TCEQ Interoffice Memorandum

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Subject: Health Effects Review of 2017 through 2019 Ambient Air Network Monitoring Data in Region 12, Houston

Key Points

- From 2017 through 2019, approximately 0.000027% (5 out of more than 10,906,689 samples) of measured hourly concentrations exceeded a health-based AMCV. These hourly levels of benzene were measured at three Region 12 sites, and four of the five concentrations were measured during the ITC fire in Houston (March 2019).
- From 2017 through 2019, only approximately 0.00017% (23 out of more than 10,906,689 samples) of measured hourly concentrations exceeded an odor-based AMCV. A few hourly levels (e.g., isoprene, styrene, 1-pentene) at five Region 12 sites could have resulted in the perception of odors if people were exposed. Assuming exposure, the monitored concentrations would not be expected to cause direct, short-term adverse health effects (e.g., eye irritation), and the infrequency and generally low magnitude of the exceedances are not indicative of persistent, strong odors with the potential to cause odor-related health effects (e.g., nausea, headache).
- With the exception of annual averages of hexachlorobutadiene, benzene, and chromium $PM_{2.5}$, annual average concentrations for all other chemicals and metals from 24-hour measurements in 2017 through 2019 were below their respective TCEQ AMCVs. However, all 3-year average concentrations were below their respective TCEQ AMCVs, which is a more appropriate comparison as the long-term AMCV is a lifetime comparison value.
    - At three Texas City/La Marque sites (2nd Ave, Ave A, and North Site), the 2017 annual averages of hexachlorobutadiene exceeded the long-term health-based AMCV. These low magnitude exceedances would not be expected to cause adverse health effects.
    - At Houston Deer Park #2 and Houston Aldine, the 2017 and 2018, respectively, annual averages of chromium $PM_{2.5}$ exceeded the long-term health-based AMCV. However, the three-year averages for both sites were below the long-term health-based AMCV, which is a more appropriate comparison as the long-term AMCV is a lifetime value. Moreover, the long-term AMCV is based on a

form of chromium (hexavalent) that generally represents only a small fraction of environmental chromium (e.g., ≈1%). Importantly, all annual averages are well below the more comparable long-term AMCV for other forms of chromium and that which more reasonably assumes 1% hexavalent chromium (or even conservatively assuming 10% hexavalent chromium).

- At Jacinto Port, the 2019 annual average of benzene slightly exceeded the AMCV. However, the three-year average was below the long-term AMCV, which is a more appropriate comparison as the long-term AMCV is a lifetime value.

Background

The primary purpose of this memorandum is to convey the Toxicology, Risk Assessment, and Research Division's (TD) evaluation of ambient air toxics sampling conducted at monitoring sites in Region 12-Houston during 2017, 2018, and 2019. The TD reviewed summary results for volatile organic compounds (VOCs) from 24-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, 30-minute rolling averages of 1-hour hydrogen sulfide samples, 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 (PM_{10}), and 24-hour lead total suspended particulate (TSP) samples.

Historically, this memorandum has evaluated data from the TCEQ and Enhanced Industry-Sponsored Monitoring (EISM) sites, which are reported to the TCEQ on a regular basis. For this memorandum, industry-sponsored air monitoring networks that are not routinely reported to the TCEQ are also included. The TD requested these data from the respective industry groups and included them in our evaluation, as detailed below. Except for lead, data for criteria pollutants (i.e., compounds having National Ambient Air Quality Standards (NAAQS)) were not evaluated for this memorandum. Appendix 1 contains a list of the target analytes evaluated for this review.

Information regarding monitoring sites and target analyte data reviewed by the TD is presented in Table 1 and summarized below:

- 24-hour canister VOC sampling at:
  - 12 TCEQ sites
  - 6 Houston Regional Monitoring (HRM) sites outside of the EISM sites, and
  - 3 Texas City/La Marque Community Air Monitoring Network (TCLAMN) sites.
- 24-hour carbonyl sampling at 2[1] sites.
- 8-hour carbonyl sampling at 1 site.
- 3-hour carbonyl sampling at 1 site.
- 24-hour metals sampling at 4[2] sites.

[1] Carbonyl sampling is seasonal, depending on the site, part of the year could be 24 hour, 8 hour, or 3 hour.
[2] PM_{10} metals sampling discontinued on 6/30/2018 at one site.

- 24-hour PAH/SVOC sampling at 1[3] site.
- 1-hour autoGC VOC sampling at:
  - 6 TCEQ sites,
  - 10 EISM sites,
  - 1 TCLAMN site, and
  - 1 HRM site.
- 5-minute hydrogen sulfide (H_2S) sampling at:
  - 1 TCEQ site,
  - 3 EISM sites.

