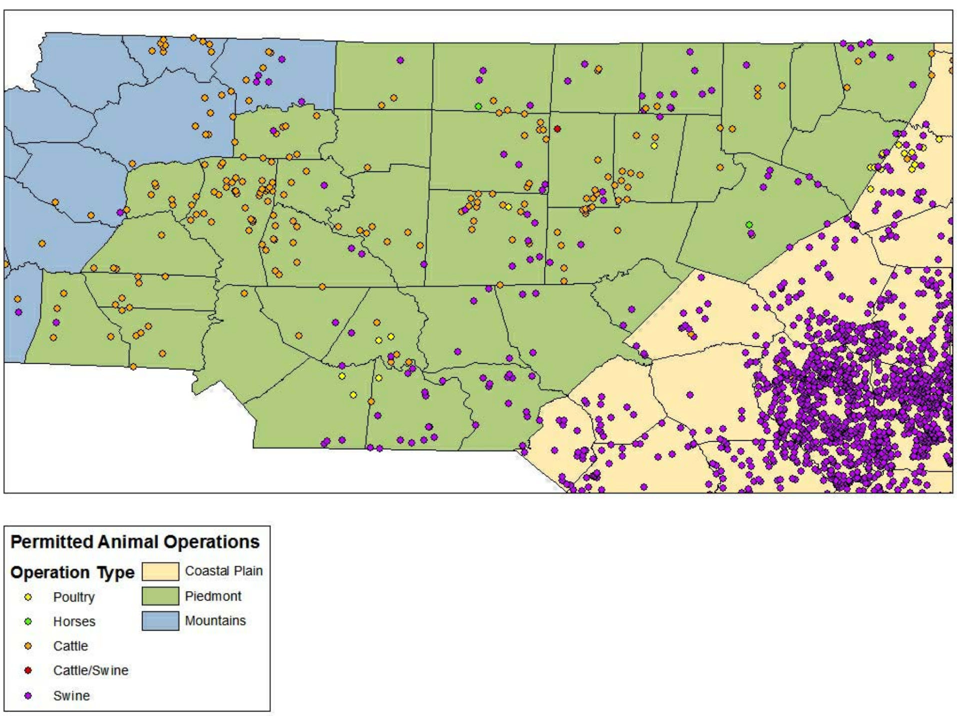


Appendix C – Maps of Permitted Animal Operations per Region Across NC

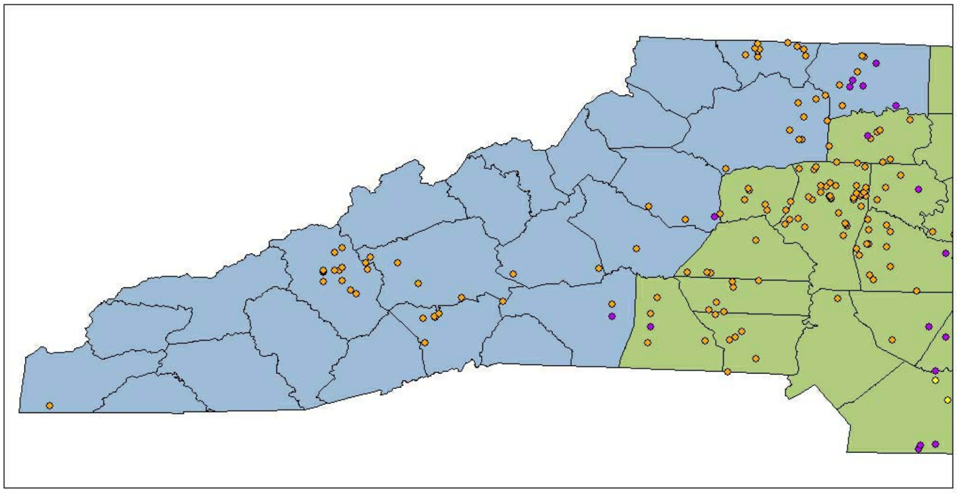
Coastal Region Permitted Animal Operations

