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Air Quality Modeling and Impacts on the Mining Industry: An Overview

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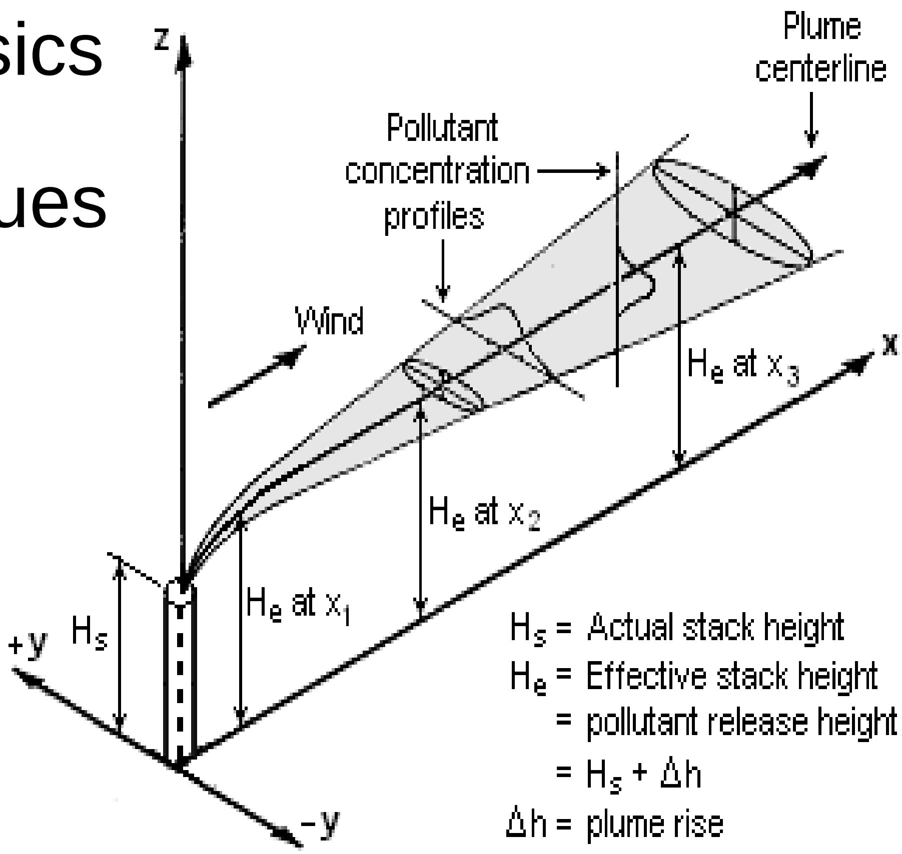
AGENDA

1. Air Quality Modeling basics
2. Air Quality Modeling Issues
   - Focus on Mining and PM2.5
3. Path Forward
4. Questions



Take Away

Avoid having your project delayed (or high-jacked) by air dispersion modeling during permitting….

- Be aware of the air modeling issues and options
- Plan ahead

Air Quality Modeling Basics

What is Air Dispersion Modeling?

Air dispersion modeling is the mathematical simulation of how air pollutants disperse into the ambient air. A key permitting tool:

- To predict downwind concentration
- To determine if facility is, or will comply with ambient air standards
- To assist in the design of emission control strategies to reduce emissions

Inputs to the model include:

- Meteorological data – wind speed/direction temperature, etc.
- Stack parameters – emission rate, stack height, gas velocity, gas temperature, etc.
- Emission Source parameter – source location and elevation
- Other – building dimensions

Air Dispersion Modeling - When is it Required?

- An essential step in site permitting process:
  - New Project (greenfield, EA, PSD Permitting)
  - Modifying existing facility (increase capacity)
- Compliance demonstration to new/existing (federal, state, province)
- Hazardous emission risk assessment (new HAPs = New Limits?..Mn)