Table 1. Monitoring Sites Located in TCEQ Region 12

County	EPA Site ID	Site Name and Location	Network	Monitored Compounds
Galveston	N/A	2nd Avenue Monitoring Station (29.386981, -94.91912)	TCLAMN[4]	VOC (24-hour canister, 1/12 days[5]; autoGC)
Galveston	N/A	Avenue A Monitoring Station (29.37435, -94.96364)	TCLAMN	VOC (24-hour canister)
Harris	48-201-0058	Baytown 7201 ½ Bayway Dr	TCEQ	VOC (24-hour canister)
Harris	48-201-6000	Cesar Chavez 4829A Galveston Rd	TCEQ	VOC (autoGC)
Harris	48-201-0026	Channelview 1405 Sheldon Rd	TCEQ	VOC (autoGC)
Harris	48-201-1035	Clinton 9525 ½ Clinton Dr	TCEQ/City of Houston Health Department[6]	VOC (autoGC), Carbonyls[7]

[3] PAH/SVOC sampling discontinued on 6/30/2018.
[4] TCLAMN – Texas City/La Marque Community Air Monitoring Network.
[5] The typical schedule for 24-hour canisters is to collect one 24-hour sample every six days. This sampler is collecting one 24-hour sample every twelve days.
[6] City of Houston Health Department owns and is responsible for the PM_{10} metals monitor at this site.
[7] This carbonyl sampler collects seasonally: in 2017, one 24-hour sample every six days from January through June and October through December, from July through September, this sampler switched to a more intensive sampling schedule where it collected eight 3-hour samples every three days; in 2018, one 24-hour sample every six days from January through May and September through October, from June through August, this sampler switched to a more intensive sampling schedule where it collected three 8-hour samples every three days; in 2019, one 24-hour sample every six days from April through October, from January through March and November through December no samples were collected.

County	EPA Site ID	Site Name and 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[8] - SI Group[9]	VOC (autoGC)
Brazoria	48-039-1012	Freeport South Ave I 207 South Avenue I	TCEQ	Metals ($PM_{2.5}$)
Harris	48-201-0057	Galena Park 304 Stewart St	TCEQ	VOC (autoGC / 24-hour canister)
Harris	48-201-0024	Houston Aldine 4510 ½ Aldine Mail Rd	TCEQ	Metals ($PM_{2.5}$)[10]
Harris	48-201-0055	Houston Bayland Park 6400 Bissonnet St	TCEQ	VOC (24-hour canister)
Harris	48-201-1039	Houston Deer Park #2 4514 ½ Durant St	TCEQ	VOC (autoGC, 24-hour canister[11]), Carbonyls[12], Metals ($PM_{2.5}$, PM_{10}[13]), PAHs/SVOCs[14]
Harris	48-201-0803	HRM #3 Haden Rd 1504 ½ Haden Dr	TCEQ/EISM - HRM[15]	VOC (24-hour canister)/VOC (autoGC)
Harris	N/A	HRM 1 Central Street 1501 Central Street, Houston	HRM	VOCs (24-hour canister)
Harris	N/A	HRM 4 Sheldon Rd 16200 Miller Road 1, Channelview	HRM	VOC (24-hour canister)

[8] EISM – Enhanced Industry-Sponsored Monitoring, this acronym is followed by the industry group responsible for the sampling.
[9] Sweeny Industry Group.
[10] $PM_{2.5}$ metals sampler deactivated on 12/18/2019.
[11] This site had two co-located 24-hour canister samplers, one was deactivated on 6/30/2018.
[12] This carbonyl sampler collects seasonally: in 2017, one 24-hour sample every six days from January through December; in 2018, one 24-hour sample every six days from January through October and no samples were collected November through December; in 2019, one 24-hour sample every six days from April through May and September through October, from June through August, this sampler switched to a more intensive sampling schedule where it collected three 8-hour samples every three days, and from January through March and November through December no samples were collected.
[13] This site had two co-located PM_{10} metals samplers; both were deactivated on 6/30/2018.
[14] This site had two co-located PAH/SVOC samplers; both were deactivated on 6/30/2018.
[15] HRM – Houston Regional Monitoring.

