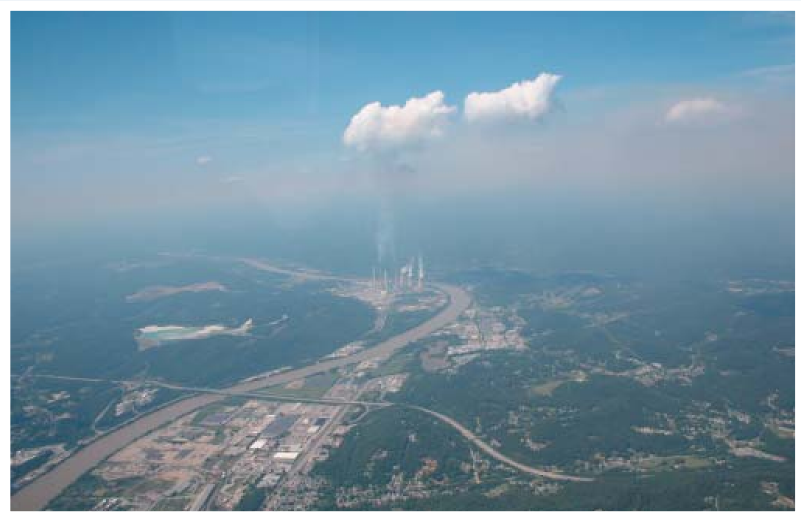
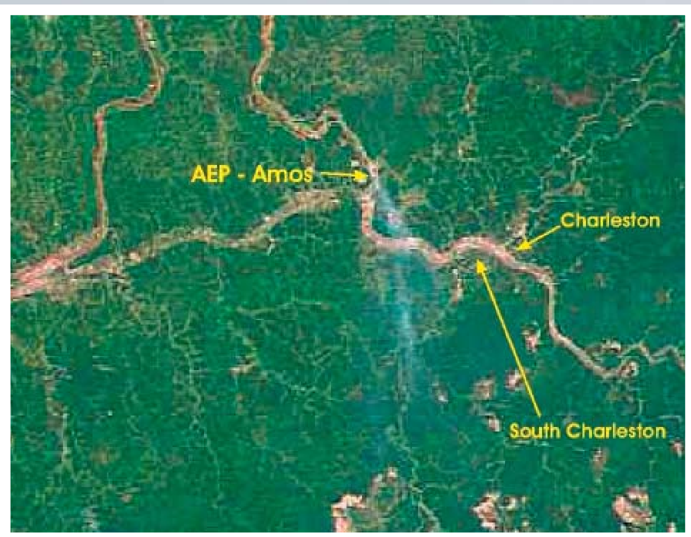


# Kanawha Valley "Blue Haze" Incident of July 11, 2008




West Virginia
Department of Environmental Protection
Division of Air Quality

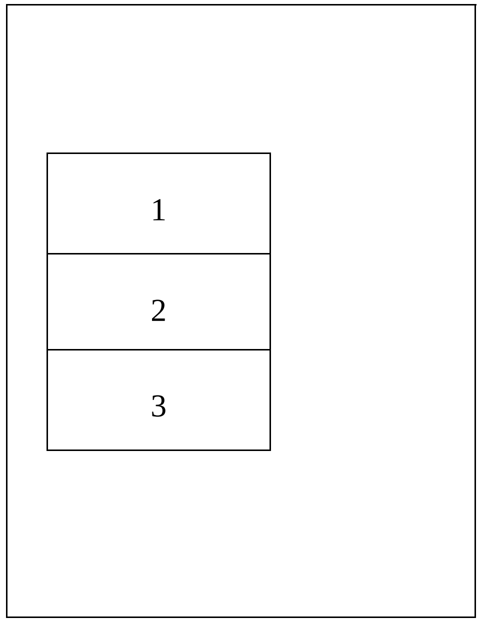
January 23, 2009

# Kanawha Valley
# "Blue Haze" Incident
# of
# July 11, 2008

**West Virginia Department of Environmental Protection**
**Division of Air Quality**
**601 57th Street, S.E.**
**Charleston, W.Va. 25304**
**(304) 926-0499**

**January 23, 2009**

## LIST OF PHOTOGRAPHS ON FRONT COVER




1. View of John E. Amos Power Plant (Amos plant), owned by American Electric Power Co. and operated by subsidiary Appalachian Power Co., taken from a state helicopter approximately above the Nitro-St. Albans area. For reference, note that the left-most stack from which blue smoke exhausts—the second stack from the left—is approximately 1,000 feet tall. Note, too, that the two large white cumulus clouds are not directly over the plant, but closer to the helicopter than the plant. Photograph taken at approximately 3:37 p.m. Eastern Daylight Time (EDT) July 11, 2008.

2. Satellite image of the Kanawha River Valley at 12:10 EDT on July 11. Note the distinctive white plume emanating from the Amos plant that has dispersed not only laterally as it moved south-south-easterly, but also had intense density in the Institute-Jefferson area.

3. Looking east-southeast from above Nitro. Bayer CropScience in Institute is in the left foreground. South Charleston and Charleston are in the upper right quadrant of the photograph. The Amos plant is outside the frame of the photograph, south-west of the center of the photograph. Photograph taken at approximately 3:34 p.m. EDT July 11, 2008.

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Note: All photographs taken July 11, 2008, by engineers in the Division of Air Quality (DAQ) of the West Virginia Department Environmental Protection, during the aerial re-connaissance by DAQ using a state helicopter.

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# EXECUTIVE SUMMARY

At about noon on July 11, 2008, an air-pollution-related event marked by a dense white cloud, or haze, appeared in the Jefferson-Institute area of the Kanawha River Valley (valley), just west of South Charleston, W.Va. By the end of the day, the haze had spread eastward into, and upriver of, Charleston, as well as to the south-southeast of the city. That haze has been described as blue, white or gray, or some combination thereof. For purposes of this report, however, it will be called haze or blue haze.

This was the second significant haze-related incident in 2008 in the greater Charleston region. The first occurred Jan. 25. This chapter mentions briefly that earlier event and lists enforcement-related actions that have occurred.

Chapter one discusses the July 11 incident and presents the following:

- information on the West Virginia Department of Environmental Protection's (DEP's) response—specifically, by the Division of Air Quality (DAQ)— including the information that the DAQ used in reaching its conclusion that day as to the source of the haze

- regulatory and meteorological conditions and situations prior to and after the incident

- the DAQ conclusion regarding the source of the haze

- information regarding mitigation of technical issues at the John Amos Power Plant, focused on minimizing potential visibility-related problems

**ES-1. "Blue Haze" Incident of July 11**

The DAQ received the first public complaint at approximately 1:15 p.m. Eastern Daylight Time (EDT). By that time, DEP had already initiated its response.

- Calling at approximately the same time from the South Charleston area, the supervisor of the DAQ's Compliance & Enforcement group (C&E supervisor)—who had conducted an aerial reconnaissance of the valley during the Jan. 25, 2008, blue-haze incident—reported that there was dense haze in the Jefferson-Institute area. The haze blocked the view downriver to the west, toward the Amos power plant which is operated by Appalachian Power Company (APCO), a subsidiary of American Electric Power Company (AEP)

- Immediately thereafter, in preparation of a field investigation, the Assistant Director for Compliance & Enforcement (assistant director for C&E) contacted an engineer in his group. Then at approximately 1:40 p.m. EDT, the assistant director and that engineer left DEP headquarters in Kanawha City in a state vehicle, traveling west on MacCorkle Ave

- Just after 3 p.m. EDT, following telephoned instructions from the DAQ director, the two employees and another C&E engineer who had been dispatched from DEP headquarters, met at Yeager Airport (Yeager). Then, in the state helicopter, the three conducted an aerial reconnaissance of the Kanawha River Valley. They traveled as far west as Poca, then circled the Amos plant. Then they proceeded back east up the valley to the Nitro-St. Albans area, then to the Southridge area, located south of Charleston. From there they turned east-northeast, flew to the Marmet/Belle area and then returned to Yeager

- Back at DEP Headquarters, the DAQ director answered questions from news media, was apprised of complaints that had been received from the public, and remained in contact with the field staff

- One C&E engineer also fielded telephone inquiries from the West Virginia Division of Homeland Security and Emergency Management

By late afternoon July 11, 2008, based upon staff observations made on the ground and by aerial surveillance, DAQ concluded that the Amos power plant was the source responsible for the haze.

Photograph ES-1 shows the plant in operation midday July 11.

**ES-2. “Blue Haze” Incident of Jan. 25**

The Jan. 25 incident, which had odors associated with it, also involved the Amos plant.

Based on the analysis contained in a May 2008 report titled, “Kanawha Valley ‘Blue Haze’ Incident of January 25, 2008,” the DAQ concluded that “a preponderance of evidence” clearly showed the Amos plant was a major contributor to the haze problem, once the meteorological inversion occurred that day.

Subsequent enforcement-related actions occurred. The following highlight the more significant ones:

- May 9: Notice of Violation(s) regarding the Amos plant sent to Greg Massey, General Manager, APCO, for violations of the National Ambient Air Quality Standard for particulate matter (PM) having an aerodynamic diameter of less than or equal to approximately 2.5 microns and for a statutory-air-pollution violation

- June 6: Notice of Appeal, filed by Jackson Kelley PLLC on behalf of APCO, asserting that no violation of any ambient-air-quality standard had occurred

**Photograph ES-1.** View of Amos power plant taken from a state helicopter, approximately above the Nitro-St. Albans area. For reference, note that the left-most stack from which blue smoke exhausts—the second stack from the left—is approximately 1,000 feet tall. Note, too, that the two large white cumulus clouds are not directly over the plant, but closer to the helicopter than the plant. Photograph taken at approximately 3:37 p.m. EDT.

- June 23: draft Agreed Order of Dismissal sent by DEP to Jackson Kelly PLLC, pursuant to Appalachian Power Appeal No. 08-02-AQB, filed by APCO

- July 7: Notice to the AQB by DEP that the agency would be issuing an Agreed Order of Dismissal of APCO's appeal of the NOVs, *not* the NOVs

- Aug. 6: DEP and APCO submitted to AQB the Agreed Order of Dismissal that states that an NOV cannot be appealed

Note carefully that the Aug. 6 action did not and does not preclude DEP and APCO/AEP reaching an agreement, through some other enforcement instrument such as a Consent Order, to resolve the causes of the violations presented in the May 9 NOVs.

**ES-3. Mitigation of Visibility Problems**

In a Feb. 6, 2006, document titled, "John E. Amos Plant FGD Material Handling Construction Permit Application," AEP stated in Attachment G "Process Descriptions," in the section "$SO_3$ Mitigation System," that:

> If not mitigated, the increase in $SO_3$ [from the selective catalytic reduction (SCR) units] and subsequent formation of $H_2SO_4$ can result in visible emissions downwind of the stack. It is anticipated that a supplemental $SO_3$ mitigation system will be needed to help reduce $SO_3$ concentrations.

Thus, for at least approximately two years prior to the first of the 2008 blue-haze incidents, it appears AEP understood that the Amos facility could contribute to blue-haze conditions downwind of the plant.

To better understand the conditions that caused the visibility problem, identify and develop remedies, and to assist AEP in doing the same, the agency analyzed Amos' operating data and applied its long-term observations of plant operations, particularly deterioration of the PM collection efficiency of Unit 3 ESP.

Through these analyses, communications and meetings about the Amos plant's contribution to blue-haze problems in the Kanawha River Valley region, both groups agreed on at least the following: (1) the ESP's worsened performance helped create the conditions at the plant that led to the Jan. 25 and July 11 blue-haze incidents; (2) $SO_3$ injection contributed to the July 11 incident; and (3) $SO_3$ control was needed to minimize, if not eliminate, the $H_2SO_4$ emissions problem.

