

TCEQ Interoffice Memorandum

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Date: March 9, 2011

Subject: Health Effects Review of 2009 Ambient Air Network Monitoring Data in Region 12, Houston

Key Points

- The 2009 benzene averages being below the long-term air monitoring comparison value (AMCV) at the Lynchburg Ferry and Galena Park sites represent a significant and continued improvement in air quality in these areas.
- The reported 2009 average benzene concentration at the Lynchburg Ferry site indicates a continued decrease, and was below TCEQ's long-term AMCV for the second time since monitoring began at this site in 2003. Due to the significant and continued improvement in long-term benzene concentrations measured at Lynchburg Ferry, in 2010 benzene was removed from the Air Pollutant Watch List (APWL) area which contains this site (Site# [APWL1204](#)).
- The annual average benzene level reported for the Galena Park site in 2009 was also below TCEQ's long-term AMCV for the second time in several years. This site is contained within an APWL area for benzene (Site# [APWL1206](#)), and the Toxicology Division (TD) recommends a continued effort to control and/or reduce benzene emissions such that the long-term AMCV will continue to be met at this site.
- The reported 2009 average 1,3-butadiene concentration at the Milby Park site indicates a continued downward trend and a significant reduction in reported annual concentrations over the last five years. In 2009, 1,3-butadiene was able to be removed from the APWL for this area (Site# [APWL1207](#)) due to significant improvements in long-term concentrations, which are below levels of health concern.
- Although 2007-2008 average benzene concentrations at the British Petroleum (BP)-sponsored site in Texas City declined and were well below TCEQ's long-term AMCV, the 2009 average equals the AMCV. The TD recommends a continued effort to control and/or reduce benzene emissions such that the long-term AMCV will continue to be met at this site.
- While the 2009 benzene concentration at the Marathon-sponsored site in Texas City exceeds TCEQ's long-term AMCV, preliminary data for 2010 suggest that the 2010 average will be below the AMCV for the first time since monitoring began in 2005. Due

to historical AMCV exceedances, the TD continues to recommend the identification of potential benzene sources which may be affecting long-term benzene levels at this site and subsequent benzene emissions reductions in this area.

- There was a significant downward trend in monitored styrene levels at Milby Park beginning in 2008-2009 as a result of efforts by Goodyear in 2008 to address a potential source of elevated styrene emissions detected at the Milby Park monitor. The frequency of odor-based AMCV exceedance was reduced 94% from 2008 to 2009. The TD recommends continued vigilance to maintain or improve this reduction.
- Hourly levels of a few volatile organic compounds (VOCs) monitored in the Lynchburg Ferry area would result in the perception of odors if people were exposed (e.g., styrene). While direct, short-term health effects (e.g., eye irritation) would not be expected as a result of exposure to these concentrations, sufficiently strong and persistent odors have the potential to cause odor-related health effects (e.g., nausea, headaches).
- While there was a 38% reduction in the number of odorous styrene concentrations at Lynchburg Ferry in 2009 compared to 2008, the TD recommends continued efforts to identify sources and reduce styrene emissions in the area due to the frequency of exceedance of the odor-based AMCV.
- Acrolein sampling and analysis is difficult. While carbonyl analyses at the Deer Park site indicate concentrations below TCEQ's long-term, health-based AMCV, the reported 2009 average acrolein level based on one of the two co-located canister samplers at this site is above the AMCV. However, TCEQ's comparison values are not threshold concentrations for health effects, and health effects would not be expected to occur based on a thorough evaluation of the reported results and scientific toxicological data.

Background

The primary purpose of this memorandum is to convey the Toxicology Division's (TD) evaluation of ambient air toxics sampling conducted at monitoring sites in Region 12-Houston during 2009. Additionally, summary information concerning various specific TCEQ actions (e.g., investigations) relevant to identifying and/or reducing emissions is provided for several of the areas/chemicals discussed. The TD reviewed summary results for VOCs from 24- and 1-hour canister samples, 1-hour automated gas-chromatography (autoGC) VOC samples, 24- and 3-hour carbonyl samples, 24-hour polycyclic aromatic hydrocarbon (PAH)/semivolatile organic compound (SVOC) samples, and 24-hour metals samples from filters designed to collect particulate matter with an aerodynamic diameter of 2.5 microns or less (PM_{2.5}) and from filters collecting particulate matter with an aerodynamic diameter of 10 microns or less (PM₁₀). Criteria pollutant (i.e., compounds having National Ambient Air Quality Standards) data were not evaluated in this memorandum. Appendix 1 contains a list of the target analytes evaluated for this review. Information regarding monitoring sites and target analytes is presented in Table 1 and summarized below:

- 24-hour canister VOC sampling at 16 sites
- 1-hour canister VOC sampling at 3 sites
- 24-hour carbonyl sampling at 3 sites
- 3-hour carbonyl sampling at 1 site
- 24-hour metals sampling at 3 sites
- 24-hour PAH/SVOC sampling at 1 site

- 1-hour autoGC VOC monitoring at:
 - 5 TCEQ sites
 - 7 Enhanced Industry-Sponsored Monitoring (EISM) sites
 - 1 TCEQ-Industry Agreed Order Monitoring site (AOM)
 - 1 USEPA/DOJ-Industry Agreement Monitoring site (EPA/DOJAM)

Table 1. Monitoring Sites Located in TCEQ Region 12

County	EPA Site ID	Site Location	Network	Monitored Compounds
Brazoria	48-039-1003	Clute 426 Commerce St.	TCEQ	VOC (24-hour canister)
Brazoria	48-039-0618	Danciger Along US Hwy 1459 in Brazoria County	EISM	VOC (autoGC)
Brazoria	48-039-1016	Lake Jackson 109-B Brazoria Hwy 332-W	EISM	VOC (autoGC)
Brazoria	48-039-0619	Mustang Bayou Liverpool	EISM	VOC (autoGC)
Galveston	48-167-0005	Texas City, Ball Park 2516 ½ Texas Ave.	TCEQ	VOC (24-hour canister)
Galveston	48-167-0056	Texas City, 34th St. 2212 North 34th St.	EISM	VOC (autoGC)
Galveston	48-167-1034	Galveston, 99th St. 9511 Avenue V ½	TCEQ	VOC (1- & 24-hour canister)
Harris	48-201-0036	Jacinto Port 1st St. and Elsbeth St.	TCEQ	VOC (24-hour canister)
Harris	48-201-1039	Deer Park 4514 ½ Durant St.	TCEQ	VOC (autoGC, 24-hour canister), Carbonyls, Metals, PAHs/SVOCs
Harris	48-201-0024	Houston, Aldine 4510 ½ Aldine Mail Rd.	TCEQ	VOC (1- & 24-hour canister), Metals
Harris	48-201-1035	Houston, Clinton 9525 ½ Clinton Dr.	TCEQ	VOC (autoGC), Carbonyls, Metals
Harris	48-201-0057	Galena Park 304 Stewart St.	TCEQ	VOC (24-hour canister)
Harris	48-201-0026	Houston, Channelview 1405 Sheldon Rd.	TCEQ	VOC (autoGC), Carbonyls

County	EPA Site ID	Site Location	Network	Monitored Compounds
Harris	48-201-0061	La Porte, Shoreacres 3903 ½ Old Hwy 146	TCEQ	VOC (24-hour canister)
Harris	48-201-0069	Houston, Milby Park 2201-a Central St.	TCEQ	VOC (autoGC)
Harris	48-201-6000	Houston, Cesar Chavez 4829A Galveston Rd.	TCEQ	VOC (autoGC)
Harris	48-201-1015	Baytown, Lynchburg Ferry 1001 B Lynchburg Rd.	TCEQ/EISM	VOC (autoGC, 24-hour canister)
Harris	48-201-0617	Baytown, Wallisville Rd. 4727 Wallisville Rd.	EISM	VOC (autoGC)
Harris	48-201-0307	Houston, Manchester/Central 9401 ½ Manchester Rd.	TCEQ	VOC (24-hour canister)
Harris	48-201-0029	Tomball, NW Harris County 16822 Kitzman St.	TCEQ	VOC (1- & 24-hour canister)
Harris	48-201-0055	Houston, Bayland Park 6400 Bissonnet St.	TCEQ	VOC (24-hour canister)
Harris	48-201-0058	Baytown 7201 ½ Bayway Dr.	TCEQ	VOC (24-hour canister)
Harris	48-201-0803	Haden Rd. (HRM-3) 1504 ½ Haden Dr.	TCEQ/EISM	VOC (autoGC, 24-hour canister)
Harris	48-201-1049	Pasadena North 702 Light Company Rd.	TCEQ	VOC (24-hour canister)
Galveston	N/A	BP North America Products, Inc.-Texas City 31 st St. (Between Texas Ave. and 5 th Ave.)	AOM	VOC (autoGC)
Galveston	N/A	Marathon Petroleum Company, LLC-Texas City 11 st St. S. at 6 th Ave. S.	EPA/DOJAM	VOC (autoGC)
Montgomery	48-339-0078	Conroe 9472A Hwy 1484	TCEQ	VOC (24-hour canister)

All data collected at TCEQ monitors are analyzed by the TCEQ laboratory and should meet a 75% data completeness objective. At EISM monitors, data are collected by a third party contractor and should meet a 75% data completeness objective. The data collected at the AOM and EPA/DOJAM monitors are analyzed by a third party contractor and should meet an 85% data completeness objective. One-hour canister VOC, 1-hour autoGC VOC, and 3-hour carbonyl

data were evaluated for potential acute health (e.g., irritation) and odor concerns, as were 24-hour sample results (VOCs, carbonyls, and metals) that exceeded short-term air monitoring comparison values (AMCVs). The annual averages from 1-hour autoGC and 24-hour samples (VOCs, carbonyls, and metals) were evaluated for potential chronic health concerns. Measured chemical concentrations were compared to appropriate TCEQ health-, odor-, and vegetation-based AMCVs. Information on AMCVs may be obtained via the internet (<http://www.tceq.state.tx.us/implementation/tox/AirToxics.html>) or by contacting the TD (512-239-1795).