County	EPA Site ID	Site Name and Location	Network	Monitored Compounds
Harris	N/A	HRM 7 W Baytown 4606 W. Baker Rd, Baytown	HRM	VOC (24-hour canister)
Harris	N/A	HRM 8 LaPorte 11426 Fairmont Pkwy, La Porte	HRM	VOC (24-hour canister)
Chambers	N/A	HRM 10 Mont Belvieu 13618 Hatcherville Rd, Mont Belvieu	HRM	VOC (24-hour canister)
Chambers	N/A	HRM 11 E Baytown 8620 West Bay Rd, Baytown	HRM	VOC (24-hour canister)
Harris	N/A	HRM 16 Deer Park 601 East 8th Street, Deer Park	HRM	VOC (autoGC)
Harris	48-201-0036	Jacinto Port [16] 1st St and Elsbeth St	TCEQ	VOC (24-hour canister)
Brazoria	48-039-1016	Lake Jackson 109-B Brazoria Hwy 332-W	EISM – FI Group[17]	VOC (autoGC)
Harris	48-201-1015	Lynchburg Ferry 1001 B Lynchburg Rd	TCEQ/EISM - HRM	VOC (24-hour canister)/VOC (autoGC)
Harris	48-201-0307	Manchester/Central 9401 ½ Manchester Rd	TCEQ	VOC (24-hour canister)
Harris	48-201-0069	Milby Park 2201-a Central St	TCEQ	VOC (autoGC)
Galveston	N/A	North Site (29.429228, -94.971503)	TCLAMN	VOC (24-hour canister, 1/12 days)
Brazoria	48-039-1607	Oyster Creek 901 County Road 792	EISM - Freeport LNG	VOC (AutoGC), H_2S[18]
Harris	48-201-1049	Pasadena North 702 Light Company Rd	TCEQ	VOC (24-hour canister)
Harris	48-201-0061	Shoreacres 3903 ½ Old Hwy 146	TCEQ	VOC (24-hour canister)

[16] Site was moved in 2020 and re-named to Channelview Drive Water Tower
[17] FI Group – Freeport Industry Group.
[18] H_2S sampler activated 1/1/2017

County	EPA Site ID	Site Name and Location	Network	Monitored Compounds
Galveston	48-167-0056	Texas City 34th St 2212 North 34th St	EISM - TCLAMN	VOC (autoGC)
Galveston	48-167-0005	Texas City Ball Park 2516 ½ Texas Ave	TCEQ	H_2S, VOC (24-hour canister)
Galveston	48-167-0615	Texas City BP 31st Street (Site 1) 302 31st Street South	EISM – Marathon Petroleum Co.	H_2S, 4 VOCs (SRIGC)
Galveston	48-167-0621	Texas City BP Logan Street (Site 3) 303 Logan Street	EISM – Marathon Petroleum Co.	H_2S, 4 VOCs (SRIGC)
Galveston	48-167-0683	Texas City 11th Street 569 11th Street South	EISM – Marathon Petroleum Co.	1 VOC (SRIGC)
Harris	48-201-0617	Wallisville Rd 4727 Wallisville Rd	EISM - HRM	VOC (autoGC)

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 also meet a 75% data completeness objective. One-hour autoGC VOC, 30-minute H_2S, as well as 8-hour and 3-hour carbonyl data were evaluated for potential acute health (e.g., irritation), odor, and vegetation concerns, as were any 24-hour sample results (e.g., VOCs, carbonyls, metals) that exceeded short-term air monitoring comparison values (AMCVs). Twenty-four-hour air samples collected every 6th day on a yearly basis are designed to provide representative long-term average concentrations. In order to be able to evaluate 24-hour monitoring data more fully, the TCEQ has developed 24-hour AMCVs for specific chemicals. As such, 24-hour samples were compared to the available TCEQ 24-hour AMCVs for the following:

- 1,3-butadiene
- 2,2-dimethylbutane
- 2,3-dimethylbutane
- 2-methylpentane
- 3-methylpentane
- acrolein
- benzene
- cadmium
- chromium
- cobalt
- manganese
- crotonaldehyde
- ethylene dibromide
- ethylene dichloride
- formaldehyde
- n-hexane

However, because short-term or peak concentrations may be significantly different than 24-hour sample concentrations, daily concentrations have limited use in evaluating the potential for more acute health effects, unlike the shorter-term data reviewed herein (e.g., 1-hour autoGC data, 30-minute H_2S data). The annual averages from 1-hour autoGC and 24-hour

samples (VOCs, carbonyls, and metals) were evaluated for potential chronic health and vegetation concerns. Measured chemical concentrations were compared to appropriate comparison values (e.g., the National Ambient Air Quality Standards (NAAQS) value, TCEQ health-, odor-, and vegetation-based AMCVs). Information on AMCVs may be obtained via the internet (https://www.tceq.texas.gov/toxicology/amcv/about) or by contacting the TD (512-239-3900). Exceedance of an AMCV does not necessarily mean that adverse effects would be expected, but rather that further evaluation is required.