As a result of this communication, AEP/APCO assured the DEP that it would take action at the Amos plant to mitigate the $SO_3$ that creates sulfuric acid.

In September 2008, APCO idled Unit 3 for scheduled major repairs and upgrades. According to the utility, those activities will be completed in the first quarter of 2009, and will include the following:

- connection and startup of the new wet flue-gas desulfurization device (wet FGD) or scrubber that reduces sulfur dioxide ($SO_2$)

- installation and continuous operation of a dry-sorbent-injection (DSI) system to reduce $SO_3$ generated by the boiler and the associated SCR system that is used to reduce nitrogen oxides ($NO_X$)

- repair and upgrade of the existing ESP

Since receipt of a Sept. 19 letter from AEP describing those planned actions, DAQ has been working to develop an agreement that would embody enforceable commitments to control the $SO_3$ and $H_2SO_4$ from the Amos plant's three boilers. The agency believes it is appropriate to include the commitments as conditions in a federally-enforceable permit or consent order.

Therefore, DAQ sent a letter to AEP on Nov. 24, 2008, having two general purposes.

- One was to gather additional, more specific information to determine if the DSI system or systems being installed at the Amos plant would minimize $SO_3$ and $H_2SO_4$ generated by the boilers and boiler trains

- The other equally important purpose was to apprise the company that DAQ believes enforceable commitments are necessary to ensure that the $SO_3$ mitigation systems are used continuously and operated properly. DAQ indicated AEP should give this matter the highest priority and that it should be finalized prior to the re-start of Unit 3

AEP responded Dec. 12, 2008. The utility indicated its willingness to discuss permit conditions in which the agency's continuing concerns, regarding operation of the $SO_3$-control equipment, could be addressed. The utility committed to maintain or reduce $SO_3$ below current levels and mitigate any visible trailing plume. However, AEP indicated this must be accomplished without impacting the operation of other air-pollution control devices, or the overall operation of the boiler. AEP also presented information on sorbent selection, efficiency and system flexibility. About the design and operation of the Trona-based DSI system, AEP established certain general design and operating conditions.

DAQ believes that when completed, the repairs to and upgrade of the Unit 3 ESP, as well as the use of the DSI systems installed at each of the three Amos boilers, will decrease the likelihood of—if not prevent—additional Amos-related blue-plume/blue-haze incidents in the region.

But to do so, DAQ also believes it is essential that the following two conditions be met by AEP for that level of control to occur at the facility:

- that AEP install, operate and maintain air-pollution-control technology or technologies that continuously minimize $SO_3$ generated by Unit 3 and its associated SCR system

- that AEP then install, operate and maintain air-pollution-control technology or technologies that continuously minimize $SO_3$ generated by Units 1 and 2 and their associated SCR systems

As just noted, in its Dec. 12 response to DAQ, AEP indicated its willingness to discuss permit conditions in which the agency's continuing concerns, regarding operation of the $SO_3$-control equipment, could be addressed. But while the utility's responses encouraged the agency, DAQ still needed more clarification of the specific operating parameters for the DSI system.

Subsequently, DAQ met with the utility on Jan. 13, 2009, to discuss acceptable enforceable conditions. At the meeting, AEP reiterated its willingness to develop specific language regarding $SO_3$ control. However, a major obstacle surfaced: the uncertainty about how the Trona system would perform specifically at the Amos plant. To date, the utility's experience using this technology for at least two other locations shows that the system's performance is very site-specific. According to AEP, there also can be adverse interactions with the other air-pollution controls, particularly the ESP, that do or may lead to materials corrosion. Site water-quality discharge issues may arise, among others.

After some discussion, DAQ and AEP agreed that the utility would enter into a consent order. Through it, AEP will be required to conduct a 12-month study, beginning with the restart of Unit 3, to determine appropriate operating parameters for the $SO_3$-control system on that boiler. Most importantly, DAQ expects the consent order to require the operation of the Trona-injection system whenever Unit 3 is operating, though not during its start-up/shut-down and maintenance. Operation of the system will also be required on Unit 1 and Unit 2 after the units have been tied into the $SO_2$ scrubber and restarted.

Through the order, AEP will also be required to monitor and record various operating parameters. Those include, but are not limited to, boiler load, boiler heat input and Trona injection rate. Then, AEP must make those data available to the agency upon request. The agency will use these data to determine specific permitting conditions for the $SO_3$-mitigation systems.

Ultimately, DAQ will develop a federally-enforceable permit that will apply to the operation of the $SO_3$-reduction systems at the Amos plant, thereby reducing the likelihood of future localized haze events.

## LIST OF ACRONYMS, ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| % | percent |
| & | and |
| AEP | American Electric Power Company |
| AQB | Air Quality Board |
| APCO | Appalachian Power Company |
| ASOS | Automated Surface Observation System |
| C&E | Compliance & Enforcement |
| Chap. | Chapter |
| $^{o}C$ | degrees Celsius |
| DAQ | Division of Air Quality |
| DEP | West Virginia Department of Environmental Protection |
| DSI | dry-sorbent injection |
| Homeland Security | Division of Homeland Security and Emergency Response |
| ESP | electrostatic precipitator |
| EST | Eastern Standard Time |
| EDT | Eastern Daylight Time |
| Fig. | figure |
| $^{o}F$ | degrees Fahrenheit |
| $H_2O$ | water |
| $H_2SO_4$ | sulfuric acid |
| HCl | hydrochloric acid |
| Jan. | January |
| MPH | miles per hour |
| MW | megawatts; or 1,000,000 watts |
| NAAQS | National Ambient Air Quality Standard |
| $NO_X$ | nitrogen oxides |
| NWS | National Weather Service |
| $O_2$ | oxygen |
| $^{o}F$ | degrees Fahrenheit |
| PM | particulate matter |
| $PM_{10}$ | PM with an aerodynamic diameter of less than or equal to 10 microns; or less than or equal to approximately 4/10,000$^{th}$ of an inch |
| $PM_{2.5}$ | PM with an aerodynamic diameter of less than or equal to 2.5 microns; or less than or equal to approximately 1/10,000$^{th}$ of an inch |
| ppm | part per million (for example, 1 percent = 10,000 ppm) |
| S | sulfur |
| SCR | selective catalytic reduction |
| $SO_2$ | sulfur dioxide |
| $SO_3$ | sulfur trioxide |
| VOCs | volatile organic compounds |
| W.Va. | West Virginia |
| $\mu g/m^3$ | microgram per cubic meter of air |

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# CHAPTER 1
# INTRODUCTION

At about noon on July 11, 2008, an air-pollution-related event marked by a dense white cloud, or haze, appeared in the Jefferson-Institute area of the Kanawha River Valley (valley), just west of South Charleston, W.Va. By the end of the day, the haze had spread eastward into and upriver of Charleston, as well as to the south-southeast of the city.

This was the second significant haze-related incident in 2008 in the greater Charleston region, including the valley. The first occurred Jan. 25. This chapter mentions briefly the earlier event and lists enforcement-related actions that have subsequently occurred.

About the July 11 incident, which is discussed first, this chapter:

- presents information on the West Virginia Department of Environmental Protection ( DEP's) response, specifically the Division of Air Quality (DAQ), including the information used in reaching its conclusion that day as to the source of the haze;

- establishes the regulatory and meteorological conditions and situations prior to and after the incident.

This chapter also briefly presents information on a more widespread July 29 haze incident, including photographs and a brief assessment. DAQ notes that, unlike the two incidents just mentioned, this late-July incident did not appear to be caused by any single stationary facility or mobile source in the area.

## 1.1. "Blue Haze" Incident of July 11

The July 11 haze has been described as blue, white or gray or some combination thereof. For purposes of this report, however, it will be called haze or blue haze.

The DAQ received the first public complaint at approximately 1:15 p.m. EDT that day. By that time, DEP had already initiated its response.

- Calling at approximately the same time from the South Charleston area, the supervisor of the DAQ's Compliance & Enforcement group, who had conducted an aerial reconnaissance of the valley during the Jan. 25, 2008, blue-haze incident—reported that there was dense haze in the Jefferson-Institute area. The haze blocked the view downriver to the west, toward the Amos power plant, operated by Appalachian Power Co. (APCO), a subsidiary of American Electric Power Co. (AEP).

- Immediately thereafter, in preparation of a field investigation, the Assistant Director for Compliance & Enforcement contacted an engineer in his group. Then at approximately 1:40 p.m. EDT, the assistant director and that engineer left DEP headquarters in Kanawha City in a state vehicle, traveling west on MacCorkle Ave. to the South Charleston area. Their plans included going as far west as the vicinity of the Amos plant, approximately 15 miles downriver of Charleston.

- Just after 3 p.m. EDT, following telephoned instructions from the DAQ director, the two employees and another C&E engineer who had been dispatched from DEP headquarters met at Yeager Airport (Yeager). Then, in the state helicopter, the three conducted an aerial reconnaissance of the Kanawha River Valley. They traveled as far west as Poca, then circled the Amos plant. Then they proceeded back east up the valley to the Nitro-St. Albans area, then to the South Ridge area, south of Charleston. From there they turned east-northeast, flew to the Marmet/Belle area and then returned to Yeager.

Photographs 1-1 and 1-2 show, respectively, their view that afternoon of the Amos plant and the inversion layer.

**Photograph 1-1.** View of Amos power plant taken from a state helicopter, approximately above the Nitro-St. Albans area. For reference, note that the left-most stack from which blue smoke exhausts—the second stack from the left—is approximately 1,000 feet tall. Note, too, that the two large white cumulus clouds are not directly over the plant, but closer to the helicopter than the plant. Photograph taken July 11 at approximately 3:37 p.m. EDT.

**Photograph 1-2.** Looking north of east from above Institute. Note Bayer CropScience in the extreme left-bottom corner; Interstate 64 runs from the left-bottom quadrant to the right-center; and South Charleston is at right center. Photograph taken July 11 at approximately3:41 p.m. EDT.

Activities also occurred during this period at DEP headquarters.

- The DAQ director answered questions from news media, was apprised of complaints that had been received from the public and remained in contact with his field staff.

- One C&E engineer also fielded telephone inquiries from the West Virginia Division of Homeland Security and Emergency Management (Homeland Security).

## 1.2. "Blue Haze" Incident of Jan. 25

Based on the analysis in a May 2008 report, titled "Kanawha Valley 'Blue Haze' Incident of January 25, 2008," the DAQ concluded that "a preponderance of evidence" clearly showed the Amos plant was a major contributor to the haze problem, once the meteorological inversion occurred that day.

### 1.2.1. Initial Enforcement Action

The first enforcement action to take place was a Notice of Violation (NOV) document issued by DEP on May 9. It was issued to "Appalachian Power Company c/o Mr. Greg W. Massey, General Manager; John Amos Power Plant, PO Box 4000; St. Albans, WV 25177." The principal parts of the document indicated:

- that the Amos plant violated West Virginia Code §22-5-3, titled "Causing statutory [air] pollution unlawful; article not to provide persons with additional legal remedies," because of its contribution to, or causing of a violation, of the 24-hour National Ambient Air Quality Standard for $PM_{2.5}$, which is fine particulate having an aerodynamic diameter of approximately 2.5 microns

- that the Amos plant, which as the major source of sulfuric acid ($H_2SO_4$) emissions on Jan. 25, violated West Virginia Code §22-5-3 because of its contribution to, or causing of, conditions that caused statutory air pollution that then interfered with the public's enjoyment of life or property

- that AEP must file a written response within 30 days after receiving the NOVs

DAQ notes that with respect to the $H_2SO_4$ emissions from Amos, last spring, the company significantly increased its estimates of the continuous release of this chemical.

