

Weather Impacts on Air Dispersion

Prepared for:	SMC St. Marys Cement Plant Community Liaison Committee Meeting
Presented by:	Winnie Song, M.Sc., P.Eng. BCX Environmental Consulting March 14, 2020



Opening

- Weather conditions have significant impacts on air dispersion.
- Wind direction is not the only factor.
- Air dispersion is also impacted by how stable the atmosphere is (i.e. atmospheric stability).











- Atmospheric Stability and Lapse Rates
- P Air Dispersion under Different Weather Conditions
- Air Dispersion in the Town of St. Marys
- What will the Stack Extension Do for Air Dispersion











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Atmospheric Stability and Lapse Rates

- The driver for air movement is temperature variance.
- Air temperature varies with height. This vertical temperature variance directly
 impact air stability.
- The vertical temperature gradients are called "Lapse Rates".
- Lapse rates are used to describe how stable the atmosphere is (i.e. atmospheric stability).
- The two important lapse rates are Adiabatic Lapse Rate (ALR) and Environmental Lapse Rate (ELR).





Adiabatic Lapse Rate (ALR) - Benchmark

- Adiabatic Lapse Rate (ALR) is the rate at which the temperature changes/decreases with height in an "ideal" environment.
- The ALR is approximately -1°C every 100m or -10°C/km.
- The ideal environment assumes that the air particles are "isolated" from the environment and warm or cool without losing or gaining any energy.





Adiabatic Lapse Rate (ALR) - Benchmark

The closest analogy to describe ALR is a hot air balloon.

- The air in the hot air balloon is "isolated".
- When the hot air balloon shrinks it does not work on its surroundings or does it require any work to stretch.
- The heat transfer between balloon and the environment is slow enough to be ignored.





Environmental Lapse Rate (ELR)

- **Environmental Lapse Rate** (ELR) is the rate at which the temperature changes/decreases with height in actual environment.
- The ELR is influenced by patterns of heating, cooling and mixing and the past history of the air mass.
- The difference between ELR and ALR determines how stable the atmosphere is.





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Air Dispersion under Unstable Conditions -Looping





- Atmospheric Stability: Unstable, strong vertical mixing
- Wind speed: Low

- Time/Weather of occurrence: Sunny Day
- P Air Dispersion Condition: Good, dominated by thermally induced turbulence



Air Dispersion under Stable/Neutral Conditions - Coning

Temperature Changes with Height





- 9 Atmospheric Stability: Stable, OK vertical mixing
- Wind speed: Moderate to strong
- Time/Weather of occurrence: Cloudy days, day/night transitions
- Air Dispersion Condition: OK, dominated by mechanically induced turbulence (winds)



Air Dispersion under Stable/Inversion Conditions - Fanning



- Atmospheric stability: Very Stable, very little mixing
- Wind speed: not specific

- Time/weather of occurrence: Clear night the surface cools
 - Air dispersion condition: Suppressed turbulence



Air Dispersion under Stable/Inversion Conditions – Lofting



- Atmospheric Stability: Stable below the inversion layer
- Wind speed: not specific
- Time/weather of occurrence: Late afternoon and early under clear skies



P Air dispersion condition: Favorable for ground level for tall stacks.

Air Dispersion under Stable/Inversion Conditions – Capping (Fumigation)



- Atmospheric stability: Stable above the inversion layer
- Wind speed: not specific

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Time/weather of occurrence: Early morning after a stable night

- BCX
- **?** Air dispersion condition: **Poor**. Plume trapped by inversion above stack height.



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Air Dispersion in the Town of St. Marys



- The kiln stack is located in a former quarry below grade. The stack is short relative to the elevated receptors in town. The river valley runs
- through town.
- Radiation inversions are intensified in the valley to result in very stagnant air.
- Short stack + valley climate = Poor air dispersion.



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What will the Stack Extension Do for Air Dispersion under Good/Ok Dispersion Conditions



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The stack extension will elevate the plume from the ground and provide more volume for mixing and dilution.



What will the Stack Extension Do for Air Dispersion under Poor Dispersion Conditions



In Summary:

- Atmospheric Stability has significant impacts on air dispersion
- P Air dispersion can be very poor when inversion occurs
- Inversion can occur in the morning or early evening
- Stack extension can minimize ground level concentrations by providing more mixing volume/height and lifting the plume (at least a portion of it) above the inversion layer





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