

## Office of Science

# Research Project Summary

May 2013

### Delineation of a Potential Gaseous Elemental Mercury Emissions Source in Northeastern New Jersey

#### Authors

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#### Abstract

In order to assist in the identification of possible mercury (Hg) emission sources in northeastern New Jersey, this project was undertaken to delineate geographic areas in which these sources may be located. The objectives of this project were to measure gaseous elemental mercury (GEM) concentrations at a site on Staten Island, New York to the east of the putative emissions source and analyze these results with those obtained by the NJDEP at their air monitoring site (ELAB) in Elizabeth, New Jersey. Additional local measurements were to be obtained near possible emission sources. From September 30, 2011 to September 3, 2012, GEM data were collected for more than 200 days at the Staten Island site. Together with wind speed and direction data from the NOAA Bergen Point West Reach naval observatory station these measurements were analyzed and transport trajectories of GEM in the region were determined. GEM concentration and wind direction data from the ELAB site for the same period of time were also analyzed. Local measurements of GEM in the area were limited by access to appropriate sites and difficulties maintaining stable calibration of the portable Hg analyzer. Directional analysis of the number frequency and concentration-weighted distributions of GEM peaks with concentrations  $>4 \text{ ng m}^{-3}$  at the ELAB site revealed a single source located to the south of the sampling site (bearing  $173.4^\circ$ ). Similar analysis of GEM results for the Staten Island site revealed two possible sources, one to the west (bearing  $280.5^\circ$ ) and a second to the southwest (bearing  $213.8^\circ$ ). The intersections of the two Staten Island transport trajectories with the ELAM trajectory delineate two possible GEM source areas. The first is centered in Rossville, NY on Staten Island ( $40.5514 \text{ N}$ ,  $74.1947 \text{ W}$ ) and the second near Pralls Island in the Arthur Kill along the eastern border of Linden, NJ ( $40.6119 \text{ N}$ ,  $74.2039 \text{ W}$ ). Temporal analysis of GEM peaks for the three source directions indicates that the eastern Linden source may contribute more GEM to elevated measurements recorded in Elizabeth than the Rossville source.

#### Introduction

Monitoring studies of atmospheric mercury in northeastern New Jersey report that gaseous elemental mercury (GEM) concentrations episodically exceed the average ambient level of  $2 \text{ ng m}^{-3}$  (Goodrow et al., 2005; Aucott et al., 2009). For example, in a study of GEM concentrations at the NJDEP air monitoring site in Bayonne, New Jersey from September 2001 to February 2003, spikes of elevated GEM ( $>6 \text{ ng m}^{-3}$ ) lasting 15 minutes to a few hours and occurring primarily between midnight and 5 am were observed. During one such event that occurred between 2 am and 5 am on June 30, 2002, GEM levels sustained an hourly averaged concentration of  $26 \text{ ng m}^{-3}$  and a peak level of  $54 \text{ ng m}^{-3}$  (Goodrow et al., 2005). Similar spikes in atmospheric mercury, including gaseous elemental

mercury, reactive gaseous mercury, and particulate mercury, were observed at Elizabeth and New Brunswick, New Jersey during the period of 2003 to 2006 (Aucott et al., 2009).

No relationship between the occurrence of episodic spikes in atmospheric mercury and meteorological conditions (season, temperature, precipitation) has been found, and such events are likely related to local industrial activities. Similar spikes observed in New York City were also attributed to local anthropogenic sources (Carpi and Chen 2002). In Elizabeth, elevated atmospheric mercury concentrations appear to correlate with a southerly wind direction (Aucott et al., 2009), indicating a possible location of a mercury point source, but no known source of mercury

emissions lies to the south of the Elizabeth monitoring site. An analysis of Elizabeth monitoring results from 2010 again showed a source to the south. A similar directionality was also apparent in the 2002-2003 Bayonne dataset.

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## Measurements

Gaseous elemental mercury (GEM) concentrations were measured using a Tekran 2537A continuous mercury vapor analyzer on the campus of the College of Staten Island (CSI). The intake line for the GEM analyzer (¼" Teflon tubing) was held open end down in a plastic rain shield attached to an existing meteorological tower on the roof of the CSI gymnasium (40.6040° N, 74.1484° W) approximate 22 m above the land surface. GEM concentrations were measured nearly continuously at CSI between September 30, 2011 and September 3, 2012 with breaks due to power outages or analyzer malfunction. Due to the malfunction of the Tekran's air pump, no measurements were collected in March 2012. Meteorology data corresponding to the CSI measurements were obtained from the NOAA Bergen Point West Reach naval observatory station (ID: 8519483, 40° 38.2' N, 74° 8.5' W). GEM concentrations and meteorology data for the ELAB site in Elizabeth, New Jersey (40.6414° N, 74.2084° W) were obtained from the NJDEP.