Evaluation

1-Hour Concentrations

The vast majority of the 1-hour canister VOC, autoGC VOC, and carbonyl concentrations were below their respective TCEQ short-term, health- and/or odor-based AMCVs. More specifically, over 99.999% of the approximately 4,030,000 1-hour VOC measurements from TCEQ and EISM autoGC monitors in Region 12 in 2009 were below their short-term AMCVs. Approximately 0.00005% of the hourly autoGC measurements collected in Region 12 in 2009 exceeded TCEQ short-term, health-based AMCVs. Approximately 0.0009% exceeded odor-based AMCVs, and the majority of those (81%) occurred at one site (Lynchburg Ferry) in very close proximity to industrial sources and the Houston Ship Channel. One-hundred percent of the approximately 2,500 1-hour VOC concentrations from canister samples were below their respective short-term, health- and odor-based AMCVs. Additionally, except for eight exceedances of the odor-based AMCV for isovaleraldehyde at Clinton Dr., all of the approximately 3,500 3-hour carbonyl concentrations measured in Region 12 in 2009 were below AMCVs. That is, 99.8% of the 3-hour carbonyl levels were below their respective short-term, health- and odor-based AMCVs. Therefore, we would not expect short-term, adverse health effects or odors to be associated with the vast majority of hourly measurements reported for Region 12 in 2009.

For the reported 1-hour concentrations that exceeded their respective short-term, health- and/or odor-based AMCVs, further evaluation was conducted to determine the potential for adverse health effects or odors. Benzene and isoprene were the only chemicals for which any of the reported 1-hour concentrations exceeded their respective short-term, health-based AMCVs in 2009. These exceedances occurred only at the Lynchburg Ferry site monitor, where there was one hourly benzene concentration (209.3 parts-per-billion by volume or ppb_v) and one hourly isoprene concentration (24.9 ppb_v) above their short-term, health-based AMCVs of 180 and 20 ppb_v, respectively. This maximum reported hourly benzene concentration is significantly below benzene levels attributable to short-term, adverse health effects such as central nervous system depression and irritation, with the same being true for isoprene. Therefore, exposure to these 1-hour concentrations would not be expected to cause short-term, adverse health effects. However, as relatively high benzene hourly levels contribute to long-term benzene concentrations at the Lynchburg Ferry site, which have historically been of some concern, benzene emissions resulting in significantly elevated short-term levels should be prevented.

The reported 1-hour autoGC VOC concentrations that exceeded their respective odor-based comparison levels are shown below in Table 2. The Wallisville Rd. site, which was listed in

Table 2 of the 2008 data review, is no longer listed due to reductions in the measured isoprene and n-propylbenzene concentrations. The Channelview site has been added due to a single isoprene odor-based comparison level exceedance. The total number of odor-based AMCV autoGC exceedances in Region 12 has decreased significantly, from 82 in 2008 to 37 in 2009, a decrease of 55%. Compared to 103 total 1-hour autoGC odor-based exceedances in 2007, the decrease for 2009 is 64%. In regard to 3-hour carbonyl sample results, eight 3-hour isovaleraldehyde concentrations (0.18, 0.17, 0.16, 0.14, 0.13, 0.13, 0.12, and 0.11 ppb_v) reported for the Clinton Dr. site exceeded the odor-based AMCV (0.1 ppb_v).

Table 2. Odor-Based AMCV Exceedances by 1-Hour AutoGC VOC Concentrations

Site	Chemical	Number of 1-Hour Concentrations above Odor-Based AMCV	Maximum Measured Concentration (ppb _v)	Odor-Based AMCV (ppb _v)
Danciger	Isoprene	1	5.8	5
Haden Rd.	Isoprene	1	5.7	5
	m- + p-Xylene	2	134.3	41
Lynchburg Ferry	Styrene	20	102.0	25
	Isoprene	9	24.9	5
	m- + p-Xylene	1	95.6	41 ^a
Milby Park	Styrene	2	28.7	25
Channelview	Isoprene	1	18.3	5

^a The lowest of the odor thresholds for m- and p-xylenes.

The relatively high frequency of the reported odor-based AMCV exceedances for styrene at the Lynchburg Ferry site warrants further evaluation and discussion. Although the styrene concentrations reported at the Lynchburg Ferry site would not be expected to cause direct acute health effects such as eye irritation, the perception of sufficiently strong and persistent unpleasant odors has the potential to cause odor-related health effects (e.g., nausea, headache). The Milby Park site is also discussed as it has been of historic interest due to frequent odor-based exceedances for styrene in the past several years.

Lynchburg Ferry – Styrene

At the Lynchburg Ferry site, there were 20 hourly styrene concentrations reported above the odor-based AMCV of 25 ppb_v, with a maximum concentration of 102 ppb_v. This represents an approximate 38% reduction in the number of odorous styrene concentrations when compared to 32 such concentrations reported in 2008 (maximum of 494 ppb_v), a 52% reduction in the number of odorous styrene concentrations when compared to 42 such concentrations reported in 2007 (maximum of 155 ppb_v), and approximately a 62% reduction compared to 52 such concentrations reported in 2006 (maximum of 358 ppb_v). When compared to the 92 odorous styrene concentrations reported for the Lynchburg Ferry site in 2005, which included a maximum concentration of 433 ppb_v, the 20 occurrences in 2009 represent a reduction of approximately 78%. Thus, the 2009 data represent a significant improvement in the frequency (and magnitude) of styrene odor-based AMCV exceedances over the 2005-2009 period (see Figure 1).

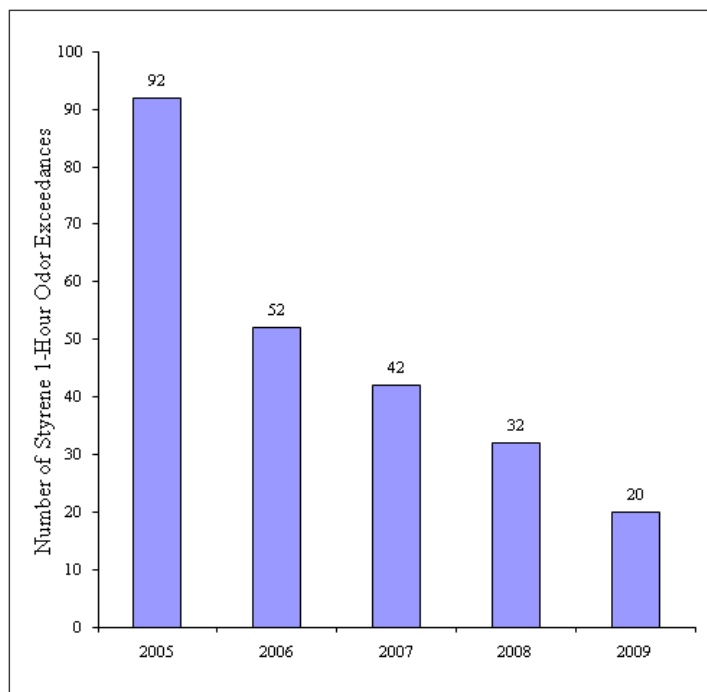


Figure 1. Exceedances of the Styrene Odor-Based AMCV at the Lynchburg Ferry Site

Preliminary data for 2010 indicate there may have been approximately 25 exceedances of the styrene odor-based AMCV, which would represent a 25% increase compared to 2009. The TD recommends continued efforts to identify sources and reduce styrene emissions in the area. The direction of potential styrene sources near the Lynchburg Ferry site was evaluated by the TD through the use of hourly styrene autoGC data and wind directional data collected at the site. Based on both average styrene concentrations (Appendix 2a) and maximum concentrations (Appendix 2b) for 2009, styrene concentrations reported at the Lynchburg Ferry site were highest when winds were from the north/northeast. The source direction evaluation based on 2009 styrene concentrations at this site (Appendices 2a and b) is similar to that contained in previous TD evaluations (i.e., [2008 Region 12 data](#), [2007 Region 12 data](#), [2006 Region 12 data](#))

in that higher levels are associated with winds from the north/northeast. Although the frequency of odorous styrene concentrations reported at the Lynchburg Ferry site has decreased from 2005 to 2009, reductions in styrene emissions which contribute to odorous levels at the Lynchburg Ferry site continue to be recommended. Styrene is currently listed on the Air Pollutant Watch List (APWL) for this area (Site# [APWL1204](#)) because of previously monitored odorous conditions, and the 2009 data support styrene remaining on the APWL for this area.

Milby Park - Styrene

Milby Park styrene odor exceedance data for 2009 show obvious improvement compared to previous years (see Figure 2). There were only two odorous styrene concentrations reported at the Milby Park site in 2009 (maximum of 28.7 ppb_v) compared to 33 exceedances in 2008 (maximum of 69.7 ppb_v), 28 such instances in 2007 (maximum of 49.4 ppb_v), and 16 exceedances in 2006 (maximum of 53.8 ppb_v). Thus, the two exceedances of the odor-based AMCV in 2009 represent a 94% exceedance frequency reduction compared to 2008, a 93% reduction compared to 2007, and approximately an 88% reduction compared to 2006. Additionally, the maximum 1-hour concentration for 2009 (28.7 ppb_v) is below that for 2006-2008 (49.4-69.7 ppb_v). This is a significant improvement in both the frequency and magnitude of exceedances.

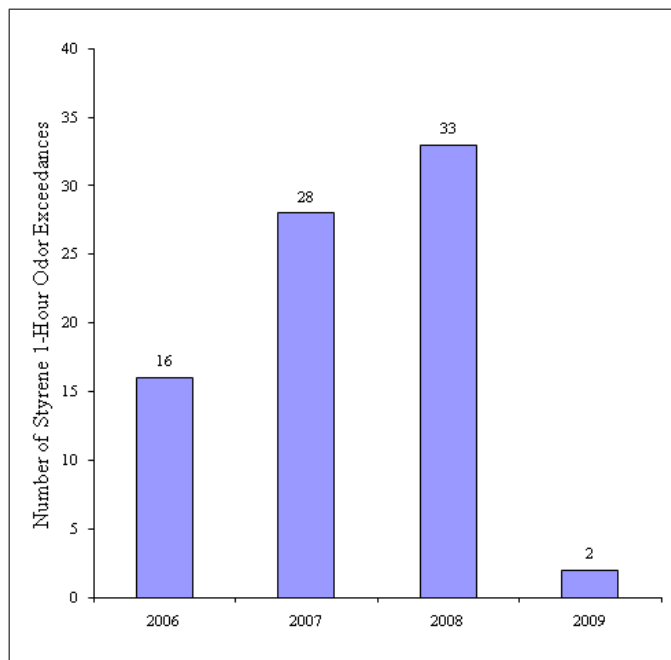


Figure 2. Exceedances of the Styrene Odor-Based AMCV at the Milby Park Site

In previous reviews of annual Region 12 data, the TD has recommended reductions in styrene emissions which contribute to these odorous levels measured at the Milby Park site. Goodyear took steps during 2008 to address a potential source of the elevated styrene emissions detected at the Milby Park monitor. Specifically, Goodyear altered operational practices, amended their permit to include a 25% reduction in allowable styrene emissions, and signed a voluntary Emissions Reduction Agreement (ERA) with the TCEQ. As a result of these efforts, a decreasing

trend in the monitored levels of styrene in Milby Park was evident beginning in 2008. For example, there was only 1 exceedence (25.5 ppb_v) of the odor-based AMCV for styrene (25 ppb_v) from July through December 2008 as compared to 19 exceedences over the same period in 2007. Importantly, preliminary data indicate there may have been zero exceedences of the styrene odor-based AMCV in 2010. The TD will continue to monitor styrene concentrations at the Milby Park site to determine whether these improvements will be maintained.

