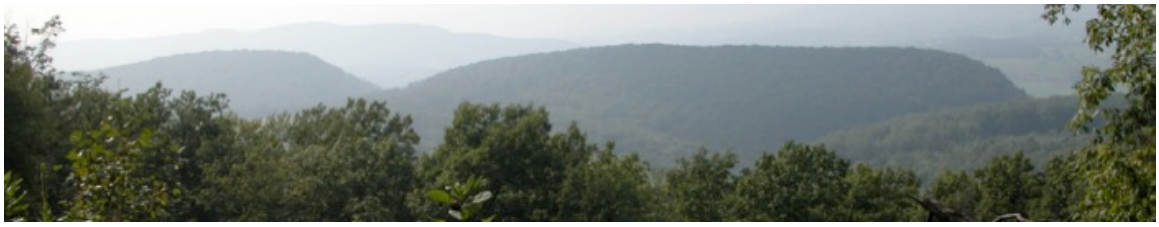

Instructor's Manual

Module 2: *Major Air Pollutants in the Mid-Atlantic United States*

A. Typical class length:
45-60 minutes

B. Target students:
Entry-level state employees; possibly the general public

C. Module objectives:
The goals of this module are to have the students identify:
• Understand the difference between ambient and indoor air pollution
• Identify the criteria pollutants
• Identify the pollutants of concern to the Mid-Atlantic U.S.
• Understand the sources, trends and spatial patterns of some of the criteria pollutant concentrations in the Mid-Atlantic U.S.
• Understand the sources, patterns, and trends of major air toxics in the Mid-Atlantic U.S.

D. Instructor preparation:
Go to the course web site and download all relevant materials for Module 2:
Instructor's Slides (Powerpoint)
Student Handouts (PDF)
Instructor's Manual Overview (PDF)

http://bigmac.cee.mtu.edu/marama/Modules/Modules.html

Review all the materials, make any changes you feel are necessary for your version of the course, master the material, then deliver your class!

E. Understand the sub-module objectives
Each course module is constructed of a series of sub-modules based on modern learning theory. The sub-module typically focuses on a narrow aspect of the module topic. The module can be viewed as the collection of several discrete topics presented in a fashion more appropriate for the range of learning styles among students in your class. Most sub-modules are constructed around a *motivation-theory-application-analysis* learning cycle. While it is good practice to have this cycle for each sub-module, it is acceptable to have a portion of the sub-modules that do not have all four components of the cycle. In general though, it is poor practice to have only the theory sections, as this will likely achieve the

low-retention rates found in lecture-based learning environments. The rest of this manual provides tips and insight into specific slides. Please refer to the *Module 2 Instructor's Slides* to follow along.

Sub-Module 1: Introduction (Slides 1-6)
The primary purpose of these slides is to engage the student almost immediately upon entering the classroom. Educational research suggests that in a typical class, the first ten minutes is lost on most students as they are disconnecting from what they were previously doing. A suggested approach for this phase of the module is:

Slide 1 – Have this photograph projecting before the students enter the classroom. Each module starts with a photograph connected to the content. Most students will subconsciously begin thinking about the course material when looking at a photograph. For this photo, students will have an image demonstrating a visual connection to poor air quality.

Slide 2 – Introduce the topic. This will make sure everybody in the room belongs in the class.

Slide 3 – The *Did You Know?* slide serves as the initial motivation. Feel free to substitute a similar compelling fact, observation, or finding from your own experiences. This slide should be put up long enough for the students to review, and perhaps some short comment from you. Note that these improvements are based on Air Quality Index data, not specific pollutant concentrations.

Slide 4 – All modules have a preliminary quiz. The purpose of the preliminary quiz is two-fold: (1) it gets the students thinking more about the subject, and (2) gives you a comparative benchmark at the post-module quiz. Feel free to substitute questions with some of your own, but bear in mind that the total time expended here should be no more than one minute. Simply have the students circle the answers on their copies of the student handouts, or produce a handout quiz if you want to tally the results. One way to engage the class as a whole is simply to ask for a show of hands for each answer. The solutions to this quiz can be found in the post-course quiz slide below.

