



Environmental Justice and Refinery Pollution:

Benzene Monitoring Around Oil Refineries
Showed More Communities at Risk in 2020

ACKNOWLEDGEMENTS

This report was researched and written by Ben Kunstman, Eric Schaeffer and Alexandra Shaykevich of the Environmental Integrity Project with data analysis provided by Keene Kelderman and Courtney Bernhardt.

THE ENVIRONMENTAL INTEGRITY PROJECT

The Environmental Integrity Project

(<http://www.environmentalintegrity.org>) is a nonpartisan, nonprofit organization established in March of 2002 by former EPA enforcement attorneys to advocate for effective enforcement of environmental laws. EIP has three goals: 1) to provide objective analyses of how the failure to enforce or implement environmental laws increases pollution and affects public health; 2) to hold federal and state agencies, as well as individual corporations, accountable for failing to enforce or comply with environmental laws; and 3) to help local communities obtain the protection of environmental laws.

For questions about this report, please contact EIP Director of Communications

Tom Pelton at (443) 510-2574 or tpelton@environmentalintegrity.org.

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Benzene Monitoring Around Oil Refineries Found More Communities at Risk in 2020

A 2015 federal Clean Air Act rule requires oil refineries to install air pollution monitors at their boundaries to identify benzene emissions escaping into surrounding neighborhoods. Benzene is a well-known carcinogen that contributes to cancer of the blood cells (leukemia) and respiratory ailments, and high concentrations indicate the presence of other air pollutants dangerous to human health.¹ Whenever the monitoring results show that benzene levels at refinery fencelines average more than nine micrograms per cubic meter above background levels over a year, the 2015 rule requires the refinery to investigate and take action by cleaning up the emission sources causing the problem.² The regulation is designed to keep benzene and other toxins from drifting into communities adjacent to refineries, many of which are lower-income communities of color.

Thirteen refineries exceeded EPA's "action level" in 2020 for the 12 months ending on December 31, 2020, reporting annual benzene concentrations that range from 9.36 micrograms to more than 31 micrograms for the year.³ More than 530,000 people live within three miles of these refineries, with 57 percent being people of color and 43 percent living below the poverty line, according to U.S. Census Bureau and EPA data.⁴ The number of facilities over EPA's action level last year represents more communities at risk from benzene than in 2019, the first year for which data are available, when 11 refineries exceeded EPA's action level.



A refinery owned by the Delek corporation in Krotz Springs, Louisiana, about 45 minutes west of Baton Rouge, topped the 2020 list with benzene concentrations at its fenceline averaging more than 31 micrograms per cubic meter last year. That was more than three times EPA's action level, and 29 percent worse than the previous year. A public library and a daycare center that serves low-income children are located a quarter mile from the refinery (see map on page 20.)

Cancer-causing benzene detected at the fence lines of oil refineries exceeded EPA action levels in 13 communities across the U.S. in 2020, including in Louisiana, Pennsylvania, Texas, and Alabama.

Table 1. Refineries Exceeding EPA's Benzene Action Level, 2019-2020

Facility	Location	2019 Net Concentration (micrograms/cubic meter)	2020 Net Concentration (micrograms/cubic meter)	% Change Between 2019 and 2020	% Over EPA's Action Level (2020)
Delek Krotz Springs	Krotz Springs, LA	24.2	31.1	29%	246%
Philadelphia Energy Solutions	Philadelphia, PA	49.1	28.1	-43%	212%
Shell Chemical Mobile	Saraland, AL	8.6	20.3	137%	126%
Total Refinery Port Arthur	Port Arthur, TX	17.0	16.7	-2%	86%
Marathon Galveston Bay	Texas City, TX	12.1	15.1	25%	68%
Shell Norco Manufacturing	Norco, LA	8.5	14.6	72%	62%
Marathon Catlettsburg	Catlettsburg, KY	3.1	13.8	344%	53%
HollyFrontier Lovington	Lovington, NM	3.6	11.8	230%	31%
HollyFrontier Artesia	Artesia, NM	24.8	11.3	-55%	25%
Chalmette Refining	Chalmette, LA	12.1	11.2	-8%	24%
CITGO Corpus Christi East	Corpus Christi, TX	10.0	11.0	10%	22%
Phillips 66 Lake Charles	Westlake, LA	6.2	10.5	70%	17%
Phillips 66 Alliance	Belle Chasse, LA	7.7	9.4	22%	4%
Chevron Pascagoula	Pascagoula, MS	15.1	8.0	-47%	-11%
Pasadena Refining	Pasadena, TX	30.0	7.1	-76%	-21%
Flint Hills Resources East	Corpus Christi, TX	13.4	6.8	-49%	-24%
Phillips 66 Wood River Docks	Wood River, IL	11.9	5.1	-57%	-43%