24-Hour Concentrations

Eight 24-hour Summa canister p-diethylbenzene concentrations in 2009 exceeded the recently-adopted odor-based AMCV for this chemical (0.39 ppb_v). The seven highest 24-hour concentrations of p-diethylbenzene measured at the Pasadena North site (0.44, 0.63, 0.67, 0.73, 0.91, 1.3, and 1.6 ppb_v) exceeded the odor-based value. The Pasadena North site is located in a heavily industrialized area. The highest level reported at Galveston 99th St. (0.44 ppb_v) also exceeded the odor-based AMCV.

A single 24-hour chromium (PM_{2.5}) concentration at Deer Park (0.5 µg/m³) exceeded an initial conservative comparison to the short-term AMCV for hexavalent chromium (0.1 µg/m³). Thus, further evaluation was conducted. The initial comparison was based on the extremely conservative and highly unlikely assumption that all chromium is present as hexavalent chromium. For example, based on a year's worth of sampling recently conducted in Midlothian, only about 1% of chromium was in the hexavalent form. Data (2007-2008) from Deer Park and Karnack yield very conservative (biased high) estimates of percent hexavalent chromium because hexavalent chromium data are collected based on total suspended particulate (TSP) while total chromium data are collected based on PM₁₀. Even with this significant high bias, the percent hexavalent chromium estimate based on this dataset is only about 7.5%. Therefore, hexavalent chromium in this 24-hour sample would be expected to be well below the hexavalent chromium AMCV (0.1 µg/m³). Regardless, the reported level is below levels at which adverse effects (e.g., respiratory) have been reported even for intermediate duration (e.g., 4-13 week) hexavalent chromium exposure in human and laboratory animal studies (2-3,630 µg/m³). Additionally, the reported 24-hour level is well below the total chromium short-term AMCV of 12 µg/m³. Therefore, for several reasons, the TD would not expect adverse health effects to occur as a result of exposure to this reported 24-hour chromium concentration.

Annual Average Concentrations

Based on the approximately 5,500 24-hour metals measurements in Region 12 in 2009, 100% of the reported annual average concentrations of metals were below their respective long-term AMCVs. All annual average concentrations of carbonyls were also below their respective long-term AMCVs based on the approximately 2,275 24-hour measurements in 2009. Additionally, 100% of the average concentrations for PAHs/SVOCs were below long-term AMCVs based on approximately 1,800 24-hour measurements. Except for benzene at the Marathon-sponsored 11th St. S. Texas City site and acrolein at the Deer Park site, all annual VOC concentrations for 2009 met their respective long-term AMCVs based on averages from approximately 82,500 24-hour canister measurements and approximately 4,030,000 hourly VOC measurements from monitors in Region 12. Therefore, no long-term, adverse health effects would be expected due to exposure to those concentrations meeting (i.e., at or below) their respective long-term, health-based

AMCVs. Further evaluation was conducted for those chemicals with annual average concentrations above their respective long-term AMCVs to determine the potential for long-term, adverse health effects (see below). In addition, sites/chemicals of ongoing agency and/or public interest exhibiting reductions or increases in reported annual benzene or 1,3-butadiene concentrations are discussed.

Lynchburg Ferry - Benzene

The reported 2009 annual average benzene concentration based on hourly samples collected at the autoGC at the Lynchburg Ferry site was 0.89 ppb_v. The annual average at the co-located, every sixth-day 24-hour canister sample site was 1.3 ppb_v. However, the annual average based on hourly autoGC samples (0.89 ppb_v) more accurately represents the long-term average in 2009 as it analyzed 7,421 hourly measurements in 2009 (85% of the year) compared to 58 valid canister samples covering only 1,392 hours (16%) of the year, providing over 5 times more temporal coverage. The annual average is below the long-term, health-based AMCV (1.4 ppb_v) for the second time since monitoring began at the Lynchburg Ferry site in 2003 (see Figure 3). The 2008 annual average of 1.1 ppb_v was also below the long-term AMCV. This represents a significant improvement in air quality and is likely the result of significant efforts in the area by TCEQ (e.g., focused agency resources, special investigations utilizing the latest technology, enhanced compliance and enforcement, source directionality evaluations), industry (e.g., ERAs, Monument Area Air Quality Focus Group), and others (e.g., US Coast Guard). The 2009 annual benzene average of 0.89 ppb_v (autoGC) represents an approximate reduction of 19% when compared to the 2008 annual average, an approximate reduction of 41% when compared to the 2007 annual average, an approximate 63% reduction compared to the 2006 annual average, and an approximate 72% reduction compared to the 2005 annual average. This downward trend in annual benzene concentrations at the Lynchburg Ferry site is clearly evident (see Figure 3).

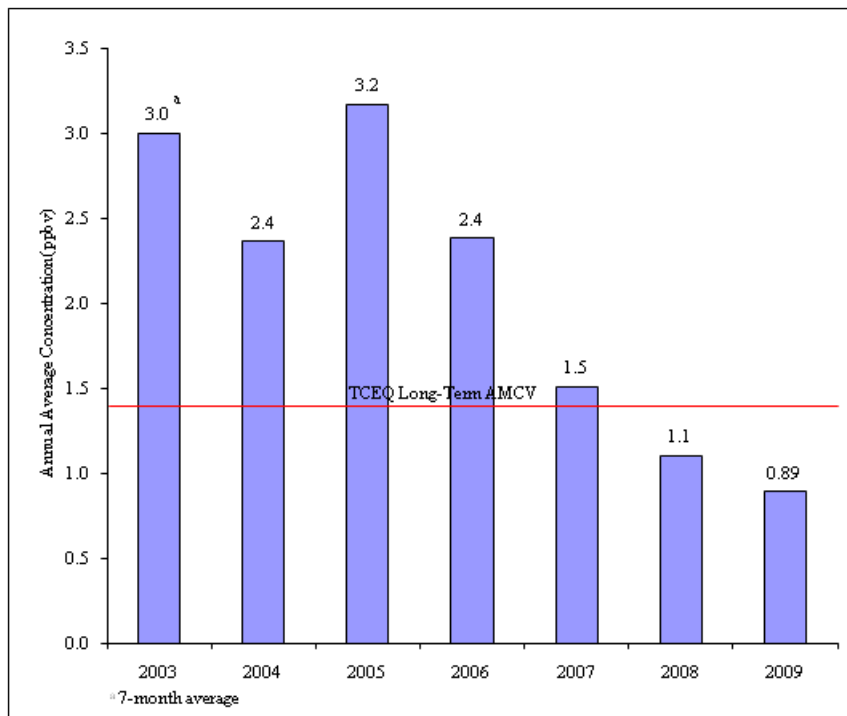


Figure 3. Annual Average Benzene Concentrations at the Lynchburg Ferry Site

Preliminary autoGC data for 2010 suggest that benzene concentrations in the Lynchburg Ferry area are similar to or slightly lower than those in 2009. The preliminary 2010 average of autoGC benzene measurements is 0.83 ppb_v. The significant decrease in annual averages over the past several years is attributable to TCEQ activities and other initiatives in the Lynchburg Ferry area.

TCEQ Region 12 staff report that activities in 2009 in the Lynchburg Ferry area included, but were not limited to, the following:

- Special investigations when relatively high levels of benzene were detected by area monitors. In response to benzene trigger level exceedances (1-hour levels ≥ 75 ppb_v) at the Lynchburg Ferry monitoring site, Region 12 staff reviewed air concentration and meteorological data to identify potential sources, which often resulted in focused facility investigations.
 - Region 12 air investigators conducted enhanced investigations at Channel Shipyard and Southwest Shipyard, which included the use of the GasFindIR camera.
 - Two Notices of Violation (NOVs) were issued during two investigations at Channel Shipyard.
 - Compliance investigations were also conducted at Southwest Shipyard and NOVs were issued.
- Combinations of reconnaissance investigations, compliance investigations, stack sampling reviews, and emission event investigations at Vopak Terminals and Intercontinental Terminals. Multiple NOVs and Notices of Enforcement (NOEs) were issued to these two facilities.

- In 2009, four NOEs and four NOV's were issued to Vopak alone.
- A 2009 full site inspection conducted at Vopak Terminals resulted in the issuance of 27 violations that included:
 - Failure to seal open ended lines;
 - Failure to maintain the pilot on the flare; and
 - Failure to maintain records of VOC emissions from tanks and from loading and unloading operations.
- Cooperative efforts with Region 12, TCEQ Pollution Prevention (PP), and the US Coast Guard (USCG) to identify sources of monitored benzene spikes (5-minute concentrations ≥ 50 ppb_v) which could be related to barges in transit on the Houston Ship Channel. When short-term benzene spikes were monitored at the Lynchburg Ferry auto-GC from a wind direction associated with marine transit, an e-mail alert was sent to both TCEQ and USCG staff. The USCG would use radar tracking information to identify the tug boat(s) in operation near the monitor at the time of the spike and PP staff would then contact the owner(s) to determine if any benzene-containing materials were being transported at the time. This effort raised awareness of the potential impact of emissions from barges and resulted in better adherence to emission reduction plans implemented by barge owners, tug and tow operators, and area industries.
- Tank degassing operations initiative at various facilities located in the Lynchburg area in response to complaints received regarding the release of uncontrolled VOC emissions during the degassing or cleaning of stationary marine and transport vessels. NOV's were issued in 2009 to Oil Tanking, Intercontinental Terminals, and Vopak.
- Reconnaissance investigations with the GasFindIR camera. These investigations were performed approximately every six weeks in the south Houston Ship Channel area along Battleground Road/Independence Highway.