Evaluation

1-Hour, 3-hour, and 8-hour Concentrations

The vast majority of the 1-hour autoGC VOC concentrations were below their respective TCEQ short-term, health-, odor-, and/or vegetation-based AMCVs. For example, about 99.9998% of the approximately 10,906,689 1-hour VOC measurements from the TCEQ, EISM, HRM, and TCLAMN network autoGC monitors in Region 12 collected from 2017 through 2019 were below their short-term AMCVs. Only five (approximately 0.000027%) hourly autoGC measurements collected at these Region 12 monitors from 2017 through 2019 exceeded a TCEQ short-term, health-based AMCV (see discussion below). Twenty-three hourly measurements (approximately 0.00017%) exceeded an odor-based AMCV over this 3-year period (Table 2). Additionally, 100% of the approximately 3,570 3-hour and 3,077 8-hour carbonyl concentrations measured in Region 12 from 2017 through 2019 were below their respective AMCVs. Therefore, the TD would not expect short-term, adverse health effects, vegetation effects, or odors to be associated with the vast majority of 1-hour, 3-hour, or 8-hour measurements monitored in Region 12 from 2017 through 2019. AMCV exceedances require a more detailed evaluation.

Further evaluation was conducted for the monitored concentrations that exceeded their respective short-term, health- and/or odor-based AMCVs to determine the potential for adverse health effects or odors. Five concentrations of benzene were the only instances in which any of the monitored 1-hour concentrations exceeded their respective short-term, health-based AMCVs from 2017 through 2019. Two of the benzene exceedances occurred at Lynchburg Ferry, where hourly benzene concentrations of 182.7 (on 10/28/2018) and 196.9 (on 3/30/2019) ppb_v were above the current health-based 1-hour AMCV of 180 ppb_v. Another exceedance of the benzene 1-hour AMCV (180 ppb_v) occurred at Houston Deer Park #2 with a reported 1-hour concentration of 190.7 (on 3/21/2019) ppb_v. The other two exceedances occurred at HRM 16, where hourly benzene concentrations of 1,227 (on 3/21/2019) and 250.8 (on 3/20/2019) ppb_v were reported. Four of these exceedances occurred during the ITC Fire in March of 2019. The magnitude of exceedance for four of the five hourly AMCV exceedances is low (< 1.4-fold), and considering the inherent precautionary nature of the 1-hour AMCV along with the underlying toxicity data, adverse health effects would not be expected if exposure to these concentrations had occurred.

The 1-hour benzene concentration of 1,227 ppb was measured at the HRM 16 monitoring site on March 21, 2019, at 5:00 am (CDT). HRM contacted TCEQ to share this datum as soon as the

near real-time data came through the system. The subsequent two hours of data were 949 ppb and 473 ppb (at 6:00 and 7:00 am). These three hourly measurements were the only ones to exceed the 1-hour AMCV for benzene (180 ppb_v) that day, and caused the associated 24-hour benzene concentration (128 ppb_v based on hourly measurements) to somewhat exceed the 24-hour AMCV (100 ppb_v). Further evaluation of these short-term concentrations shows that they are below those scientifically demonstrated to cause even the most sensitive adverse health effects (i.e., hematotoxicity) of short-term benzene exposure (e.g., 10,200 ppb_v was the lowest observed adverse effect level, based on depressed blood lymphocytes, in mice exposed to benzene 6 hours per day for 6 days, 36-hour total exposure (Rozen et al. 1984); https://www.tceq.texas.gov/assets/public/implementation/tox/dsd/final/benzene.pdf).[19] Considering the inherent precautionary nature of short-term AMCVs (e.g., 1- and 24-hour AMCVs) along with the underlying toxicity data, these reported short-term benzene concentrations would not be expected to cause short-term, adverse health effects.

For additional perspective, since the highest reported 1-hour benzene levels were reported during the ITC fire, the TD notes that USEPA acute exposure guideline levels (AEGLs) are derived for this type of emergency situation. AEGL-1 values are intended to represent health effect threshold levels for the least significant effects. The 1-hour AEGL-1 for benzene is 52,000 ppb_v (https://www.epa.gov/aegl/benzene-results-acute-exposure-guideline-levels-aegl-program), which is well above (i.e., 42 times) the maximum 1-hour benzene concentration reported. As an additional point of reference, the longest duration AEGL-1 is for 8 hours, and for benzene is 9,000 ppb_v. By comparison, the highest 8-hour concentration associated with the maximum 1-hour benzene on March 21, 2019 was 348.8 ppb_v, which is over 25 times lower than the 8-hour AEGL-1 value. These comparisons provide context in addition to that based on the discussion of AMCVs above, and with measured concentrations being over an order of magnitude lower, are consistent with the conclusion above that reported short-term benzene concentrations would not be expected to cause short-term, adverse health effects. In regard to the potential for odor associated with any exposure, benzene is an aromatic with a sweet, solventy odor. Odor thresholds for benzene, for example, range from a 50% odor detection threshold of 2,700 ppb_v to a 100% recognition threshold of 4,680 ppb_v (https://www.tceq.texas.gov/assets/public/implementation/tox/dsd/final/benzene.pdf). Considering that the reported levels are well below these odor thresholds and that benzene does not have a pungent disagreeable odor, the benzene AMCV exceedances discussed above would not be expected to cause persistent, strong odors with the potential to cause odor-related health effects (e.g., nausea, headache).