- In an April 12, 2000 letter to Region III of the U.S. Environmental Protection Agency (EPA), as required through 40 Code of Federal Regulations, Part 60 Subpart J: Superfund, Emergency Planning and Community Right-to-Know Programs, the company indicated that the upper bound of $H_2SO_4$ emitted from stack number 1, which exhausts Amos Units 1 and 2, was 2,317 lb/day; and from stack number 2, which exhausts Amos Unit 3, was 1,784 lb/day. The estimated upper bound of the combined estimated daily rate was, therefore, 4,101 lb/day, which equals approximately 171 lb/hr

- In a March 6, 2008 letter to EPA Region III, AEP substantially enlarged those year 2000 estimates for sulfuric acid (and, incidentally, hydrochloric acid[HCl]). AEP indicated that stack number 1 emits between 2,834 and 14,662 lb/day of $H_2SO_4$; and that stack number 2 emits between 2,714 and 17,184 lb/day. Thus, the combined total estimated $H_2SO_4$ emissions, per day, from Amos equal 5,548 to 31,846 lb/day. Respectively, those equal approximately 231 to 1,327 lb/hr., which is approximately four times higher than AEP's original estimates

### 1.2.2. Follow-up Enforcement Activities

Following the May 9 issuance of the NOVs, subsequent enforcement actions occurred. The following highlight those that are more significant:

- May 9: Notice of Violation(s) regarding the Amos plant sent to Greg Massey, General Manager, APCO, for violations of the National Ambient Air Quality Standard for $PM_{2.5}$ and for a statutory-air-pollution violation

- June 6: Notice of Appeal, filed by Jackson Kelley, PLLC, on behalf of APCO, asserting that no violation of any ambient-air-quality standard had occurred

- June 23: draft Agreed Order of Dismissal sent by DEP to Jackson Kelly, PLLC, pursuant to Appalachian Power Appeal No. 08-02-AQB, filed by APCO

- July 7: Notice to the AQB by DEP that the agency would be issuing an Agreed Order of Dismissal of APCO's appeal of the NOVs, *not* the NOVs

- Aug. 6: DEP and APCO submitted to AQB the Agreed Order of Dismissal that states that an NOV cannot be appealed

Note carefully that the Aug. 6 action did not and does not preclude DEP and APCO/AEP reaching an agreement, through some other enforcement instrument such as a Consent Order, to resolve the causes of the violations presented in the May 9 NOVs.

In early September 2008, APCO idled Unit 3 for scheduled repairs and upgrades. According to the utility, those activities will be completed in the first quarter of 2009 and will include the following:

- Connection and startup of the new wet flue-gas desulfurization device (wet FGD) or scrubber that reduces sulfur dioxide ($SO_2$)

- Installation and continuous operation of a dry-sorbent-injection (DSI) system to control any $SO_3$ generated by the boiler and associated SCR system

- Repair and upgrade of the existing ESP

### 1.3. Haze Incident of July 29

Though not directly tied to the July 11 incident, another haze incident occurred on July 29. Starting at midday, DAQ received more than 20 complaints. Most were from the St. Albans-Nitro-Institute area of the valley and came during early afternoon.

The DAQ responded by sending staff to conduct ground and aerial surveillance.

- Two ground teams went into the St. Albans-Nitro area. The first left DEP headquarters in Kanawha City at approximately 1:49 p.m. EDT.

- The aerial team departed Yeager Airport at approximately 2:30 p.m. in a state helicopter. It flew to Poca, circled the Amos plant twice, then flew east-southeast to St. Albans. It hovered there briefly before proceeding upriver near South Charleston, then to the Southridge area. From there, the helicopter flew to the air space above Exit 95 on Interstates 64 and 77 in Kanawha City. Then the aircraft turned westerly to Yeager Airport, arriving there at approximately 3:30 p.m. EDT. Photographs 1-3 and 1-4 show, respectively, an aerial view of the Amos plant and the area east and northeast of Charleston.

DAQ notes that during the aerial reconnaissance, the aircraft did not ascend higher than 2,800 feet above mean sea level—or approximately 2,200 feet above ground level—because of the pilot's concern over losing visual contact with the ground, due to haziness. Even so, the aerial investigators found that while it did appear that the haze was thicker in the St. Albans area, that was potentially affected that afternoon by the Amos plant emissions, the haze was regional, and more widespread than just the Kanawha River Valley.

For that reason, the haze could not be ascribed to any particular stationary and/or mobile source of air pollution in the valley or its vicinity.

**Photograph 1-3.** Looking north-northeast from above the Winfield area. Steam is being emitted from the cooling towers. Of the four small stacks, the two outside ones are, respectively, the new one for Unit 3 and the new one for Units 1 and 2 combined. They will go in service when the new wet-flue-gas-desulfurization, or wet FGD, scrubbing units go online. The two inner taller stacks are respectively, from left to right, for Unit 3 and for Units 1 and 2 combined. Photo taken July 29 at approximately 3:15-3:20 p.m. EDT.

**Photograph 1-4.** Looking-northeast toward Kanawha City from above the Davis Creek area, which is east of Southridge. Photo taken July 29 at approximately 3:50 p.m. EDT.

# CHAPTER 2
# BACKGROUND

To establish the background for the agency's response, this chapter presents various facets of the background of the day. Primarily, these include regulatory and meteorological events and perspectives.

## 2.1. Regulatory

### 2.1.1. Prior to the First Complaint

On July 11, in the approximately 35-mile portion of the Kanawha River Valley from Poca, located west of Charleston, to Belle, east of Charleston; two general types of air pollution sources operated: stationary and mobile.

Stationary sources included, for example, general manufacturing; heavy or light industry; chemical-processing or manufacturing facilities; power plants, such as the APCO-operated Amos plant in Winfield; industrial, commercial and institutional boilers; industrial or commercial liquid-storage vessels; incinerators; natural-gas compressor stations; restaurants; gasoline stations; a landfill; wood- and/or coal-burning stoves; natural-gas and wood fireplaces; etc.

Mobile sources included, for example, trains and railway tank cars; river barges and/or vessels on those barges; gasoline- and diesel-powered passenger vehicles; light and heavy-duty trucks powered by gasoline or diesel, which include tankers and buses; construction equipment; motorcycles; aircraft; recreational vehicles; etc.

Regarding air pollution-related complaints from citizens about operations of industries in the valley, according to the DAQ's assistant director for C&E, there was nothing unusual reported until the haze incident unfolded at midday July 11. DAQ was not aware of any malfunctions at any major stationary source of air pollution. Nor were there any accidental releases or spills of chemicals from those sources or from any of the industrial-related mobile sources. Nor were there any complaints received by DAQ that day for anything other than the haze.

### 2.1.2. The Complaints

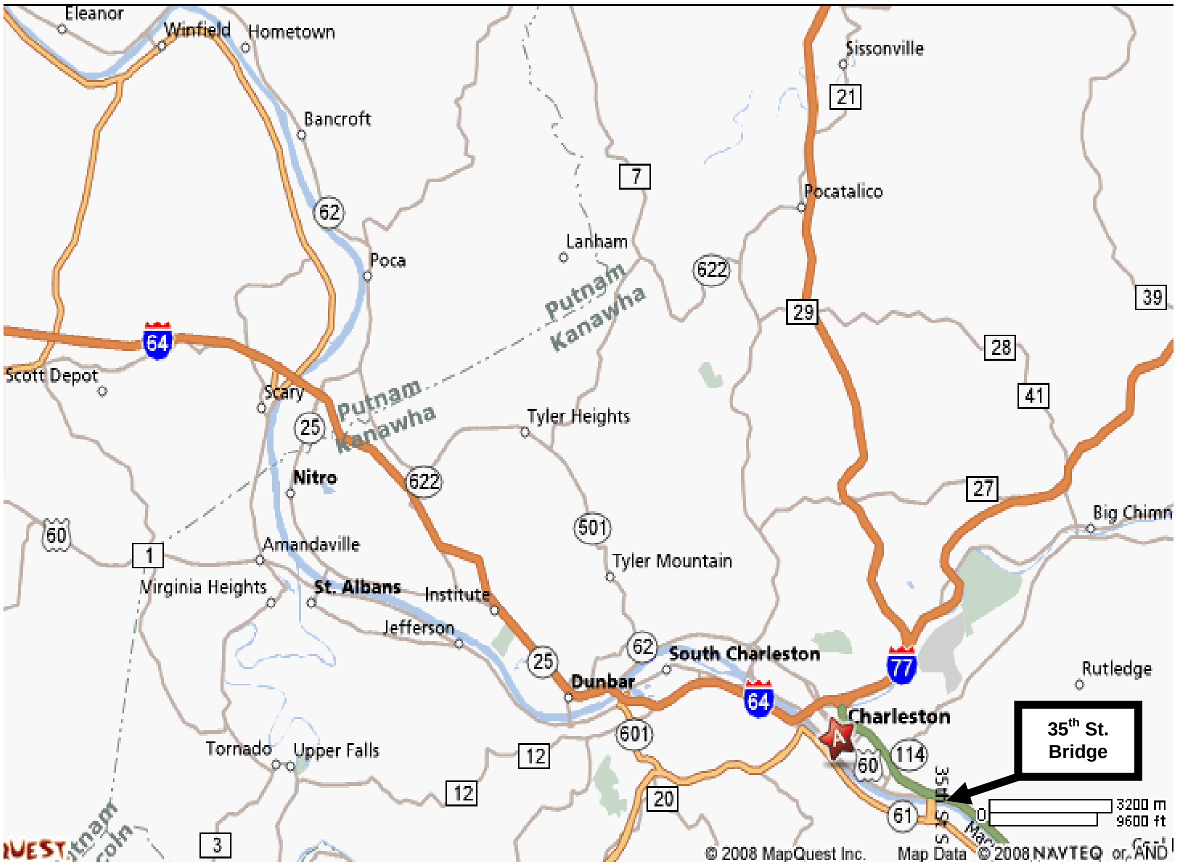
Calling at approximately 1:15 p.m. EDT from South Charleston area, the supervisor of the DAQ’s C&E group, who had conducted an aerial reconnaissance of the valley during the Jan. 25 blue-haze incident, reported the haze to the assistant director for C&E.

The supervisor noted that at approximately noon, in the Jefferson-Institute area, there was a haze with enough density to block the view downriver to the west, toward the Amos plant. He noted there appeared to be a defined upper boundary to the haze.

Simultaneously, citizens began to lodge complaints with DEP about the haze. Four were received by DAQ/DEP, beginning at approximately 1:55 p.m. EDT and ending at approximately 4:26 p.m. EDT.

At approximately 2 p.m. EDT, Homeland Security contacted DAQ on behalf of the Kanawha County Emergency Services group.

All citizen complaints received by DEP concerned the haze, which one caller described as smokey and three others described as blue.  One indicated that he had heard via some broadcast media that the haze was blue. Complainants called from Institute, Nitro, Dunbar and near Sherwood Forrest on U.S. 19 South, or Corridor G. Map 2-1 shows the primarily affected area of the valley that day.




**Map 2-1.** Map of primarily affected portion of Kanawha River Valley. Towns or cities in the actual river valley include, among others, Charleston, South Charleston, Dunbar, Institute, St. Albans, Nitro, Poca and Winfield.

## 2.1.3. The Response

### 2.1.3.1. At DEP

After speaking with the supervisor, the assistant director for C&E immediately made plans with a C&E engineer, who had conducted the ground surveillance during the Jan. 25 blue haze incident, to travel to the South Charleston-Spring Hill area and then further west to the power plant.

At approximately 2 p.m. EDT, Homeland Security contacted DAQ and requested that the agency contact Dale Petry, Kanawha County Emergency Services director, because of a report of a blue haze in the Institute/Jefferson area. The DAQ engineer who responded gave Homeland Security the mobile telephone numbers of the assistant director of C&E and himself.

