Final Report

Design Considerations for an Ambient Air Monitoring Network and Related Components of an Environmental Monitoring and Response System in the Houston Ship Channel

HARC Project H31-PhaseIB

Prepared for

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EXECUTIVE SUMMARY

Currently, the Houston-Galveston area (HGA) does not meet EPA's National Ambient Air Quality standard for ozone. Results of air monitoring and emission inventory analyses have shown that emissions of volatile organic compounds (VOCs) in general, and highly reactive volatile organic compounds (HRVOCs) in particular, from industrial petrochemical facilities in the HGA are highly variable on sub-hourly to daily time scales. Modeling analyses have shown that short-term releases of large quantities of HRVOCs (a relatively common occurrence) can, under the right conditions, contribute significantly to exceedances of the ozone standard. These findings prompted new regulations designed to limit HRVOC releases, and the establishment of an Environmental Monitoring and Response System (EMRS) pilot program for HRVOCs. Under the pilot program, HRVOCs are monitored by automated gas chromatographs (auto-GCs) installed at seven locations in the vicinity of the Houston Ship Channel. Hourly data are transmitted to TCEQ and any values exceeding a pre-selected threshold concentration trigger an automated communications alert system which notifies participating facilities located within a 90 degree wedge oriented upwind of the trigger event location. Facilities notified of an event then review their operations for conditions that might be associated with a release of HRVOCs and, if appropriate, take actions to reduce or eliminate the release of excess emissions. One of the principal goals of an EMRS is to foster pollution prevention by providing for the rapid transmittal of environmental changes to decision makers. Given the demonstrated role of HRVOC releases from facilities in the Ship Channel area in the formation of high ozone concentrations, reducing or preventing HROVC releases from these facilities will make an important contribution to achieving attainment of the ozone air quality standard.

In keeping with its mission of enhancing the understanding of, and improving air quality in Texas, the Houston Advanced Research Center contracted with ENVIRON to develop recommendations for the design and operation of an EMRS capable of detecting potential sources of episodic releases of VOCs from sources in the vicinity of the Houston Ship Channel on a near real-time basis. Our investigation of EMRS system design alternatives included an analysis of ambient monitoring network designs, applicability of alternative monitoring technologies to EMRS, and a review of available analytical and procedural options for responding to an event identified by the EMRS monitoring network.

EMRS Monitoring Network Design

Implementation of an effective EMRS targeting HRVOCs requires deployment of an ambient monitoring network that has sufficient spatial coverage, sensitivity, selectivity, and a sufficiently fast response time to provide useful near real-time data on high HRVOC concentration events to participating government agencies and industrial facility operators. Ideally, the EMRS ambient monitoring network would be able to detect a significant fraction of emission events within the size range of concern. For HRVOC releases in the HGA, simplified photochemical modeling results from previous studies have shown that HRVOC releases of 1,000 lb/hour are potentially capable of producing a 2 to 3 ppb increase in ambient ozone levels under the right conditions so releases of at least this size should be given highest priority. Examinations of records of reported emission events show that such events occur on average once per day somewhere in the HGA.

EMRS ambient monitoring network designs were evaluated using an emissions simulator and photochemical dispersion modeling system to simulate a random sample of the types of emission events the EMRS is intended to detect. This system was used to quantitatively analyze the ability of existing or potential future alternative monitoring networks to detect and identify the source of each release event. Results indicate that tens of monitoring sites would be required to adequately detect significant releases from potential HRVOC emissions sources in the Ship Channel area. In particular, the existing 7-site network used in the 2004 EMRS pilot study can be expected to detect only the largest releases (i.e., those exceeding 10,000 lb/hr) with any degree of reliability. For reliable detection of events exceeding 1,000 lb/hr (i.e., a probability of detection of such events of at least 50%), a much larger network with spatial coverage similar to that provided by the expanded, 27 site network analyzed in this study and using event trigger threshold concentrations set near the low end of the range of thresholds used in the pilot study would be needed for reliable detection. Furthermore, analysis of the predicted spatial distribution of impacts from the simulated release events suggests that new monitoring sites in the eastern portion of the area (around Baytown, North Channelview, and Bayport) may be particularly useful for detecting emission events which the current seven site network does not appear to be picking up particularly well. These conclusions, derived from the emission event simulation study described in Section 3, are based on the frequency, size, and locations of *reported* emission events in Harris County during the January 2003 – January 2004 period for which records were available for this study and does not account for the impacts of any unreported events or changes in the spatial distribution of events that might occur in future years.

