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A Description of Lake Ontario Effects on Shoreline Emission Sources

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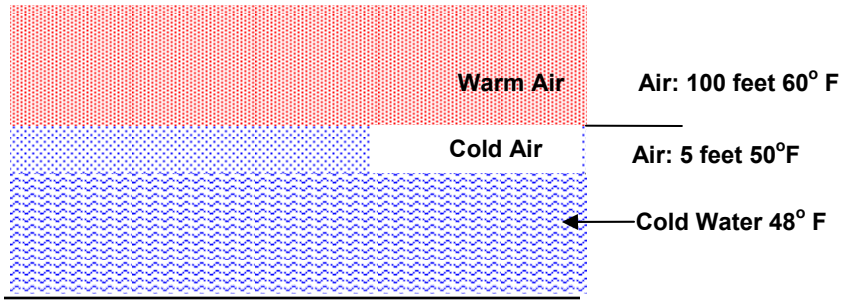
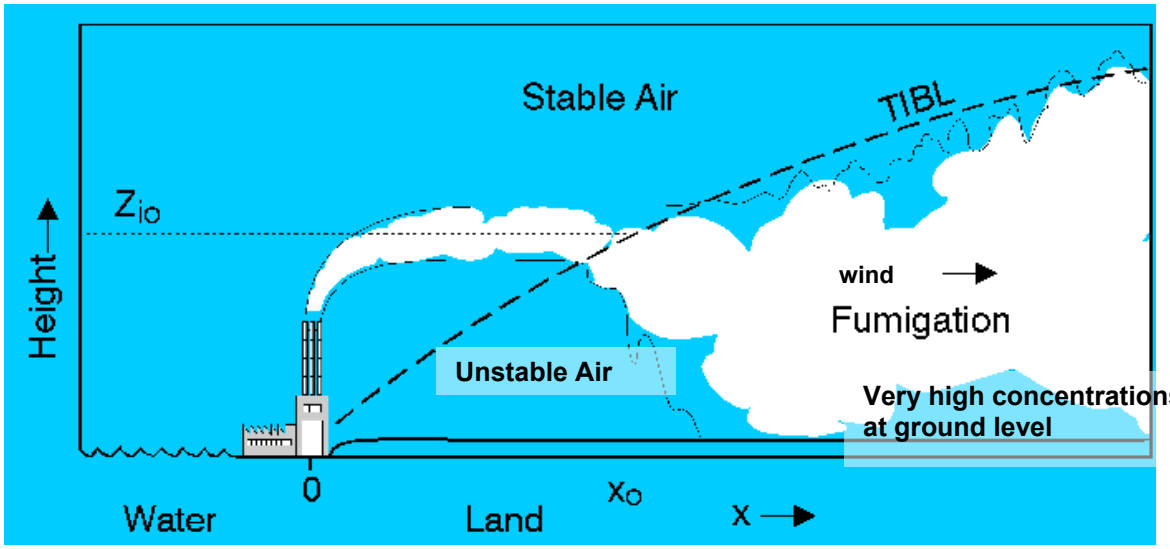
Summary: During the spring and summer months the temperature of lake water is colder than the air, especially during the day time. Lake Ontario is a deep lake that takes a long time during the warm season to heat up. Flow over the cold lake means that temperature of the air increases with height. Increasing temperature with height is known as a temperature inversion which causes the air to be very stable. When air is stable there is very little convection or turbulence to mix (disperse or dilute) pollutant concentrations. See diagram below.



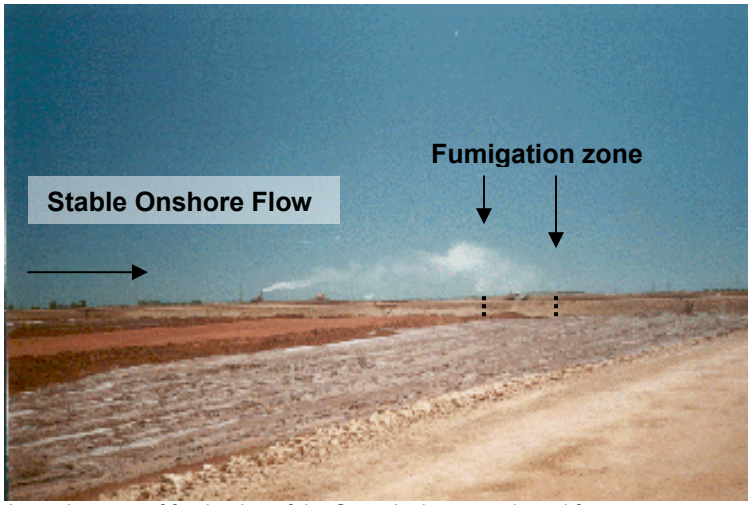
The effect of the stable air over Lake Ontario and other Great Lakes can be seen in the following satellite photos. Over the much of the land areas convective turbulence leads to cumulus cloud formation. However, over Lake Ontario the cloud forming turbulence (vertical motions) is absent and so are the clouds. Note also that there is an absence of cumulus clouds over the land in the shoreline areas, this resulting from a stable flow onshore (which limits cloud forming convective activity).