Just after 2 p.m. EDT, after speaking with the DEP's chief communications officer, the DAQ director arranged for the field investigators and another C&E staff member to make an aerial reconnaissance.

The DAQ director also called Tim Mallen, the APCO environmental manager, to determine whether abnormal operations had or were occurring at the Amos plant. Mallen told the director that he would contact the facility.

Then, at approximately 3:45 p.m. EDT, the director received a phone call from the assistant director of C&E, who was airborne, informing him that the three C&E staff on-board attributed the haze to the Amos plant's emissions.

At approximately 4 p.m. EDT, after the helicopter landed, the DAQ director received another telephone call from the assistant director for C&E. He noted that the haze was moving into the Charleston area more than noticed earlier in the day. The assistant director reported the height of the inversion layer was about 5,800 feet, according to observations made using the helicopter's altimeter.

Following this conversation, the DAQ director responded to a request for information from a reporter for a local newspaper.

At 4:10 p.m. EDT, Homeland Security contacted DAQ again. The C&E engineer who responded suggested, again, that the individual contact the assistant director for C&E.

At approximately 4:15 p.m. EDT, the DAQ director contacted Mallen and learned that there appeared to be no unusual operation at the Amos plant. At the request of the newspaper reporter, the director called to apprise him of what he'd learned from APCO.

### 2.1.3.2. In the Field

The assistant director of C&E and his engineer departed from DEP headquarters in Kanawha City at about 1:40 p.m. EDT. Travelling west on MacCorkle Ave. toward South Charleston, they first noticed the haze at the Patrick Street Bridge. Then, at the vicinity of the South Charleston Indian Mound, they noticed that the visibility across the river, to the north, was much clearer than visibility to the south, in the hills of South Charleston.

Just before 2 p.m. EDT, the assistant director C&E and the engineer reached Spring Hill. The visibility was worse than in South Charleston, "like driving through fog," remembered the assistant director. But upon entering the Jefferson area, the haze was lighter, and it appeared to clear as they approached St. Albans.

After receiving telephone instructions from the DAQ director, the C&E team departed the vicinity of the Amos plant at approximately 2:30 p.m. EDT, heading to Yeager Airport. Driving on Interstate 64 East, the assistant director and the engineer noted that the visibility was relatively clear until approximately the crest of Goff Mountain, between Cross Lanes and Institute.

On the South Charleston or eastern side of Goff Mountain, both C&E staff noted the density of the haze in Dunbar, Institute and even into South Charleston. "It was just like I'd seen [in my investigation, while driving around the Kanawha River Valley] in January [on the 25th, when the first blue-haze incident occurred]," noted the engineer.

The assistant director and his engineer arrived at Yeager Airport at approximately 3 p.m. EDT, met their colleague from DEP headquarters and boarded the helicopter. It departed Yeager at approximately 3:15 p.m. EDT.

The aircraft flew on the north side of the Kanawha River, to just west of the Amos plant, in the Poca area. Then it circled around the plant and headed east, up the valley toward Charleston. Flying toward the plant from Charleston and using the aircraft's altimeter as a reference, the C&E staff noted the top of the haze layer at approximately 5,800 feet above sea level, which is also about 5,200 feet above the river.

In the South Charleston and Dunbar areas, the haze was denser, C&E staff stated. However, there was a slight amount of haze over Nitro, Cross Lanes and Poca, one staff member recalled.

The aircraft proceeded to the Southridge-Corridor G area. C&E staff observed that the heavy swath of haze appeared to come from the Amos plant. They also noted that the dense plume continued in a south-southeasterly direction from the Southridge area.

The aircraft then flew to the Marmet/Belle area, then back to Yeager Airport.

At approximately 4 p.m. EDT, just after the helicopter landed, the assistant director for C&E called the DAQ director. In that conversation, the assistant director apprised the director that the plume was touching down at ground level and that a narrow swath of haze existed.

Further, the assistant director for C&E noted, “The Amos plume was bending over a little bit, heading that way [to the Dunbar-Institute-South Charleston-Southridge area].” The assistant director also offered his opinion that, “Realistically, I don’t think it could be anything else [other than the plume from the Amos power plant].”

The C&E staff who made the aerial reconnaissance arrived back at DEP headquarters at approximately 4:30 p.m. That concluded the field investigation.

## 2.2. Meteorological

### 2.2.1. Wind

Wind data was obtained from both the DAQ’s 30-meter meteorological-monitoring tower in Institute and the National Weather Service’s (NWS) ASOS—automated surface observation system at Yeager Airport. At the latter, where there is a Federal Aviation Administration-contracted weather observer on duty, nothing unusual appeared to have occurred with respect to winds. Note, though, that both sites measure only surface winds.

Fig. 2-1 shows the wind rose from the Institute site. Instrument height was approximately 22 meters, or approximately 72.2 feet, above ground level. Readings would be considered representative of ground-surface winds. Note the following about this graphic:

- Bars indicate the direction from which the wind blew and colors indicate the wind speed

- The data at the rose's center indicates that winds were not calm at any point

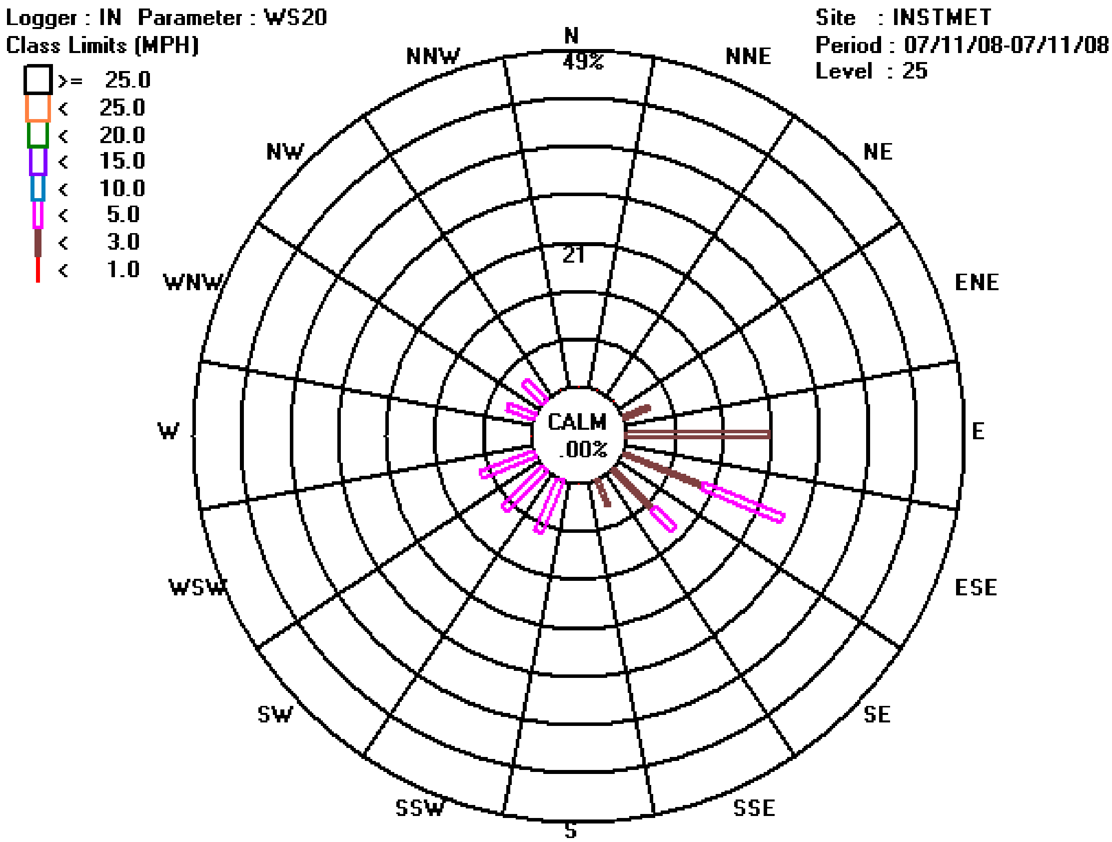
Table 2-1 shows the data from the NWS ASOS site at Yeager. Note that those data show essentially calm winds—that is, no wind direction and wind speed—for most of the day. Fig. 2-2 displays the wind rose based on the regular hourly, not special, readings.

### 2.2.2. Inversion

Sometime during the day, it appears that an inversion layer capped the greater Charleston region, if not a larger geographic area. As mentioned earlier, according to the altimeter reading in the state helicopter, taken by DAQ staff on that flight, the top of that layer was at approximately 5,800 feet. Photograph 2-1 shows that layer and how the atmosphere appeared below and above that layer.

DAQ notes that during an inversion, pollutants beneath the boundary layer get trapped. Though not reported by the NWS, clearly, such inversion occurred.

**Fig. 2-1.**
Wind Rose For Institute, W.Va., on July 11, 2008
Data Source: WVDEP / DAQ Meteorological Monitoring Station




Notes:
MPH = miles per hour
The color of the bars indicates the wind speed.
The length of the colored bars indicate the percent of the time, during this 24-hour period, that the winds blew from the direction given for that sector. For example, the winds at a speed less than 3 miles per hour blew from the east for approximately 21 percent of the total time.
“Calm .00%” indicates no periods of calm winds.

**Table 2-1. Wind Speed, Wind Direction, Air Temperature and Visibility Recorded at NWS ASOS site, July 11, 2008, Yeager Airport**

| REGULAR HOURLY READINGS | | | | | | |
|---|---|---|---|---|---|---|
| **Hour** | **Air Temperature °C** | **Dew Point, °C** | **Wind Speed, knots** | **Wind Direction** | **Visbility, miles** | **Visibility comment** |
| 1 | 17 | 16 | 0 | 0 | 5 | Broken, clear, valley fog |
| 2 | 17 | 16 | 0 | 0 | 4 | Broken, few, dense valley fog. |
| 3 | 16 | 15 | 0 | 0 | 4 | Broken; vertical visibility = 100 feet; dense valley fog |
| 4 | 16 | 15 | 0 | 0 | 4 | Broken; vertical visibility = 100 feet; dense valley fog |
| 5 | 16 | 15 | 0 | 0 | 0.25 | Fog; vertical visibility = 100 feet |
| 6 | 16 | 15 | 0 | 0 | 0.125 | Fog; vertical visibility = 100 feet |
| 7 | 16 | 16 | 0 | 0 | 0.068 | Fog; vertical visibility = 100 feet |
| 8 | 17 | 16 | 3 | 100 | 0.5 | Fog; vertical visibility = 100 feet |
| 9 | 19 | 17 | 3 | 10 | 4 | Broken; few at 100 feet; scattered at 11,000 feet; valley fog |
| 10 | 23 | 18 | 0 | 0 | 10 | Clear, valley fog |
| 11 | 26 | 17 | 0 | 0 | 10 | Clear |
| 12 | 27 | 16 | 0 | 0 | 10 | Clear |
| 13 | 28 | 16 | 0 | 0 | 10 | P |
| 14 | 29 | 17 | 4 | 30 | 10 | Clear |
| 15 | 29 | 16 | 6 | 320 | 10 | Few at 5,000 feet |
| 16 | 30 | 15 | 0 | 0 | 10 | Clear |
| 17 | 30 | 16 | 5 | 350 | 10 | Clear |
| 18 | 29 | 16 | 0 | 0 | 8 | Clear |
| 19 | 28 | 19 | 0 | 0 | 8 | Clear |
| 20 | 25 | 20 | 3 | 150 | 6 | Hazy, clear |
| 21 | 23 | 19 | 0 | 0 | 6 | Hazy, clear |
| 22 | 22 | 20 | 0 | 0 | 5 | Broken, clear |
| 23 | 21 | 19 | 0 | 0 | 4 | Broken, clear |
| 24 | 21 | 18 | 0 | 0 | 4 | Broken, clear, valley fog |
| SPECIAL READINGS | | | | | | |
| **Time (EST)** | **Air Temperature °C** | **Dew Point, °C** | **Wind Speed, knots** | **Wind Direction** | **Visbility, miles** | **Visibility comment** |
| 1:32:26 | 17 | 16 | 0 | 0 | 4 | Broken, few at 100 feet |
| 2:35:26 | 16 | 15 | 0 | 0 | 4 | Broken 100 feet, dense valley fog |
| 4:06:26 | 16 | 15 | 0 | 0 | 0.25 | Fog; vertical visibility = 100 feet |
| 5:09:26 | 16 | 15 | 3 | 30 | 0.125 | Fog; vertical visibility = 100 feet |
| 7:40:26 | 17 | 16 | 4 | 140 | 0.5 | Fog; vertical visibility = 100 feet |
| 8:20:26 | 18 | 17 | 0 | 0 | 1 | Broken; few at 100 feet; scattered at 900 feet; scattered at 11,000 feet |
| 8:23:26 | 18 | 17 | 0 | 0 | 3 | Broken; few at 100 feet; scattered at 900 feet; scattered at 11,000 feet |
| 13:56:26 | 29 | 17 | 4 | 30 | 10 | Few at 5,000 feet |

*Notes:*

Observations of visibility that indicated vertical visibilities--for example, 100 feet; or cloud cover at 11,000 feet--are for observations made at or above the instrument at Yeager.
Thus, a vertical reading of 100 feet means 100 feet above the runway at Yeager. And valley fog would be an observation made by the FAA-contracted weather observer.