The monitored 1-hour autoGC VOC concentrations that exceeded their respective odor-based comparison levels from 2017 through 2019 are shown below in Table 2. In total, there were 23 odor-based AMCV exceedances by 1-hour autoGC data in Region 12 from 2017 through 2019: 9

[19] Longer-term averages for benzene in ambient air are also relevant to the potential for benzene-induced hematotoxicity, and the TCEQ notes that the associated annual average of 1.1 ppb_v at HRM 16 (for 2019) is below the chronic AMCV for benzene (1.4 ppb_v) as well as the chronic ReV (86 ppb_v) based on protecting the general public, including sensitive subpopulations, against hematotoxicity (e.g., decreased lymphocyte count) specifically.

in 2017, 8 in 2018, and 6 in 2019. These annual exceedances are slightly higher than, or similar to, the number of exceedances in 2016 (7 exceedances), 2015 and 2014 (5 exceedances each year), and 2013 (8 exceedances), and are lower than the number of exceedances in 2012 (14 exceedances), 2011 (19 exceedances), and 2010 (75 exceedances). Additionally, they are significantly lower compared to 2009 (37 exceedances), 2008 (82 exceedances), and 2007 (103 exceedances).

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)
Lynchburg Ferry	Styrene	10	134.5	26
Lynchburg Ferry	Isoprene	1	155.3	47
Danciger	Isoprene	1	52.4	47
Galena Park	Isoprene	1	108.8	47
Houston Milby Park	Styrene	2	32.01	26
HRM #3 Haden Rd	Styrene	3	29.7	26
HRM #3 Haden Rd	Isoprene	1	165.2	47
HRM 16	Isoprene	3	382*	47
HRM 16	1-Pentene	1	335*	100

**Concentrations occurred during ITC Fire*

The monitored odor-based AMCV exceedances from 2017 through 2019 would not be expected to cause direct acute adverse health effects (e.g., eye irritation). Additionally, the infrequency (only ≈0.00017% of hourly measurements) and generally low magnitude of the exceedances (e.g., < 3 times the odor-based AMCV except for three isoprene, three styrene, and one 1-pentene concentrations) are not indicative of persistent, strong odors with the potential to cause odor-related health effects (e.g., nausea, headache), although exposure to some

chemical concentrations monitored during the ITC fire could have resulted in the perception of disagreeable odors (e.g., 1-pentene, styrene).

24-Hour Concentrations

All of the 24-hour canister measurements, for which there are 24-hour, chemical-specific AMCVs available, were below their health-based AMCVs in Region 12 from 2017 through 2019. There were seven odor exceedances measured in canister samplers. At the HRM 4, HRM 7, and HRM 8 sites, four butyraldehyde concentrations (9.4, 9.3, 9.3 and 9.9 ppb_v, respectively (two occurred at HRM 8)) slightly exceeded the odor based AMCV (9.1 ppb_v). At the Avenue A Texas City/La Marque air monitoring site, a total of three butyraldehyde concentrations (10, 10, and 13 ppb_v) also somewhat exceeded the odor-based AMCV. These monitored concentrations would not be expected to cause direct acute health effects (e.g., eye irritation). Additionally, although the perception of sufficiently strong and persistent unpleasant odors has the potential to cause odor-related health effects (e.g., nausea, headache), these concentrations are not indicative of strong odors with the potential to cause odor-related health effects due to the low frequency (e.g., only ≈0.002% of the 173, 524 24-hour canister measurements at TCEQ and TCLAMN sites) and magnitude of the exceedances (all samples were < 1.5 times the odor-based AMCVs). The monitored 24-hour VOC concentrations that exceeded their respective odor-based comparison levels from 2017 through 2019 are shown below in Table 3.

Table 3. Odor-Based AMCV Exceedances by 24-Hour VOC Concentrations

Site	Chemical	Number of 1-Hour Concentrations above Odor-Based AMCV	Maximum Measured Concentration (ppb_v)	Odor-Based AMCV (ppb_v)
HRM 4	Butyraldehyde	1	9.4	9.1
HRM 7	Butyraldehyde	1	9.3	9.1
HRM 8	Butyraldehyde	1	9.9	9.1
Avenue A	Butyraldehyde	3	13	9.1

Annual Average Concentrations

From 2017 through 2019, all annual averages were below their respective long-term AMCVs for the eighth, nineth, and tenth consecutive years in many years of sampling in Region 12, except for three compounds (hexachlorobutadiene, chromium $PM_{2.5}$, and benzene).

