The connections that link environment, energy and health are as historic and direct as the 446 bridges that crisscross Pittsburgh, the city with more bridges than anywhere else in the country. The 2017 Air & Waste Management Association’s Annual Conference & Exhibition (ACE) will examine how leaders in industry, government, academia, and non-governmental citizen groups work together to improve community health and protect the environment. The Pittsburgh area is a great example of the amazing improvements in environmental quality and health that can occur when these groups are bridged together. Industry in this region has evolved to a diverse portfolio of energy suppliers, manufacturing plants, medical facilities and technology companies that are harnessing energy in sustainable and innovative ways.

Come join us as we advance the science of air and waste management and recognize the many bridges to environment, energy and health.
DISCOVER-AQ Update: Advancing Air Quality Measurement Knowledge

This issue of *EM* provides an update on the DISCOVER-AQ project over Denver, focusing on FRM/FEM evaluations for ozone and nitrogen dioxide; remote sensing methods; small sensor technology evaluation; citizen science; and fine-scale modeling.

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**Evaluation and Comparison of Methods for Measuring Ozone and Nitrogen Dioxide Concentrations in Ambient Air during DISCOVER-AQ**


**The Use of LIDAR Technology for Measuring Mixing Heights under the Photochemical Assessment Monitoring Stations (PAMs) Program; Leveraging Research under the Joint DISCOVER-AQ/FRAPPÉ Missions**

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by Rachelle M. DuVall, Russell W. Long, Melinda R. Beaver, and James J. Szykman, U.S. Environmental Protection Agency; and Keith G. Kronmiller and Michael L. Wheeler, Jacobs Technology Inc.

**Multi-Perspective Observations of Nitrogen Dioxide over Denver during DISCOVER-AQ: Insights for Future Monitoring**

by James H. Crawford and Jassim Al-Saadi, NASA Langley Research Center; Gordon Pierce, Colorado Department of Public Health and Environment; Russell W. Long and James J. Szykman, U.S. Environmental Protection Agency; James Leitch, Ball Aerospace; Caroline Newhall, Harvard Smithsonian Astrophysical Observatory; Jay Herman, University of Maryland, Baltimore County; and Andrew Weinheimer, National Center for Atmospheric Research

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**Etcetera:** NESHAPs...No Exemptions: EPA to Require All Site Cleanups Adhere to MACT

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My family has started a tradition of a vacation in August right before the kids start back to school. Somehow the thought of them only having three months off is crazy and we need to give them a big send off. But it gives us an opportunity to reconnect as a family and remind ourselves of why we work hard.

This past academic year, I was impressed by the science curriculum my 6th grade daughter was bringing home. She had full modules on chemistry, biology, physics, and anatomy. But most interesting to me were her modules on meteorology and pollution. She was learning about convection, weather patterns, and the dynamics of airborne chemistry and particle movement. Obviously, their investigation was limited by their knowledge of math and other scientific disciplines, but conceptually they were being provided with enough of a base to have a conversation.

As I do each year after leaving A&WMA’s Annual Conference, I reflected back on the students I met and was amazed by their academic accomplishments. Each time I rest on the same conclusion of “wow, they are way ahead of where I was at that point in my education.” Then I wonder how they got started. When did they first consider air pollution? What drove them to this field? What will their future be? How can we encourage them to remain engaged?

Considering all of the progress the scientific community has made, the early involvement of future generations can only improve our ability to develop new technologies and practices. Just talking to my daughter about her schoolwork, even at the age of 11, she was asking basic questions that were forcing me to reconsider some of the things I have held as basic truths for years.

That type of natural curiosity, questioning things that many of us consider to be fundamentals exemplifies the type of natural curiosity which makes young minds so powerful. Occasionally, I push myself to try and ask questions the way my children would, it helps me gain perspective. It provides the freedom to truly question everything. And I can’t help but think that it will be that type of thinking which will potentially lead my daughter to be a great scientist, or drive A&WMA’s current student population into the spotlight with the next great theory.

So celebrate the forthcoming new academic year and think like you have no answers. Review the basics and allow yourself to question literally everything. Well, maybe don’t reconsider career paths, we need the intellect of our current and future members to continue pushing us forward.

[Editor’s Note: A complete list of the student award winners from this year’s conference can be found on the following page.]
CONGRATULATIONS
To the 2016 Student Award Winners

Doctoral Dissertation Paper Winners
Masoud Jahanbarg-Lashaki 1st Place $700
Stephen Neil Feinberg 2nd Place $500
Ho-Tang Liao 3rd Place $300

Master's Thesis Paper Winners
Yen-Hau Chen 1st Place-Tie $400
Saeid Niknaddaf 1st Place-Tie $400

Student Platform Paper Winners
Mohsen Ghafari 1st Place $500
Sheena Martenies 2nd Place-Tie $250
Xinyi Niu 2nd Place-Tie $250

Student Poster Winners—Undergraduate
Christian Jarquin 1st Place $400

Student Poster Winners—Masters Level
Keerthisaranay Palanisamy 1st Place $600
Li-Ting Yen 2nd Place $400
Mounika Sajja 3rd Place $300

Student Poster Winners—Ph.D. Level
Jian Sun 1st Place $900
Andrew Keebaugh 2nd Place $500
Nebechi Osia 3rd Place $300

2016 ECI Competition Winners

Michigan State 1st Place $4000
Avik Chakrabarti
Tiffany Sheroch
Rachael Underwood

Virginia Tech 2nd Place $3000
Syeed Iskander
Akshay Jain
Shiqi Jiang Zou

Cal Poly 3rd Place $2000
San Luis Obispo
Naomi Hennefeld
Chris Leclar
Shea Oades
Emily Miller
Lisa Vance

2016 Exceptional Education Contributor Award

Violette Roberts, Community Relations/Education Manager
Mojave Desert Air Quality Management District (MDAQMD)

The Exceptional Education Contributor Award is given each year to an individual from any background who has contributed to A&WMA's educational mission as implemented through its Education Council.

Violette has been the manager and founder of the MDAQMD's award-winning education and outreach program since 1997. The program serves to educate more than 500,000 residents across California's second largest air district regarding the health effects of air pollution, its causes, and the public's important role in preventing pollution. She is also the Founder/Executive Board Chair of the Mojave Environmental Education Consortium, a unique public-private non-profit partnership which brings together business, government and the educational community for the purpose of increasing the environmental literacy of students.
This article summarizes ambient evaluations of the performance of ozone and nitrogen dioxide methods that were conducted under the umbrella of the NASA-led DISCOVER-AQ mission.
Under the U.S. Clean Air Act, the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six “criteria” pollutants—carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead, and particulate matter—that are set forth in Title 40, Part 50 of the Code of Federal Regulations (40 CFR Part 50). EPA and the states are jointly responsible for monitoring the ambient air for these pollutants. This monitoring is carried out as part of a national network of monitoring sites, called the State and Local Air Monitoring Stations (SLAMS). The air quality data obtained from these sites are reported to EPA’s Air Quality System (AQS) database, along with other information, and are used for determining compliance with the NAAQS; assessing effectiveness of State Implementation Plans (SIPs) in addressing NAAQS nonattainment areas; characterizing local, state, and national air quality status and trends; and associating health and environmental damage with air quality levels/concentrations.

To assure the accuracy, integrity, and uniformity of the SLAMS air quality monitoring data collected, EPA has established one or more Federal Reference Methods (FRM) for measuring each of the six criteria pollutants. These FRMs are set forth in appendices to 40 CFR Part 50 and specify a particular measurement principle to be implemented in commercially produced monitoring instrumentation. These FRM instruments must be shown to meet detailed performance specifications in addition to other requirements detailed in the EPA regulations at 40 CFR Part 53.

To encourage innovation and development of new air quality monitoring methods, EPA has provided for Federal Equivalent Methods (FEMs). An FEM is not constrained to the particular measurement principle specified in the corresponding FRM. However, an FEM must meet the same or similar performance requirements as specified for the corresponding FRM, and must show a high degree of comparability to collocated FRM measurements at one or more field testing sites. These FEM requirements are also detailed in 40 CFR Part 53, and a monitor that is shown to meet all applicable requirements may be designated by EPA as an FEM monitor and used for NAAQS compliance monitoring.

This article summarizes ambient evaluations of the performance of ozone and nitrogen dioxide methods that were conducted under the umbrella of the NASA led DISCOVER-AQ Earth Venture Mission. In addition to contributing to the overall goals and desired outcomes established for the DISCOVER-AQ study, EPA conducted extensive ambient testing of the various ozone and nitrogen dioxide methods to verify that the methods meet all existing and anticipated future requirements for FRM and FEM analyzers used in NAAQS compliance monitoring. The tests also evaluated the various analyzers’ performance (comparability) relative to each other in unique operating environments such as near roadway sampling locations.

**Experimental Methods**

Ambient evaluations of the various ozone and nitrogen dioxide methods were conducted during field intensive studies as part of the NASA DISCOVER-AQ project conducted during July 2011 near Baltimore, MD; January–February 2013 in the San Juaquin Valley, CA; September 2013 in Houston, TX; and July–August 2014 near Denver, CO. During field intensive studies, instruments were calibrated according to manufacturers’ operation manuals and in accordance with FRM requirements listed in 40 CFR 50.

During the ambient evaluation campaigns, nightly automated zero and span checks were performed to monitor the validity of the calibration and control for drifts or variations in the span and/or zero response. Both the calibration gas concentrations and the nightly zero and span gas concentrations were delivered using a dynamic dilution calibration system (T700U/T701H, Teledyne API). The analyzers were housed...
within a temperature-controlled shelter during the sampling campaigns. A glass inlet with sampling height located approximately 5 m above ground level and a subsequent sampling manifold were shared by all instruments. Data generated by all analyzers were collected and logged using a field deployable data acquisition system (Envidas Ultimate). A summary of instruments used during DISCOVER-AQ deployments is listed in Table 1. Figure 1 shows a typical DISCOVER-AQ site (Houston 2013) where EPA (and others) instrumentation was deployed.

### Ozone Methods Results and Implications

On October 1, 2015, revisions to the NAAQS for Ozone were promulgated setting the level at 0.070 parts per million (ppm) or 70.0 parts per billion (ppb) in the form of the annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years. Prior to the 2015 revision, the NAAQS for ozone was 0.075 ppm (75.0 ppb) in the same form as the revised NAAQS. During the DISCOVER-AQ campaigns, field evaluations and comparisons of existing FRM and FEM analyzers for ozone show good agreement among the methods for 1-hr average ozone determinations.