In regard to Intercontinental Terminals, referred to in the bullets above, an elevated instantaneous benzene concentration (200 ppb_v) was detected downwind of that facility during a February 27-March 6, 2009, mobile monitoring trip.

As indicated in previous annual reviews of Region 12 air data, several Lynchburg Ferry area industrial facilities previously formed the Monument Area Air Quality Focus Group (MAAQFG) in a collaborative attempt to reduce benzene emissions. The MAAQFG is comprised of: Rohm and Haas Texas Inc., Shell Chemicals Inc., Texas Molecular, Intercontinental Terminals, Channel Shipyard, Kirby Inland Marine, and Vopak Terminals-Deer Park. An automatic alert is sent to TCEQ and MAAQFG when hourly benzene levels at the Lynchburg Ferry monitor exceed an hourly benzene trigger concentration (≥ 75 ppb_v). These triggers initiate investigations by MAAQFG members and TCEQ. This project continues to create timely awareness of benzene emissions. TCEQ continues to work collaboratively with both the MAAQFG and the USCG to identify and mitigate potential sources of benzene emissions from both barges in transit and stationary sources. Efforts in this area have been successful, as the number of 5-minute trigger notifications and annual benzene concentrations have decreased over time.

As a result of successful collaborative efforts to significantly decrease ambient benzene concentrations, benzene was removed from the Lynchburg Ferry APWL area (Site# [APWL1204](#)) in 2010. The TD will continue to monitor benzene concentrations in the Lynchburg Ferry area to determine whether long-term benzene concentrations remain below the long-term AMCV.

Galena Park - Benzene

The reported 2009 average benzene concentration based on every sixth-day 24-hour canister samples at the Galena Park site was 0.82 ppb_v, and is below the long-term, health-based AMCV (1.4 ppb_v) for the second time in several years (see Figure 4). The 2008 annual average (1.3 ppb_v) was also below the long-term AMCV. The 2008-2009 averages represent a significant improvement in air quality that is likely the result of significant efforts in the area by TCEQ (e.g., focused agency resources, special investigations utilizing the latest technology, enhanced compliance and enforcement), along with the cooperation of industry (e.g., ERAs). For example, this reduction in the annual benzene concentration may partially reflect the results of ERAs previously entered into by TCEQ with several facilities identified during an earlier Find-and-Fix investigation (Kinder Morgan Terminals, Vopak Terminals, TEPPCO Pipeline) to reduce VOCs, including benzene. The 2009 average is approximately 37% lower than the 2008 annual average of 1.3 ppb_v, 52% lower than the 2007 annual average of 1.7 ppb_v, 49% lower than the 2006 annual average of 1.6 ppb_v, and approximately 59% lower than the 2005 annual average of 2.0 ppb_v.

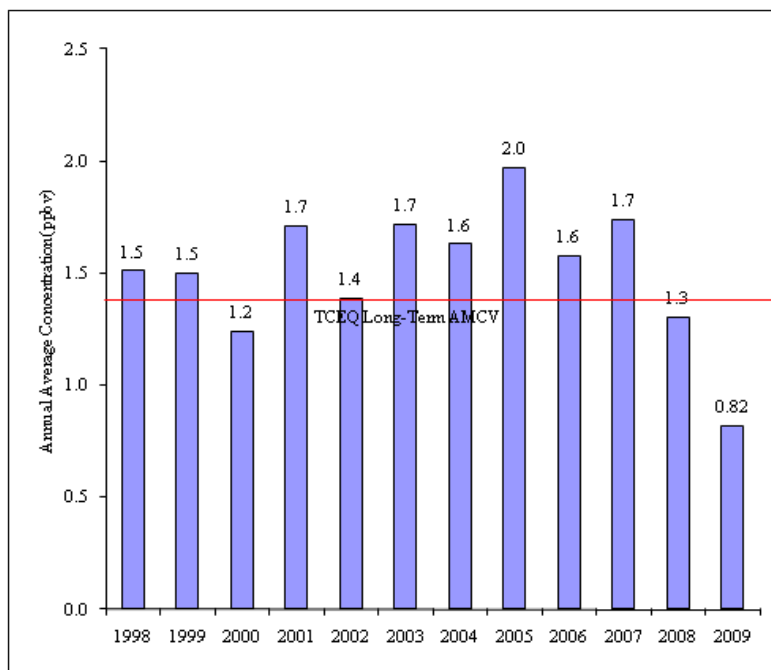


Figure 4. Annual Average Benzene Concentrations at the Galena Park Site

TCEQ efforts in the Galena Park area have been significant, and the 2008-2009 annual benzene averages appear to suggest a downward trend. In addition, available preliminary 24-hour canister data indicate that the 2010 average for benzene of 1.1 ppb_v at the Galena Park site is also well below the long-term AMCV (1.4 ppb_v). Although the 2008-2009 annual average benzene concentrations at the Galena Park site were below the long-term AMCV, this area will remain on the APWL (Site# [APWL1206](#)). The TD recommends a continued effort to control and/or reduce benzene emissions in the area such that the long-term AMCV will continue to be met at the Galena Park site, and will continue to monitor benzene concentrations at this site to determine whether current improvements are maintained.

TCEQ activities in 2009 (and 2010) in the Galena Park area included, but were not limited to, the following:

- Periodic focused investigations and GasFindIR reconnaissance investigations in the Galena Park area.
- Stack test reviews, compliance investigations, and emission event investigations at Pasadena Refining Systems. In 2009, four NOEs and four NOV's were issued.
- Region 12 efforts regarding Pasadena Refining Systems continued in 2010, and three NOV's were issued. In addition, a full on-site compliance investigation was conducted for the entire Pasadena Refining Systems site and resulted in 54 total violations.
 - There were 19 violations associated to an NOE and 35 violations associated to an NOV. Included in these violations were the unauthorized release of approximately 260 tons VOC and 149 tons of sulfuric acid.
- Compliance investigations, emission event investigations, and a leak detection and repair (LDAR) investigation at the Houston Refining and Valero Houston Refinery facilities. These investigations resulted in the issuance of seven NOEs in 2009 and seven NOEs in 2010. Additionally, there were nine NOV's issued during this time frame.
 - The investigations at Houston Refining included a review of their compliance certification and resulted in the issuance of 38 violations.
 - The investigations at the Valero Houston Refinery included a review of their compliance certification and resulted in the issuance of 19 violations.
- Stack test reviews, compliance investigations, and emission event investigations at Kinder Morgan GP Terminal, Kinder Morgan Pasadena Terminal, Texmark Chemicals, and Gulf Coast Waste Disposal. NOV's and NOEs were issued at all.
- Tank degassing operations initiative at various facilities located in the Galena Park area in response to complaints received regarding the release of uncontrolled VOC emissions during the degassing or cleaning of stationary marine and transport vessels. NOV's were issued in 2009 to Kinder Morgan and Magellan Terminals.

Benzene sources located on the south side of the Houston Ship Channel also have the potential to impact the annual averages measured at the Galena Park site, especially those located in relative close proximity to the south/southeast of the Galena Park monitor (given predominant southeast winds). US Oil Recovery is one of the facilities on the south side of the Houston Ship Channel that has been previously identified as potentially impacting benzene levels at the Galena Park site (Pasadena Refining and Houston Refining were also identified) based on mobile monitoring data. Until US Oil Recovery ceased operations in March 2010, Region 12 had been conducting ongoing multimedia investigations there. An NOE was issued to US Oil Recovery in February 2009 for several violations, including but not limited to: failure to obtain authorization to operate all processes (i.e., used oil recovery process, distillate process, wastewater treatment process), which constitutes a violation of 30 TAC 116.110(a); failure to maintain complete and up-to-date records sufficient to demonstrate continuous compliance with the control requirement and/or exemption criteria for the boiler, storage tank, water separator, and wastewater streams, which constitutes various violations; failure to provide sufficient information to determine compliance or applicability for the Permit By Rule cited in a previous NOV; and failure to have the lid closed on the parts washer, which constitutes a violation of 30 TAC 115.412(1)(A) and (C). A previous NOE had been issued to US Oil Recovery in 2008, the same year an NOE related to

benzene releases was issued to Houston Refining, also located on the south side of the Houston Ship Channel with the potential to impact benzene levels at the Galena Park site.

TCEQ will continue to use information from various investigations, mobile and fixed-site monitoring (e.g., Pasadena North and Galena Park sites), and the latest technology (GasFindIR) to aid in the identification of sources and reduction of benzene emissions impacting the Galena Park area.

Milby Park-1,3-Butadiene

Like Lynchburg Ferry and Galena Park, the Milby Park site area continues to be of interest to TCEQ and others. Remarkably, annual average 1,3-butadiene levels continue to decline (see Figure 5). The reported 2009 average concentration of 0.51 ppb_v at the Milby Park site is approximately 43% lower than the reported 2008 average concentration, 49% lower than the reported 2007 average, 61% lower than the 2006 average, 66% lower than the 2005 average, and 87% lower than the 2004 average concentration. The 2009 average 1,3-butadiene concentration is the lowest annual average measured at this site since monitoring began, and is well below the long-term AMCV (9.1 ppb_v).