Slide 5 – The point of this activity is to get the students comfortable sharing their thoughts with the whole class. Some students will be eager to do so with no prompting, many will not. The group discussion activities are venues for the latter type of student to interact in a more comfortable setting. There are no right or wrong answers, simply impressions to listen to. Another benefit of this sharing is that it provides you a way to gauge the knowledge level of the students, and perhaps make real-time adjustments in the language you use to describe subsequent topics.

Slide 6 – The course goals slide is a good one to emphasize. Tell the students clearly what they will learn by the end of the class. If you add to, or delete, any material modify the course goals if needed.

Sub-Module 2: Pollution Introduction (Slides 7-9)
The primary purpose of this sub-module is to address the first three course objectives, namely understanding the difference between outdoor (ambient) and indoor air pollution, identifying the criteria pollutants, and highlighting the pollutants of particular concern for the Mid-Atlantic region.

Slide 7 – This slide starts with the basics: a definition for air pollution, and distinction between atmospheric environments (indoor versus ambient). A critical difference between these environments is the ambient air can be considered a shared common resource, whereas indoor air is often influenced mainly by personal actions. The transport of ambient pollutants is governed by atmospheric physics, whereas engineered ventilation systems dominate transport of pollutants indoors. Ambient pollutant sources can be distant from points of impact, whereas indoor pollutant sources are usually collocated with receptors.

Slides 8 – This slide introduces the six criteria air pollutants. These pollutants are described by the U.S. EPA this way:

> *The 1970 amendments to the Clean Air Act required EPA to set National Ambient Air Quality Standards for certain pollutants known to be hazardous to human health. EPA has identified and set standards to protect human health and welfare for six pollutants: ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide. The term, "criteria pollutants" derives from the requirement that EPA must describe the characteristics and potential health and welfare effects of these pollutants. It is on the basis of these criteria that standards are set or revised.*

Consult the glossary mentioned in the Instructor's Manual Overview for EPA definitions of most air quality terms in these modules:

http://www.epa.gov/OCEPAterms/cterms.html

Slides 9 – This slide sets up the main message of this module: *the Mid-Atlantic has considerable challenges from ozone and particulate matter air pollution*. Then again, so do most urbanized areas around the world. The density of urban development in the Mid-Atlantic make this a regional problem experienced by even smaller cities amidst the cluster of major metropolitan centers.

Sub-Module 3: Ozone (Slides 10-13)
The goal of this sub-module is to provide depth into the second, third, and fourth objectives, notably that ozone is a criteria pollutant of concern for the Mid-Atlantic and exhibits distinct trends and patterns.

Slides 10-11 – These slides introduce key information regarding ozone. Ozone is typically measured on an hourly basis. Its National Ambient Air Quality Standards

include the concentration that cannot be exceeded in a one-hour period (0.12 ppm), and the average concentration that cannot be exceeded for any eight-hour period (0.08 ppm). Actually, the one-hour standard looks at the fourth highest one-hour ozone concentration in the community for the year. This is a way to permit three one-hour periods as acceptable "lapses" without penalty. The standards reflect the belief that higher concentrations are acceptable over a shorter period of time, as dose is a function of these two, and ultimately it is dose that elicits a response in the receptor (human body, or environment). This slide also summarizes a couple common impacts and recent trends. Progress has been hard to come by for this pollutant, partly due to the complex origins of ozone (none is emitted directly from sources, rather it results from the chemical reactions involving nitrogen oxides and organic compounds with sunlight – see Slide 11 – the emissions of these pre-cursor compounds have been difficult to reduce). The photograph is an example of the type of air discoloration associated with high levels of precursor pollutants, and is often coincident with high levels of ozone.

Slide 12 – This chart shows regions in the Mid-Atlantic States with repeated problems meeting the ozone 8-hr NAAQS. The DC-Baltimore-Philadelphia-New York City urban corridor has the most frequent violations of this standard (as does the Charlotte area). Communities designated as *Early Action Compact* agreed to reduction strategies prior to being required to do so by the U.S. EPA (the requirements started in 2004) and in doing so were granted exemption from regulatory impacts as long as the area:

- Developed and implemented air pollution control strategies;
- Accounted for emissions growth, and;
- Achieved and maintained the national 8-hour ozone standard by December 31, 2007

Slide 13 – This activity allows the students to pause and digest the ozone story. Have them think of one way to improve the ozone issues in the Mid-Atlantic. If you feel that the class has an open environment, then ask for students to volunteer their ideas (this problem has no easy solutions, so it may be that the students may have little to offer). It may be good to have the students chat in small groups then offer the group's best idea.