### Table 1. Methods for ozone and nitrogen dioxide used during DISCOVER-AQ.

<table>
<thead>
<tr>
<th>Manufacturer and Model</th>
<th>Operation Principle (Abbreviation)</th>
<th>FRM/ FEM</th>
<th>DISCOVER-AQ Field Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ozone Methods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bendix Model 8002</td>
<td>Ethylene-Chemiluminescence (ET-CL)</td>
<td>FRM</td>
<td>Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>Teledyne API Model T265</td>
<td>NO-Chemiluminescence (NO-CL)</td>
<td>FEM, FRM</td>
<td>Baltimore 2011; Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>2B Technologies Model 211</td>
<td>“Scrubberless” UV Photometric (SL-UV)</td>
<td>FEM</td>
<td>Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>2B Technologies Model 205</td>
<td>UV Photometric (UV-Drier)³</td>
<td>FEM</td>
<td>Houston 2013</td>
</tr>
<tr>
<td>Ecotech Model EC9810</td>
<td>UV Photometric (UV-Drier)³</td>
<td>FEM</td>
<td>Baltimore 2011</td>
</tr>
<tr>
<td>Thermo Scientific Model 49i</td>
<td>UV Photometric (UV)⁴</td>
<td>FEM</td>
<td>Houston 2013</td>
</tr>
<tr>
<td><strong>NO2 Methods</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Teledyne API Model T200U</td>
<td>Thermal convertor-chemiluminescence (Moly-CL)</td>
<td>FRM</td>
<td>San Joaquin Valley 2013; Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>Thermo Scientific Model 42c</td>
<td>Thermal convertor-chemiluminescence (Moly-CL)</td>
<td>FRM</td>
<td>Baltimore 2011</td>
</tr>
<tr>
<td>Teledyne API Model 200EUP</td>
<td>Photolytic Convertor-Chemiluminescence (Photo-CL)</td>
<td>FEM</td>
<td>Baltimore 2011; San Joaquin Valley 2013; Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>Teledyne API Model T500U</td>
<td>Cavity Attenuated Phase Shift spectroscopy (CAPS)</td>
<td>FEM</td>
<td>Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>Environment SA Model AS32M</td>
<td>Cavity Attenuated Phase Shift spectroscopy (CAPS)</td>
<td>FEM</td>
<td>Houston 2013; Denver 2014</td>
</tr>
<tr>
<td>Aerodyne CAPS NO2 Analyzer</td>
<td>Cavity Attenuated Phase Shift spectroscopy (CAPS)</td>
<td>NA⁶</td>
<td>San Joaquin Valley 2013; Houston 2013</td>
</tr>
<tr>
<td>Los Gatos Research CRDS NO2 Analyzer</td>
<td>Cavity Ringdown Spectroscopy (CRDS)</td>
<td>NA⁶</td>
<td>San Joaquin Valley 2013; Houston 2013</td>
</tr>
</tbody>
</table>

**Notes:**
1. The ET-CL method was established as a FRM for Ozone in 1971.
2. The Teledyne API T265 analyzer was designated and operated as an FEM during all DISCOVER-AQ deployments. The T265 has since been re-designated as a FRM after the NO-CL method was established as a new FRM for ozone as part of the October 1, 2015 Ozone NAAQS rulemaking.
3. Both the 2B Technologies Model 205 and Ecotech EC9810 contain sample conditioning systems to remove water from the sample stream.
4. Thermo Scientific Model 49i does not contain a sample conditioning system to remove water from the sample stream.
5. Instruments were deployed in near roadway locations.
6. The Aerodyne CAPS and Los Gatos Research CRDS NO2 analyzers are research grade instruments that have not been designated as FEMs.
To allow for evaluation of the various ozone analyzers’ performance as compared to the ET-CL FRM with respect to monitoring for the ozone NAAQS and in preparation for proposing a new FRM for ozone, maximum daily 8-hr average (MDA8) ozone concentrations were calculated. In ambient air evaluations during DISCOVER-AQ deployments in Houston, TX, and Denver, CO, MDA8 ozone results from the T265 and 2B Model 211 compared very closely with those from the Bendix 8002 FRM, as shown in Figure 2. Further results of the ozone methods evaluation and comparisons performed during DISCOVER-AQ are given in Long et al. 2014.

Two methods for determining ozone in ambient air, the NO-chemiluminescence method (T265) and the scrubberless UV photometric method (2B 211), performed particularly well. As a direct result of the ozone methods research performed during DISCOVER-AQ deployments, a new ozone FRM based upon NO-chemiluminescence was promulgated as part of the October 1, 2015, revisions to the NAAQS for Ozone.

Nitrogen Dioxide Methods Results and Implications

In 2010, EPA promulgated a 1-hr nitrogen dioxide primary NAAQS to limit exposures to short-duration concentrations of nitrogen dioxide. Along with the new standard, EPA enacted new monitoring requirements targeted at areas of potential maximum exposure (e.g., near major roadways). The current automated Federal Reference Method (FRM) for measuring nitrogen dioxide is an indirect method based on the oxidation of the nitrogen dioxide to nitric acid, which is then measured as nitric acid. However, the new requirement necessitated the development of a direct method to measure nitrogen dioxide, which was achieved by the promulgation of the NO-chemiluminescence FRM.
on thermal conversion/gas-phase chemiluminescence where nitrogen dioxide is determined by the difference of measured oxides of nitrogen and nitric oxide. Due to potential interferences/artifacts in the FRM nitrogen dioxide determination, other methods for quantifying nitrogen dioxide have been explored, including replacement of the FRM thermal converter with a photolytic converter. Although more specific for nitrogen dioxide, the photolytic converter-chemiluminescence based option is still an indirect method and prone to similar artifacts as those associated with the FRM. Optical analyzers based on cavity ring-down spectroscopy and cavity attenuated phase shift spectroscopy provide for the direct, high-time resolution, spectroscopic determination of nitrogen dioxide concentration in ambient air.

During DISCOVER-AQ, EPA performed research on methods for the measurement of nitrogen dioxide in near-roadway environments during the field deployments in Visalia, CA (January–February 2013) and Denver, CO (July–August 2014). The Visalia and Denver near-roadway sampling sites relative to the nearby roadways are shown in Figure 3. EPA also evaluated the same nitrogen dioxide methodology at other urban and background locations during DISCOVER-AQ deployments. At the near-roadway sites, direct impact on the nitrogen dioxide concentrations was observed from the adjacent roadways with the highest nitrogen dioxide concentrations occurring when winds were blowing from the direction of the roadway, as shown in Figure 4.

The results of the nitrogen dioxide comparisons at the near-roadway locations indicate that indirect nitrogen dioxide analyzers (FRM and photolytic) may struggle in the dynamic near-roadway environment when measuring high-time resolution (1-minute average) nitrogen dioxide concentrations. Large, rapid increases and/or decreases in nitric oxide cause positive and negative artifacts in the 1-minute average indirect nitrogen dioxide determination resulting in significant scatter in the nitrogen dioxide results. However, when averaged to 1-hr concentrations, the scatter was minimized. The nitrogen dioxide comparisons at the urban and background sites show a significant improvement (decreased scatter) in the performance of the indirect methods as compared to indirect method results at near-roadway locations.

The direct spectroscopic nitrogen dioxide methods performed extremely well at both the near-roadway and urban background locations. One-hour average comparison results collected at both the near roadway and urban background studies indicate that the indirect nitrogen dioxide analyzers are adequate for determining nitrogen dioxide concentrations for comparison to the 1-hr primary NAAQS even in near-roadway locations.

Conclusion
During the DISCOVER-AQ study, EPA performed research on methods for the measurement of ozone and nitrogen dioxide in ambient air. Ozone and nitrogen dioxide methods evaluations and comparisons performed during DISCOVER-
As a direct result of the DISCOVER-AQ study, a new ozone FRM was promulgated as part of the October 1, 2015, revisions to the NAAQS for Ozone.

AQ deployments in Baltimore, MD, San Joaquin Valley, CA, Houston TX, and Denver, CO, have directly contributed to the establishment of a new ozone FRM based upon nitric oxide-chemiluminescence. The results of the methods research performed during DISCOVER-AQ have and will continue to serve an informative role in the NAAQS review process for both ozone and nitrogen dioxide, including the identification and designation of a new FRMs and FEMs for use in regulatory determinations.

Acknowledgment:
The U.S. Environmental Protection Agency (EPA) wishes to thank the following collaborating institutions and their staff members for their contribution to the success of this research. NASA Langley Research Center (LaRC), the National Oceanic and Atmospheric Administration (NOAA), Maryland Department of the Environment (MDE), San Joaquin Valley Air Pollution Control District (SJVAPCD), Texas Commission on Environmental Quality (TCEQ), Colorado Department of Public Health and the Environment (CDPHE), and Alion Science and Technology are acknowledged for their contributions in supporting EPA in the execution of complex data collection and analysis.

Disclaimer:
The U.S. Environmental Protection Agency (EPA) through its Office of Research and Development funded and managed the research described here. It has been subjected to agency review and approved for publication. Mention of products or trade names does not indicate endorsement or recommendation for use by the agency.

Russell W. Long, Melinda R. Beaver, Rachelle M. Duvall, James J. Szykman, and Surender Kaushik are all with the U.S. Environmental Protection Agency’s National Exposure Research Laboratory in Research Triangle Park, NC. Keith G. Kronmiller, Michael L. Wheeler, and Samuel Garvey are all with Jacobs Technology Inc. in Research Triangle Park, NC. James H. Crawford is with NASA Langley Research Center in Hampton, VA. E-mail: long.russell@epa.gov.

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3. National Ambient Air Quality Standards for Ozone; Final Rule; Federal Register, Vol. 73, No. 60, March 27, 2008.
Use of Air Quality Sensors during DISCOVER-AQ by Duvall et al.

This article summarizes the data collected from the performance evaluation and citizen science-led data collection during the DISCOVER-AQ mission.
Use of Air Quality Sensors during DISCOVER-AQ by Duvall et al.

The air sensor tools market continues to grow and expand on capabilities to measure a variety of air pollutants. These emerging tools can be used in a number of applications, including air quality monitoring, fence line monitoring, near source monitoring, and community or individual monitoring. The low-cost, portability, small footprint, and user-friendliness of air sensors has made it possible to collect measurements over many locations often at the same time, move instruments around easily, sample in locations in which it would be difficult to sample using conventional methods, and reduce the need for highly specialized training to operate the technologies. The performance and accuracy of numerous sensors are showing a great deal of promise and improvements continue to be made by sensor manufacturers. However, there is still a need to better understand the accuracy of sensors in particular their performance and stability over long periods of time (one year or more), performance in highly polluted environments, cross-interferences with other pollutants, and meteorological impacts such as temperature and relative humidity.

From 2011 to 2014, the U.S. Environmental Protection Agency (EPA) participated in the NASA-led DISCOVER-AQ Earth Venture Mission. During the last two DISCOVER-AQ field deployments in Houston, TX (fall 2013) and Denver, CO (summer 2014), air sensor technologies were included among the ground-based instruments collecting air quality data. Sensor measurements were focused on ozone and nitrogen dioxide, both of which are criteria air pollutants regulated under the National Ambient Air Quality Standards (NAAQS). EPA investigated sensor performance and a community monitoring application in which citizen scientists operated sensors. This article summarizes the data collected from the performance evaluation and citizen science-led data collection during the DISCOVER-AQ study and discusses educational outreach included with citizen science activities.