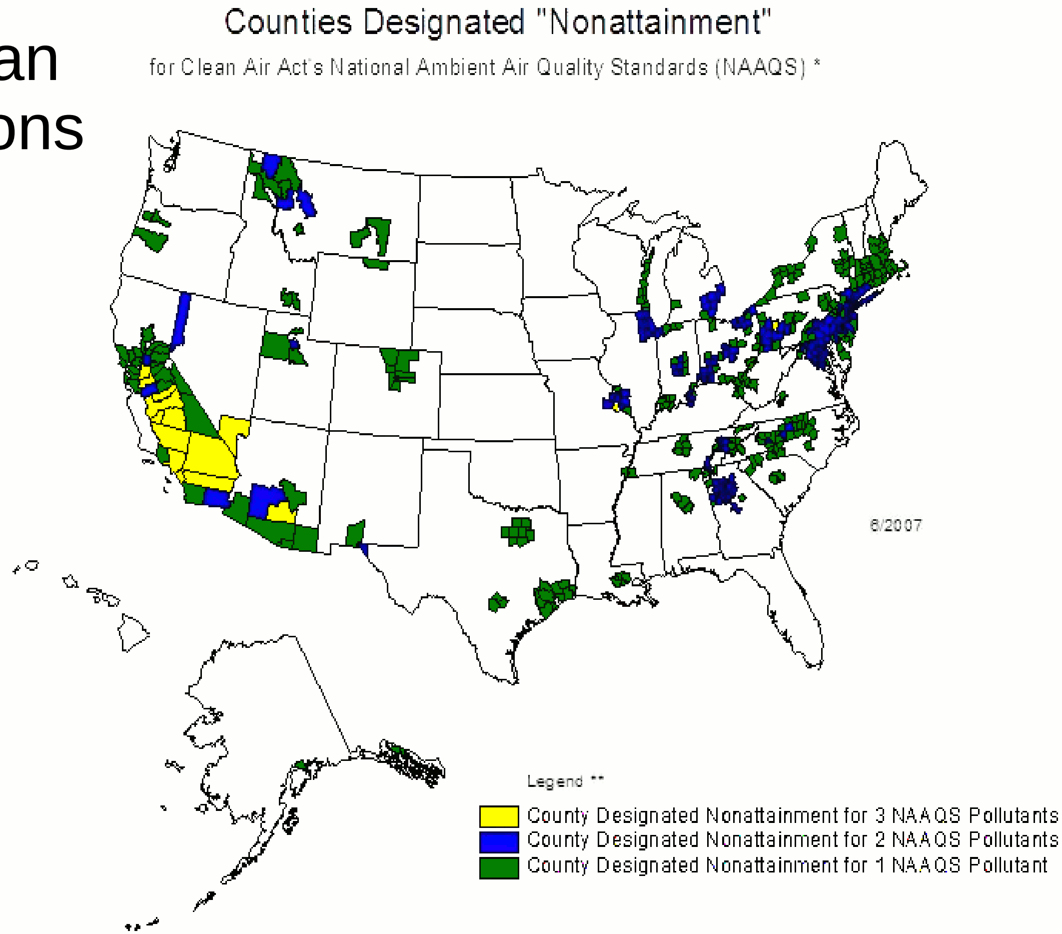
What is the Preferred Model?

- Stationary Sources with 50 km radius
  - AERMOD is the USEPA's Preferred Model
  - 40 CFR 51 Appendix W
  - Quebec (and other governments) reference use of USEPA air dispersion modeling tools and guidance in 40 CFR 51 Appendix W (EQA Q-2, r.4.1 Sch. H)

National Ambient Air Quality Standards (NAAQS))

Primary stds - protect human health for sensitive populations (e.g. children, elderly)

Secondary stds - protect public welfare (e.g. crops, domestic animals, building facades, etc.)



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Ambient Air Quality Challenges

Ambient Air Quality Standards (comparison of common variables)

Pollutant	**Canada (Quebec)**	**U.S.A (U.S.EPA)**	**Australia (*Western)**
	Quebec (1)	**Today**	**Today**
PM10 (24-hour)	150 ug/M3	150 ug/M3	National - 50 ug/M3 *Area A – 150 ug/M3 (TSP) *Area B,C – 90 ug/M3 (TSP)
PM2.5 (24-hour)	**30 ug/M3**	35 ug/M3	National **- 25 ug/M3 (goal**)
Ozone (1-hr)	.080 ppm	Revoked	0.1 ppm
Ozone (8-hr)	**.063 ppm**	.075 ppm	0.08 ppm (4-hr)
SO2 (1-hr)	**525 ug/M3 (4-min avg.)**	196 ug/M3	National – 572 ug/M3 *Area A - 700 ug/M3 *Area B – 500 ug/M3 *Area C – 350 ug/M3
NO2 (1-hr)	414 ug/M3	188 ug/M3	225 ug/M3

(1) Quebec EQA Q-2, r.4.1: (197) As of 30 June 2011, the construction or alteration of a stationary source or an increase in the production is prohibited if it will likely result in an increase in the concentration of a contaminant listed in Schedule K or in excess of the concentration of a contaminant for which the limit is already exceeded.