Regular readings occur typically at 54 minutes and 26 seconds after the top of the hour.

Special readings occur when the conditions being monitored by the ASOS sensor(s) crosses some pre-established threshold.

$^{o}$C equals degrees Celsius, where $^{o}$F = [1.8($^{o}$C )+ 32]. For example, O$^{o}$C = 32$^{o}$F and 100$^{o}$C = 212$^{o}$F. Temperatures are rounded by ASOS to the nearest whole number. One knot = 1.15 iles per hour.

Wind direction given in degrees of compass heading. For example, 000 would be due north; 090 would equal due east; 180 would equal due south; and 270 would equal due west.

Dew point temperature, a measure of atmospheric moisture, is the temperature to which air must be cooled to reach saturation, assuming air pressure and moisture content are constant.

Visibility comments: Broken approx. equals haze, according to NWS/Charleston. "Few" = sky cover greater than zero and up to 25 percent of sky. "Scattered" = 37.5 - 50 percent sky cover.
"Broken" = 67.5 percent up to, but not including, 100 percent. "Overcast" = 100 percent sky cover.

Time, in EST, for special observations begins at midnight, which is 00:00:00 hours.

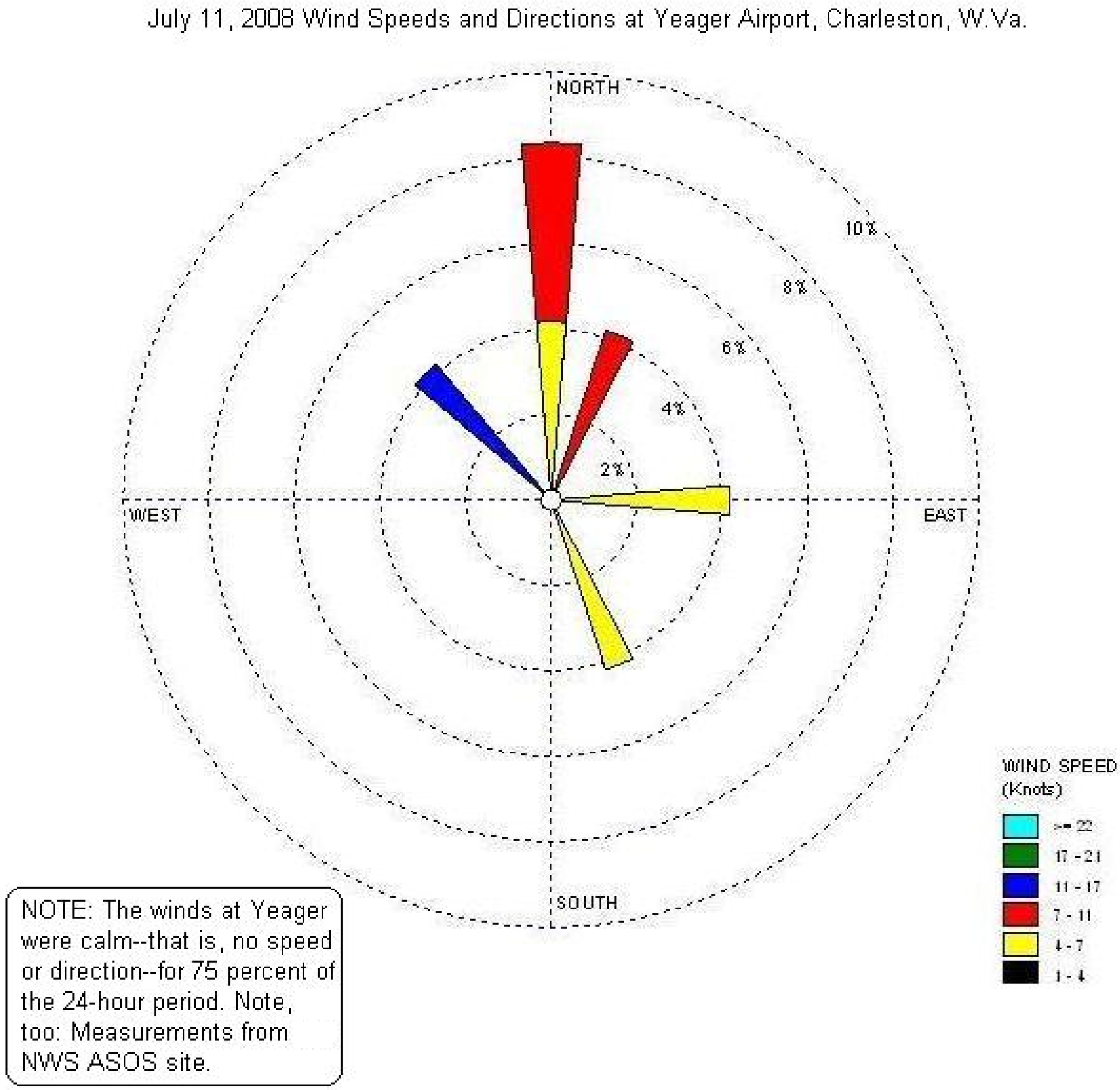
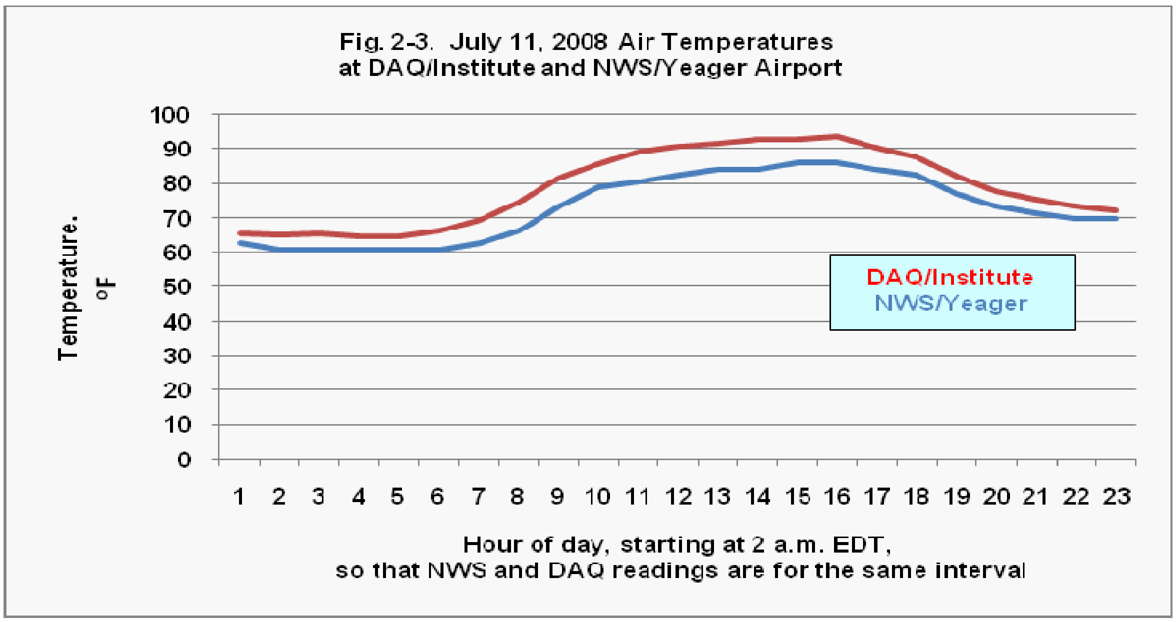



**Fig. 2-2.** Wind rose of July 11, 2008, for regular hourly readings recorded by the NWS ASOS site at Yeager Airport.

**Photograph 2-1.** Looking north of east from above Institute. Note Bayer CropScience in the extreme left-bottom corner; Interstate 64 runs from the left-bottom corner to the right-bottom quadrant; and South Charleston is at right center. Photograph taken at approximately 3:41 p.m. EDT.

### 2.2.3. Temperature

Fig. 2-3 shows the hourly temperature readings for both locations on July 11. Note that to have the temperatures match the correct times of measurements, the data start at the second hour of the day. That is because the NWS data are in Eastern Standard Time, not EDT. The time ends at midnight EDT on July 12; on the figure, this would be hour 23.




Note, too, in Fig. 2-3 that there is very little temperature difference between the temperature measurements. The monitor on the DAQ tower was approximately 300 feet lower in elevation than Yeager Airport.

### 2.2.4. Visibility

As the data in Table 2-1 show, at Yeager, the NWS described the early hours of July 11 as a few clouds or broken clouds at 100 feet above the runway. According to NWS, these readings are made by a sensor, though the on-site trained observer may override any reading if he/she believes that is unrepresentative of the actual conditions. Note, however, that the observer cannot override altimeter readings that are broadcast to aircraft, nor can the observer override any recorded pressure readings. Later visibility comments note a "dense valley fog" and limited vertical visibility for several hours.

Then, at approximately 11 a.m. EDT, NWS records "clear" readings until 2 p.m., when it reports a "few" clouds at 4,500 feet. Few means that the sky is not completely clear and the sky cover may be as much as 25 percent.

Then the reading changed back to clear and then back to "few" at 5,000 feet by 3 p.m. At 4 p.m., NWS reassigned variations of "clear" (e.g. "Clear" and "Hazy, clear") for the remainder of the hours on July 11.

However, as photographs shown earlier in this chapter depict, what DAQ identified as haze existed at ground level up to the inversion layer recorded at 5,800-feet elevation, during the DAQ field staff's surveillance using the state helicopter.

Photograph 2-2, one of the last photographs taken before the helicopter landed at Yeager, shows the downriver perspective at approximately 4 p.m. EDT. Note in the left foreground are the 36$^{th}$ and 35$^{th}$ Street bridges, as well as Interstates 64 and 77.

**Photograph 2-2.** Looking east of Charleston, toward South Charleston. The 36th and 35th Street bridges are in the left foreground, with the 36th being closer. The Kanawha River runs along the lower left quadrant until left center, when it turns diagonally toward the upper right-hand corner of the photograph. Photograph taken at approximately 3:58 p.m. EDT.