Elevated GEM concentrations that formed recognizable peaks were selected for source direction analysis. Recognizable peaks were defined as those with GEM concentrations

>4 ng m<sup>-3</sup>. The lower limit of 4 ng m<sup>-3</sup> was chosen since it exceeded the upper 95% confidence limit of all GEM concentrations measured at CSI (mean = 1.66, SD = 1.16, upper 95% limit = 3.94 ng m<sup>-3</sup>). In order to exclude possibly spurious measurements of GEM concentrations >4 ng m<sup>-3</sup>, an additional criteria for selecting peaks was

the occurrence of at least three measurements above the local baseline.

Wind speed and direction data were interpolated to GEM peak times. For ELAB results, 1 min. wind speed and direction data were averaged over the 5 min. GEM sampling times. For CSI results, 6 min. wind speed and direction data were averaged over 18 min. and interpolated to GEM sampling times.

Wind directions associated with all GEM peaks for both sites were sorted in 12 degree bins to establish dominant source directions. In addition, maximum GEM concentrations associated with all peaks for each site were sorted by wind direction in 12 degree bins to assess the strength of identified source directions. The distributions of peak frequency clusters associated with dominant wind directions were fit to a Gaussian model in order to determine the central direction and variance associated with these source directions. Potential emissions source areas were delineated by determining the intersections of the central bearing and 95% confidence intervals bounding each GEM source direction. Finally, GEM peaks were sorted by time of day into 1 hour bins to assess temporal patterns.

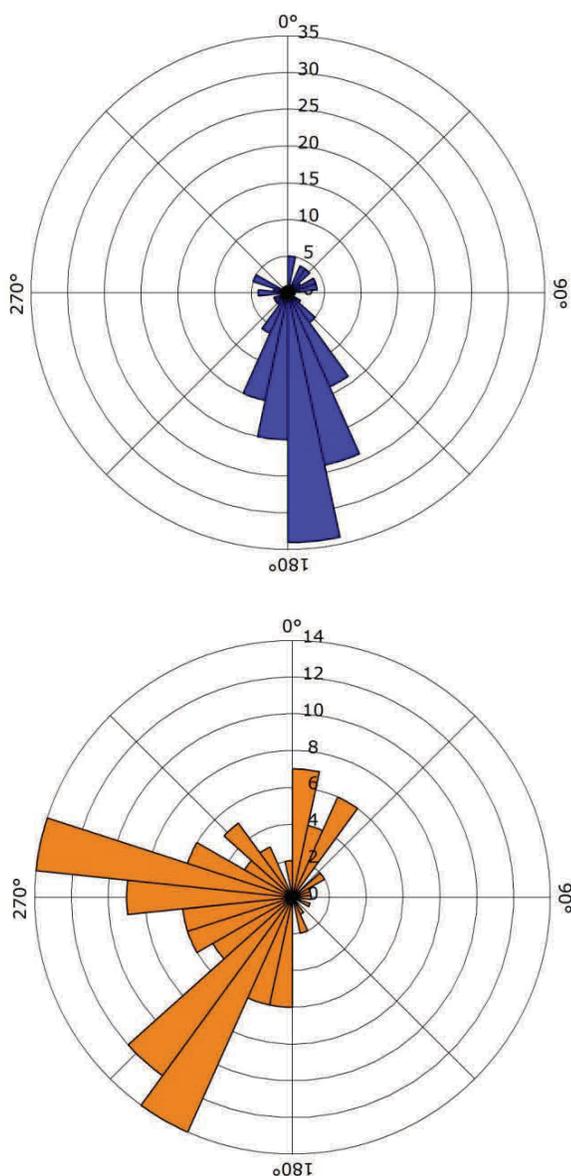
Methods were also developed for computer control and data logging for the Lumex gaseous mercury analyzer and a rain-sheltered air intake support for field use was constructed. Access was sought and granted to the Graselli Point Industries property in Linden, New Jersey. Short term monitoring was carried out at the at the Graselli Point property on November 10-11, 2011. Local scale measurements of GEM were also conducted in western Staten Island on July 23, 2012.