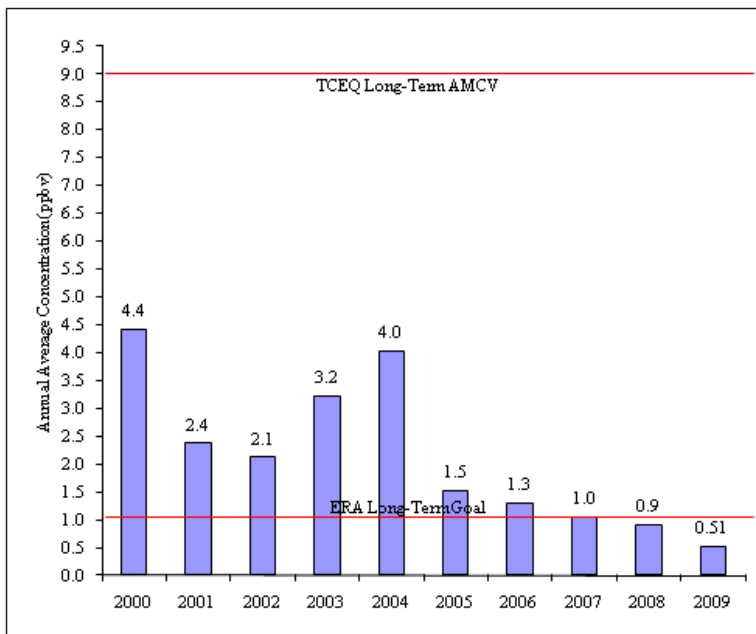


Figure 5. Annual Average 1,3-Butadiene Concentrations at the Milby Park Site

Preliminary data indicate that the 2010 average 1,3-butadiene concentration at Milby Park (0.59 ppb_v) is similar to 2009 and continues to be well below the long-term AMCV. The reductions in annual average concentrations of 1,3-butadiene can be attributed to corrective activities associated with the TCEQ voluntary ERAs entered into by Texas Petrochemical and Goodyear in 2004. Despite the significant reduction in the annual average 1,3-butadiene concentration at the Milby Park site, TCEQ continues to conduct activities to help reduce emissions in the area. Region 12 activities in 2009 (and 2010) in the Milby Park area included, but were not limited to, the following:

- Review of investigation reports submitted by Texas Petrochemical and Goodyear when relatively high levels of styrene and 1,3-butadiene were detected by area monitors.
- Compliance investigations in 2009 and 2010 at both Goodyear and Texas Petrochemical.
 - Goodyear was issued an NOV in both 2009 and 2010.
 - Texas Petrochemical was issued four NOVs and five NOEs in 2009. All NOEs and all but one of those NOVs issued to Texas Petrochemical were due to emission event releases.

This area (Site# [APWL1207](#)) was on the APWL for 10 years due to 1,3-butadiene levels which were historically considered to be elevated. However, in 2009, 1,3-butadiene was able to be removed from [APWL1207](#) due to success in achieving significant improvements in long-term concentrations measured at the Milby Park site. Most importantly, the results of a 2008 TD assessment of the most up-to-date science and data for 1,3-butadiene (see the [1,3-Butadiene Development Support Document](#)) indicate that these reported annual averages are below levels of health concern.

Texas City Marathon-Sponsored 11th St. S. Site-Benzene

Marathon Petroleum Company (Marathon) initially collected benzene data at this off-site monitor just north of Marathon from October 2004 to October 2005 under a TCEQ agreed order (Agreed Order 2001-0575-AIR-E). Then, under a benzene emission investigation plan with TCEQ and EPA, Marathon collected data at the site from January 30, 2006, to January 31, 2007. Per an agreement with EPA and the US Department of Justice (DOJ), Marathon again began collecting benzene data at the site on April 1, 2007. The site was moved 1 block north to the corner of 11th St. S. and 6th Ave. S. on November 5, 2007.

Similar to previous years, the 2009 average benzene concentration measured at the Marathon-sponsored site (2.0 ppb_v) exceeds TCEQ's long-term AMCV (1.4 ppb_v) (see Figure 6). The area of Texas City located south of State Highway 1765, which contains this Marathon-sponsored site, is currently on the APWL (Site# [APWL1202](#)) for elevated long-term concentrations of benzene. Therefore, the identification of potential benzene sources which may be affecting long-term benzene levels at this site is important.

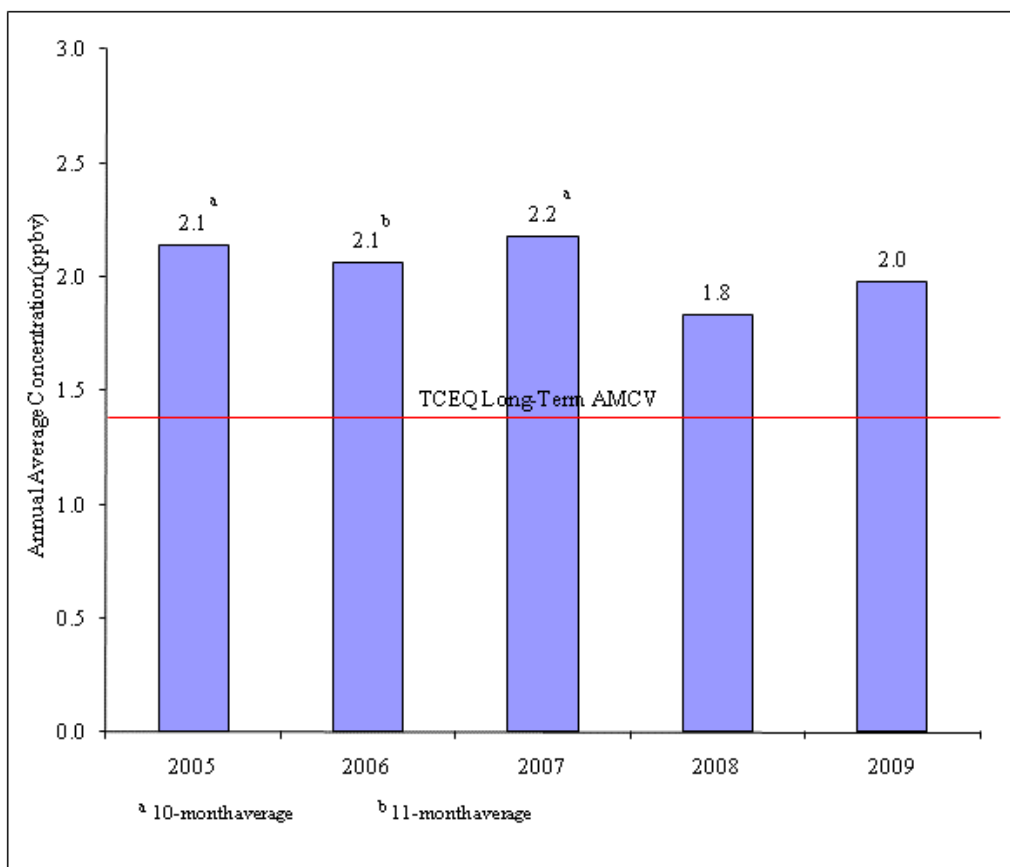


Figure 6. Annual Average Benzene Concentrations at the Marathon-Sponsored 11th St. S. Site

As high hourly benzene levels can significantly impact the annual average at a site, the direction of potential benzene sources near the Marathon-sponsored 11th St. S. site was evaluated using wind directional data associated with hourly benzene concentrations greater than 10 ppb_v in 2009. Based on this analysis (see Figure 7), elevated concentrations above 10 ppb_v were most frequently associated with winds from the southeast (with most between 120-161 degrees) and southwest (193-212 degrees). These directional results are similar to those discussed in the evaluation of [2008 Region 12 data](#), except that there were approximately 25% fewer benzene concentrations above 10 ppb_v in 2009 compared to 2008 data, and 62% fewer compared to [2007 Region 12 data](#). The direction of potential benzene sources near this site was also evaluated by the TD through the use of all available 2009 air concentration data (not just concentrations greater than 10 ppb_v) and wind directional data collected at the site (see Appendix 3). Unlike the pollution roses in Appendices 2a and 2b where the length of the roses (i.e., yellow tapered bars) represent the relative concentrations (part-per-billion carbon) from the various directions, the length of the roses in Appendix 3 represent the percent of time wind was from that direction. The various widths of the bars represent the relative concentrations in ppb_v (see the map key). Similar to Figure 7, this source direction analysis shows that higher benzene levels occurred in 2009 when winds were from the southeast and southwest, where the nearby Marathon facility is located.

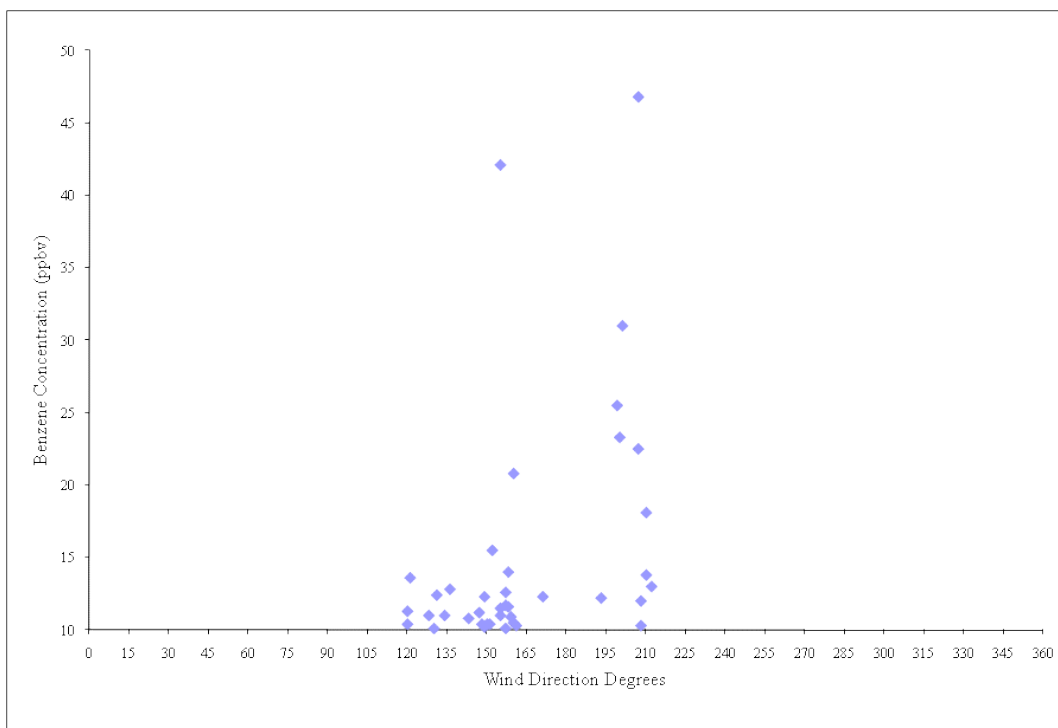


Figure 7. Hourly Benzene Concentrations > 10 ppb_v vs. Wind Direction for 2009 at the Marathon-Sponsored 11th St. S. Site

In addition to the off-site 11th St. S. monitoring site, Marathon also provides on-site (generally upwind) air monitoring data. Although the public is not exposed to benzene on Marathon property, on-site hourly data were also used to evaluate the direction of potential benzene sources both on- and off-site. Based on this analysis (see Figure 8), concentrations above 10 ppb_v were most frequently associated with winds from the north/northwest (approximately 322-359 degrees), southwest (approximately 200-261 degrees), and east/northeast/southeast (approximately 63-117 degrees). These directional results are fairly similar to those discussed in the evaluation of [2008 Region 12 data](#), except that there were approximately 14% more benzene concentrations above 10 ppb_v at the Marathon on-site monitor and maximum values were higher in 2009 (1,682 ppb_v) compared to 2008 (116 ppb_v). Still, compared to [2007 Region 12 data](#), there were 41% fewer concentrations above 10 ppb_v in 2009. The direction of potential benzene sources near the on-site monitor was also evaluated through the use of all available 2009 air concentration data (not just concentrations greater than 10 ppb_v) and wind directional data collected at this site (see Appendix 3). Again, unlike the pollution roses in Appendices 2a and 2b, the length of the roses in Appendix 3 represent the percent of time wind was from that direction, with the various widths of the bars representing the relative concentrations in ppb_v (see the map key). Similar to Figure 8, this source direction analysis shows that higher benzene levels at the on-site monitor occurred in 2009 when winds were from the north/northwest and northeast, where various areas of the Marathon facility are located.