Sub-Module 4: Particulate Matter (Slides 14-18)

The goal of this sub-module is to provide depth into the second, third, and fourth objectives, notably that particulate matter is a criteria pollutant of concern for the Mid-Atlantic and exhibits distinct trends and patterns.

Slide 14 – Introduces the important point that size is critical to particulate matter. Different sources create different size particles, and the particles are made of different compounds. The NAAQS are also differentiated by size. The PM10 standard limits the concentration of all particles less than 10 micrometers in diameter, whereas the PM2.5 standard targets the concentration of all particles less than 2.5 micrometers in diameter. Over the past few decades the standards have focused more intently on smaller particles as health research begin to connect respiratory disease to fine particulate matter.

Slide 15 – PM10 is often generated from mechanical processes (grinding, erosion, etc.) whereas PM2.5 is often created from combustion processes (sometimes combustion gases

coalescing into particles after emission to the atmosphere). The difference in size strongly influences the transport of the particles in the air (bigger particles settle out of the air much more quickly), impacts (different technologies are needed to control fine versus coarse particle emissions), and solutions (fine particles require a regional approach due to their long-range transport possibilities). Progress is being made on PM10, whereas PM2.5 continues to be a challenging problem in the Mid-Atlantic.

Slide 16 – Covers some of the ways that particles of different types are created. This will be of interest to technical staff, skip for lay audiences.

Slide 17 – The colored areas in this map reveal the areas that have air quality that exceeds the PM2.5 NAAQS. Note the strong connection to urban areas of any reasonable size; this highlights the widespread challenges to solving this air quality problem.

Slides 18 – This problem is a challenging one, so it is best done in small groups of 3-5, or whatever is convenient based on the room layout. Some reasonable explanations could be: (1) that other sources of sulfate-PM2.5 are increasing (cars are not a major source of PM2.5, but diesel-powered vehicles are), (2) PM2.5 composition could be changing in the Mid-Atlantic (less dependence on sulfates), or (3) sulfate is coming from someplace other than power plants located in the Mid-Atlantic.

Sub-Module 5: Other Criteria Pollutants (Slides 19-25)
The goal of this sub-module is to provide depth into the second and fourth objectives, notably details on the other criteria pollutants.

Slide 19 – Reinforce that there are some success stories with this slide. The Mid-Atlantic has problems with two of the criteria pollutants, but has reasonably controlled four of them.

Slide 20 – A point to emphasize with nitrogen dioxide is its involvement in other problems. It is a precursor to ozone and particle formation, while also causing some impacts on its own. It also turns the air yellowish-brown color familiar to many urban areas (as shown in the photo).

Slide 21 – This slide highlights spatial differences; cities have higher concentrations. This is a good place to ask the students why? Vehicle traffic is one important contributor to nitrogen dioxide emissions.

Slide 22 – This highlights the key features of sulfur dioxide. This is largely a success story, vast reductions have been made, mainly due to emission controls at coal-fired power plants. There are, however, lingering ecosystem impacts from acid rain, as lake systems slowly recover from suppressed pH levels.

Slide 23 – This slide is a good example of a pollutant deposition that is closely connected to pollutant emissions. The graph also strongly reveals the influence of one type of source (power plants) on the pollutant levels, suggesting the source is the major contributor.

Slide 24 – Another success story. Carbon monoxide levels have been reduced dramatically due to engineering improvements on combustion and emission control technologies for vehicles. Additional emission reductions have been achieved through the adoption of oxygenated fuels (ethanol, or MTBE, for example) and policies targeting small sources like replacing fireplaces with efficient wood-burning stoves.

Slide 25 – The greatest success story? Lead emissions have been reduced more than 95% in the past three decades, largely due to elimination of lead as a gasoline additive. Some localized problems exist due to industrial emissions, as such lead no longer meets the definition of a criteria pollutant (that it is a widespread problem). In fact, of all the criteria pollutants, lead is the only one not continuously measured Lead may be removed from the criteria pollutant list in coming years and instead be listed as a hazardous air pollutant (see below).