Sensor Technologies and Performance Evaluation

A variety of sensor technologies can be obtained commercially to measure air pollutants. Two low-cost (< $2,000) sensors, the CairClip sensor (manufactured by Cairepol) and the Aeroqual sensor (manufactured by Aeroqual Ltd.) were evaluated during DISCOVER-AQ. To learn how well a sensor performs, it is important to know the quality of data the sensor collects. Typically, this is determined by running sensors alongside traditional federal reference and federal equivalent methods (referred to as reference methods in this article). Federal reference and equivalent methods must undergo strict testing protocols to ensure the data is accurate for regulatory air monitoring and other purposes. Because of these strict testing procedures, we have great confidence in the quality of reference data and have a reliable source of comparison for sensor data.

During the DISCOVER-AQ Houston and Denver sampling campaigns, sensors were installed at monitoring sites containing reference methods for ozone and nitrogen dioxide. The sensors were run continuously (24 hours per day, 7 days a week) from September 4 to September 27, 2013, in Houston and Denver.

Figure 1: Comparison of 1-hr average sensor data to reference data for the CairClip sensor operated in Houston (left), CairClip sensor operated in Denver (center), and Aeroqual sensor operated in Denver (right).
July 14 to August 12, 2014, in Denver. Figure 1 shows a typical comparison of 1-hr average sensor data to 1-hr average reference data.

The CairClip sensor evaluated in this study reports a combined ozone and nitrogen dioxide measurement (referred to as O3+NO2). The reference ozone and nitrogen dioxide data were summed to provide a direct comparison to sensor data. The CairClip sensor measurements showed good agreement to reference measurements in both Houston and Denver (Figure 1). The CairClip sensor data in Houston were lower than reference data, whereas in Denver, the sensor data were higher. Weather conditions likely contribute to these differences. For example, relative humidity was higher in Houston (on average 74%) compared to Denver (on average 50%).

The Aeroqual sensor was only evaluated during the Denver study and also showed good agreement to reference measurements, although the intercept was larger (Figure 1). For any sensor type, differences between the sensor data and reference data are anticipated as the measurement techniques and calibration procedures vary. This performance evaluation provided insight on the data quality from the sensors and provided a means to validate the sensors for use in other applications including community air monitoring.

**Citizen Science and Educational Outreach**

Community members are becoming more and more engaged in collecting data to support research studies. Data collection in this way is commonly referred to as “citizen science”. The introduction of low-cost, easy-to-use sensor technologies has motivated interest among communities in monitoring air quality where they live, work, and go to school. During the DISCOVER-AQ Houston and Denver campaigns, we enlisted the help of citizen scientists at schools, colleges/universities, and other venues to collect air quality data using sensor technologies.

In the Houston area, teachers and students at seven schools operated the CairClip sensor on their respective school properties (see Figure 2). In the Denver area, citizen scientists operated the CairClip sensor at three locations, including a university, an office building, and a local residence. EPA provided in-person training and handouts to facilitate data collection and ensure that the data was of good quality. Citizen scientists participated in selecting locations to place the sensors, retrieving the sensor data, and conducting general sensor maintenance. The citizen science data was analyzed by EPA and compared to the reference monitoring sites where we conducted the performance evaluation of the sensor technologies.

Figures 2 and 3 show data from two citizen science sites in Houston and two sites in Denver, respectively. In Houston, the citizen scientists decided which days to collect data; in Denver, the sensors ran continuously (24 hours a day, 7 days a week). The citizen science data from both campaigns showed similar trends compared to the reference data. Combined
ozone and nitrogen dioxide levels appeared to be fairly consistent across the study areas. As part of DISCOVER-AQ, aircraft measurements were collected throughout each sampling campaign. All of the citizen science sites were located in or near the aircraft flight paths. These data will be used in the future to investigate spatial variability of ozone and nitrogen dioxide across the study areas and support comparative analysis with aircraft measurements and other data collected throughout the study.

The addition of citizen scientist-operated sites during DISCOVER-AQ provided a valuable resource and enhanced the research study capabilities as it:

• Showed that community members can easily collect good quality data. This gives us confidence that a study such as this can be repeated in the future.

• Provided more sampling locations beyond only the reference monitoring sites. These data can be used to support other analyses and comparisons.

• Helped us better understand and fine-tune the types of information that should be provided to citizen scientists to assist in quality data collection. Specifically, providing both in-person training and a handout containing detailed operating instructions with pictures was most useful.

In addition to the research benefits, the citizen science efforts and educational outreach activities also benefited the local community. In the Houston study, teachers were able to use the citizen science efforts to enhance and complement their lesson plans and the students were able to participate in real science to enrich their learning experience. EPA visited the Houston area schools that hosted the sensors and provided a combination of science lectures, hands-on science activities, and story time sessions for younger children in which we read the book, “Why is Cocoa Orange?” written and published by EPA.

In Denver, EPA presented a variety of fun and interactive science activities during a free admission day at the Denver
Museum of Nature and Science and a joint DISCOVER-AQ/FRAPPÉ Mission community open house. Across both Houston and Denver, EPA reached out to about 1,500 individuals through educational outreach. These events were important as they helped EPA interact with the local community and share information about air quality, science, and the DISCOVER-AQ study.

**Conclusion**

During the DISCOVER-AQ Houston and Denver campaigns, EPA gained knowledge about the performance of sensor technologies for measuring ozone and nitrogen dioxide in real-world conditions. Information about sensor performance is especially important for applications associated with supplementing regulatory monitoring. This study also provided valuable information on a community monitoring application utilizing citizen scientists. Citizen scientists collected good quality data that will be used to further explore spatial variability of ozone and nitrogen dioxide and supplement other data analysis efforts. The performance evaluation and community air monitoring application will continue to inform future research in the progressing field of sensor technologies.

**Acknowledgment:**

The authors would like to acknowledge all of the citizen scientists who hosted and collected data from the CairClip sensors. The authors would also like to acknowledge EPA National Exposure Research Laboratory (NERL), EPA Region 8, NASA Langley Research Center, Texas Commission on Environmental Quality (TCEQ), Colorado Department of Public Health and the Environment (CDPHE), and Alion Science & Technology, Inc. for facilitating this research.

**Disclaimer:**

The U.S. Environmental Protection Agency (EPA) through its Office of Research and Development funded and managed the research described here. It has been subjected to agency review and approved for publication. Mention of products or trade names does not indicate endorsement or recommendation for use by the agency.

**References**

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- S. Smith Griswold Outstanding Air Pollution Control Official Award
- Charles W. Gruber Association Leadership Award
- Honorary A&WMA Membership
- Richard Beatty Mellon Environmental Stewardship Award
- Outstanding Young Professional Award
- Lyman A. Ripperton Environmental Educator Award
- Richard C. Scherr Award of Industrial Environmental Excellence
- Richard I. Stessel Waste Management Award

Go to: www.awma.org/about-awma/honors-awards for award descriptions and criteria.
This article presents results from the joint DISCOVER-AQ/FRAPPÉ field campaigns conducted over Denver and the Front Range area, where Lidar technology was used to measure mixing heights and compared to atmospheric boundary layer heights determined by radiosondes.
The operational use of ceilometers—a device that uses a laser or other light source to determine distance or height—across the United States has been limited to detection of cloud-base heights across the Automatic Surface Observing Systems (ASOS) primarily operated by the National Weather Service and the Federal Aviation Administration. Continued improvements in the underlying technology over the past decade has resulted in the use of ceilometers to identify aerosol layers throughout the troposphere, including the atmospheric mixing heights.

With the forthcoming requirement to measure hourly mixing heights under the U.S. Environmental Protection Agency’s (EPA) Photochemical Assessment Monitoring Stations (PAMS) program, ceilometers may provide a cost-effective technological solution. During the joint DISCOVER-AQ/FRAPPÉ field campaigns conducted over Denver and the Front Range area two CL-51 ceilometers were used to measure mixing heights and compared to atmospheric boundary layer heights determined by radiosondes.

The PAMS Program
The PAMS network was established more than 20 years ago to focus on collecting data to characterize causes of ozone exceedances in severe non-attainment areas across the United States. At many of the urban locations with PAMS sites, the nature of the ozone problem has changed over the past two decades. As a result, the PAMS program recently finalized a re-engineering of the network with the new requirements contained in the 2015 National Ambient Air Quality Standard for Ozone.

Starting in 2019, the revised PAMS monitoring requirements mandate hourly mixing height as a required meteorological parameter. Seibert et al. (2000) defined mixing height (MH) as “the height of the layer adjacent to the ground over which pollutants or any constituents emitted within this layer or entrained into it become vertically dispersed by convection or mechanical turbulence within a time scale of about an hour.” The spatial and temporal variability of the mixing height over an urban area is a critical parameter in properly modeling pollutant concentrations and developing appropriate air pollution control strategies. However, measuring mixing height at PAMS sites on an operational basis has remained a technological and resource challenge over the span of the program.

As monitoring was implemented under the original PAMS program, most state and local agencies installed radar or sodar wind profilers to measure vertical profiles of horizontal winds, with some agencies adding the Radio Acoustic Sounding System (RASS) extensions for temperature profiling, where the virtual temperature could be used to determine Atmospheric Boundary Layer Height (ABL/ABLH). The ability to systematically archive and process the data from these systems across the PAMS has been sporadic. Over the years, NOAA has worked to incorporate data from some of these systems into their Cooperative Agency Profilers (CAP) Network.

Recently, researchers using measurements collected at Howard University Beltsville Research Campus (HUBRC) in Beltsville, MD, showed a robust method to determine ABLH from the Maryland Department of the Environment RADAR wind profiler. However, RASS temperature profile measurements often do not extend above 1 km, and the wind profilers suffer from poor vertical resolution. Additionally, most of the initial RADAR/RASS profilers are a decade or more old and are in need of either upgrade or replacement.

Measuring Mixing Height over Denver
The Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) Earth Venture Mission focused on the collection of routine and systematic measurements of the vertical distribution of atmospheric trace gases, aerosols, and a variety of physical parameters at the altitudes from the surface through the boundary layer and into the lower troposphere. The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) focused on photochemistry and emissions characterization. Both field missions conducted in 2014 over the greater Denver and Front Range area provided an opportunity to assess the performance of two Vaisala CL-51

Figure 1: Students from the Millersville University Clarke Atmospheric Research Group preparing to launch a radiosonde at the Golden, CO, research site during the DISCOVER-AQ Earth Venture Mission, August 2014. Photo by: Richard Clarke, Millersville University.
Ceilometers for continuous measurements of MH through the measurement of attenuated backscatter and variations in the structure of aerosol layers detected through the troposphere.