## Results and Conclusions

During the period of monitoring at the College of Staten Island (CSI), 124 GEM peaks with concentrations >4 ng m<sup>-3</sup> were recorded. Over the same time period, 171 GEM peaks were measured at the ELAB site. For the CSI site, most of the GEM peaks were recorded between April and August, 2012 with the highest maximum concentrations associated with peaks recorded in July and August 2012. At the ELAB site, GEM peaks were observed throughout the year with the highest maximum concentrations occurring in peaks during May and July.

The association of GEM peaks measured at the CSI and ELAB sites with wind direction are shown in Figure 1 on the following page.

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**Figure 1.** Frequencies of GEM peaks ( $>4 \text{ ng m}^{-3}$ ) by wind direction (12 degree resolution) measured in Elizabeth, New Jersey (blue) and at the College of Staten Island, New York (orange).

These plots show a dominant GEM source for the ELAB site associated winds from just east of south and two source directions for the CSI site, one to the southwest and a second to the west.

The Gaussian fit to the cluster of peaks measured during south winds at the ELAB site had an  $R^2$  of 0.985 and a central value of  $173.4^\circ$ . Based on the range of values within the 95% confidence limits of the Gaussian distribution, the direction from the ELAB site to the possible GEM emissions source was between  $164.0^\circ$  and  $182.7^\circ$ .

For the CSI results, Gaussian fits to the two clusters of peaks for west and southwest winds had  $R^2$  values of 0.962 and 0.919 and central values of  $280.5^\circ$  and  $213.8^\circ$ , respectively. For these fits, 95% confidence limits place possible GEM emissions sources at bearings of  $206.0^\circ$  to  $221.5^\circ$  and  $275.1^\circ$  to  $286.0^\circ$  with respect to the CSI site, respectively. The highest 7 GEM peaks measured at the CSI site that were associated with southwest winds had an average duration of  $2.5 \pm 1.6$  hours. The highest 7 GEM peaks associated with west winds had an average duration of  $0.8 \pm 0.3$  hours.

GEM peaks associated with south winds at the ELAB site occurred in the early morning (before 6am) or in the evening (after 7pm). Peak GEM concentrations at the CSI site associated with southwest winds occurred primarily in the mid-morning (7 to 8 am) while those associated with west winds occurred in the early morning and evening. Distributions of GEM concentrations among hours of the day matched hourly peak frequencies for all peak clusters at both the ELAB and CSI sites. Background concentrations of GEM ( $1$  to  $4 \text{ ng m}^{-3}$ ) at the CSI site measured during southwest winds occurred most frequently during overnight and morning hours (11pm to 7am) and somewhat less frequently from 11am to 10pm. Background concentrations of GEM associated with west winds were recorded with relatively constant frequency during the day. The number and intensity of GEM peaks associated with south winds at the ELAB site was highest on Sunday through Wednesday, but decreased from Wednesday to Saturday. At the CSI site, GEM peaks associated with southwest winds occurred primarily on Wednesdays, Thursdays and Fridays with lower frequencies on Tuesdays, Saturdays and Sundays and no occurrences on Monday. In contrast, the number of GEM peaks observed at the CSI site associated with west winds decreased from Monday to Thursday, were zero on Thursday, Friday, and Saturday, and picked up on Sunday.

The similarity of temporal patterns for the cluster of GEM peaks at CSI associated with west winds and the cluster of GEM peaks at ELAB associated with south winds indicates that they may have a common source. Background GEM ( $1$  to  $4 \text{ ng m}^{-3}$ ) frequencies and cumulative GEM concentrations were evenly distributed among days of the week at the CSI site for both southwest and west winds.

Local scale measurements of GEM concentrations were deemed unreliable since values appeared to drift and did not match those measured at the CSI or ELAB sites in concentration or trend.

The intersections of the two Staten Island GEM wind trajectories with the ELAM trajectory delineate two possible GEM source areas. The first is centered in Rossville, NY on Staten Island ( $40.5514 \text{ N}$ ,  $74.1947 \text{ W}$ ) and the second near Pralls Island in the Arthur Kill along the eastern border of Linden, NJ ( $40.6119 \text{ N}$ ,  $74.2039 \text{ W}$ ). Potential specific Hg emissions sources within these areas should be identified and investigated further.

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## Funding

This project was funded by the NJDEP Office of Science contract # SR11-018.

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## Acknowledgements

The PIs would like to thank Alyssa DeVincentis for help in the collection and analysis of meteorological data and Christine Bruno for helping with data collection at the CSI site.

### RESEARCH PROJECT SUMMARY

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