Sub-Module 6: Hazardous Air Pollutants (Slides 26-30)
The goal of this sub-module is to provide depth into the fifth objective, notably details on air toxics (or hazardous air pollutants).

Slide 26 – This slide introduces the challenge: there are numerous pollutants on the HAPs list (this depends on which section of regulatory code you refer to: 187 by counting compounds on EPA's hazardous air pollutant list, 360 via the EPA's Toxics Release Inventory – bottom line is there are hundreds of compounds and the list is growing). While they are generally "hotspot" pollutants, some are nearly ubiquitous, benzene for example. Should benzene be a criteria pollutant? Perhaps a good question to pose to your students.

Slide 27 – This slide defines some of the broad families of compounds denoted as HAPs. Note that one successful strategy in reducing emissions has been making the emissions data publicly available. This is the focus of the Analysis activity on Slide 30.

Slide 28 – This slide presents a simple county-level map for mercury emissions in Pennsylvania. The point is to provide an example of the range in emissions, and also that many counties have no such emissions ("hotspot" phenomena). How might this influence impacts?

Slide 29 – To re-examine the local nature of HAPs, this figure reveals emissions of benzene throughout Pennsylvania. The emission magnitudes and distribution are different than that for mercury, due to the different industrial sources that release these compounds.

Slide 30 – This is a good activity for a small group. The solution that seems to be effective is that used in the Toxics Release Inventory: self-reporting of emissions by industry, auditing, and public release of data. The public, often educated via media attempts to vilify local emission sources, have little tolerance for perceived major polluters. This public perception of corporate neighborliness can create effective pressure

on industry to reduce their emissions. Your students may come up with other workable solutions, but this one is remarkable effective and low cost compared to other fixes. Are there any limitations to the approach, though?

Sub-Module 7: Indoor Air Pollution (Slides 31-32)
The goal of this sub-module is to provide additional substance to the first objective, notably differentiating indoor and ambient air pollution.

Slide 31 – This slide summarizes key differences between indoor and ambient air pollution. A very important point to return to is that of dosage. Two critical factors in dose estimates are the concentration of the pollutant of concern and the time of exposure. Concentrations are only regulated in work settings, and only by building design code, and worker safety devices (in industrial settings). There are no regulations governing residential settings. In most developed countries most people spend more than 90% of the time indoors. For many health impacts, indoor air pollutant exposure can be a critical contributor to the total dose received. This leads to the question in Slide 32.

Slide 32 – An important question with no one answer. Clearly, the challenges of regulating, monitoring, and controlling so many different indoor "atmospheres" partly explains the current state of affairs. Should the government be worried about indoor air quality, or simply about the quality of the shared "atmospheric commons" in the ambient air? What solutions would have any chance of success in the indoor air quality arena? One possibility is building design, as is happening through emerging "green building" design guidelines.

Sub-Module 8: Conclusion (Slides 33-36)
These slides provide a meaningful ending to the learning. Don't underestimate their importance.

Slide 33 – The post-quiz goes here. The students should only need 30-60 seconds. Collect their responses, if assessment is needed, else a show of hands with discussion is fine. The purpose of the post-quiz is simply to force retention of key points. The answers for this quiz are:

1.) From the choices available it is clearly *c.) ozone*
2.) Mechanical processes generally do not create fine particulate, therefore both *a.) windblown dust*, and *d.) unpaved roads* are good choices for this question.
3.) After years of negotiation, *a.) ozone* received a reduction (from 0.12 ppm to 0.08 ppm). At about the same time, fine particulate was added as a new NAAQS.

Slide 34 – This slide has some resources for the students to learn more on their own. Add to it, as relevant. Encourage additional learning with references that you know to be particularly helpful. The first two resources provide more depth into the two problematic pollutants, ozone and particulate matter. The MARAMA Guide is particularly relevant for what's happening closer to home for your class.

Slide 35 – The moment to reflect is an important pause before concluding the class. It helps the student sort and summarize what they have learned, and if desired can be a good summative assessment for your efforts. For example, as an assessment tool, simply ask the students to write their response to the question on a scrap of paper and leave it behind following the class. Read through the responses to adjust any future offerings of the class. It is always interesting to see what the *students* feel is the most important lesson.

Slide 36 –Thank the class for coming and for their participation! This is a simple yet powerful way to end the class.