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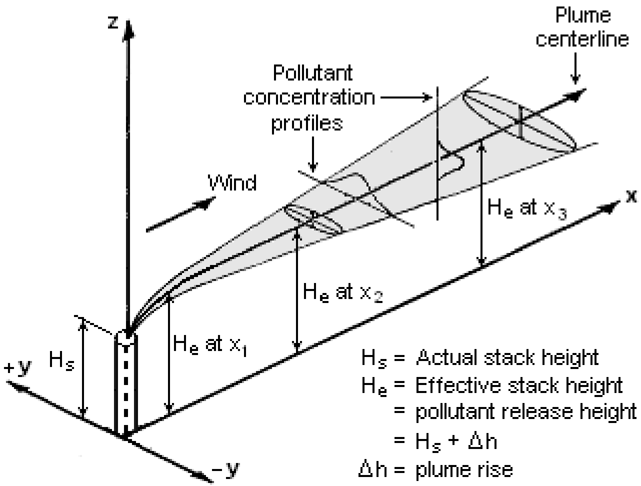
Lower Ambient Air Quality Standards - Issues

As ambient air standards become more restrictive, there is more strain on model accuracy and the limitations of modeling…Decisions on non-attainment, costly new controls & facility viability could be based on air dispersion modeling and guidance that is:

- overly conservative
- over-predicts impacts



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Air Quality Modeling Issues
Focus on PM2.5

Comparisons between Monitoring and Modeling Show Large Over-predictions (Examples)

AERMOD and Appendix W is overly conservative as applied to mining:

- **Single facility modeling**: Where monitor data show NAAQS compliance, AERMOD modeling used only iron and steel facility emissions (no background and no local source contributions):
  - Initial SO_2 modeling results were 7 x the 1-hr NAAQS
  - Initial $PM_{2.5}$ modeling results were 36 x the 24-hr PM2.5 NAAQS

- **Regional iventory modeling**: A peer-reviewed study of AERMOD predictions at monitoring sites in NW Indiana in 2008, where several iron and steel sources were operating at high production rates:
  - Predicted SO_2 design value at Gary IN monitoring site was 4.38 x monitored value using conservative inputs (actual annual emissions/8760 hours for major sources; no background)
  - Predicted SO_2 design value at the Hammond monitoring site was 6.5 x monitored value using conservative model inputs

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Mining Industry Modeling Challenges: Non-Stack Fugitive Sources

- AERMOD is best suited to model steady state emissions from traditional stacks (like a power plant or industrial boiler)
- The mining industry has numerous “non-stack” area or volume fugitive emission sources that pose challenges for accurate air modeling:
  - Haul roads
  - In-pit mining activities
  - Material Handling
  - Storage Piles
  - Roof Monitors – fugitive intermittent roof-top emission releases
  - Batch processes - do not sustain a maximum hourly emission rate

- AERMOD was NOT validated with these types of sources…….
- And the Emission factors (AP-42)and particle size data is not accurate

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Haul Road Fugitive PM10/PM2.5 Emissions (1 of 3)

It has been widely documented that atmospheric dispersion models used for predicting impacts from non-Gaussian fugitive sources lead to over-prediction of transportability and the resultant air quality impacts of fugitive dust emissions. AERMOD does not account for:

- Dust plume depletion due to particle electrostatic agglomeration, gravitational settling and deposition near the point of release.
- Proper representation of source configuration (e.g., moving point source vs. continuously emitting line or elongated volume source)
- Pit trapping

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Haul Road Fugitive PM10/PM2.5 Emissions (2 of 3)

This first became clear from receptor analysis of fugitive dust impacts at monitoring sites, in comparison with the predictions of mainstream dispersion models. The over-prediction was found to be in the range of a factor-of-4 for a representative mix of fugitive dust sources that are typically at grade.

Table 4. Modeling Deficiencies for Dust Dispersion Analyses

Modeling deficiency	Estimated over-prediction	Principal Investigator—[Ref.]	Comments
Misrepresentation of haul roads as continuously emitting area sources	Factor of 2	Randy Reed (NIOSH)—[13]	Based on algorithm comparisons
Cumulative effects of modeling deficiencies	Factor of 4 for "average" groundcover	Pace (USEPA)—[1]	Based on comparisons of modeled with measured dust impacts for grid models.
Exclusion of near-source agglomeration and enhanced deposition	Up to a factor of 6, depending on wind and groundcover	Cowherd (MRI)—[7,8] Etyemezian (DRI)—[9]	Based on field tests of near-source impacts of unpaved road emissions with various adjacent groundcover types
Exclusion of trapping by vertical obstacles during horizontal transport	Factor of 2 to 6, depending on wind and groundcover	Yayi Dong (Idaho DEQ)—[15]	Based on modeling comparisons and field validation
Lack of treatment of pit trapping	Factor of 2	Randy Reed (NIOSH)—[13]	Extensive literature review that references model validation studies Cole (TRC)—[13]
Instant vertical mixing in grid models	Factor of 2	Yayi Dong (Idaho DEQ)—[15]	Applies to grid models only