The most widely accepted method to measure the ABLH involves the use of radiosondes to profile the atmosphere and then use a skew-T plot of the temperature and dew point collected from radiosonde profiles. A radiosonde is a small, expendable instrument package that is suspended below a large balloon inflated with hydrogen or helium gas. As the sonde rises, typical rates of ascent are about 300 meters/minute (about 1,000 feet/minute), sensors on the radiosonde measure profiles of pressure, temperature, and humidity. The data are then transmitted back to a ground receiving station during the weather balloon ascent. Wind speed and direction aloft are also obtained by tracking the position of the radiosonde in flight using GPS or a radio direction finding antenna.

While radiosondes provide excellent vertical resolution of the atmospheric structure for determining ABLH, the temporal resolution is poor because it is not cost effective, due to labor and materials, to launch continuous sondes throughout the day to profile the atmosphere. Conversely, ABLH or MH from remote sensing instruments is often employed to obtain improved temporal resolution and capture the diurnal variations. During the DISCOVER-AQ and FRAPPÉ campaigns radiosondes were launched from several of the ground-based research sites, including the research sites at Golden, CO, and the NOAA Boulder Atmospheric Observatory (BAO) in Erie, CO. Both the Golden and BAO sites hosted multiple remote sensing profiling instruments, including two CL-51 ceilometers operated by EPA. Figure 1 shows students from Millersville University Atmospheric Research Team launching a radiosonde from the Golden research site on one of the NASA P-3B flight days.

Over the past decade improvements in light detection and ranging (lidar) technology have resulted in greater use of optical remote sensing as a method for MH estimation. The lidar method operates, much like radar, by emitting light into the atmosphere, typically using pulsed lasers. These light pulses are reflected back to a receiver by aerosols, clouds, or different forms of precipitation throughout the atmosphere. The resulting signal strength of each laser pulse return is measured and, based on the time delay between the laser pulse emission and the detection of the backscatter signal, a vertically resolved time-height backscatter profile is generated from the ceilometers.

The Vaisala CL-51 ceilometers deployed at the Golden and BAO sites used lidar with a single-wavelength diode laser (910 nm +/- 10 nm) pulsed at 6.5 kHz (110 ns pulse width). The ceilometers provide 10 m vertical resolution +/- greater...
of 1% or 5 m precision, and a vertical range that extends just past 15 km. Ceilometer profiles can be reported with up to 2 s temporal resolution (depending on the control software), with typical averaging being 16–36 s to improve the signal-to-noise ratio (SNR). While it has been shown that ceilometers experience interference from water vapor lines near 910 nm when used for retrieval of aerosol optical properties, the impact of this interference on aerosol profile, aerosol layer detection, and MH estimation is negligible.

For two CL-51 instruments located at Golden and BOA, the MH was estimated using the Vaisala BL-View software. BL-View

![Figure 3: Radiosonde potential temperature and CL-51 ceilometer backscatter profiles collected at the Golden, CO, site. The horizontal lines indicate MH as determined via BL-View.](image)
uses a proprietary algorithm to identify the minimum negative-gradient (-dβ/dx) altitude in the backscatter profile. In most cases, the lowest of these gradient minima marks the top of the mixed layer in a well-mixed boundary layer. However, the inherent assumption in using lidar technology (e.g., ceilometers) to estimate MH is that the vertical aerosol distribution adapts rapidly to the changing thermal structure of the boundary layer, and the aerosol remains well mixed within the boundary layer as the ABL increases/decreases throughout the day, allowing the top of the MH to be identified. The BL-View software is capable of identifying up to three aerosol layers based on this approach, so care must be taken when analyzing the data to determine if the lowest layer identified is the actual MH or if residual-layer influences are at play.

The BL-View software also contains the ability to discriminate between MH inversions and changes in backscatter intensity induced by cloud, precipitation, and fog. Figure 2 shows a characteristic backscatter plot generated in BL-View, with MH and cloud heights.

Over the duration of the Denver field campaign, radiosondes were launched from the Golden and BOA sites in close time proximity with the NASA P-3B spirals over each site. Figure 3 shows potential temperature profiles from both the Millersville radiosonde launches during the NASA P-3B spirals over Golden along with the co-incident backscatter measured by the CL-51 during the field campaign. This figure also shows the height of the first major gradient identified by the BL-View software, which is assumed to be the MH. A similar set of plots was generated for the BAO site. Both the Golden and BAO potential temperature profiles from the sondes agreed well with the near co-incident potential temperature profiles from the NASA P-3B over both sites.

### Ceilometer Mixing Heights vs. Radiosonde Atmospheric Boundary Layer Heights

The radiosonde-derived ABLH was compared to the CL-51 MH at the BAO-Tower and Golden, CO, sites. A radiosonde captures a snapshot of atmospheric conditions as it ascends, and traverses several kilometers in the horizontal direction due to winds, and hence is a point based measurement in time and space that represents the ABLH of the immediately surrounding area. The CL-51 data represents a temporal and spatial average of the MH due to the averaging of the backscatter measurements. To account for spatial difference between the radiosonde and the CL-51, the ceilometer data were averaged over 30-minutes for comparison. Additionally, each measurement is subject to different potential biases. A radiosonde can be impacted by local updrafts or downdrafts, and result in MH estimates higher or lower than the true MH. The CL-51 MH is sensitive to the backscatter gradient, so if there are additional aerosol layers just above the MH, the contrast between the aerosol layers may not be strong enough for the CL-51 to identify each layer or the correct altitude of the MH. Therefore, resampling the data to reasonable average values (e.g., 30-min means) mitigates the impact of the short-lived perturbations.
To determine the ABLH, the temperature, relative humidity, and pressure data collected by each radiosonde was used to calculate potential temperature as a function of altitude, and an objective criteria was applied to identify steep gradients within the potential temperature profile. At this point, a fundamental difference between the ceilometer and sonde methodologies is worth noting. The ABLH is based predominantly on the atmosphere's turbulent kinetic energy (i.e., a thermodynamically based condition), while the MH is a product of mixing associated with turbulent kinetic energy (i.e., mixing within the ABL). While this may sound like the same thing, it is not. The ABL is the thermodynamically driven parameter, and MH represents how aerosol responds to this change by either mixing within the ABL or mixing into the ABL. A degree of separation remains between the two.

Figure 4 shows the comparison of the CL-51 MH compared to sonde ABLH for the BOA and Golden sites. There is an apparent discrepancy between Figures 3 and 4 in the number of sonde launches represented in the two. This is due to the lack of an identifiable ABL in the sonde-based profiles for each flight. The initial Golden site correlation was strongly impacted by 2 morning radiosonde launches, which is a transition period when the boundary layer is experiencing rapid growth. Radiosonde ABLH was less than 500 m for these two points, while the CL-51 MH was greater than 2 km, indicative of an aerosol residual layer from the previous day. These two points serve as good examples of how complicated MH estimations can be within the real (i.e., non-ideal) atmosphere.

Upon applying appropriate filtering criteria to the CL-51 MH data where the 5-minute standard deviation ($\sigma$) exceeded 200 m or the relative standard deviation ($\sigma/\mu$) exceeded 20 percent the 2 early morning data points were removed resulting in a much improved correlation. For the BOA site, the initial correlation shows moderate agreement ($R=0.63$; $N=16$), with a lower correlation when the filter criteria is applied ($R=0.58$; $N=14$). Based on the data from the Golden site it appears to indicate the CL-51 may have difficulty capturing an accurate MH during rapidly changing conditions, such as early morning growth and late evening collapse.

It is somewhat surprising that the filtered correlation for the Golden site is better than the filtered result for the BOA-Tower site, given the BOA-Tower site is situated further to the east of the mountain range, at the start of the High Plains, which is less influenced by very local geographic influences. To check the radiosonde reliability, the radiosonde potential temperature profiles were plotted with profiles collected on the NASA P-3B as it spiraled around the ground site (figure not shown), wherein it is observed that the two profiling methods are in agreement. This adds confidence in the sonde's representation of the surrounding area's ABL since the P-3B spiral was approximately 5 km in radius. The observed differences may be due to the inherent difference between the two profiling methodologies as discussed above.

**Conclusion**

The results show the CL-51 is capable of capturing hourly mixing height values. Examples were shown, Figure 4B, of how aerosol residual layers influence MH estimation. However, when appropriate screening criteria were applied to the
CL-51 data, the correlations between the CL-51 MH and ABLH estimates from the radiosondes significantly improved for the Golden site, and slightly decreased for the BAO site. On average, the radiosonde ABLH was higher than the CL-51 MH at the BAO (Erie, CO) (390 m (15%)) site, and lower at the Golden (CO) site (~240 m (9%)). A limited number of radiosondes was conducted during nighttime hours, and therefore nighttime MH were not evaluated. Despite differences in the two methodologies, the agreement remains encouraging.

Through an active collaboration among NASA, EPA, NOAA, NCAR, and several Universities during the joint DISCOVER-AQ and FRAPPÉ Missions, the EPA Air, Climate, and Energy Research Program leveraged resources to assess the performance of the CL-51 ceilometer MH with co-incident sonde measurements of ABLH. The in-field evaluation of the CL-51 ceilometers was conducted over a month-long time period in the Denver–Front Range Urban Corridor, at two sites with distinct meteorology, Golden, CO, and BOA Tower in Erie, CO. This demonstration shows the CL-51 ceilometer is a viable solution for satisfying the new PAMS requirement to measure hourly MH.

Acknowledgment:
The authors would like to acknowledge the support from the U.S. Environmental Protection Agency (EPA) Air, Climate, and Energy Research Program, NASA Earth Venture Program, Colorado Department of Public Health and the Environment (CDPHE), and National Center for Atmospheric Research (NCAR). The authors would also like to acknowledge the National Oceanic and Atmospheric Administration (NOAA) and CDPHE for use of their facilities under DISCOVER-AQ and helping to facilitate this research.

Disclaimer:
The U.S. Environmental Protection Agency (EPA) through its Office of Research and Development funded and managed the research described here. It has been subjected to agency review and approved for publication. Mention of products or trade names does not indicate endorsement or recommendation for use by the agency.

References
This article considers the measurements of nitrogen dioxide collected during the DISCOVER-AQ series of air quality field campaigns.
The final deployment in the DISCOVER-AQ series of air quality field campaigns focused on the Northern Front Range of Colorado, including the Denver Metropolitan Area in July and August 2014. The overarching goal of these campaigns was to improve the interpretation of satellite observations for diagnosing near-surface air quality conditions. This called for observations to be combined from multiple perspectives that included ground-based, as well as airborne in situ and remote sensing measurements. These observations were collected to demonstrate how future geostationary satellites could provide information of direct benefit to agencies responsible for monitoring and regulating air quality. This article focuses specifically on measurements of nitrogen dioxide, a short-lived pollutant with a distribution that is closely aligned with emissions from fossil fuel combustion sources. Better knowledge of nitrogen dioxide distributions on regional scales is critical to understanding the photochemical production of ozone in nonattainment areas as well as production of other secondary reactive nitrogen species such as nitric acid and peroxyacyl nitrates (PAN), which are related to issues of nitrogen deposition and long-range transport, respectively.