Auto-GC monitoring equipment used in the EMRS pilot study, while capable of detecting HRVOCs with sufficient sensitivity, suffers from a slow response time (nearly two hours from sample initiation to reporting of results) and limited availability due to high equipment and operating expenses. Currently available alternatives to the auto-GC network for EMRS applications are for the most part limited to FTIR devices such as the dual cell extractive FTIR currently operating at the Seabrook monitoring site. FTIRs offer the requisite response time at detection levels adequate for EMRS applications but the costs of setup and operation are roughly on par with that of the auto-GCs. New technologies based on micro electromechanical systems (MEMS) hold considerable promise for building denser ambient monitoring networks with greater capability (primarily with respect to speed of response) at relatively low cost in the not to distant future. MEMS devices are expected to begin to become available on the market place by the end of this decade and should be given serious consideration in future EMRS network development efforts.

Source Identification

Current procedures for identifying sources potentially responsible for a give trigger event (based on examining a 90 degree upwind wedge) are too imprecise. Several procedures are recommended for improving the precision of source identification, thus reducing the number of trigger alerts any given source would need to respond to and making it more acceptable to increase the detail and scope of the follow-up activities that local officials and source operators would undertake in response to a trigger alert. One approach which has already been considered for implementation in Houston is the automated calculation of near real-time air parcel back trajectories showing the paths most likely to have been taken by air parcels arriving at the time and location of each trigger event. These results could then be used to determine with greater precision the upwind area within which sources potentially contributing to the event should be notified. Another approach involves the use of ground level or airborne mobile monitoring equipment to trace the source of a release. This would, however, be limited to longer releases which could be captured within the total response time of the ambient surveillance network and the mobile monitoring resources. A more sophisticated approach which has been suggested by some participants in the current EMRS program is to compile information on unique chemical identifiers which may be associated with a small subset of (or even individual) potential sources. In theory, a library of source "fingerprints" could be developed by conducting source-oriented multi-species monitoring of routinely emitted chemicals just downwind of the sources of interest. Some of the newer remote sensing monitoring technologies described in Section 4 are well suited to this purpose. Once the key identifier species have been determined, the EMRS ambient network could be modified to include these species among the list of target compounds in addition to the HRVOCs of interest. By including data on correlations between HRVOCs and concentrations of the key indicator compounds during the trigger event, it would be possible to further refine the set of potential upwind sources at which follow-up activities would be needed.

Local Response to Trigger Events

Procedures employed within the EMRS protocol for responding to the occurrence of a trigger event should be refined to include expanded follow-up activities at facilities notified of an event, including examining fence-line or other routine on-site monitoring data. The quantity, quality and usefulness of these data would be greatly enhanced by the use of advanced remote sensing instrumentation that has been developed for fence-line monitoring applications and leak detection programs, including open path optical methods and plume visualization cameras such as those described in Section 4. Automated integrative analyses of process control data such as is used in predictive emission monitoring systems (PEMS) could in theory also be useful for identifying potential HRVOC releases.[1] It must be recognized, however, that the equipment and personnel time needed for these expanded follow-up activities will be expensive. One method for reducing costs would be to limit the number of trigger alerts requiring a full-scale response by giving highest priorities to facilities that are closest to the trigger event and focusing only on the largest events.

[1] PEMS have been developed, for example, by Pavilion Technologies but have not been used for this particular type of application.