- Based on the approximately 13,871 24-hour metals measurements, all monitored annual and three-year average concentrations of metals were below their respective long-term comparison values (e.g., long-term AMCVs), with the exception of the 2017 chromium $PM_{2.5}$ annual average at Houston Deer Park #2 and the 2018 annual average at Houston Aldine:
    - The 2017 chromium $PM_{2.5}$ annual average concentration was 0.0044 ppb_v at Houston Deer Park #2, which is 1.02 times greater than the AMCV of 0.0043 ppb_v. However, the three-year chromium $PM_{2.5}$ average (0.0031 ppb_v) is lower than the respective long-term AMCV, which is a more appropriate comparison as the long-term AMCV is a lifetime value. More importantly, the long-term AMCV is based on a form of chromium (hexavalent) that generally represents only a small fraction of environmental chromium (e.g., ≈1%). All annual averages are well below the more comparable long-term AMCV for other forms of chromium (0.14 $\mu g/m^3$) and that which more reasonably assumes 1% hexavalent chromium (0.11 $\mu g/m^3$), or even that which very conservatively assumes 10% hexavalent chromium (0.034 $\mu g/m^3$).
    - The 2018 chromium $PM_{2.5}$ annual average concentration was 0.0060 ppb_v at Houston Aldine, which is 1.4 times greater than the AMCV of 0.0043 ppb_v. However, the three-year chromium $PM_{2.5}$ average (0.0033 ppb_v) is lower than the respective long-term AMCV, which is a more appropriate comparison as the long-term AMCV is a lifetime value. Moreover, as previously mentioned, the long-term AMCV is based on a form of chromium (hexavalent) that generally represents only a small fraction of environmental chromium (e.g., ≈1%). Importantly, all annual averages are well below the more comparable long-term AMCV for other forms of chromium (0.14 $\mu g/m^3$) and that which more reasonably assumes 1% hexavalent chromium (0.11 $\mu g/m^3$), or even that which very conservatively assumes 10% hexavalent chromium (0.034 $\mu g/m^3$).
- Based on the approximately 4,097 24-hour measurements, all annual and three-year average concentrations of carbonyls were also below their respective long-term AMCVs;
- Based on approximately 2,720 24-hour measurements, all annual and three-year average concentrations for PAHs/SVOCs were below long-term AMCVs; and
- Based on averages from approximately 173,534 24-hour canister measurements and approximately 10,906,689 hourly autoGC measurements (TCEQ, EISM, HRM, and TCLAMN network autoGC sites), all annual and three-year VOC concentrations were also less than their respective long-term AMCVs, with the exception of two chemicals (hexachlorobutadiene in 2017 at three Texas City/La Marque Sites (2nd Ave, Avenue A, and North Site), and benzene in 2019 at Jacinto Port):
    - The 2017 long-term averages of hexachlorobutadiene at three sites [2nd Ave (0.04 ppb_v), Ave A (0.06 ppb_v), and North Site (0.04 ppb_v)] may exceed the long-term health-based AMCV of 0.020 ppb_v. However, the method detection limit (MDL), which is the minimum concentration of a chemical the laboratory would

measure and report with 99% confidence that the analyte concentration is greater than zero, for this chemical is approximately 0.166 ppb_v and is well above the long-term, health-based AMCV (0.02 ppb_v). In addition, sixteen of the thirty (16/30) samples collected at 2nd Ave were non-detects, forty of the sixty samples (40/60) at Ave. A were not detected, and twenty-four of the thirty (24/30) samples at the North Site were non-detects. Therefore, the sampling and analytical techniques currently used do not achieve a sufficiently low MDL for comparison of long-term averages predominantly driven by non-detects to the current long-term AMCV and regardless, these "exceedances" would not be expected to cause adverse health effects based on available toxicity data.

- The 2019 benzene annual average concentration at Jacinto Port was 1.51 ppb_v, which is 1.08 times greater than the long-term AMCV of 1.4 ppb_v. However, the long-term AMCV is designed to protect an individual over a lifetime of exposure (e.g., 70 years). A minimum of 1-years' worth of data is ordinarily used for comparison to this long-term AMCV, but longer-term data are even more appropriate for comparison to a lifetime AMCV. Since this evaluation covers three years' worth of data, a three-year average, which provides more information for the long-term, can be calculated. The three-year benzene average is 1.18 ppb_v, which is lower than the long-term, health-based AMCV.