The sampling domain covered approximately 75 miles along the Front Range from Fort Collins in the north to Chatfield Park just south of Denver and reached roughly 30 miles east of the Rocky Mountain foothills to Greeley and Platteville located northeast of Denver (see Figure 1a). Working closely with the Colorado Department of Public Health and Environment (CDPHE), sites within the state’s monitoring network were chosen for focused sampling on the ground and by overflying aircraft. CDPHE has an extensive network for monitoring ozone, but nitrogen dioxide monitoring is limited.

To address this gap during the field study, the area was saturated with nitrogen dioxide measurements that included both in situ and remote sensing instruments operating on the ground and in the air. EPA researchers equipped six ground sites with research-grade instruments for in situ measurements of nitrogen dioxide. In addition to this augmentation by EPA, NASA installed Pandora spectrometers at a dozen ground sites to remotely sense the total abundance of nitrogen dioxide in the overhead atmospheric column by direct-sun observations throughout the day.

To complement these ground-based instruments, several aircraft flew overhead. One aircraft, NASA’s P-3B, provided in situ information on the vertical distribution of nitrogen dioxide in the lower atmosphere by conducting spiral soundings over the ground sites throughout the day. Another aircraft, NASA’s HU-25C flew high overhead carrying the Geo-TASO
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The instrument capable of detecting the nitrogen dioxide column abundance from beneath the aircraft down to the surface.

While this article will focus on the observations listed above, additional nitrogen dioxide measurements were collected from other partnering research aircraft (NCAR C-130 and NASA B200), ground sites, and mobile labs. The discussion below demonstrates how each of these perspectives offer a unique and important piece of information regarding the distribution of nitrogen dioxide across the Front Range.

Figure 1 (panels b and c) provides a sample of the type of information that future geostationary satellites will provide each hour over the entire continental United States, wherever skies are clear. Looking down from high altitude onboard the HU-25C, the Geo-TASO instrument was used to map the distribution of nitrogen dioxide across the region during the morning and afternoon of August 2, 2014.

While the view is dominated by the large nitrogen dioxide enhancement northeast of central Denver, there are clear differences between morning and afternoon. In the morning, the main enhancement is more concentrated and lesser enhancements are observed to the northeast, suggesting possible transport along the Platte River valley and up towards Greeley. In the afternoon, the distribution is more diffuse and there is evidence of transport towards the mountains in the direction of Golden. While a detailed explanation for these distributions are beyond the scope of this article, they are consistent with the general morning and afternoon atmospheric circulation in the Denver area.

The view of the regional nitrogen dioxide distribution from Geo-TASO represents conditions for a single day. To evaluate its representativeness, Geo-TASO data are compared to average conditions observed from the NASA P-3B, which sampled the region on 15 flight days during the study. The white line on panels b and c in Figure 1 shows the flight route which

Figure 2: Diurnal variation of NO2 column abundance and values at ground-level for three locations in the Denver area during the DISCOVER-AQ campaign. Column abundances are in Dobson Units (DU), where one DU is equivalent to 2.69 x 10^16 molecules cm^-2. The diamond symbols indicate median values with the spread covering the inner quartile range observed by Pandora spectrometers at each location during the study period. The solid lines indicate median values throughout the day observed by surface monitors.
was flown two to three times per day. Circles indicate locations where spiral soundings were collected over ground sites.

All data collected in the lowest kilometer were spatially binned and averaged at 0.01 x 0.01 deg resolution and plotted in panel d of Figure 1. The data are plotted by their latitude to enable direct comparison with the distributions in panels b and c. To indicate the longitude of the P-3B observations in panel d, symbols sizes are varied, with smaller symbols indicating observations farther to the east. The P-3B and Geo-TASO data agree in several important respects. The most obvious is the large and persistent enhancement of nitrogen dioxide just north of central Denver. The nitrogen dioxide baseline is also higher in the southern portion of the domain. A more subtle observation is that to the north, P-3B nitrogen dioxide is more abundant over the eastern portion of the domain, consistent with the morning enhancements in the Geo-TASO observations.

To complement the spatial remote sensing from the air, Pandora spectrometers provided continuous observations of the total nitrogen dioxide column abundance over ground sites. This enabled a comparison of nitrogen dioxide measurements at the surface from ground monitors with column abundances equivalent to what would be seen by a satellite. In Figure 2, surface and column measurements are compared for three ground sites. The LaCasa and I-25 sites are both located in Denver just south of the largest enhancements in nitrogen dioxide observed by Geo-TASO. Both sites show similar behavior in the diurnal trend of nitrogen dioxide column abundance. The Golden site is located closer to the mountains due west of Denver. It exhibits a similar trend with only about half the total nitrogen dioxide abundance in the early morning. By late afternoon, nitrogen dioxide column has increased to about 70 percent of the values in Denver, consistent with the behavior of afternoon observations of Geo-TASO shown in Figure 1c.

When looking at the surface monitor observations in Figure 2, a very different pattern emerges. During the morning, in particular, nitrogen dioxide decreases at the surface while column abundances increase. This is most striking at LaCasa where surface nitrogen dioxide decreases by nearly a factor of two while column abundance increases by a factor of two. This suggests that vigorous mixing and boundary layer
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growth is diluting surface nitrogen dioxide during a period when total emissions are continuing to accumulate. Evidence for this is provided in Figure 3 showing how the average profile of nitrogen dioxide changes above the LaCasa site depending on the time of the spiral soundings of the P-3B. While the soundings do not occur often enough to fully resolve the diurnal cycle in column abundance, the data demonstrate that vertical mixing causes dramatic changes in the lower atmospheric distribution of nitrogen dioxide throughout the day. It is important to understand these mixing effects alongside the photochemical factors contributing to the diurnal behavior of nitrogen dioxide.

**Conclusion**

Through the examples presented above, a picture emerges for the essential role of geostationary satellite observations in future monitoring and regulation of air quality. Satellites can provide the broad spatial coverage and total column abundances needed to complement surface observations that are spatially limited but key for assessing exposure. Interpreting differences in the variability of surface and column measurements will also provide critical information on vertical mixing, which affects the exposure to primary pollutants, as well as the rates of ozone and particulate matter formation. This information will be critical to model assessments of air quality and improvement strategies.

By contrast, the density of ground-based Pandora observations and airborne sampling used in DISCOVER-AQ cannot be sustained. Rather, these represent vital validation tools that will need to be used in a targeted fashion to ensure that ground-based and satellite observations are connected and able to provide a more complete picture of air quality than is possible with either alone. This vision of an integrated air quality observing system will be fulfilled by NASA’s launch of a satellite instrument called TEMPO (Tropospheric Emissions: Monitoring of Pollution) later this decade. DISCOVER-AQ observations such as those described here are playing an important part in the preparation to take immediate advantage of TEMPO observations as soon as possible after launch.

**Disclaimer:**
The U.S. Environmental Protection Agency (EPA) through its Office of Research and Development funded and managed the research described here. It has been subjected to agency review and approved for publication. Mention of products or trade names does not indicate endorsement or recommendation for use by the agency.

**References**

Researchers at the University of Washington have completed an unprecedented decade-long study that reveals a direct link between long-term air pollution exposure and the progression of heart disease. The body of research, called the Multi-Ethnic Study of Atherosclerosis Air Pollution Study (MESA Air), is funded by the U.S. Environmental Protection Agency’s (EPA) Science to Achieve Results (STAR) program and is a part of a larger study by the National Heart, Lung, and Blood Institute.

The study’s findings provide evidence that links long-term exposures to specific air pollutants to the progression of the number one killer in the United States—cardiovascular disease. According to the American Heart Association, someone in the United States dies from cardiovascular disease every 40 seconds. Almost half of all Americans have at least one of three main risk factors for heart disease: high blood pressure, high cholesterol, and a smoking habit. Healthcare providers tell their patients to exercise more, watch what they eat, and quit smoking to lower their cardiovascular risk. Yet, MESA Air encourages us to recognize another factor that affects us over the long term—air pollution.

The MESA Air findings answer many questions about long-term exposure to air pollution and its connections to atherosclerosis, which is the build-up of plaque in arteries and an important cause of heart disease. Atherosclerosis can restrict blood flow to the heart and to major blood vessels—increasing the likelihood of cardiovascular events like heart attack and stroke.

Nearly 100 peer-reviewed papers summarizing findings from MESA Air have been published since the study began in 2004, but most recently a seminal paper was published in the medical journal *The Lancet* by lead investigator Dr. Joel Kaufman. A major finding announced in the paper is that long-term exposure to particulate matter and nitrogen oxides at ambient concentrations close to the levels of the current National Ambient Air Quality Standards (NAAQS) can prematurely age blood vessels and contribute to a more rapid buildup of calcium in the coronary artery, which indicates the progression
of atherosclerosis. In fact, the investigators found that the higher the exposure level the faster atherosclerosis progresses, so reduction in air pollution exposure should be a clear goal.

While previous studies have linked air pollution and heart disease, this study’s extensive length, diversity of subject participants, definitive scope, and rigorous data collection provides “a finer degree of evidence that air pollution accelerates the process of atherosclerosis” says Kaufman.

To reach this conclusion, researchers collected and analyzed substantial amounts of data on 6,800 diverse participants and air quality in six regions where they lived. Regional air quality data was collected from the State and Local Air Monitoring Stations—a group of regulatory monitors that EPA uses to assess air quality and gain an understanding of how and to what degree study participants were exposed to air pollution.

In addition, researchers also conducted air quality monitoring at various sites in the communities and directly outside the homes of study participants. Some homes were equipped with indoor air monitors to assess particulate matter pollution inside the homes. Researchers also equipped certain participants with personal air monitors to wear with the goal of refining exposure estimates.

To collect medical data, researchers used noninvasive medical exams that tracked heart health in participants over the study period. Participants received ultrasound exams to determine the thickness of the arterial wall, CT scans to track coronary artery calcium accumulation as an indicator of the rate of plaque build-up in participants’ arteries, and blood pressure tests. Participants also received personal health recommendations based upon their tests as part of the study.

It is known that some atherosclerosis results from normal aging and that lifestyle can contribute to this process. But now, using the air quality and medical data, researchers have determined that healthy individuals exposed to air pollution over the long term had accelerated accumulation of calcium in the coronary artery directly related to their exposures, with accelerated atherosclerosis and an increased risk for heart attack.

The MESA Air study provides more evidence to help policymakers consider the long-term impacts of particle pollution concentrations close to the levels of the NAAQS for PM2.5. Additionally, the new findings from MESA Air should motivate health care providers to learn more about the effects of air pollution on the cardiovascular system.

Healthcare providers should also consider providing guidance to their patients with heart disease who might benefit their health by lowering exposure to PM2.5. Individuals can use EPAs Air Quality Index to obtain daily forecasts in a given area. Recommendations for actions for individuals with heart disease to take during high pollution days are available on the AirNow website.