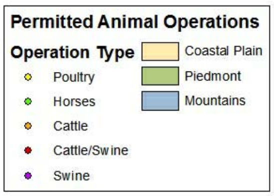


Piedmont Region Permitted Animal Operations



Mountains Region Permitted Animal Operations





Appendix D – Climate Action Plan Advisory Group Recommendations

Residential, Commercial and Industrial GHG Mitigation Options

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)
		2010	2020	Total 2007–2020	2007–2020 (NPV)	
	Residential, Commercial, and Industrial (RCI)					
RCI–1	Demand Side Management Programs for the RCI Sectors - Recommended Case: "Top-Ten States" EE Investment	1.9	11.6	77.1	–1,895	–25
RCI–2	Expand Energy Efficiency Funds	1.5	8.0	54.8	–1,346	–25
RCI–3	Energy Efficiency Requirements for Government Buildings	0.0	1.1	6.4	–88	–14
RCI–4	Market Transformation and Technology Development Programs	0.0	2.0	10.5	–339	–32
RCI–5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	5.3	–336	–63
RCI–6	Building Energy Codes	0.5	3.5	23.1	–400	–17
RCI–7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.7	5.2	34.2	–494	–14
RCI–8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	Not quantified				
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.5	3.5	11	3
RCI–10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	33.5	392	12
RCI–11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.5	2.1	14.9	–494	–33
	Sector Total After Adjusting for Overlaps	**5.3**	**33.0**	**218.7**	**–3,994**	**–18**
	Reductions From Recent Actions**	**0.5**	**1.2**	**10.1**		
RCI–1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	0.3	0.7	6.2		
RCI–2	Expand Energy Efficiency Funds	0.2	0.4	3.6		
RCI–6	Building Energy Codes	0.0	0.0	0.0		

RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.0	0.0	0.3		
	Sector Total Plus Recent Actions	**5.8**	**34.2**	**228.8**		

Energy GHG Mitigation Options

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
		2010	2020	Total 2007–2020	2007–2020 (NPV)	
	Energy Supply (ES)					
ES-1	Renewable Energy Incentives	0.01	0.04	0.33	15	45.1
ES-2	Environmental Portfolio Standard					
ES-2a	Original Analysis	6.94	44.3	288.7	1,634	5.7
ES-2b	20% Combined Target	5.90	23.4	166.2	409.80	2.5
ES-2c	Load Growth Offset Target	5.53	22.3	160.3	393.95	2.5
ES-3	Removing Barriers to CHP and Clean DG	0.69	2.8	20.1	127.98	6.4
ES-4	CO_2 Tax and/or Cap-and-Trade					
ES-4a	Electric Sector Only	0.84	3.3	20.4	119	5.8
ES-4b	Economy-wide	1.84	7.1	47.7	284	6.0
ES-5	Legislative Changes to Address Environmental and Other factors	Not quantified				
ES-6	Incentives for Advanced Coal					
ES-6a	Replacement of New 800 MW Pulverized Coal Plant	0.00	3.9	31.0	949	30.6
ES-6b	Replacement of Existing 800 MW Pulverized Coal Plant	0.00	5.4	42.9	2,061	48.1
ES-7	Public Benefit Charge	0.8	3.4	24.4	329	13.5
ES-8	Waste to Energy	0.0	0.0	0.02	–0.7	–36.8
ES-9	Incentives for CHP and Clean DG	Combined with ES-3				
ES-10	NC GreenPower Renewable Resources Program	0.01	0.2	0.95	35	37.0
	Sector Total After Adjusting for Overlaps*	**6.5**	**62.7**	**375**	**–5.9**	**–0.016**
	Reductions From Recent Actions (None)	**0**	**0**	**0**	**0**	**0**
	Sector Total Plus Recent Actions*	**6.5**	**62.7**	**375**	**–5.9**	**–0.016**