This table shows net annual average concentrations of benzene in micrograms per cubic meter at the end of 2020, and excludes benzene from background, off-site, or non-refinery sources. The EPA action level is nine micrograms per cubic meter, with the figures above colored red exceeding the action level. Some refineries rounded when they reported their net annual average concentrations to EPA. The net concentrations in this table were calculated by EIP to correct for inconsistencies in rounding by refineries.⁵

Although shut down after a fire and explosion in July of 2019, fenceline benzene concentrations at the Philadelphia Energy Systems Refinery in Pennsylvania still averaged over 28 micrograms by the end of 2020 – more than three times EPA's action level. The persistently high levels in densely-populated South Philadelphia are likely due to the ongoing removal of petrochemical products from the site. Shell Chemical's Saraland refinery and chemical plant in Mobile, Alabama, reported more than 20 micrograms per cubic meter for 2020 – more than twice the federal action level and a 137 percent increase from the previous year.

The number of refineries with annual benzene concentrations above EPA’s action level in 2020 included five in Louisiana (Chalmette, Phillips 66 Lake Charles, Phillips 66 Alliance, Shell Norco, and Delek Krotz Springs) three in Texas (Total Port Arthur, Marathon Galveston Bay, and Citgo Corpus Christi East), two in New Mexico (HollyFrontier Lovington and HollyFrontier Artesia), and one in Kentucky (Marathon Catlettsburg).

It should be noted that the figures for all of the refineries in Table 1 are *net* annual benzene levels – not the *actual* benzene levels – because the federal regulations allow refineries to exclude “background” concentrations of benzene in their calculations, as well as emissions from benzene storage tanks and other non-refining equipment and off-site facilities.

Actual Benzene Levels Are Even Higher

Under the 2015 rule, the lowest concentrations of benzene measured along a refinery’s fenceline are considered “background” pollution and are subtracted from the highest measurements when determining the annual net benzene levels for the refineries in Table 1. The regulations also allow refiners with site-specific monitoring plans approved by EPA to make further adjustments to exclude benzene that comes from specific sources, including plants outside the refinery’s boundary and certain sources within the refinery that are exempt from the fenceline monitoring rule (such as benzene storage tanks). These adjustments allow some refiners to avoid triggering the EPA action level that requires cleanup of the plant’s emission sources, even when their monitors report very high benzene levels.



Actual benzene emissions are often higher than the levels reported by oil refineries, because EPA rules allow companies to exclude emissions that come from benzene storage tanks or other facilities that are not part of refinery operations.

For example, monitors at the Valero Corpus Christi East refinery measured annual concentrations of 26 micrograms in 2020, based on the average of the highest readings at its property line, while Houston Refining averaged 18 micrograms in the same year. But after adjusting these results to exclude any emissions from “non-refinery” and offsite sources, the “net” annual benzene levels from each refinery fell below the nine microgram action level in 2020. As a result, neither facility was required to identify and clean up emissions contributing to the very high levels of benzene at their property lines. Those adjustments are

based on methodologies approved by EPA. But from a public health perspective, what matters to nearby communities are the actual benzene levels at the perimeter of refineries close to their neighborhoods, regardless of where they come from.