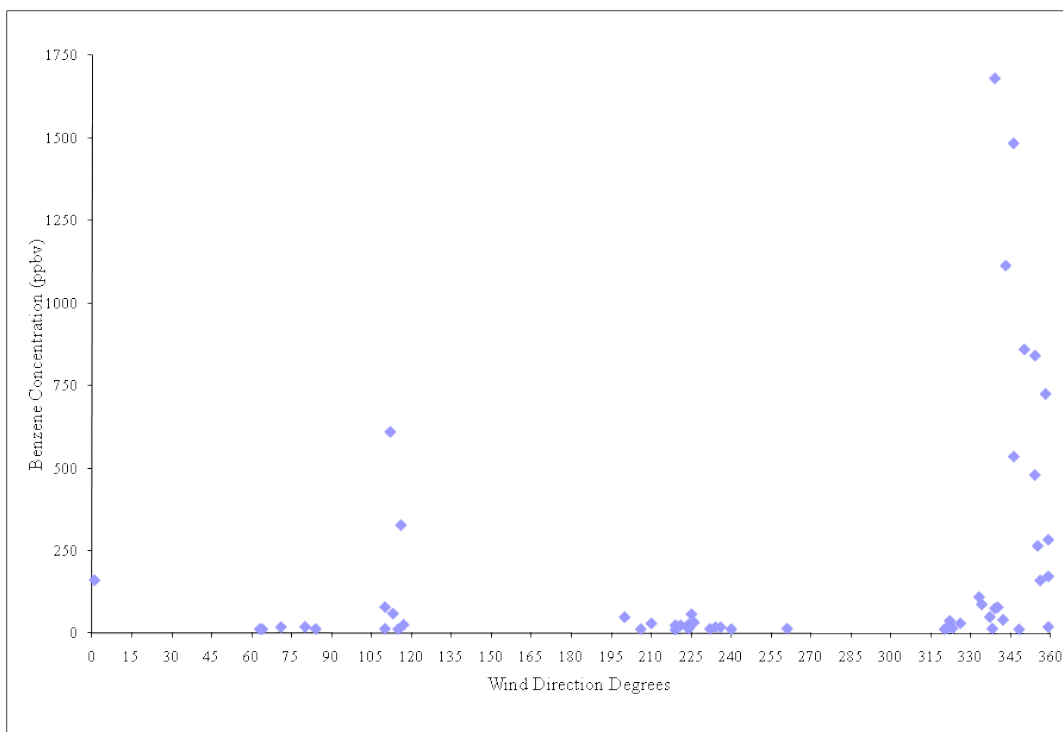


Figure 8. Hourly Benzene Concentrations > 10 ppb_v vs. Wind Direction for 2009 at the Marathon-Sponsored On-Site Monitor

Higher benzene concentrations from the northerly directions for the on-site monitor are consistent with higher levels from the southerly directions for the 11th St. S. site and would seem to imply common emission sources between these sites are impacting both monitors. Benzene emissions impacting the 11th St. S. site should be identified and reduced to help this monitor meet the long-term AMCV.

TCEQ activities in 2009 (and 2010) related to benzene in Texas City included, but were not limited to, the following:

- Focused investigations and reconnaissance investigations in the Texas City area to address on-going issues discovered through use of GasFindIR or through visual observations. Fence-line reconnaissance investigations during normal business hours and at night.
- Investigation of all reportable emissions events, resulting in the issuance of 17 NOEs and 10 NOVs at the BP Texas City Refinery in 2009.
- Region 12 efforts continued at the BP Texas City Refinery in 2010.
 - There were 21 NOEs and five NOVs issued to the BP Texas City Refinery.
 - A full site inspection was conducted at the BP Texas City refinery from May 26 through June 14, 2010. A total of 49 violations were identified with 17 violations associated to an NOE, and 32 violations associated to an NOV. The violations cited included:
 - Failure to inspect and/or repair tank seals;
 - Exceeding NO_x, CO, SO₂ and ammonia emission limits;

- Failure to operate NO_x, CO, SO₂ and HRVOC analyzers;
 - Failure to seal open ended lines;
 - Failure to monitor pumps, connectors and valves; and
 - Failure to conduct stack testing.
- Also in 2010, the BP Texas City Refinery was issued an NOE along with an Excessive Emission Event determination for Incident 138052 which began on April 6, 2010 and ended May 16, 2010. The event resulted in the release of over 500,000 lbs of emissions including over 17,000 lbs of benzene.
- Investigation of all reportable emission events at the Valero Texas City Refinery, which resulted in the issuance of multiple NOV_s and NOE_s. A full site inspection was conducted at the Valero Texas City Refinery in 2009. There were 38 violations identified with five violations being associated with an NOE and 33 violations associated with an NOV.
- Other investigations in the Texas City area included compliance and emission event investigations at BP Chemical and Marathon Petroleum.
 - Compliance investigations conducted in 2009 at BP Chemical resulted in the issuance of one NOV in 2010.
 - During 2009, an LDAR investigation conducted at Marathon resulted in the issuance of an NOV. Other compliance investigations in 2009 and 2010 included a site investigation and emission event investigations that resulted in the issuance of two NOV_s and one NOE in 2009 and six NOV_s and two NOE_s in 2010.
- Tank degassing operations initiative for various facilities located in the Texas City area in response to complaints received regarding the release of uncontrolled VOC emissions during the degassing or cleaning of stationary, marine and transport vessels. NOV_s were issued in 2009 to BP Products, Oil Tanking, and Valero Refining.

Based on continued exceedances of the long-term AMCV for benzene, reductions in benzene emissions continue to be recommended for this area, especially those impacting the Marathon-sponsored 11th St. S. site. Preliminary data for 2010 (January through November) suggest that TCEQ activities in the area may have helped reduce benzene emissions as the 11-month average (0.91 ppb_v) is below the AMCV. The 2010 benzene average will likely meet the long-term AMCV for the first time since monitoring began in 2005. This area (Site# [APWL1202](#)) will remain on the APWL until the TD has determined the benzene concentrations in the area are no longer of potential health concern.

Texas City BP-Sponsored Site-Benzene

Annual average benzene concentrations at the BP-sponsored site in Texas City declined significantly from 2005 to 2008 (see Figure 9). While the reported 2009 average benzene concentration at the site (1.4 ppb_v) is 75% higher than the 2008 average, it does not exceed the long-term AMCV (1.4 ppb_v). As mentioned in the evaluation of [2008 Region 12 data](#), the 2009 average was going to increase because of some higher benzene concentrations (particularly January through May) due to a leaking, floating roof benzene storage tank discovered in May 2009. The tank was immediately emptied and taken out of service. BP reports that the benzene concentrations measured at the monitor then returned to normal. For example, the July to December 2009 average (0.98 ppb_v) is fairly similar to the average over the same duration for 2007 (0.74 ppb_v) and 2008 (0.79 ppb_v), and much lower than that over the same period in 2006

(1.9 ppb_v). Preliminary benzene data for 2010 (January through November average of 0.42 ppb_v) suggest that the 2010 average will again be well below the long-term AMCV. The TD recommends a continued effort to control and/or reduce benzene emissions such that the long-term AMCV will continue to be met at this site.

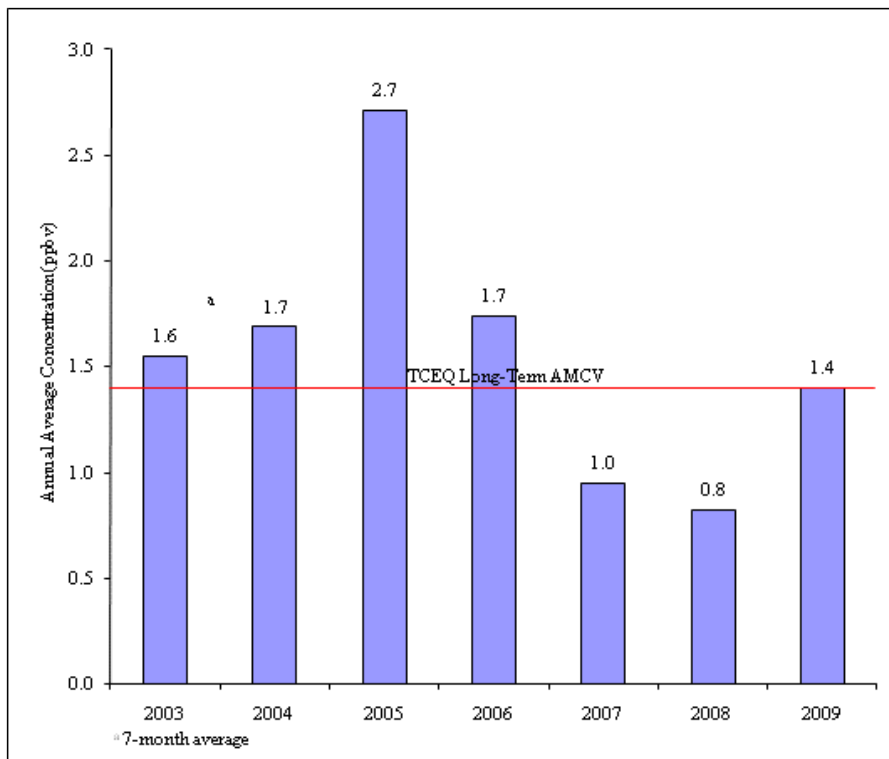


Figure 9. Annual Average Benzene Concentrations at the BP-Sponsored Site

Despite the 2005-2009 benzene concentrations meeting the long-term AMCV at the BP-sponsored site, the 2009 average at the nearby Marathon-sponsored site to the east is above the TCEQ AMCV. As the area of Texas City which contains the BP-sponsored site is currently on the APWL (Site# [APWL1202](#)) for the elevated long-term concentrations of benzene reported in previous years, and high hourly benzene levels can significantly impact long-term averages, the direction of potential benzene sources near the BP-sponsored site was evaluated using wind directional data associated with hourly benzene concentrations greater than 10 ppb_v in 2009 (see Figure 10). Based on this analysis, elevated concentrations above 10 ppb_v were frequently associated with winds from the south/southwest (181-201 degrees) and south/southeast (118-178 degrees), the direction of the BP facility.