# CHAPTER 3
# ASSESSMENT and CONCLUSIONS

Like the Jan. 25, 2008, blue-haze incident, the visual impact of the most recent haze incident requires assessment and explanation.

As noted in Chap. 1, in the late afternoon of July 11, 2008, based on the observations made that afternoon by DAQ staff who made the ground and aerial surveillances—and which are presented in Chap. 2—the DAQ concluded that the AEP-operated Amos power plant was the source responsible for the haze.

This chapter presents after-the-fact and, in some cases, post-July-11 information that confirms DAQ's July conclusion. This chapter also provides to-date actions and conclusions regarding ongoing efforts to resolve the technical issues that contributed to the blue-haze incidents.

## 3.1. Overall Assessment of the Incident

### 3.1.1. Emissions

As stated in Chap. 2.1.1. of this report, on July 11, in the 35-or-so-mile portion of the Kanawha River Valley—from Poca, west or downriver of Charleston, to Belle, east or upriver of Charleston—two general types of air pollution sources operated: stationary and mobile. Of them, the largest of all and the one with the most emissions—particularly, PM, $SO_2$ and nitrogen oxides, or $NO_X$, as well as potential visibility impairing $H_2SO_4$ and HCl—was the Amos plant.

Also, as noted earlier in this report, regarding air pollution-related complaints from citizens about operations of industries in the valley, according to the DAQ's assistant director for C&E, there was nothing unusual reported that day until the haze incident unfolded at midday July 11.

Nor did any of the following occur that day:

- report, of which DAQ was aware, of any malfunction at any major facility or stationary source of air pollution

- report of any accidental release or spill of chemicals or any other substance that might cause visibility problems from those stationary sources

- report of any accidental release or spill of chemicals from any mobile sources—for example, trains or railway cars, barges or vessels on those barges, or highway tanker trucks, etc.—that might cause visibility problems

- air-pollution-related complaints received by DAQ for anything other than the haze

### 3.1.2. Principal and/or Potential Industrial Contributors

While, as noted in Chap. 2.1.1., there are many major and minor stationary sources of air pollution in the Kanawha River Valley from Belle to Winfield, the Amos power plant stands out as the principal source of pollutants that could cause visibility impairment. This is true, especially throughout the valley and into an even broader geographic area.

- In the valley, the Amos plant is the largest single emitter of $PM_{2.5}$. Particles at this size contribute to visibility impairment, through absorption and scattering of visible light

- Amos is the valley's largest single emitter of $SO_2$ and $NO_X$. Both chemical compounds, when atmospherically changed to sulfates and nitrates, respectively, contribute to haze because of their transformation into $PM_{2.5}$

- Amos is the valley's largest single emitter of both sulfuric and hydrochloric acids, both of which may be transformed into aerosols. These particles, classified as $PM_{2.5}$, can reflect or scatter light in the atmosphere, creating haze

On July 11, the following describes the operation of the Amos plant, to the best of DAQ's knowledge:

- Compliant coal—that is, coal with the allowable amount of sulfur—was burned
- The plant operated as a base-load station within normal range of power output
- All three of the plant's boilers—Units 1 and 2, each rated at 800 megawatts (MW); and Unit 3, rated at 1,300 MW—operated normally
- On those boilers, the respective selective catalytic reduction, or SCR, unit—which reduces the amount of $NO_X$ emitted and must be operated during ozone season, from May 1 through Sept. 30—operated as designed
- No malfunctions or abnormal operating conditions occurred

However, DAQ notes there was and remains reason to be concerned about the operation of the electrostatic precipitator, or ESP, associated with Unit 3—as well as the other control technology currently associated with the boiler—that could have generated higher emissions of visibility-impairing pollutants PM, particularly $PM_{2.5}$, and $H_2SO_4$:

- For approximately two years, if not longer, problems have occurred with the operation of this unit that would have decreased its PM-collection efficiency
- Due most likely to this operational fatigue, in May 2008, AEP resumed injecting sulfur trioxide, or $SO_3$, into the boiler's exhaust gas to improve PM resistivity to bolster the ESP's collection efficiency
- However, AEP may also have had to inject $SO_3$ because the company replaced one of the three catalyst beds in the SCR unit with material that converted less of

the $SO_2$ in the exhaust gas to $SO_3$. Thus, there was less innate $SO_3$ in the gas stream to help improve ESP control efficiency after catalyst replacement

### 3.1.3. Valley Wind Patterns

Based on data taken from the DAQ's meteorological monitoring tower in Institute and the National Weather Service's site at Yeager Airport, nothing unusual appeared to have occurred with respect to winds. Note, though, that both sites measure surface winds, rather than winds aloft. Fig. 2-1 and Table 2-1 in the previous chapter show these data.

### 3.1.4. Regional Wind Patterns

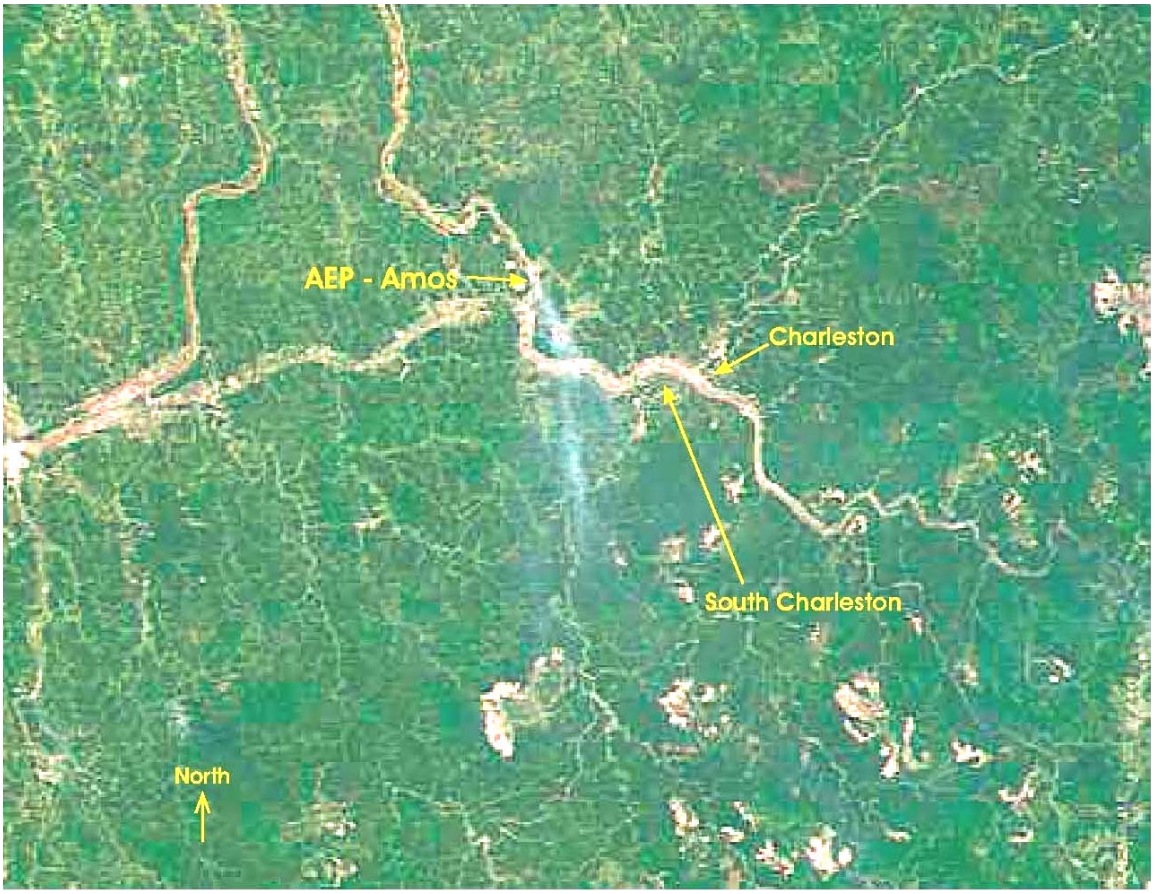
Photograph 3-1 shows how the Amos plume impacted the Kanawha River Valley and even extended into the area south of the metropolitan area.

This photograph was taken at 12:10 p.m. EDT by a National Aeronautics and Space Administration low-earth-orbit satellite. What this photograph depicts is essentially one small area on the original image, which encompasses most of the eastern U.S.

Supporting this is Fig. 3.1, which is a map of regional air flow presented using the EPA AIRNow-Tech technology. Note the following about the figure:

- The curved lines represent the trajectory or path of air moving across the region
- The red square dot to the left of "West Virginia" on the figure is Charleston
- The figure presents trajectories at three different elevations above ground level:
  - The darkest line represents 1,000 meters; or 3,281 feet of altitude
  - The next-darkest line represents 1,500 meters; or 4,921 feet of altitude

- The lightest line represents 2,000 meters; or 6,562 feet of altitude




**Photograph 3-1.** Satellite image of the Kanawha River Valley at 12:10 EDT on July 11. Note the distinctive white plume emanating from the Amos plant that has dispersed not only laterally as it moved south-south-easterly, but also had intense density in the Institute-Jefferson area.

- The lines south of Charleston, called forward-trajectories and extending into southern West Virginia and southwestern Virginia, represent a single six-hour interval. It begins at 11 a.m. Eastern Standard Time (EST)—or noon EDT—in Charleston to 5 p.m. EST (6 p.m. EDT)

Given the observations made during the aerial reconnaissance on July 11 by DAQ staff, as well as the satellite photograph of the Kanawha Valley, DAQ believes the data presented graphically in Fig. 3-1 confirm that the Amos plant emissions caused the haze incident.


**Fig. 3-1.** Forward trajectories of regional air flow over Charleston on July 11, 2008. Source: EPA AIRNow-Tech. The darkest line represents 1,000 meters (m) above ground level (AGL); the next-lightest, 1,500 m AGL; and the lightest, 2,000 m AGL.

### 3.1.5. Plume Fumigation

With the exception of the inversion layer at 5,800 feet, there seemed to be nothing meteorologically unusual on July 11. However, there must have been some mechanism for the plume from Amos to have touched down within approximately seven air miles south-southeast of the plant. DAQ surmises that even though the inversion layer was high, fumigating conditions occurred that caused the plume to touch down at the ground surface.

DAQ also notes that two photographs taken from the helicopter depict the plant's combined plumes' movement upriver from the plant and from altitude to ground level.

The first, Photograph 3-2, shown earlier as photograph ES-1, gives a perspective of the upper air flow and the top of the inversion layer.

**Photograph 3-2.** View of Amos power plant taken from a state helicopter, approximately above the Nitro-St. Albans area. For reference, note that the left-most stack from which blue smoke exhausts—the second stack from the left—is approximately 1,000 feet tall. Note, too, that the two large white cumulus clouds are not directly over the plant, but closer to the helicopter than the plant. Photograph taken at approximately 3:37 p.m.EDT.

The second, Photograph 3-3, was taken above Institute at approximately the Bayer CropScience facility. Note that the Amos plant would be behind the aircraft, to its left.

- In that photograph, to the left of the aircraft en route to Amos plant, a distinctly noticeable vertical boundary exists at the edge of the denser whitish cloud moving from the Amos plant—off the frame, to the left-center—to the south-southeast

- On the photograph, that line extends from the extreme left-center edge to approximately the upper right-hand corner

**Photograph 3-3.** Looking east-southeast from above Nitro. Bayer CropScience in Institute is in the left foreground. South Charleston and Charleston are in the upper right quadrant of the photograph. The Amos plant is outside the frame of the photograph, southwest of the center of the photograph. Note the Amos plume's edge, shown at leftmost center and running in an approximate straight line to rightmost corner. Photograph taken at approximately 3:34 p.m. EDT.