Learn More


Brunekreef, B.; Hoffmann, B. Commentary: Air pollution and heart disease; The Lancet 2016

AirNow

Heart Disease and Stroke Statistics (AMA)

Healthy Heart Toolkit (EPA)

Monitored Air Quality Data Access (EPA)

For more information on the research discussed in this column, contact Ann Brown; phone: 1-919-541-7818; e-mail: brown.ann@epa.gov.

Disclaimer:
The research described here has been subjected to EPA review and approved for publication.

Dr. Wayne Cascio, cardiologist and researcher, and Christina Burchette, student services contractor, are both with the U.S. Environmental Protection Agency’s (EPA) Office of Research and Development.
NESHAPs…No Exemptions:
EPA to Require All Site Cleanups Adhere to MACT

EPA proposes to rescind exemptions and require that even CERCLA and RCRA cleanup operations adhere to NESHAP rules and procedures.

In 2003, the U.S. Environmental Protection Agency (EPA) adopted rules establishing National Emissions Standards for Hazardous Air Pollutants (NESHAPs) generated by site remediation activities. The agency also decided to exempt Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; commonly known as Superfund)- and Resource Conservation and Recovery Act (RCRA)-sanctioned cleanups from these rules and their recordkeeping and work practice standards. EPA now proposes to rescind these exemptions and require that even CERCLA and RCRA cleanup operations adhere to NESHAP rules and procedures.

On October 8, 2003, pursuant to its authority under Section 112 (d) of the U.S. Clean Air Act, EPA promulgated new rules establishing NESHAP emission standards applicable to hazardous air pollutants (HAPs) generated by site remediation (see 68 FR 58172). These site remediation activities are intended to clean up contaminated environmental media (i.e., soil) or certain stored or disposed materials that “pose a reasonable potential threat” to contaminate environmental media. The rules are located at 40 CFR Subpart GGGGG (40 CFR Sections 63.7880-7957).

As explained by EPA at the time, Section 112 of the Clean Air Act requires the agency to list categories and subcategories of “major sources” and “area sources” of hazardous air pollutants (which are identified in the law) and to establish NESHAP standards for these categories. As noted by the agency, “site remediation” was identified by EPA as a “major source” for purposes of regulation under Section 112. “Major sources” of hazardous air pollutants are defined by the Clean Air Act as sources having the potential to emit greater than 10 tons per year of any one HAP, which are also identified at Table 1 to Subpart GGGGG of Part 63 of the rules) or 25 tons per year of any combination of HAP. “Area sources” are stationary sources of HAP that are not major sources.
The intent of the 2003 rule is to impose these Clean Air Act emissions standards on many cleanup operations when they are, or may be, a source of HAPs. The rules apply HAP emissions standards and work practice standards to site remediation activities involving such facilities and units as process vents, tanks, containers, separators, and surface impoundments. In addition, each NESHAP standard must reflect the “maximum degree of reduction in emissions of HAPs that is achievable for that specific source or subcategory.” The level of control is commonly referred to as the maximum achievable control technology, or MACT for short.

However, EPA also decided to exempt CERCLA and RCRA cleanups from the application of these rules. EPA made this determination because, in its view, “the Superfund program under CERCLA and the corrective action program under RCRA [are] the functional equivalent of MACT standards under Section 112. These programs, as part of the ROD (Record of Decision) process for Superfund cleanups and the RCRA permitting process for corrective action cleanups require consideration of the same HAP emissions that we do in establishing MACT standards.”

The exemption was controversial, and a petition for reconsideration, and a follow-up legal challenges were filed by several environmental groups. However, there appears to have been little or no resolution of this challenge until March 2015, when EPA decided that it would consider this issue in a new rulemaking proceeding. Consequently, on May 13, 2016, a notice of proposed rulemaking to eliminate this exemption was published in the Federal Register (see 81 FR 29821).

What caused this volte-face by the agency? EPA now argues that by its listing of “site remediation” as a source category under Section 112 of the Clean Air Act, it was obligated to extend these technology-based NESHAP standards to all sources covered by the Site Remediation Site Category, including cleanups conducted under the authority of either CERCLA or RCRA that involve the release or potential release of HAPs by these cleanups. The agency asked for responsive comments by June 28, 2016, and the rulemaking has been placed on EPA’s Regulatory Calendar, which indicates that the agency hopes to complete this rulemaking in December 2016.

The overall impact of the elimination of these exemptions figures to be fairly small; EPA estimates that, nationwide, there are 69 major source cleanup operations that may be affected, and the amount of HAPs emitted by these cleanups may also be fairly small. The agency also believes that the economic impact may also be minimal. However, the agency does not address the possibility that adding these Clean Air Act requirements to an already cumbersome and complicated cleanup process authorized by separate legislative authorities may not be needed.
Twelve Key Decisions to Make Before Implementing Software

Congratulations! You have selected an environment, health, and safety (EH&S) software platform. Now it’s time to start implementation. The decisions you make now can make your implementation a triumph or a disaster.
You spent months gathering business requirements and selecting EH&S software. You found software that closely meets your needs, and are excited to start implementation. Now what? Now—between software selection and implementation—is when you finalize key decisions that set the tone for implementation. These decisions affect how users adopt the software and, ultimately, how you achieve the expected benefits.

Successful software implementation requires competent people, clear processes, and good technology (see Figure 1). You need to make key decisions in each of these areas before implementation. You should have already addressed some of these issues during the needs assessment process completed before requesting software vendor quotes. You can make final decisions as you enter into contracts with software vendors and implementers. Software implementation involves many stakeholders, so solicit input and arrive at decisions that reflect stakeholder consensus. Document each decision, the date made, and the parties involved.

Key Decisions
You should make at least 12 key decisions before implementing new software.

People
1. Who will manage the implementation?
   Once you select a specific software package, the next most important decision is to select someone to lead the implementation. While you are selecting a person to lead this effort, not a company, be sure to verify credentials. Ideally, identify a strong project manager who understands EH&S issues in your industry, has expertise in implementing the software you selected, has great communication skills, and brings a proven approach and methodology.

2. What internal and external resources do we need?
   Software implementation requires a team effort. A quick gap analysis between project staffing needs and your available EH&S, IT, and operations resources determines which resources come from within, and which come from outside sources. While it’s nice to have resources in your neighborhood, local is not always better. Choose the more proven and capable resource and provide a reasonable travel budget. Today’s implementations do not require onsite resources for the duration of the project. Agile methods engage stakeholders in a series of one- or two-week “sprints.” In between, each project team member completes tasks and deliverables from their own office. Web conferences and collaboration tools bridge the gap between face-to-face meetings.

3. Who are our users?
   What type(s) of people will use the software? How many are EH&S professionals, facility operators, or managers? This determines how many licenses you need, and how to set up user access and security. Keep it simple, and limit access to three or four types of users (e.g., admin, power user, casual user, and management).

Technology
4. Which software installation model shall we use?
   Software installation options include on-premises (i.e., your company’s servers) or hosted or Cloud (i.e., software vendor’s or third-party servers). Your decision affects the need for hardware, software, and IT resources to upgrade and maintain the software. More and more companies are comfortable with applications in the Cloud.

5. Which systems must we integrate with the new software?
   Focus on what you must versus can integrate. In the end, your “integration” ranges from once-daily data dumps to more complex, live integration.

To start, consider integration with five basic data sources:
- active directory—for software login;
- asset management database—for site and equipment hierarchy;
- human resources database—for contact information and incident management;
- email—for alerts and notifications; and
- document management system—native to the software and/or via document hyperlinks.
Beyond these basic connections, consider where you will gain the greatest value. If you plan to manage air emission calculations, Toxic Release Inventory (TRI) reporting, or other complex tasks, then consider integration with process data historians and other sources.

**Processes**

6. What benefits do we expect?
This is perhaps the most important strategic decision. Do you seek better integration among EH&S business processes and data; improved reporting; increased productivity; or other benefits? Quantify where possible to allow measurement of benefits.

7. How closely does the software meet our needs “out of the box?”
If the software meets your needs out of the box, then consider a standard configuration. This can allow quick rollout of EH&S task management, incident management, audits/assessments, though may not be practical for air emissions management or TRI reporting. Even with standard implementation, you can follow with some “one-off” configuration to create custom workflows, reports, and dashboards.

8. What is our plan?
Whether you lead the implementation yourself, or hire the software vendor or a third party, you need to have plans in place.

9. Should we implement in phases?
If you plan to automate several EH&S business processes, then implement functionality in phases. This lets you apply the proper resources, rather than overwhelming them. Implement supporting processes first, such as task management, document management, metrics and dashboards, and audits/assessments. Implement top-priority processes next, and then medium-priority processes. This allows quick wins, and gets the software users up to speed more quickly than a “big bang” approach.

10. How will we roll out globally?
If you have a large, complex organization, consider rolling out functionality in waves, especially if you require multiple languages. Roll out first in the most common language, then in other languages.

11. How will we manage risks?
Like other projects, software implementations have built-in risks. When not managed well, they can go beyond the planned scope, schedule, and budget. Moreover, they can fail to deliver the desired benefits.

12. How will we manage change?
You must decide how to manage project scope creep and organizational change. You can manage project scope by putting change process in place, having a change approval team, setting aside a change budget, and so forth.

Organizational change management starts with strategy and continues through the software lifecycle. Address issues like communications, the software’s impacts on jobs, training, and other areas. Don’t overlook organizational change management for budget reasons.

**A Strategy for Success**

Now that you have selected software—no small task—you’re on to implementation. Making key decisions related to people, processes, and technology can set up your organization for success and allow you to achieve the benefits of implementing new software.

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**Jill Barson Gilbert** is a thought leader on environment, health, and safety (EH&S) and sustainability software. Her perspective reflects more than 30 years of EH&S, information management, and business experience. As President, CEO, and founder of Lexicon Systems, LLC, she advises senior management in industrial and software companies, venture capital, and consulting firms. She is a Board Member of the IPEP Foundation and past Vice President and Director of A&WMA. E-mail: jbgilbert@lexicon-systems.com.

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The Obama administration tried to strike a cautious compromise in setting new biofuel quotas for a renewable fuels program that pits “Big Oil” against “Corn Belt” interests.

The U.S. Environmental Protection Agency (EPA) proposed compelling refiners to blend 18.8 billion gallons of biofuel into the U.S. gasoline and diesel supply next year, with no more than 14.8 billion gallons of that coming from conventional corn-based ethanol.

The overall number—which is higher than oil companies wanted, but lower than what biofuel producers sought—represents a modest increase over the 18.11 billion gallons of total renewable fuels the agency required for 2016. But it is still far below a 24 billion gallon biofuel target that lawmakers established in a 2007 statute, and it dips below the law’s 15 billion cap on conventional renewable fuel, limiting the potential for ethanol producers such as POET LLC, Green Plains Inc. and Pacific Ethanol Inc.