In conclusion, approximately 99.99997% of all annual averages were below their respective long-term AMCVs and no long-term, adverse health or vegetation effects would be expected due to exposure to those concentrations.

Freeport APWL Area for Arsenic, Cobalt, Nickel, & Vanadium Concentrations Exceeding Short-Term, Health-based AMCVs.

Elevated short-term nickel, arsenic, vanadium, and cobalt levels exceeding their respective AMCVs were measured near Gulf Chemical and Metallurgical Corporation in Freeport during yearly mobile monitoring trips conducted 2005-2010. Due to the elevated metals concentrations, the Freeport area (Site# 1201) was added to the APWL in 2005. In May of 2011, the Freeport South Avenue I monitoring site was activated. This site is located northeast of the facility of concern, within a residential area, and monitors for speciated $PM_{2.5}$ metals. Since this site's activation in May of 2011, 100% of all speciated $PM_{2.5}$ metals short-term and annual averages have been below their respective AMCVs; no adverse health effects would be expected due to exposure to these concentrations. The TCEQ will continue to evaluate relevant air monitoring data and any additional information for this APWL site within the context of the APWL protocol.

If you have any questions regarding this memorandum, please contact Joseph T. Haney, Jr., M.S. by phone at (512) 239-5691 or by email at Joseph.Haney@tceq.texas.gov,or Tracie Phillips, Ph.D. by phone at (512) 239-2269 or by email at Tracie.Phillips@tceq.texas.gov. For questions regarding the APWL, you may visit the TCEQ website at https://www.tceq.texas.gov/toxicology/apwl/apwl-index.html.

Appendix 1. Monitored Air Toxics in Region 12 from 2017 through 2019

List 1. Target VOC Analytes in Canister Samples*

1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethylene
1,2,3-Trimethylbenzene
1,2,4-Trimethylbenzene
1,2-Dichloropropane
1,3,5-Trimethylbenzene
1,3-Butadiene
1-Butene [b]
1-Hexene & 2-Methyl-1-Pentene [b]
1-Pentene
2,2,4-Trimethylpentane
2,2-dimethylbutane [b]
2,3,4-Trimethylpentane
2,3-Dimethylbutane
2,3-Dimethylpentane
2,4-Dimethylpentane
2-Chloropentane [b,c]
2-Methyl-2-Butene [c]
2-Methylheptane
2-methylhexane [b]
2-methylpentane [b]
3-Methyl-1-Butene
3-Methylheptane
3-Methylhexane
3-Methylpentane
4-Methyl-1-Pentene
Acetylene
Acrolein – Verified [a,b,c]
Benzene
Bromomethane
Carbon Tetrachloride
Chlorobenzene
Chloroform
Chloromethane
cis-1,3-Dichloropropene
cis-2-Butene
cis-2-Hexene
cis-2-Pentene
Cyclohexane
Cyclopentane
Cyclopentene
Dichlorodifluoromethane
Dichloromethane [b]
Ethane
Ethylbenzene
Ethylene
ethylene dibromide [b]
ethylene dichloride [b]
Isobutane
Isopentane
Isoprene
Isopropylbenzene [b]
m-Diethylbenzene
Methyl Chloroform [b]
Methylcyclohexane
Methylcyclopentane
m-Ethyltoluene
n-Butane
n-Decane
n-Heptane
n-Hexane
n-Nonane
n-Octane
n-Pentane
n-Propylbenzene
n-Undecane
o-Ethyltoluene [b]
o-Xylene
p-Diethylbenzene
p-Ethyltoluene
Propane
Propylene
Styrene
Tetrachloroethylene [b]
Toluene
trans-1,3-Dichloropropene
trans-2-Butene
trans-2-Hexene
trans-2-Pentene
Trichloroethylene
Trichlorofluoromethane
Vinyl Chloride

* See Lists 6 and 7 for additional canister analytes monitored only at the industry-sponsored air monitoring network sites (TCLAMN & HRM non-EISM network sites).
[a] Only measured at Houston Deer Park #2 monitoring site.
[b] Not monitored at the HRM 1, 4, 7, 8, 10 and 11 sites.
[c] Not monitored at the TCLAMN 2nd Avenue, Avenue A, and North sites in 2017.