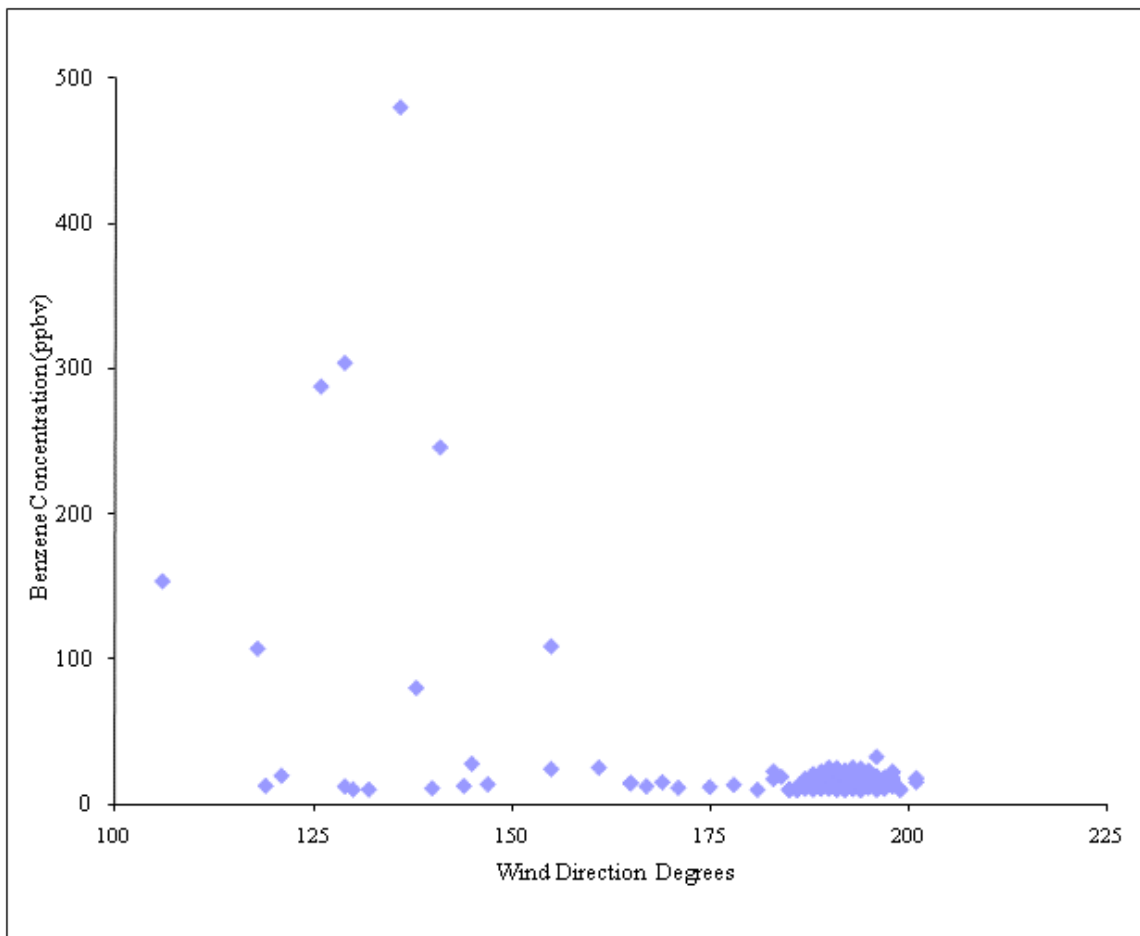


Figure 10. Hourly Benzene Concentrations > 10 ppbv vs. Wind Direction for 2009 at the BP-Sponsored Site

Please see the *Texas City Marathon-Sponsored 11th St. S. Site-Benzene* section above for information regarding TCEQ activities in 2009-2010 related to benzene in Texas City. This area (Site# [APWL1202](#)) will remain on the APWL until the TD has determined the benzene concentrations in the area are no longer of potential health concern.

Deer Park- Acrolein

Generally, the occurrence of acrolein in ambient air is widespread and primarily due to combustion. There are many sources of acrolein, including cars/trucks and other means of transportation (e.g., buses, railways, airports, construction equipment), fires, industry (e.g., industrial boilers and other emissions), and emissions from other combustion processes (e.g., smoke from wood/vegetation burning, lawn maintenance equipment). It can also form when other chemicals breakdown in the air (e.g., automobile exhaust VOCs). While acrolein was a target analyte only in carbonyl samples prior to 2008, in 2008 it was added as a target analyte in the every sixth-day 24-hour canister samples at the Deer Park site. Based on the carbonyl analyses at this site, the 2009 average concentration was 0.037 ppbv, which is below the long-term AMCV (0.22 ppbv). However, the reported 2009 average acrolein concentrations based on

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co-located canister samplers at the Deer Park site were 0.25 and 0.19 ppb_v. While the average of these co-located monitors would equal the long-term AMCV, one of the annual averages (POC2) is slightly above the AMCV and will be evaluated further.

Acrolein results from the canister and carbonyl analyses are significantly different because acrolein is highly reactive and there are difficulties in the sample collection and analysis of acrolein. To the TD's understanding, both TCEQ and USEPA are evaluating which of the available methods may be most appropriate for accurate and precise measurements of acrolein in the future. Regardless of which analytical method utilized at Deer Park in 2009 may be more accurate for the calculation of an annual average, the TD would not expect long-term, adverse health effects to occur at the reported acrolein average concentrations based on data from available scientifically-conducted toxicological studies (see below).

Since acrolein is reactive and highly water soluble, the most sensitive long-term effects are point-of-entry respiratory effects at sufficiently high exposure concentrations of sufficient duration. In laboratory animal (e.g., rat, dog) exposure studies, no respiratory effects are observed in animals after long-term exposure to 200 ppb_v, with respiratory effects observed at higher concentrations (e.g., 600 ppb_v for mild/moderate respiratory epithelial hyperplasia in rats, 220 ppb_v for respiratory histopathological inflammatory changes in dogs). Based on available toxicological data, no long-term, adverse health effects are expected to occur as a result of exposure to reported acrolein annual average concentrations of 0.037-0.25 ppb_v.

If you have any questions regarding this memorandum, please contact me by phone at (512) 239-5691 or by email at Joseph.Haney@tceq.texas.gov. For questions regarding the APWL, you may visit the TCEQ website at

http://www.tceq.state.tx.us/implementation/tox/AirPollutantMain/APWL_index.html.

Appendix 1. Monitored Air Toxics in Region 12 in 2009

List 1. Target VOC Analytes in Canister Samples

1,1,1-Trichloroethane	3-Methylhexane	Methylcyclopentane
1,1,2,2-Tetrachloroethane	3-Methylpentane	Methylene Chloride
1,1,2-Trichloroethane	4-Methyl-1-Pentene	m-Ethyltoluene
1,1-Dichloroethane	Acetylene	n-Butane
1,1-Dichloroethylene	Benzene	n-Decane
1,2,3-Trimethylbenzene	Bromomethane	n-Heptane
1,2,4-Trimethylbenzene	c-1,3-Dichloropropylene	n-Hexane
1,2-Dibromoethane	c-2-Butene	n-Nonane
1,2-Dichloroethane	c-2-Hexene	n-Octane
1,2-Dichloropropane	c-2-Pentene	n-Pentane
1,3,5-Trimethylbenzene	Carbon Tetrachloride	n-Propylbenzene
1,3-Butadiene	Chlorobenzene	n-Undecane
1-Butene	Chloroform	o-Ethyltoluene
1-Hexene + 2-Methyl-1-Pentene	Cyclohexane	o-Xylene
1-Pentene	Cyclopentane	p-Diethylbenzene
2,2,4-Trimethylpentane	Cyclopentene	p-Ethyltoluene
2,2-Dimethylbutane - Neohexane	Dichlorodifluoromethane	Propane
2,3,4-Trimethylpentane	Ethane	Propylene
2,3-Dimethylbutane	Ethyl Benzene	Styrene
2,3-Dimethylpentane	Ethylene	t-1,3-Dichloropropylene
2,4-Dimethylpentane	Isobutane	t-2-Butene
2-Chloropentane	Isopentane	t-2-Hexene
2-Methyl-2-Butene	Isoprene	t-2-Pentene
2-Methylheptane	Isopropylbenzene	Tetrachloroethylene
2-Methylhexane	m & p-Xylene	Toluene
2-Methylpentane - Isohexane	m-Diethylbenzene	Trichloroethylene
3-Methyl-1-Butene	Methyl Chloride	Trichlorofluoromethane
3-Methylheptane	Methylcyclohexane	Vinyl Chloride

List 2. Target Carbonyl Analytes

2,5-Dimethylbenzaldehyde	Formaldehyde	o-Tolualdehyde
Acetaldehyde	Heptaldehyde	Propanal - Propionaldehyde
Acetone	Hexanaldehyde	p-Tolualdehyde
Acrolein	Isovaleraldehyde	Valeraldehyde
Benzaldehyde	Methyl Ethyl Ketone	
Butyraldehyde	(MEK)/Methacrolein	
Crotonaldehyde - 2-Butenal	m-Tolualdehyde	