The stable air flowing over the lake also limits the ability of the atmosphere to disperse (dilute) air emissions. This photo shows haze in stable air over L. Como in the Italian Lake District.

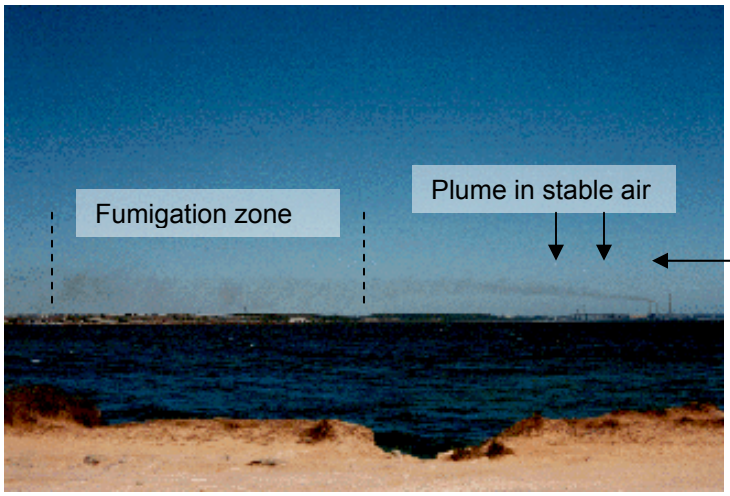
When the stable air flows onshore, it has a dramatic effect on the levels of air pollution from emission sources such as coal burning power plants, incinerators, and cement kilns. The following diagram shows what happens on many days during the year when stable air flows onshore.



The stack from the source emits its elevated plume into stable air. Dispersion (mixing) is initially limited and the plume is narrow. As the air flows over the land surface it is heated from below and a turbulent mixing develops from the bottom up. The height of this mixing layer increases as the air moves inland and heating continues. At some point, (e.g. several kilometers inland, depending on the plume height) the mixing layer intercepts the plume. At this point the strong turbulence in the mixing layer brings the pollution in the plume to the ground – often resulting in very high pollutant concentrations in the air above the surface. Notice, however, that the stable air above the plume acts as a cap which prevents the plume from dispersing upward. The cap of stable air combined with the rapid mixing below results in a process known as shoreline fumigation, shown in the following photographs from a study on the west coast of Australia. Shoreline fumigation can persist along with high concentrations in the breathing zone – for many hours (mid to late morning to late afternoon).



An early stage of fumigation of the State A plume as viewed from Alcoa Residue Site. **Source:** Kwinana (Australia) Coastal Fumigation Study http://www.cmar.csiro.au/e-print/open/sawford_1997a.html



Typical fumigation of the Stage A plume as viewed from Woodman Point.
The plume is visible due to fly ash injection. **Source:** Kwinana (Australia)
Coastal Fumigation Study http://www.cmar.csiro.au/e-print/open/sawford_1997a.html
Printing over the photo by Henry S. Cole, Ph.D.

Shoreline fumigation is well known and has been investigated in coastal areas around the world including Lake Ontario. The process has been recognized by regulatory agencies in Canada, Ontario, and the U.S. as producing maximum concentrations from shoreline emission sources. To predict concentrations before an incinerator or power plant is approved, these regulatory agencies require estimates of annual and maximum pollutant concentrations using computer-based air quality models. The models generally used, however, are not equipped to simulate coastal fumigation. This often results in estimates of maximum ground level concentration that are far lower than "real world" concentrations. Thus, neither the public nor a regulatory agency should accept an application or environmental impact statement for a shoreline emission source without requiring the application of available models that simulate shoreline dispersion conditions including fumigation.