List 2. Target Carbonyl Analytes

2,5-Dimethylbenzaldehyde	Crotonaldehyde	Methacrolein
Acetaldehyde	Formaldehyde	o-Tolualdehyde
Acetone	Heptanal	Propionaldehyde
Acrolein - Unverified	Hexanaldehyde	Valeraldehyde
Benzaldehyde	Isovaleraldehyde	m & p-Tolualdehyde
Butyraldehyde	Methyl Ethyl Ketone (MEK)	

List 3. Target Metal Analytes

Aluminum ($PM_{2.5}$, PM_{10})	Cobalt ($PM_{2.5}$, PM_{10})	Selenium ($PM_{2.5}$, PM_{10})
Antimony ($PM_{2.5}$, PM_{10})	Copper ($PM_{2.5}$, PM_{10})	Tin ($PM_{2.5}$, PM_{10})
Arsenic ($PM_{2.5}$, PM_{10})	Lead ($PM_{2.5}$, PM_{10})	Vanadium ($PM_{2.5}$)
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})	
Chromium ($PM_{2.5}$, PM_{10})	Nickel ($PM_{2.5}$, PM_{10})	

$PM_{2.5}$ metals are monitored at the Freeport South Avenue I, Houston Aldine, and Houston Deer Park #2 monitoring sites.
PM_{10} metals are monitored at the Houston Deer Park #2 monitoring site.

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

1,2,3-Trimethylbenzene	Acetylene	Toluene [e]
1,2,4-Trimethylbenzene	Benzene [c,e,f]	cis-2-Butene
1,3,5-Trimethylbenzene	Cyclohexane	cis-2-Pentene
1,3-Butadiene [c]	Cyclopentane	m/p Xylene
1-Butene [b]	Ethane	n-Butane
1-Pentene	Ethylbenzene	n-Decane
2,2,4-Trimethylpentane	Ethylene	n-Heptane
2,2-Dimethylbutane [b]	Isobutane	n-Hexane [e]
2,3,4-Trimethylpentane	Isopentane	n-Nonane
2,3-Dimethylpentane	Isoprene	n-Octane
2,4-Dimethylpentane	Isopropylbenzene [b]	n-Pentane [e]
2-Methyl-2-Butene [a]	Methylcyclohexane	n-Propylbenzene
2-Methylheptane	Methylcyclopentane	n-Undecane [a]
2-Methylhexane [b]	Propane	o-Xylene
3-Methylheptane	Propylene	trans-2-Butene
3-Methylhexane	Styrene	trans-2-Pentene

[a] Only monitored at the Danciger, HRM #3 Haden Rd, HRM 16, Lake Jackson, Lynchburg Ferry, Oyster Creek, Texas City 34th St, and Wallisville Rd monitoring sites.
[b] Not monitored at the HRM 16 monitoring site.
[c] 2nd Avenue Monitoring Station only monitored for these componds, in addition to those listed in List 8.
[e] These are the only compounds monitored at the TX City BP Logan and TX City BP 31st sites.
[f] This is the only compound monitored at the TX City 11th St site.

List 6. Additional Canister Analytes Monitored at TCLAMN sites in 2017

1,1,2-trichloro-1,2,2-trifluoroethane	1-Undecene	Benzaldehyde
1,2,4-Trichlorobenzene	2,2,3-Trimethylpentane	Benzyl Chloride
1,2-dichloro-1,1,2,2-tetrafluoroethane	2,2,5-Trimethylhexane	beta-Pinene
1,4-Dioxane	2,4,4-Trimethyl-1-Pentene	Bromochloromethane
1-Butanol	2,4,4-Trimethyl-2-Pentene	Bromodichloromethane
1-Decene	2,5-Dimethylhexane	Bromoform
1-Heptene	2-Ethyl-1-Butene	Butyl Acrylate
1-Methylcyclopentene	2-Methyl-2-Pentene	Butyl benzene
1-Nonene	Acetaldehyde	Butyraldehyde
1-Octene	Acetone	Chlorodifluoromethane
1-Propanol	Acetonitrile	Chloroethane
	Acrylonitrile	Chloroprene
	alpha-Pinene	cis-1,2-Dichloroethylene

cis-2-Octene	hexanaldehyde	Methyl tert-Butyl ether
cis-3-Hexene	Indane	Naphthalene
cis-3-Methyl-2-Pentene	Indene	Neopentane
cis-4-Methyl-2-Pentene	Isobutyl benzene	o-Dichlorobenzene
Cyclohexene	isopropanol	para-cymene
Dichlorofluoromethane	m/p-xylene	p-Chlorotoluene
Diethyl Ether	m-Dichlorobenzene	p-Dichlorobenzene
dimethylethyl benzene	Methanol	trans-1,2-Dichloroethylene
Ethanol	methyl cyclohexene	Vinyl Acetate
heptaldehyde	methyl ethyl ketone	Vinyl Bromide
Hexachlorobutadiene	Methyl isobutyl ketone	

List 7. Additional Canister Analytes Monitored at HRM sites

1-Hexene	Butyl Acrylate	Dichlorofluoromethane
1-Methylcyclohexene	Butyraldehyde	Naphthalene

List 8. Additional AutoGC Analytes Monitored at 2nd Avenue Monitoring Station

Vinyl Chloride