Transportation and Land Use GHG Mitigation Options

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective -ness ($\$/tCO_2e$)
		2010	2020	Total 2007–2020	2007–2020 (NPV)	
	Transportation and Land Use (TLU)					
TLU-1a	Land Development Planning	2.6	8.0	58.2	Net savings	
TLU-1b	Multi-Modal Transportation and Promotion (formerly TLU-2)	3.7	5.8	52.4	–1,300	–25
TLU-3a	Surcharges to Raise Revenue	1.2	2.2	15.7	–1,800	–117
TLU-3b	Rebates/ Feebates to Change Fleet Mix	0	< 0.5	2.8	Not quantified	–40 to +10
TLU-4	Truckstop Electrification	Included in TLU–8			Net savings	
TLU-5	Tailpipe GHG Standards	0	8.1	44.5	–1,150	–38
TLU-6	Biofuels Bundle	1.9	4.5	35.4	Not quantified	
TLU-7	Procure Efficient Fleets	Included in TLU–6				
TLU-8	Idle Reduction/Elimination Policies	0.1	0.2	2.2	–6	–4
TLU-9	Diesel Retrofits	0.3	2.2	13.5	Not quantified	
TLU-11	Pay-As-You Drive Insurance	2.3	5.3	42.0	Expected net savings	
TLU-12	Advanced Technology Incentives	Not quantified				
TLU-13	Buses – Clean Fuels	Included in TLU–6				
	Sector Total After Adjusting For Overlaps	**11.1**	**25.5**	**232.3**	**–4,350**	**–19**
	Reductions From Recent Actions (None)	**0**	**0**	**0**	**0**	**0**
	Sector Total Plus Recent Actions	**11.1**	**25.5**	**232.3**	**–4,350**	**–19**

Agriculture, Forestry and Waste GHG Mitigation Options

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effectiveness ($/tCO_2e$)
		2010	2020	Total 2007–2020	2007–2020 (NPV)	
	Agriculture, Forestry, and Waste (AFW)					
AFW-1	Manure Digesters & Energy Utilization	0.2	0.9	6.4	199	32
AFW-2	Biodiesel Production (incentives for feedstocks and production plants)	0.2	0.8	5.1	286	56
AFW-3	Soil Carbon Management (including organic prod. methods incentives)	0.2	0.2	3.0	–16	–5
AFW-4a	Preservation of Working Land–Agricultural Land	0.2	0.3	2.6	290	114
AFW-4b	Preservation of Working Land–Forest Land (formerly AFW-7)	1.7	4.3	36	112	3
AFW-5	Agricultural Biomass Feedstocks for Electricity or Steam Production	0.009	0.02	0.2	10	54
AFW-6	Policies to Promote Ethanol Production	0.9	6.9	38	200	5
AFW-8	Afforestation and/or Restoration of Nonforested Lands	0.2	2.4	15	128	9
AFW-9&10	Expanded Use of Forest Biomass and Better Forest Management	1.5	5.9	48	–639	–13
AFW-11	Landfill Methane and Biogas Energy Programs	1.1	2.9	20	23	1
AFW-12	Increased Recycling Infrastructure and Collection	0.2	0.5	4.1	52	13
AFW-13	Urban Forestry Measures	1.4	4.3	34	–376	–11
	Sector Total After Adjusting For Overlaps	**7.9**	**29**	**213**	**270**	**1**
	REDUCTIONS FROM RECENT ACTIONS (None)	**0**	**0**	**0**	**0**	**0**
	Sector Total Plus Recent Actions	**7.9**	**29**	**213**	**270**	**1**

Cross Cutting GHG Mitigation Options

	Mitigation Option Name	**GHG Reductions ($MMtCO_2e$)**			**Net Direct Cost (Million $)**	**Cost-Effective-ness ($\$/tCO_2e$)**
		2010	**2020**	**Total 2007–2020**	**2007–2020 (NPV)**	
	Cross-Cutting Issues (CC)					
CC-1	GHG Inventories and Forecasts	*Not quantified*				
CC-2	GHG Reporting	*Not quantified*				
CC-3	GHG Registry	*Not quantified*				
CC-4	Public Education and Outreach	*Not quantified*				
CC-5	Adaptation	*Not quantified*				
CC-6	Options for Goals or Targets (for CAPAG in support of LCGCC)	*Not quantified*				