Most importantly, given the impact of stable onshore flow on air quality, government agencies would be prudent to avoid the location of emission sources such as incinerators along the Lake Ontario shoreline.

The Author's Background. Henry S. Cole, Ph.D. was co-author with Walter A. Lyons, Ph.D. of a number of earliest journal articles to describe to describe shoreline fumigation. This research was conducted on the western (Wisconsin shoreline) of Lake Michigan. Cole's work also focused on the impact of Lake Michigan on photochemical smog (ground level ozone). During the 1970's and early 80's Cole served a senior scientist with the Office of Air Quality, Planning & Standards (OAQPS) at the US Environmental Protection Agency. There he served as Chief of the Model Application Section and helped to develop an early version of a point source model that incorporated shoreline fumigation. Dr. Cole's resume and a list of pertinent reports and publications follows.

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Henry S. Cole, Ph.D.
Summary of Professional Experience

- Since 1993 Dr. Cole has served as president of Henry S. Cole & Associates an environmental consulting firm that provides scientific support for a diverse clientele that includes environmental and community-based organizations, corporations and government agencies. Dr. Cole and the firm have provided research and technical assistance including environmental assessments and expert testimony on a variety environmental issues, including hazardous waste sites, municipal landfills, and industrial air pollution. He has provided expert testimony on the need to incorporate the impact of air emissions from coal burning power plants in utility rate structures following deregulation and provided a report on air quality impacts of the Kodak's Rochester facility to the NY State Attorney General's Office. From 2002-2005 he served as special Liaison for the Franklin County Ohio Court of Common Pleas to oversee air pollution and plant safety compliance and impact issues at Georgia-Pacific's resin plant in Columbus, OH.

- The company also promotes environmentally sound alternative products and technologies. Dr. Cole was co-recipient of the 2002 *Presidential Green Chemistry Challenge Award* (with Chemical Specialties, Inc.) for his work documenting the environmental advantages of ACQ, an arsenic-free and chromium-free alternative wood preservative. His work also helped prevent EPA's registration of a hexavalent chromium based preservative with technical comments to the Agency's Pesticide Office.

- Dr. Cole served as Science Director of Clean Water Action and Clean Water Fund from 1983 to 1992. In this role he worked with national coalitions to strengthen Superfund and RCRA to encourage waste reduction, recycling and safe disposal practices. His reports on municipal incinerators and mercury contamination received widespread media coverage and spurred successful campaigns to reduce incinerator emissions and mercury use. He also authored a series of reports and testified frequently before the U.S. Congress on Superfund and RCRA issues. Dr. Cole provided technical assistance to dozens of community organizations, corporations, and municipal governments in their efforts to obtain protective cleanups of Superfund sites and other hazardous waste and environmental release sites.

- From 1977-1983, Dr. Cole served as a senior scientist and section chief with U.S. EPA's Office of Air Quality Planning and Standards. In this capacity, he directed several programs that used air quality models to develop control strategies for stationary source, urban and regional air pollution problems. A principal area of expertise lies in the relationship between sources (emissions) and ambient air quality. Dr. Cole authored numerous journal articles and reports related to these issues.

- During the 1970's, Dr. Cole was an Associate Professor of Environmental Earth Sciences at University of Wisconsin-Parkside. In this capacity he conducted research programs involving air pollution meteorology and photochemical oxidants, led several environmental organizations and served as a member of the Wisconsin State Air Pollution Control Council and as an environmental advisor to former Congressman Les Aspin.

- Present and past professional associations: American Chemical Society, American Meteorological Society, Air Pollution Control Association, American Association for the Advancement of Science.

Dr. Cole received a Ph.D. in meteorology from the University of Wisconsin in 1969 with a minor in geology. His dissertation involved the reconstruction of past climates. He obtained his B.S. with High Honors from Rutgers University - College of Agriculture. He attained membership in Phi Beta Kappa and Sigma Xi (Honorary Research Society). His undergraduate majors included soil science and meteorology.

See publications list: Attachment 1.

Attachment 1

PUBLICATIONS, REPORTS, and TESTIMONY OF HENRY S. COLE, PH.D.

Atmospheric Science and Air Pollution

Final Report Of Environmental Liaisons' Investigation: Georgia-Pacific Resins Inc., Columbus, Ohio: Plant Safety And Environmental Issues, Submitted to Franklin County Court of Common Pleas, October 2005. (3 Volumes).