EPA’s proposal, like last year’s version, appears to accommodate oil companies’ concerns that the Renewable Fuel Standard is pushing them beyond a “blend wall” where the targets force them to mix a higher proportion of ethanol into fuel than the 10 percent level approved for use in all cars and trucks.

New Wells Regulated, EPA Eyes Methane from Existing Sources

The U.S. Environmental Protection Agency (EPA) will immediately begin collecting data on methane emissions from existing oil and gas wells after finalizing the first-ever emissions limits for new and modified wells.

“We’re going to move as quickly as we can to get the most comprehensive record we can for the next administration to rely on,” EPA Administrator Gina McCarthy told reporters as the agency unveiled its final new source performance standards.

EPA issued a two-part proposed information collection request to gather data on methane emissions from oil and gas wells currently in operation as the agency moves to regulate those sources under Section 111(d) of the U.S. Clean Air Act. Those standards have long been sought by environmental advocates and come at the same time EPA issued comparable new source performance standards for methane emissions from new and modified wells under Section 111(b) of the act.

While EPA likely won’t be able to propose methane standards for existing wells in the time left in the Obama administration, the information collection request is the latest step toward curbing the short-lived greenhouse gas, which is 25 times more potent than carbon dioxide over a 100-year period, according to EPA.

“This administration is acutely aware of the ticking clock.” — Paul Bledsoe

“In all likelihood, the next president—especially if it’s Secretary [Hillary] Clinton—will look to act on existing sources of methane as well as other climate opportunities, like emissions from refineries. This administration is acutely aware of the ticking clock,” Paul Bledsoe a former Clinton White House climate adviser and president of Bledsoe & Associates, an energy consultancy, told Bloomberg BNA.
Emerging types of pollution monitoring technologies are going to raise questions the U.S. Environmental Protection Agency (EPA) must be prepared to address, agency Administrator Gina McCarthy said. “That’s going to be a huge challenge as smart phones begin to be air monitors,” McCarthy told EPA’s Science Advisory Board.

New technologies and new ways of gathering data can reliably detect pollutants at lower and lower levels, she said. “We are going to be inundated with data, and people are going to be inundated with data.” People are going to demand to know what their exposures mean, “and we have to be ready for them,” McCarthy said.

McCarthy also referred to the U.S. Forest Service’s discovery that moss on trees could detect airborne concentrations of metals such as cadmium and arsenic. Subsequent research by the Oregon Department of Environmental Quality (DEQ) prompted two Portland companies—the Bullseye Glass Co. and Uroboros Glass Studios Inc.—to voluntarily agree to stop using arsenic, cadmium, and chromium VI, the department said.

Assessing the risks of one chemical at a time—as the agency and chemical safety community in general have done for decades—is not going be sufficient, McCarthy said. em

States Seek Better Ozone Models for Exceptional Events

Faced with more stringent ozone standards, state air officials said they need new tools from the U.S. Environmental Protection Agency (EPA) to model emissions from exceptional events like wildfires and uncontrollable emissions blown in from overseas.

The modeling needs are particularly acute in the West where EPA’s new National Ambient Air Quality Standards (NAAQS) for ozone of 70 parts per billion approach background levels of the pollutant in some places, state officials said at the Electric Power Research Institute’s Env-Vision conference in Washington, DC.

While EPA allows states to exclude emissions from events like wildfires when they demonstrate compliance with the ozone standards, providing evidence of the link between those events and elevated ozone concentrations can require a significant investment in state time and resources without assistance from EPA, Tom Moore, air quality program manager for the Western States Air Resources Council, said.

“Exceptional events is kind of an unfunded mandate,” Moore said.

States also need better tools to model uncontrollable emissions such as ozone precursors that blow into the United States from China as they try to meet the ozone standards, Moore said.

EPA has proposed an update to its exceptional events policy intended to make the process less cumbersome for states. The proposal would allow states to use approved pollution control plans to satisfy the criterion that the event was “not reasonably controllable or preventable” and removing the criterion that states show a regulatory violation wouldn’t have occurred “but for” the event. em

Washington Report is compiled by Jeremy Hunt, Bloomberg BNA (bna.com).
EPA Gives Four States Options on Cross-State Pollution Rule Compliance

Continued voluntary participation in the U.S. Environmental Protection Agency’s (EPA) interstate emissions trading program for power plants would allow four states to meet federal air quality standards for particulate matter and regional haze, the agency said in a memo to regional air directors.

The June 27 memorandum outlined options to address sulfur dioxide emissions budgets for Alabama, Georgia, South Carolina, and Texas in response to a 2014 U.S. Supreme Court ruling that found EPA’s Cross-State Air Pollution Rule had required some states to control power plant emissions more than was necessary to prevent those emissions from degrading air quality in downwind states.

The memorandum gives those four states the option of submitting state implementation plans to participate voluntarily in the second phase of EPA’s Cross-State Air Pollution Rule, which limits sulfur dioxide and nitrogen oxides emissions from power plants in 23 states.

Doing so would ensure those states also are compliant with the national ambient air quality standards for fine particulate matter issued in 1997 and 2006, as well as their obligations to address regional haze, EPA said.

If the states choose not to participate in the cross-state rule, EPA said it would withdraw by this fall the federal plans implementing the sulfur dioxide reduction requirements. The states would then be required to ensure their state plans are sufficient to comply with the air quality standards and regional haze requirements.

Deadline Looming for Emissions Allowances

July 1 was the deadline for EPA to allocate nitrogen oxides and sulfur dioxide emissions allowances for 2017 and 2018. The agency said it would continue to set aside allowances for the states that indicate they plan to voluntarily continue their participation in the cross-state rule.

The U.S. Supreme Court in 2014 upheld EPA’s Cross-State Air Pollution Rule, which is intended to prevent emissions from power plants from interfering with downwind states’ ability to meet federal air quality standards.

As part of that decision, the Supreme Court held that the agency couldn’t require states to control emissions by more than is necessary to prevent interference with downwind air quality (EPA v. EME Homer City Generation LP, 134 S. Ct. 1584, 78 ERC 1225, 2014 BL 118432 (2015)).

EPA has said its proposed second phase of the cross-state rule (RIN:2060-AS05) would address the Supreme Court’s ruling with respect to the ozone season nitrogen oxides trading program for nine states.

For More Information


—By Andrew Childers, Bloomberg BNA
The U.S. Environmental Protection Agency (EPA) expended more financial resources for Superfund remediation than approved in state contracts and failed to disclose accurate cost-share analysis for cleanups, the agency’s Inspector General said in a June 27 report.

EPA overshot the authorized amounts by roughly $135.5 million, drawn from excesses in 51 of the 504 existing Superfund State Contracts (SSC), the Office of Inspector General (OIG) said.

Those breaches may violate the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA; the Superfund statute), OIG said in a letter and report.

EPA may “be in violation of CERCLA for conducting remedial action without having a valid SSC,” the report said. “Any expenditure by the EPA in excess of the estimated project cost would be beyond the terms of the SSC, and the state may not be contractually bound to share in paying the additional costs.”

The OIG undertook the investigation, which was conducted from January to May 2015 and January to March 2016, to determine if EPA was collecting proper state payments.

**Contracts Valued at $8.8 Billion**

From 1980 through the end of 2014, EPA entered into state contracts valued at $8.8 billion, with states footing the bill for roughly 10 percent of that figure. The contracts are CERCLA-obligated agreements to set a cleanup framework.

OIG called on the agency to systemically change its monitoring and calculation framework.

“We recommend that the Office of Land and Emergency Management emphasize to the regions the importance of monitoring total [Superfund State Contract] costs and develop uniform SSC cost monitoring and financial closeout procedures,” the report said. “We also recommend that the Chief Financial Officer develop guidance for the regions to provide information for a more accurate SSC accrual calculation and make certain accrual adjustments for more accuracy.”

**EPA Agrees with Findings**

EPA officials agreed with the findings and have already implemented three recommendations, the report said.

“The remaining recommendations, for the Assistant Administrator for Land and Emergency Management to emphasize the importance of monitoring SSC costs and to develop uniform SSC financial closeout procedures for the regions, are open with agreed-to corrective actions scheduled to be completed by the end of the year,” OIG said.

The agency also fell short in performing proper oversight of Superfund obligations and expenses, OIG said.

“With improved monitoring, the EPA could reduce the risk of: interrupting an ongoing cleanup, delaying the environmental cleanup and public health protection, or making expenditures for which the state is not contractually bound to share in paying,” the report said.

**For More Information**

EPA Proposes User Fee Structure for Hazardous Waste E-Manifest System

The U.S. Environmental Protection Agency (EPA) proposed a user fee structure June 28 to fund its electronic hazardous waste manifest system.

The proposal (RIN:2050-AG80), which EPA planned to publish in the Federal Register in the coming weeks, aims to “recover the full costs” of the system.

“This includes costs incurred in developing, operating, maintaining and upgrading a national e-Manifest system, as well as any costs incurred in collecting and processing data from any paper manifest submitted to the e-Manifest system after the date on which the system begins to operate,” said the agency in a statement.

The electronic system is a 2014 rule (RIN:2050-AG20) known as e-Manifest.

The e-Manifest, set for deployment in spring 2018, authorizes the use of electronic manifests as a means to track shipments of hazardous waste from generation to receipt and disposal under the Resource Conservation and Recovery Act.

Affected Industries
Hazardous waste generators, transporters and owners and operators of treatment, storage and disposal facilities (TSDFs) are expected to pay the fees.

“This proposed rule would primarily affect the several hundred commercial TSDFs that receive hazardous and state-only regulated wastes from off-site for management at their permitted or interim status facilities,” the proposal said. “EPA has tentatively concluded that payment of this proposal’s user fees by the several hundred commercial TSDFs is the most efficient and expedient means for implementing a user fee requirement for the national e-Manifest system.”

Those entities currently use between 3 million and 5 million paper manifests and other documents in processing waste annually, EPA said in the proposal.

The proposal says the transition will save industry $34 million.

Following publication of the user fee proposal, EPA will take public comment for 60 days. The agency plans to issue a final user fee rule in 2017.

“The final rule that EPA develops in response to public comments on this action’s proposed fee methodology will include the final fee methodology,” said the proposal. “EPA will include the initial fee schedule and the implementation date for the e-Manifest system in the preamble to the final rule.”

For More Information
The proposed rule is available at http://src.bna.com/gj4.
—By Brian Dabbs, Bloomberg BNA
Harper Government Policies to Face Public Scrutiny

Many of the most contentious environmental reforms made by the Harper government will now face public scrutiny, either by a Parliamentary committee or by a public review panel.

On June 20, 2016, the Trudeau government announced draft terms of reference for two review panels: one to review the environmental assessment process, the other to modernize the National Energy Board. Simultaneously, Parliament’s Standing Committee on Fisheries and Oceans will examine the former government’s amendments to the Fisheries Act, and the Standing Committee on Transport, Infrastructure and Communities will do the same to the Navigation Protection Act. Reports from all four reviews are due early in 2017.