### 3.1.6. Haze

The color of the haze depended on who saw it and their vantage. As noted in Chap. 2, public complaints described the haze as either blue or smoky. DAQ does not have information as to the citizen observers' position relative to the sun, however. But DAQ staff who investigated the incident described the haze as whitish and/or grayish, perhaps with some bluish tint.

Regardless, visibility was limited in a certain trajectory or path south and southeast of the Amos plant, as the plume spread due to changing wind directions aloft.

DAQ believes several pollutants or physical states and forms of them would have contributed:

- Generally, dust and smoke in the atmosphere may create a bluish haze, though its intensity depends on the number of particles, their mass and their optical properties

- Aerosols—minute particles suspended in the atmosphere—produce haze through their mass concentration and particle count, which causes scattering or absorption of sunlight

- Particulate matter such as $PM_{2.5}$ can be emitted directly from stacks of combustion sources such as the Amos plant and can cause visibility problems

- Sulfates associated with fossil-fuel combustion, especially coal and oil, are a major factor in atmospheric haze. These pollutants are called secondary $PM_{2.5}$, meaning they form once the $SO_2$ reacts in the atmosphere with other pollutants

- Nitrates associated with fossil-fuel combustion, especially coal and oil, are a major factor in atmospheric haze. These pollutants are called secondary $PM_{2.5}$, meaning they form once the $NO_X$ reacts in the atmosphere with other pollutants

- As aerosols, which are at least $PM_{2.5}$, if not substantially smaller, acid mists of sulfuric acid and hydrochloric acid give bluish or blue-white haze

- Other potential contributors include VOCs. These may be released into the atmosphere by evaporated fuels, such as gasoline at filling stations; incomplete combustion of fossil fuels in internal combustion or diesel engines, as well as boilers or incinerators; and the evaporation of solvents. The VOCs photochemically react with $NO_X$ to form what is commonly called smog. On July 11, VOCs recorded as ozone at the Baptist Temple site were elevated, in part due potentially to the transport of ozone from nearby mid-western and southeastern states. That pollutant would have added, generally, to the haze that covered the area, but not the dense plume attributable to the Amos plant

- Ambient air quality data at two monitoring sites, atop the library in South Charleston and atop the Baptist Temple in downtown Charleston, show elevated $PM_{2.5}$ levels during the incident: 53.8 micrograms of $PM_{2.5}$ per cubic meter of air sampled (μg/m$^3$) at Baptist Temple; and 45.1 μg/m$^3$ at South Charleston

- As shown in Fig. 3-2, $PM_{10}$ and $SO_2$ values at the Baptist Temple site rose significantly during the incident

- While fossil-fuel-fired combustion sources; oil-fired boilers; and mobile sources generate $PM_{2.5}$, the particulate matter emissions generated by the Amos plant's three boilers eclipse all other sources in the trajectory of the combined plume from the Amos plant. DAQ notes that the plant's three boilers are among the largest coal-fired utility boilers in the world

DAQ also believes it is reasonable to conclude that the trapping of combustion gases and the associated pollutants from stationary sources was a significant, if not the primary, cause of the increased measurements of $PM_{2.5}$ and $SO_2$ on July 11.

### 3.1.7. Blue Plume

#### 3.1.7.1. Background

State and federal environmental protection agencies, as well as the coal-fired power generation industry, have known for some time about the blue-plume phenomenon from coal-fired power plants. This visual phenomenon occurs when power plants burn sulfur-containing coal and/or when those power plants use certain types of air-pollution-control equipment.

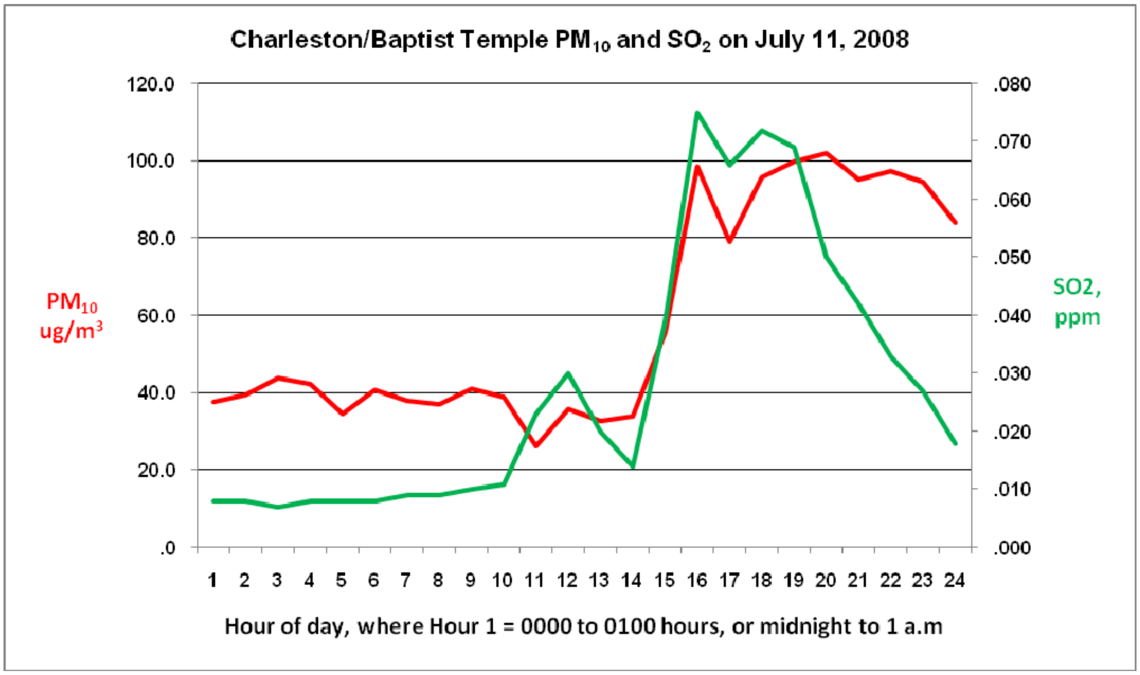



**Fig 3-2.** $PM_{10}$ and $SO_2$ ambient measurements at the Charleston/Baptist Temple monitoring site on July 11, 2008. Note that ppm equals parts per million. Note also the following: ug/m$^3$ equals micrograms per cubic meter (one microgram equals approximately 4/10,000,000$^{th}$ of an ounce; or 0.0000000353 ounce). The National Ambient Air Quality Standard (NAAQS) for $PM_{10}$, for a specified 24-hour period, is 150 µg/m$^3$. The NAAQS for $SO_2$, for a specified three-hour period, is 0.5 ppm. The NAAQS for $SO_2$, for a specified 24-hour period, is 0.14 ppm. The 24-hour NAAQS for $SO_2$ is the primary standard.

The blue plume arises from $SO_3$. Historically, it came from two sources in coal-fired power-plants: from the oxidation of sulfur during combustion of sulfur-containing coal; and through use of $SO_3$ as a performance enhancement in ESPs, to lower the electrical resistivity of particulate matter, thus making its collection easier and more complete.

DEP notes it is generally expected that 1-2 percent of the sulfur in the combusted coal converts to $SO_3$. The equation for the combustion of the sulfur in the coal is as follows:

$$\text{S (solid)} + \text{O}_2\text{ (gas)} \xrightarrow[\text{heat}]{} \text{SO}_2\text{ (gas)}$$

$$2\text{ S (solid)} + 3\text{ O}_2\text{ (gas)} \xrightarrow[\text{heat}]{} 2\text{ SO}_3\text{ (gas)}$$

However, at the Amos plant and other coal-fired power plants having SCR units to reduce $NO_X$ emissions, the SCR units typically convert 1-2 percent of the $SO_2$ to $SO_3$. DEP notes, again, that on July 11, the SCR units for the 1,300-MW Amos Unit 3 and the two 800-MW Units 1 and 2 were operating.

In the SCR, the $SO_2$-to-$SO_3$ conversion occurs as the $SO_2$-and-$NO_X$-laden exhaust gas, which also contains PM as well as $SO_3$, exits the boiler and then passes through and over the SCR control unit's catalyst beds. These are rigid rectangular-shaped containers that have materials that convert the $NO_X$ to $NO_2$ and water. The following equation describes the conversion reaction of $SO_2$ to $SO_3$ in this process:

$$2\ SO_2\ (gas) + O_2\ (gas) \xrightarrow[\text{catalyst}]{} 2\ SO_3\ (gas)$$

The 1-2-percent conversion rate across the catalyst bed means that, approximately, an additional 1-2 percent of the sulfur in the coal fed into the boiler is converted to $SO_3$. Thus, the effect of the SCR catalyst bed may approximately double the amount of $SO_3$ generated in the boiler combustion chamber. Therefore, for coal-fired boilers having SCR units, like the current configuration at the Amos plant's boilers, DAQ believes it is reasonable to assume that approximately 2-4 percent of the total sulfur content of combusted coal converts to $SO_3$. DAQ notes, though, that it does not have current information on the percent reduction in $SO_3$ created across Unit 3's SCR. Also, as stated earlier, AEP replaced one of the three catalyst beds in the spring of 2008 in that boiler's SCR with a lower-$SO_2$-to-$SO_3$-conversion catalyst.

The $SO_3$ generated in those SCR air pollution control devices and the boiler and an $SO_3$-conditioning system used with an ESP, which was the case with Unit 3 through early September 2008, then combines with water, or $H_2O$, in the exhaust gas to produce $H_2SO_4$, or sulfuric acid. The following equation describes the overall reaction, which is known as gas-phase hydrolysis of the $SO_3$:

$$SO_3\ (gas) + H_2O\ (gas/vapor) \longrightarrow H_2SO_4\ (gas)$$

But at coal-fired plants such as Amos that have no current wet flue-gas-desulfurization (wet FGD) unit operating on any of their boilers, the sulfuric acid created as a result of the combustion of coal and conversion across the SCR catalyst beds exits the stack as vaporous sulfuric acid.

At some distance from the stack, depending on the atmospheric conditions of temperature and humidity—as well as turbulence, the presence of cooling-tower plumes and, to some extent, the presence of fine particulate matter—the vapor transforms into an acid mist or aerosol. That aerosol is highly refractive, which means it easily reflects light, especially in the blue part of the visible spectrum. Consequently, observers might see a blue plume or haze.

Regardless of the amount of sulfuric acid actually emitted from the Amos stacks, given the potential acid emissions from the plant, DAQ contends that these emissions also contributed to the haze. Two factors remain unknown, however:

- how much sulfuric acid would be normally emitted
- how much additional acid would be created, given that after years of not injecting $SO_3$ into the exhaust gas as a conditioner, AEP resumed injecting $SO_3$ into the exhaust gas, upstream of Unit 3's ESP

### 3.1.7.2. Mitigation

DAQ has concluded that the acid, combined with substandard air-pollution-control-device operating conditions at Amos Unit 3 during July and unique meteorological circumstances in the Kanawha River Valley region, caused the July 11 blue-haze incident in the greater Charleston area. Problem resolution will involve control technology for $SO_3$, the precursor of $H_2SO_4$, and repair and upgrade of the affected control device. Resolution may also require the use of certain technologies used at Amos Unit 3 to be discontinued;

for example, AEP indicated in mid-December 2008 that it will discontinue use of the $SO_3$- and ammonia-injection systems when Unit 3 restarts.

### 3.1.7.2.1. Background

As noted earlier, APCO injected $SO_3$ into Unit 3's exhaust-gas stream to bolster reduced PM-collection efficiency of the unit's ESP. The injected gas lowers the electrical resistivity of the particulate matter in the boiler exhaust gas. That alteration improves the ESP's removal efficiency of those particles. According to the company, the injection began in May and continued through early September. APCO reported to DAQ that this $SO_3$-conditioning practice, though once used at Amos, had not been used for years until May 2008.