List 3. Target Metal Analytes

Aluminum (PM _{2.5} , PM ₁₀)	Chromium (PM _{2.5} , PM ₁₀)	Nickel (PM _{2.5} , PM ₁₀)
Antimony (PM _{2.5} , PM ₁₀)	Cobalt (PM _{2.5} , PM ₁₀)	Selenium (PM _{2.5} , PM ₁₀)
Arsenic (PM _{2.5} , PM ₁₀)	Copper (PM _{2.5} , PM ₁₀)	Tin (PM _{2.5} , PM ₁₀)
Barium (PM _{2.5} , PM ₁₀)	Manganese (PM _{2.5} , PM ₁₀)	Zinc (PM _{2.5} , PM ₁₀)
Cadmium (PM _{2.5} , PM ₁₀)	Molybdenum (PM _{2.5} , PM ₁₀)	

List 4. Target PAH Analytes

Acenaphthene	Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Acenaphthylene	Benzo(k)fluoranthene	Naphthalene
Anthracene	Chrysene	Phenanthrene
Benzo(a)anthracene	Dibenzo(a,h)anthracene	Pyrene
Benzo(a)pyrene	Fluoranthene	
Benzo(b)fluoranthene	Fluorene	

List 5. Target VOC Analytes in AutoGC

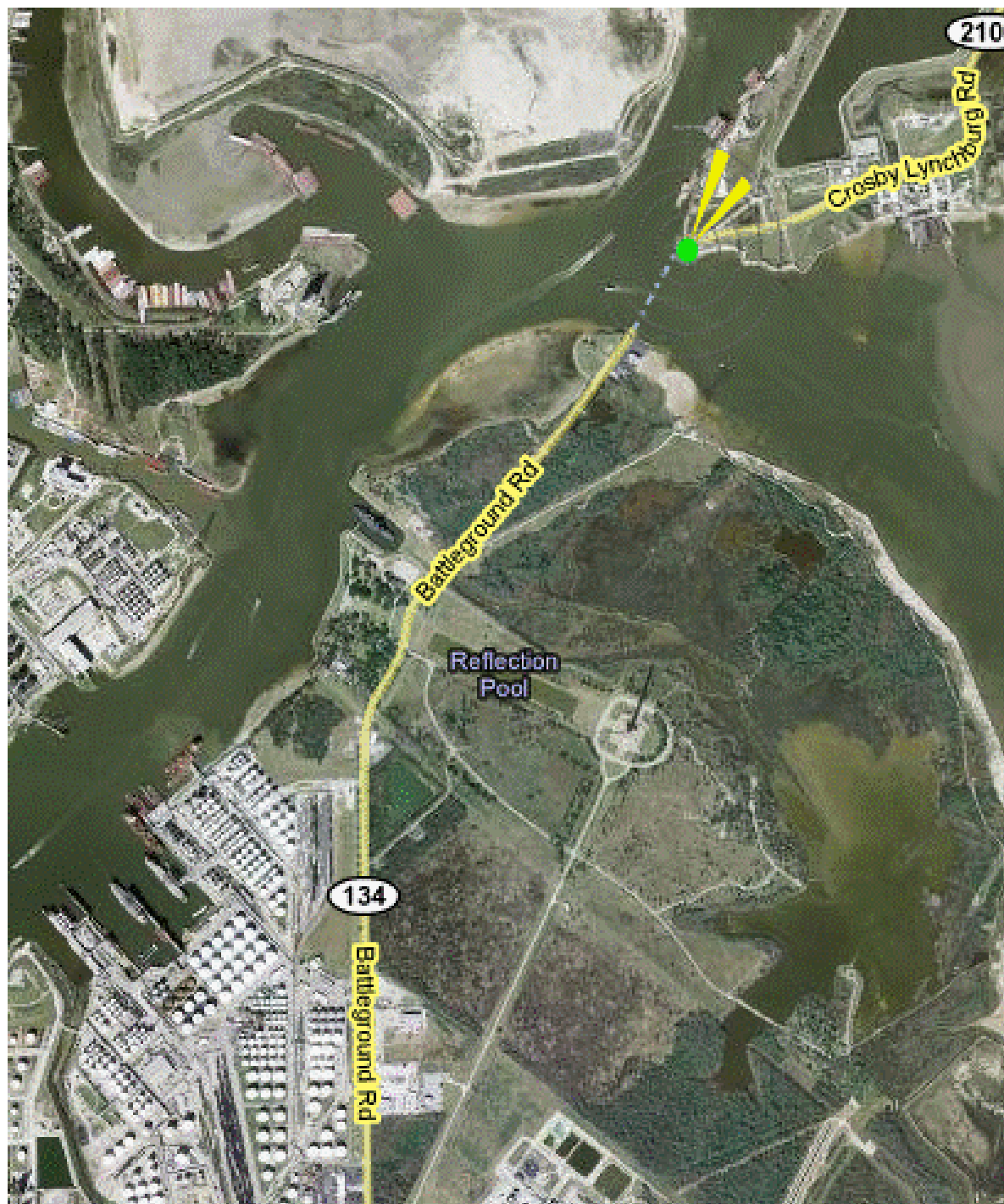
1-Butene	Acetylene	n-Decane
1-Pentene	Benzene	n-Heptane
1,2,3-Trimethylbenzene	c-2-Butene	n-Hexane
1,2,4-Trimethylbenzene	c-2-Pentene	n-Nonane
1,3-Butadiene	Cyclohexane	n-Octane
1,3,5-Trimethylbenzene	Cyclopentane	n-Pentane
2-Methyl-2-Butene*	Ethane	n-Propylbenzene
2-Methylheptane	Ethyl Benzene	n-Undecane*
2-Methylhexane	Ethylene	o-Xylene
2,2-Dimethylbutane	Isobutane	p-Xylene + m-Xylene
2,2,4-Trimethylpentane	Isopentane	Propane
2,3-Dimethylpentane	Isoprene	Propylene
2,3,4-Trimethylpentane	Isopropyl Benzene - Cumene	Styrene
2,4-Dimethylpentane	Methylcyclohexane	t-2-Butene
3-Methylheptane	Methylcyclopentane	t-2-Pentene
3-Methylhexane	n-Butane	Toluene

*Only monitored at the Danciger, Lake Jackson, Texas City 34th St., Wallisville Rd., Haden Rd., and Lynchburg Ferry monitoring sites.

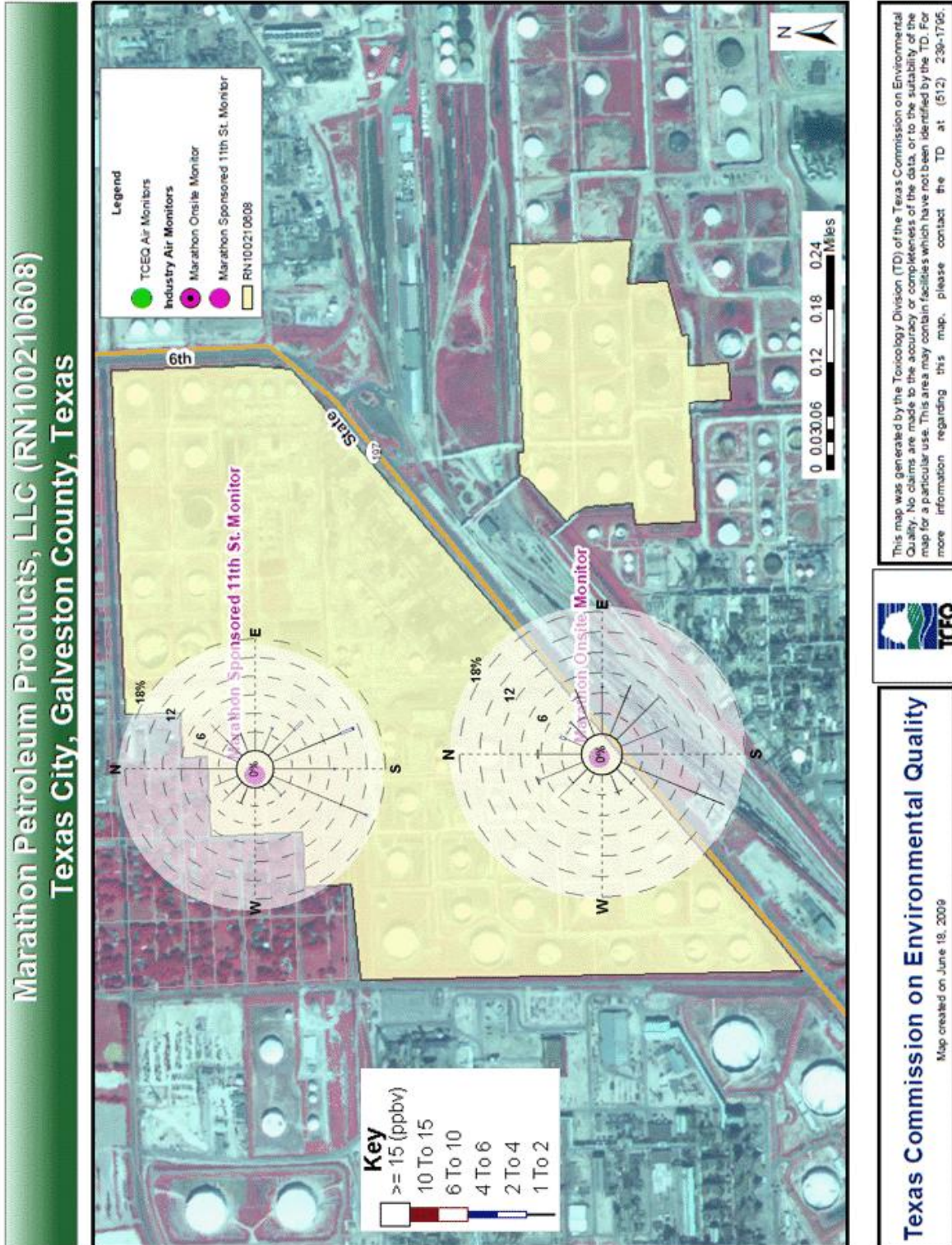
Appendix 2a. Source Direction Evaluation of Styrene Average Concentrations (2009) at the Lynchburg Ferry Site



Appendix 2b. Source Direction Evaluation of Styrene Maximum Concentrations (2009) at the Lynchburg Ferry Site



Appendix 3. Source Direction Evaluation of Benzene at the Marathon-Sponsored Off- and On-Site Monitors for 2009



cc:

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Bob Allen, Harris County

Kathy Porter, Harris County

Ronnie Schultz, Galveston County Health Dept.

Ruben Casso, Region 6 EPA

Kuenja Chung, Region 6 EPA