The Harper government reforms were intended to spur resource development, particularly pipeline projects. Critics argued that weakening environmental protections would merely lead project opponents to seek other venues, such as the courts, to have their voices heard. The policy reviews were promised in the Liberal Party’s election platform and have been cheered by environmentalists. However, the Harper-era changes will remain in place while the reviews are underway.

The draft terms of reference for the two review panels have been published online at https://www.canada.ca/en/services/environment/conservation/assessments/environmental-reviews/share-your-views.html#nebtor for public comment.

— by Mark Sabourin, EcoLog.com

Canada Poised to Help the United States Meet Clean Energy Goal

There’s good news for Canadian electricity producers in the final communiqué from the “Three Amigos” Summit among Canada, the United States, and Mexico in Ottawa on June 29, 2016. Among other things, the three countries agreed to “strive to achieve 50 percent clean power generation by 2025,” and to collaborate on cross-border energy transmission projects.

The communiqué notes that there are at least six cross-border transmission lines in the permitting or review process. These include the Great Northern Transmission Line, which would carry 500 kV of clean Manitoba Hydro electricity into Minnesota, and the New England Clean Power Link, which would bring 1,000 MW of clean electricity from Canada to Vermont.

Canada will have no trouble meeting the 50-percent clean power target. Already, more than 80 percent of Canada’s power is from nuclear and hydro and other renewable sources. Not so in the United States. According to the U.S. Energy Information Administration, in 2015 nuclear accounted for 20 percent of U.S. power, hydro only 6 percent, and all other renewables another 7 percent. Coal and natural gas accounted for one-third each.

Under the 2015 U.S. Clean Power Plan, states are each required to meet specific carbon reduction targets based on their energy consumption. The plan, which is currently under challenge, will mean that many states will likely have to close their dirtiest power sources and replace that power somehow.

Canada is prepared to be part of the solution, says Sergio Marchi, president and CEO of the Canadian Electricity Association (CEA). He says the CEA lobbied heavily to have clean Canadian power accepted within the Clean Power Plan.—by Mark Sabourin, EcoLog.com
Nova Scotia Consulting on GHG Standard for LNG Facilities

Nova Scotia Environment is seeking public comment on its proposed standard for greenhouse gas (GHG) emissions for liquefied natural gas (LNG) facilities that it expects will be built on the coast in the near future.

The standard being proposed by Nova Scotia Environment is a GHG intensity of 0.24 tons of carbon dioxide equivalent per ton of LNG produced.

LNG is natural gas that has been converted to a liquid state so that it can be easily transported to overseas markets. The liquefaction of natural gas involves two main steps: the removal of impurities such as carbon dioxide from the gas, and the liquefaction of the gas by reducing its temperature to about -162 degrees Celsius. This is an energy-intensive process, and the proposed LNG facilities are subsequently expected to contribute significantly to Nova Scotia’s carbon dioxide emissions.

As the province’s Environmental Goals and Sustainable Prosperity Act sets an ambitious GHG emission target of at least 10 percent below 1990 levels by 2020, Nova Scotia Environment hired a consulting firm, The Delphi Group, to prepare a report on the various available options for mitigating the release of GHGs by LNG facilities. Options include reducing emissions through facility design, or contributing to a compliance fund at a rate of C$25 per ton carbon dioxide equivalent for emissions that exceed the set standard. The revenue from the fund would be used for climate change and GHG reduction initiatives.


Quebec, Ontario Unveil Policies to Promote Zero-Emission Vehicles

Quebec intends to be the first province in Canada to impose a mandate on the sale of zero-emission vehicles (ZEVs). Bill 104, An Act to increase the number of zero-emission motor vehicles in Quebec in order to reduce greenhouse gas and other pollutant emissions, will put in place a system of credits and charges for vehicle manufacturers, linked to their sale of ZEVs in Quebec.

Bill 104 was introduced in the National Assembly on June 2, 2016. Credits and charges will be set by regulation, but it is expected that Quebec’s model will resemble California’s, with automakers earning credits for ZEV sales, or purchasing them from rivals if necessary in order to avoid paying a penalty. The Bill doesn’t specify the percentage of sales that must be ZEVs. California’s mandate is 15 percent by 2025.

Ontario’s Five Year Climate Change Action Plan 2016-2020, made public June 8, 2016, has a more modest ZEV goal than California’s—five percent of vehicle sales by 2020, and it specifically rejects a legislated mandate. Ontario will promote the transition to ZEVs through strong purchase incentives, including a hefty rebate on the purchase price and incentives for homeowners to install charging stations.

Ontario’s rebate program for electric vehicle purchase or lease will be extended to 2020. It rebates as much as C$14,000 of vehicle cost. Ontario will also rebate up to C$1,000 of the cost of purchasing and installing a home charging station. Electric vehicle owners will also enjoy four years of free overnight vehicle charging beginning in 2017.—by Mark Sabourin, EcoLog.com
2016 Calendar of Events

AUGUST
16–19 Power Plant Pollutant Control “MEGA” Symposium
Baltimore, MD

SEPTEMBER
20–23 A&WMA Southern Section Annual Meeting & Technical Conference
Biloxi, MS

27–30 Atmospheric Optics: Aerosols, Visibility, and the Radiative Balance
Jackson Hole, WY

OCTOBER
4–6 35th Annual International Conference on Thermal Treatment Technologies & Hazardous Waste Combustors (IT3/HWC)
Baton Rouge, LA

5–7 A&WMA Pacific Northwest Section 56th International Conference
Juneau, AK

25–26 A&WMA Ontario Section Air and Acoustic Monitoring Conference
Waterloo, Ontario

DECEMBER
7–8 Vapor Intrusion, Remediation, and Site Closure
San Diego, CA

Technical Papers
Resource allocation for mitigating regional air pollution-related mortality: A summertime case study for five cities in the United States

Early atmospheric detection of carbon dioxide from carbon capture and storage sites

Synthesis of a novel slow-release potassium fertilizer from modified Pidgeon magnesium slag by potassium carbonate

On dispersion above a forest: Measurements and methods

Microscale air quality impacts of distributed power generation facilities

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2016 EVENTS

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Critical Review: Emissions from Oil and Gas Operations
Technical Sessions: Research, Compliance, Practical Solutions
Mini Symposium: Industrial Growth and Environmental Stewardship
Networking: Exhibit Hall, Grand Reception, YP/Student Events


Power Plant Pollutant Control and Carbon Management “MEGA” Symposium
August 16-19, 2016 • Baltimore, MD

With a focus on industry response to new operational and environmental challenges for power plants, and a streamlined format, the MEGA Symposium returns in 2016 through the combined efforts of four key industry players – the Electric Power Research Institute (EPRI), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and the Air & Waste Management Association (A&WMA).

Conference topics include: MATS Controls, Carbon Management and CO2 Control, Managing Variable Load. Byproduct Discharge Management, and SOx/NOx Particulate Controls.


Atmospheric Optics: Aerosols, Visibility, and the Radiative Balance
September 27-30, 2016
Jackson Hole, WY

This international conference will provide a technical forum on advances in the scientific understanding of the effects of aerosols on urban, regional, continental, and global-scale haze and the radiative balance. The conference will take a multipronged approach by encouraging scientific submissions (e.g., related to measurements, modeling, etc.) as well as submissions addressing regulatory and policy issues.


This conference includes an excursion to Grand Teton National Park and a night sky program. Visit the website at http://visibility.awma.org.

Save the Dates:

35th International Conference on Thermal Treatment Technologies and Hazardous Waste Combustors (IT3/HWC)
October 4-6, 2016 • Baton Rouge, LA

IT3 provides a forum for the discussion of state-of-the-art technical information, regulations, and public policy on thermal treatment technologies and their relationship to air emissions, greenhouse gases, climate change, renewable energy or alternative energy production, and sustainability.

Find more details at http://it3.awma.org.

Vapor Intrusion, Remediation, and Site Closure
December 7-8, 2016 • San Diego, CA

This conference addresses the important technical considerations involving the vapor intrusion (VI) pathway, site remediation, and advancing the process of site closure.


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For more information please contact Meredith Schwartz at (410) 584-1993 or mschwartz@networkmediapartners.com.
Staff and Contributors

A&WMA Headquarters
Stephanie M. Glyptis
Executive Director
Air & Waste Management Association
One Gateway Center, 3rd Floor
420 Fort Duquesne Blvd.
Pittsburgh, PA 15222-1435
1-412-232-3444; 412-232-3450 (fax)
em@awma.org
www.awma.org

Advertising
Meredith Schwartz
1-410-584-1927
mschwartz@networkmediapartners.com

Editorial
Lisa Bucher
Managing Editor
1-412-904-6023
lbucher@awma.org

Editorial Advisory Committee
John D. Kinsman, Chair
Edison Electric Institute
Term Ends: 2019

John D. Bachmann
Vision Air Consulting
Term Ends: 2017

Robert Basl
EHS Technology Group
Term Ends: 2019

Leiran Biton
U.S. Environmental Protection Agency
Term Ends: 2019

Gary Bramble, P.E.
AES
Term Ends: 2017

Prakash Doraiswamy, Ph.D.
RTI International
Term Ends: 2017

Ali Farnoud
Ramboll Environ
Term Ends: 2017

Steven P. Fry singer, Ph.D.
James Madison University
Term Ends: 2018

Keith Gaydosh
Affinity Consultants
Term Ends: 2018

C. Arthur Gray, III
CP Kelco-Huber
Term Ends: 2019

Mingming Lu
University of Cincinnati
Term Ends: 2019

Dan L. Mueller, P.E.
Environmental Defense Fund
Term Ends: 2017

Brian Noel, P.E.
SABIC
Term Ends: 2017

Blair Norris
Ashland Inc.
Term Ends: 2017

Teresa Raine
ERM
Term Ends: 2017

Anthony J. Sadar, CCM
Allegheny County Health Department
Term Ends: 2018

Golam Sarwar
U.S. Environmental Protection Agency
Term Ends: 2019

Anthony J. Schroeder, CCM, CM
Trinity Consultants
Term Ends: 2019

Susan S.G. Wierman
Mid-Atlantic Regional Air Management Association
Term Ends: 2018

James J. Winebrake, Ph.D.
Rochester Institute of Technology
Term Ends: 2018

Layout and Design: Clay Communications, 1.412.704.7897

EM, a publication of the Air & Waste Management Association, is published monthly with editorial and executive offices at One Gateway Center, 3rd Floor, 420 Fort Duquesne Blvd., Pittsburgh, PA 15222-1435, USA. ©2016 Air & Waste Management Association (www.awma.org). All rights reserved. Materials may not be reproduced, redistributed, or translated in any form without prior written permission of the Editor. A&WMA assumes no responsibility for statements and opinions advanced by contributors to this publication. Views expressed in editorials are those of the author and do not necessarily represent an official position of the Association. A&WMA does not endorse any company, product, or service appearing in third-party advertising.

EM Magazine (Online) ISSN 2470-4741 » EM Magazine (Print) ISSN 1088-9981