"The NJ Board of Public Utilities Must Act Decisively to Protect Public Health and Environment," Comments on the NJ Master Plan Phase II Submitted to PUC, February 27, 1997, (With D. Phillips). (Testimony focuses on air pollution impact of coal burning power plants and the need for incorporate limits on air emissions in NJ's deregulation plan.)

Mercury Warning: A Study of Mercury Contamination in the United States, Published by Clean Water Fund and Clean Water Action, Washington, DC, August, 1992. (Report focuses on atmospheric sources of mercury, and its fate, transport and biomagnification in the aquatic food chain.)

Testimony before the Environment and Public Works Committee, US Senate, on the "Mercury and the Resource Conservation and Recovery Act Amendments of 1991, September 12, 1991. (Report focuses on incineration and air emissions.)

Testimony before the US Environmental Protection Agency, October 19, 1990, on proposed NSPS and Emissions Guidelines for MSW Incinerators, "Strict Numerical Emission Limits are Needed for Mercury from Municipal Waste Combustors."

Testimony before the Subcommittee on Transportation and Hazardous Materials, Committee on Energy and Commerce, U. S. House of Representatives, May 11, l989, on the Municipal Solid Waste Incinerator Act of 1989.

U.S. EPA, A Review of Recent Applications of the SAI Urban Airshed Model (Ozone/photochemical modeling), EPA-450/4-84-004, December 1983. "Needs and Application of Regional Air Quality Simulation Models for Oxidants in North America", International Conference on Long Range Transport Models, Research Triangle Park, North Carolina, April, 1983.

"Coastal (Air Pollutant) Transport and Diffusion: EPA Research and Development Needs," Workshop on Coastal Transport Processes, Brookhaven National Laboratories, Long Island, New York, July 1982.

"Application of the Airshed Model for Ozone Control in St. Louis", 75th Annual Meeting of the Air Pollution Control Assoc., New Orleans, June 1982.

"Evaluation of the Airshed Model Performance for St. Louis", Third Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society/Air Pollution Control Association, San Antonio, Texas, January, 1981.

"Basis for Simplified Modeling Approaches for Short Term NO_2 Concentrations" 75th Annual Meeting, Air Pollution Control Association, June 1981, Philadelphia (with E. Meyer and R. Kelly).

"Status of the Short-Term NO_2 Standard and Microscale NO_2 Modeling", Transportation Research Board (National Academy of Sciences), January, 1981, Washington, DC

U. S. EPA, "Summary Report on Modeling for the Avon and East Lake Power Plants", June, 1980.

"The Use of Atmospheric Dispersion Modeling for Incinerators Emitting Hazardous Wastes", Chapter for US EPA Background Document, Section 264.34 Standards for Hazardous Waste Incineration, Resource Conservation and Recovery Act, Oct. 1980 (with John Summerhays).

"Technical Basis for Developing Control Strategies for High Ambient Concentration of NO_2 "US EPA, OAQPS Guidance Document", September, 1980, (with Don Sennett and Ned Meyer), EPA 450/4-80-017.

"A Review of Techniques Available for Estimating Short-Term NO_2 Concentrations" Journal of Air Pollution Control Association, August, 1979 (with John Summerhays).

U. S. EPA, "The Impact of an NOx Diesel Waiver on NO_2 Concentrations Downwind of a Major Line Source", A Report to the Office of Mobile Source Air Pollution Control, May 1979.

U. S. EPA, "Pittston Oil Refinery, Eastport, Maine: Potential for Violation of the PSD Increment", Report to Region I, EPA. June 1978.

"Photochemical Air Pollution Transport in the Chicago-Milwaukee Corridor, a Case Study", Annual Meeting American Association for the Advancement of Science, Washington, DC, February 1978.

"Photochemical Oxidant Transport: Mesoscale Lake Breeze and Synoptic Scale Aspects." Journal of Applied Meteorology, July 1976, (with Walter A. Lyons).

"Fumigation and Plume Trapping: Aspects of Mesoscale Dispersion on the Shores of Lake Michigan during Periods of Stable, Onshore Flow", Journal of Applied Meteorology, April 1973 (with W. Lyons).

"Air Pollution and Weather", The Science Teacher, December 1973.

"The Impact of the Great Lakes on the Air Quality of Urban Shoreline Areas: some practical applications with regard to air pollution control policy and environmental decision-making", 15th Conference on Great Lakes Research, Madison, Wisconsin, April, 1972.