While it may have improved PM collection efficiency, excess or unused injected $SO_3$ also contributed to sulfuric-acid-generated visibility problems. As discussed earlier in Section 3.1.7.1., the $SO_3$-to-$H_2SO_4$ conversion mechanism is straightforward: In the presence of water, such as moisture in the exhaust gas, $SO_3$ converts to $H_2SO_4$. The excess $SO_3$ would have added to the other two significant sources of that gas which exist in coal-fired power systems: combustion of sulfur-containing coal in boilers; and, if installed, SCR control devices that reduce $NO_X$.

The substandard operational situation in Unit 3 ESP, combined with the $SO_3$-injection systems and the generation of $SO_3$ across the SCR, aggravated the visibility problems. Historically and more recently, AEP indicated Unit 3 ESP was undersized from its first day in service in 1972. Thus, the unit gave only marginal collection efficiency. That marginal operation often requires auxiliary means, such as $SO_3$ conditioning, to meet regulatory particulate and opacity limits.

Further, 36 years of near-continuous operation of that ESP caused deterioration and inefficient PM collection. The agency notes that for several years prior to September 2008, it observed continued decline in Unit 3 ESP operations. Evidence included increased visible emissions from the unit's exhaust stack. Other evidence included rust at the seams of the ESP shell, which caused openings through which smoke could be seen being released. That the company resumed $SO_3$ injection in mid-2008 further confirmed the loss of even marginal effectiveness of Unit 3 ESP.

This overall worsening performance caused the opacity of those visible stack emissions to exceed federally-enforceable state regulatory limits with greater frequency than in past years. However, the infractions did not warrant formal enforcement actions. Note that opacity is the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

**3.1.7.2.2. Analysis of Available Data**

To better understand the conditions that caused the visibility problem, identify and develop remedies, and assist AEP in doing the same, the agency analyzed Amos' operating data and applied its long-term observations of plant operations, particularly deterioration of the PM collection efficiency of Unit 3 ESP.

As part of this effort, DAQ and AEP staff have exchanged written and electronic correspondence, had telephone conversations and met on several occasions. Through these various communication methods and meetings, both groups agreed on at least the following:

- The ESP's worsened performance helped create the conditions at the plant leading to the Jan. 25 and July 11 blue-haze incidents

- $SO_3$ injection contributed to the July 11 incident

- $SO_3$ control was needed to reduce, if not eliminate, the $H_2SO_4$ emissions problem

As a result of these communications, AEP/APCO assured the DEP that it would take action at the Amos plant to mitigate the $SO_3$ that creates sulfuric acid.

In a Sept. 19, 2008, letter, AEP discussed another source at Amos that may have contributed to the haze problem. In mentioning the ammonia-injection system used to counter blue-plume conditions at Amos Unit 3, AEP said that "dry sorbent systems have none of the adverse impacts that have been experienced using the current ammonia injection system, which was difficult to optimize, and the operation of which may have been responsible for exacerbating opacity levels from Amos Unit 3 . . ."

In a Feb. 6, 2006, document, titled "John E. Amos Plant FGD Material Handling Construction Permit Application," AEP stated in Attachment G "Process Descriptions," in the section "$SO_3$ Mitigation System," that:

> If not mitigated, the increase in $SO_3$ [from the SCR units] and subsequent formation of $H_2SO_4$ can result in visible emissions downwind of the stack. It is anticipated that a supplemental $SO_3$ mitigation system will be needed to help reduce $SO_3$ concentrations.

Thus, for at least approximately two years prior to the first of the 2008 blue-haze incidents, it appears AEP understood that the Amos facility could contribute to blue-haze conditions downwind of the plant.

### 3.1.7.2.3. To-Date Actions

In September 2008, APCO idled Unit 3 for scheduled major repairs and upgrades. According to the utility, those activities will be completed in the first quarter of 2009, and will include the following:

- connection and startup of the new wet flue-gas desulfurization device (wet FGD) or scrubber that reduces sulfur dioxide ($SO_2$)

- installation and continuous operation of a dry-sorbent-injection (DSI) system to reduce $SO_3$ generated by the boiler and the associated SCR system that is used to reduce nitrogen oxides ($NO_X$)

- repair and upgrade of the existing ESP

AEP indicated it will install, at Unit 3 and the other two boiler trains at Amos, a Trona-based DSI system to reduce $SO_3$. A dry sorbent, Trona is an alkali material that has been used with apparent success for several years at AEP's General James M. Gavin Plant near Cheshire, Ohio (Gavin). Into the ductwork upstream of the ESP, but downstream of the SCR system, this DSI system injects dry powdered Trona into hot exhaust gas from the boiler. The injected material removes $SO_3$. The ESP then collects excess unreacted Trona as well as solid salts created by the Trona-$SO_3$ reaction. DAQ notes that at the Amos and Gavin boilers, the ESPs are cold-side units, meaning they are located downstream of the boiler systems' respective air preheaters.

In the previously mentioned Aug. 11, 2008 letter to DAQ, AEP also mentioned the possibility of installing magnesium hydroxide ($Mg(OH)_2$) and hydrated lime ($Ca(OH)_2$) injection systems to its Unit 3. But then, in the previously mentioned Sept. 19 letter, AEP indicated it would install only injection ports downstream of the air preheater that could accommodate both Trona and hydrated lime, but not install the $Mg(OH)_2$ injection system in the boiler.

Since receipt of a Sept. 19 letter from AEP describing those planned actions, DAQ has been working to develop an agreement that would embody enforceable commitments to control the $SO_3$ and $H_2SO_4$ from the Amos plant's three boilers. The agency believes it is appropriate to include the commitments as conditions in a federally-enforceable permit or consent order.

Therefore, DAQ sent a letter to AEP on Nov. 24, 2008, having two general purposes.

- One was to gather additional, more specific information to determine if the DSI system or systems being installed at the Amos plant would minimize $SO_3$ and $H_2SO_4$ generated by the boilers and boiler trains

- The other equally important purpose was to apprise the company that DAQ believes enforceable commitments are necessary to ensure that the $SO_3$ mitigation systems are used continuously and operated properly. DAQ indicated AEP should give this matter the highest priority and that it should be finalized prior to the restart of Unit 3

AEP responded Dec. 12, 2008. The utility indicated its willingness to discuss permit conditions in which the agency's continuing concerns, regarding operation of the $SO_3$-control equipment, could be addressed. The utility committed to maintain or reduce $SO_3$ below current levels and mitigate any visible trailing plume. However, AEP indicated this must be accomplished without impacting the operation of other air pollution control devices, or the overall operation of the boiler.

In its response, AEP also presented information on sorbent selection and system flexibility. The utility said it selected Trona for Amos Unit 3 and the other boilers for "its better overall performance in $SO_3$-mitigation systems." But, concerned about long-term supply of that sorbent, AEP noted it incorporated sufficient design flexibility in the DSI system so injection of either Trona or another dry sorbent, including hydrated lime, could occur.

About the design and operation of the Trona-based DSI system, AEP established the following through the Dec. 12 letter:

- It is designed to achieve approximately 90 percent removal of $SO_3$ into the DSI system, with sorbent injection at maximum design operating conditions

- It is designed to operate continuously under normal operating conditions, "with periodic downtime for maintenance and repairs"

- It has several levels of redundancy "to minimize the need for a wholesale back-up system"

- Its operating conditions will be monitored by AEP so the utility can optimize Trona injection and maintain consistent $SO_3$ control

## 3.2. Conclusions

As the introduction to this chapter states, the DAQ concluded in late afternoon July 11 that the AEP-owned and APCO-operated Amos plant was responsible for the haze incident that day in the greater Charleston area. In declaring that, the agency based its conclusion on the visual observations made that afternoon by DAQ staff who conducted the ground and aerial surveillances.

Moreover, based on other information gathered that day and even some information gathered prior to the July 11 incident, as well as data gathered and analyzed since, DAQ now believes more concretely that the Amos plant was the source responsible for the July 11 blue-haze incident. That information includes the following:

- photographs taken by DAQ staff during the aerial surveillance

- a NASA satellite photograph, taken July 11, highlighting the Amos plant's combined plume and its movement in the Charleston region

- airflow trajectories from the EPA's AIRNow-Tech system showing the airflow patterns in the greater Charleston area and into southern West Virginia

- analysis by DAQ staff of data from and/or about the Amos plant as it was operating on July 11

- communications between DAQ and AEP since the Jan. 25 and July 11 blue-haze incidents

- AEP statement in a Feb. 6, 2006, document, titled “John E. Amos Plant FGD Material Handling Construction Permit Application,” at Attachment G “Process Descriptions,” in the section “$SO_3$ Mitigation System,” that “if not mitigated, the increase in $SO_3$ and subsequent formation of $H_2SO_4$ can result in visible emissions downwind of the stack. It is anticipated that a supplemental $SO_3$ mitigation system will be needed to help reduce $SO_3$ concentrations”

- AEP statement in a Sept. 19, 2008 letter to DAQ that “dry sorbent systems have none of the adverse impacts that have been experienced using the current ammonia injection system, which was difficult to optimize, and whose operation may have been responsible for exacerbating opacity levels from Amos Unit 3 . . .”

### 3.3. Planned DAQ Actions

DAQ believes that when completed, the repairs to and upgrade of the Unit 3 ESP, as well as the use of the DSI systems installed at each of the three Amos boilers, will decrease the likelihood of—if not prevent—additional Amos-related blue-plume/blue-haze incidents in the region.

But to do so, DAQ also believes it is essential that the following two conditions be met by AEP for that level of control to occur at the facility:

- that AEP install, operate and maintain air-pollution-control technology or technologies that continuously minimize $SO_3$ generated by Unit 3 and its associated SCR system

- that AEP then install, operate and maintain air-pollution-control technology or technologies that continuously minimize $SO_3$ generated by Units 1 and 2 and their associated SCR systems

As noted in the previous section, in the Dec. 12 response to DAQ's Nov. 24 information request, AEP indicated its willingness to discuss permit conditions in which the agency's continuing concerns, regarding operation of the $SO_3$-control equipment, could be addressed. But while the utility's responses encouraged the agency, DAQ still needed more clarification of the specific operating parameters for the DSI system.

Subsequently, DAQ met with the utility on Jan. 13, 2009, to discuss acceptable enforceable conditions. At the meeting, AEP reiterated its willingness to develop specific language regarding $SO_3$ control. However, a major obstacle surfaced: the uncertainty about how the Trona system would perform specifically at the Amos plant. To date, the utility's experience using this technology for at least two other locations shows that the system's performance is very site-specific. According to AEP, there also can be adverse interactions with the other air-pollution controls, particularly the ESP, that do or may lead to materials corrosion. Site water-quality discharge issues may arise, among others.

After some discussion, DAQ and AEP agreed that the utility would enter into a consent order. Through it, AEP will be required to conduct a 12-month study, beginning with the restart of Unit 3, to determine appropriate operating parameters for the $SO_3$-control system on that boiler. Most importantly, DAQ expects the consent order to require the operation of the Trona-injection system whenever Unit 3 is operating, though not during its start-up/shut-down and maintenance. Operation of the system will also be required on Unit 1 and Unit 2 after the units have been tied into the $SO_2$ scrubber and restarted.

Through the order, AEP will also be required to monitor and record various operating parameters. Those include, but are not limited to, boiler load, boiler heat input and Trona injection rate. Then, AEP must make those data available to the agency upon request. The agency will use these data to determine specific permitting conditions for the $SO_3$-mitigation systems.

Ultimately, DAQ will develop a federally-enforceable permit that will apply to the operation of the $SO_3$-reduction systems at the Amos plant, thereby reducing the likelihood of future localized haze events.