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Haul Road Fugitive PM10/PM2.5 Emissions (3 of 3)

The resulting net over-prediction of fugitive dust impacts has been offset by what was termed as the "factor-of-four" correction, as referenced by Countess[1]. EPA modelers at Research Triangle Park, NC made "divide-by-four" adjustments to the popular grid-based Regional Model (Community Multi-Scale Air Quality -CMAQ) concentrations to account for the significant discrepancy between predicted and observed impacts of fugitive dust sources (see Pace[2,3]).

Recommendations (see Cowherd [4])

1. Adopt emissions pre-processing step (similar to CMAQ area-wide fugitive dust)
2. As a result of the documented factor of 4 over-prediction, and as a measure of conservatism:
   - Include a pre-processing **emission deposition reduction of 50 percent for haul roads outside of pit**
   - Include a pre-process emission deposition reduction of **75 percent for haul roads within the pit.**

(1) Countess, Richard. "Reconciling Fugitive Dust Emission Inventories with Ambient Measurements." Presented at Emission Inventory Conference. Available November 15, 2007, http://www.epa.gov/ttn/chief/conference/ei12/fugdust/countess.pdf

(2) Pace, Thompson G. Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban scale Air Quality Analyses. U.S. Environmental Protection Agency, Research Triangle Park, NC. August 3, 2005.

((3) Pace, T.G.; Cowherd, C. Jr.: "Estimating PM-2.5 Transport Fraction Using Acreage-Weighted Country Land Cover Characteristics—Examples of Concept," In Proceedings of the 96th Annual Meeting of the Air and Waste Management Association: San Diego, CA, June 2003.

(4) Cowherd, C. Jr: "Transportability Assessment of Haul Road Dust Emissions". Report Issued to USEPA. August 2009.

Low Wind Speed Issues – Specific Problems for Taconite Industry Sources

- Fugitive windblown dust is generally not a concern during low wind conditions, however, low wind speed events generally result in the maximum modeled concentrations for fugitive dust sources because emissions are assumed constant
- There are many low-level fugitive emission sources in the mining industry that are greatly affected by the low wind speed over prediction issue
- Fugitive dust modeling showed maximum impacts during low wind speed conditions
  - $PM_{2.5}$ results increased by a factor of 4 when the only variable changed was lowering the minimum wind speed threshold (AERMOD v09292 vs AERMOD v11103, using AERMINUTE)

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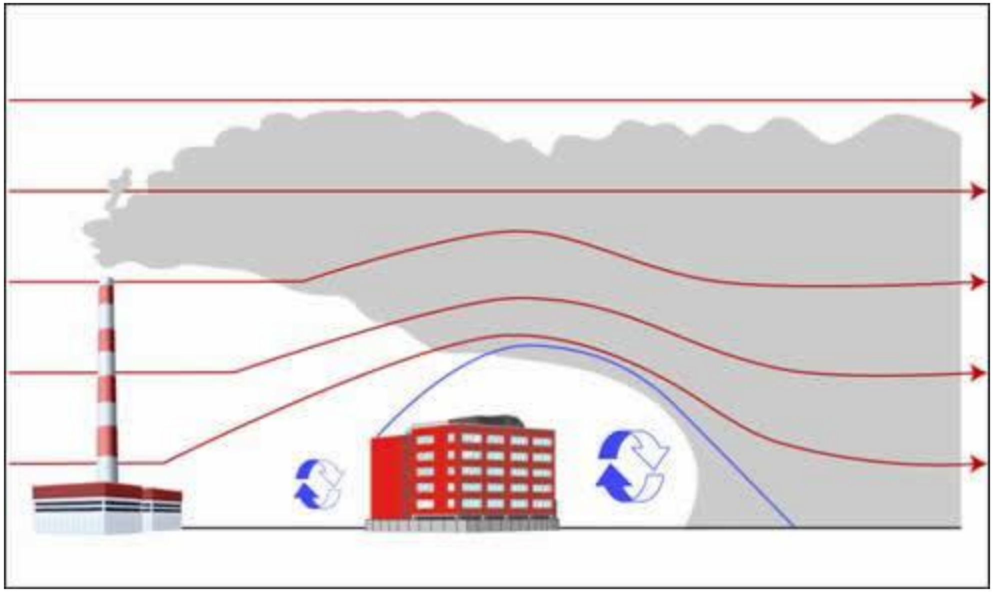
Downwash Anomalies – Low Wind Speed

Actual

Low Wind Speed AERMOD Anomaly



Picture taken from Ontario Ministry of the Environment
http://www.ene.gov.on.ca/envision/techdocs/3614e02.htm

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NOT a New Issue for Surface Coal Mining Sources

- Unacceptable performance of EPA's Models and Emission Factors When Applied to Fugitive Particulate emission and dust is well known and documented
  - CAA Section 234 (Fugitive Dust) required EPA to assess the accuracy of air dispersion models for fugitive emissions from surface coal mining operations (CAA Amendments of 1990, Pub. L. No. 101-549, Section 234, 104 Stat. 2399 (1990).
  - By 1996 EPA concluded that air dispersion model (ISC3) over-predicts the impacts of surface coal mines, the Agency decided not to use the dispersion model for regulatory applications involving these sources (Seitz letter to Sen. Simpson, June 28, 1996)

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Path Forward

- Advocacy
- Next Steps

Summary

- Air dispersion modeling plays a critical role in obtaining air permits, and influencing facility design for emission controls
- Models must be more accurate to meet demands of more stringent standards
- Air dispersion models are not currently accurate enough to meet evolving standards – especially for fugitive, area, volume, low stack sources.

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Advocacy – Expertise Deployed

- A number of coalitions and technical work groups are formed to develop solutions
- Prioritizing Action
  - NAAQS Implementation Coalition
  - AWMA Meteorology Committee (AB-3)
  - Technical Work Group formed by EPA
  - Trade Associations
    - NMA, EPRI, AISI, Others

Advocate use of “Advanced Protocols”

- Numerous viable protocols have been developed to close the gap in the modeling tools…
  - Pre-processing step for haul road and in-pit deposition (Cowherd)
  - Low wind speed and downwash anomaly corrections
    - low wind speed threshold of 1 m/s
    - Use of sigma-theta data
    - Model changes in AERMET (u_* formulation) and AERMOD (minimum sigma-v) were recommended
  - The Electric Power Research Institute (EPRI) recently (Sept 2012) created a public beta of a suite of software tools that may be used with the AERMOD air dispersion modeling system:
    - SHARP: Sub-Hourly AERMOD Run Processor
    - EMVAP: Emissions Variability Processor (more representative of actual emissions
  - These tools do not alter the code of the AERMOD model, these tools operate as a collection of pre- and post- processors for the AERMOD modeling system.
  - These tools were all shared with EPA during the “10-Modeling Conference “ (2012)

Three tools (SHARP, EMVAP and DISTANCE_DEBUG) can be downloaded at the following location: http://sourceforge.net/projects/epri-dispersion/

Explore Monitoring in Lieu of Modeling

- Apply Appendix W Section 10 guidance allowing monitoring where models are inadequate (10.2.3.1 (b))
  - Source specific enhanced monitoring network is deployed to clarify/determine the source compliance to air quality thresholds (in lieu of inaccurate models)
  - Information could be used to calibrate the model
  - April 12, 2012 McCarthy memo considering monitoring in lieu of modeling for "sources that may not be as conducive to modeling…" regarding the SO_2 SIP.
    - Expecting further guidance on this

Avoid Getting Blind Sided

- If the facility is in a growth mode…………..
- If the facility is located in or adjacent to a non-attainment or maintenance area………
- If the facility has a significant emission profile………

AND you have not started assessing the New NAAQS risks………

Next Slide

Start the NAAQS Assessment **NOW** - Path Forward

- Update emission inventories (especially NO_2, SO_2 and $PM_{2.5}$, speciate filterable and condensable components)
- Jump start the process to identify modeling issues
  - Identify Emission Inventory/Modeling Refinement
  - Identify culpable sources to NAAQS exceedance
    - Is the exceedance attributed to one of known gaps (low wind speed, downwash, secondary PM, fugitive sources, etc.)
    - Consider model refinements (on-site met tower, advance protocols, etc.)
  - Develop modeling scenarios
- Strategic Projects – Get out in front to identify fatal flaws and additional budgetary considerations to resolve modeling issues.

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Questions?