Table 2 below presents the *actual* annual benzene concentrations based on the measurements for 17 refineries, as well as the highest short-term (two-week) concentration that each reported for the year. This data has not been adjusted downward to exclude emissions from background, off-site, or non-refinery sources.

Table 2. Actual Benzene Concentrations and Nearby Populations, 2020

Location	Actual Benzene Levels (micrograms per cubic meter)		Population Within 3 Miles		
Facility	Highest 2-week Avg.	Annual Average Concentration	Total Residents	% People of Color ⁶	% Below Poverty Level
Delek Krotz Springs (LA)	114.0	31.6	1,280	3%	43.1%
Philadelphia Energy Solutions (PA)	190.0	28.8	306,335	61%	45.1%
Valero Corpus Christi East (TX)	386.0	26.0	38,223	87%	58.7%
Shell Chemical Mobile Saraland (AL)	92.4	21.0	18,229	31%	43.8%
Marathon Galveston Bay Texas City (TX)	40.6	19.6	36,328	57%	38.8%
Houston Refining LP (TX)	98.0	18.0	86,718	89%	55.7%
Total Refinery Port Arthur (TX)	38.1	17.8	24,375	42%	37.3%
Shell Norco Manufacturing Complex (LA)	79.3	15.3	12,499	30%	24.0%
Marathon Catlettsburg Refining (KY)	166.0	14.1	11,538	3%	44.6%
HollyFrontier Lovington (NM)	210.0	14.0	120	42%	15.8%
HollyFrontier Artesia (NM)	31.0	12.7	13,522	54%	35.4%
CITGO Corpus Christi East (TX)	47.0	11.9	40,616	87%	59.7%
Chalmette Refining (LA)	57.5	11.7	56,803	55%	33.5%
Phillips 66 Lake Charles Westlake (LA)	49.0	11.2	11,255	20%	34.5%
Phillips 66 Alliance Belle Chasse (LA)	54.5	10.5	700	50%	25.4%
Flint Hills Resources Corpus Christi West (TX)	51.8	9.4	6,893	64%	37.7%
Shell Deer Park (TX)	32.1	9.2	31,653	41%	25.0%
TOTAL			697,087	62%	44.7%

Benzene levels are expressed in micrograms per cubic meter. The benzene sampling concentrations above reflect actual annual measurements as of December 31, 2020, not "net" concentrations that refineries use to assess compliance with EPA's action level of nine micrograms. Demographic data is from EPA's Enforcement and Compliance History Online. The totals reflect the percentage of total population that are people of color or living below the poverty line.

Short-Term Benzene Concentrations May Threaten Public Health

Short-term benzene spikes are alarmingly high at some refineries, which report the average benzene concentration for each two-week monitoring period. The National Institute for Occupational Safety and Health (NIOSH) advises limiting worker exposure to no more than 319 micrograms (100 parts per billion) over a 10-hour work period.⁷ The Chevron refinery in Pasadena, Texas, recorded benzene concentrations averaging 77 percent higher than that -- 565 micrograms or 177 ppb -- for the two-week period ending October 30, 2019. Valero Corpus Christi East reported 386 micrograms (121 ppb) for the two weeks ending on May 27, 2020, while claiming that the benzene came from offsite sources. Other refineries reported two-week concentrations that are high enough to suggest that benzene could have exceeded the NIOSH limit for one or more 10-hour periods, as benzene concentrations can vary widely from one hour to the next within a two-week period.

The federal Agency for Toxic Substances Disease Registry has identified a “minimal risk level” of 29 micrograms (9 ppb) for inhalation exposures up to 14 days, as higher concentrations may pose risks to the immune system.⁸ This acute inhalation minimal risk level is defined as the exposure to benzene that is likely to be without an appreciable risk of adverse non-cancer effects. At least 23 refineries across the U.S. reported exceeding this threshold for one or more two-week periods between January 1 and December 31 of 2020. **See Appendix A** for the list.

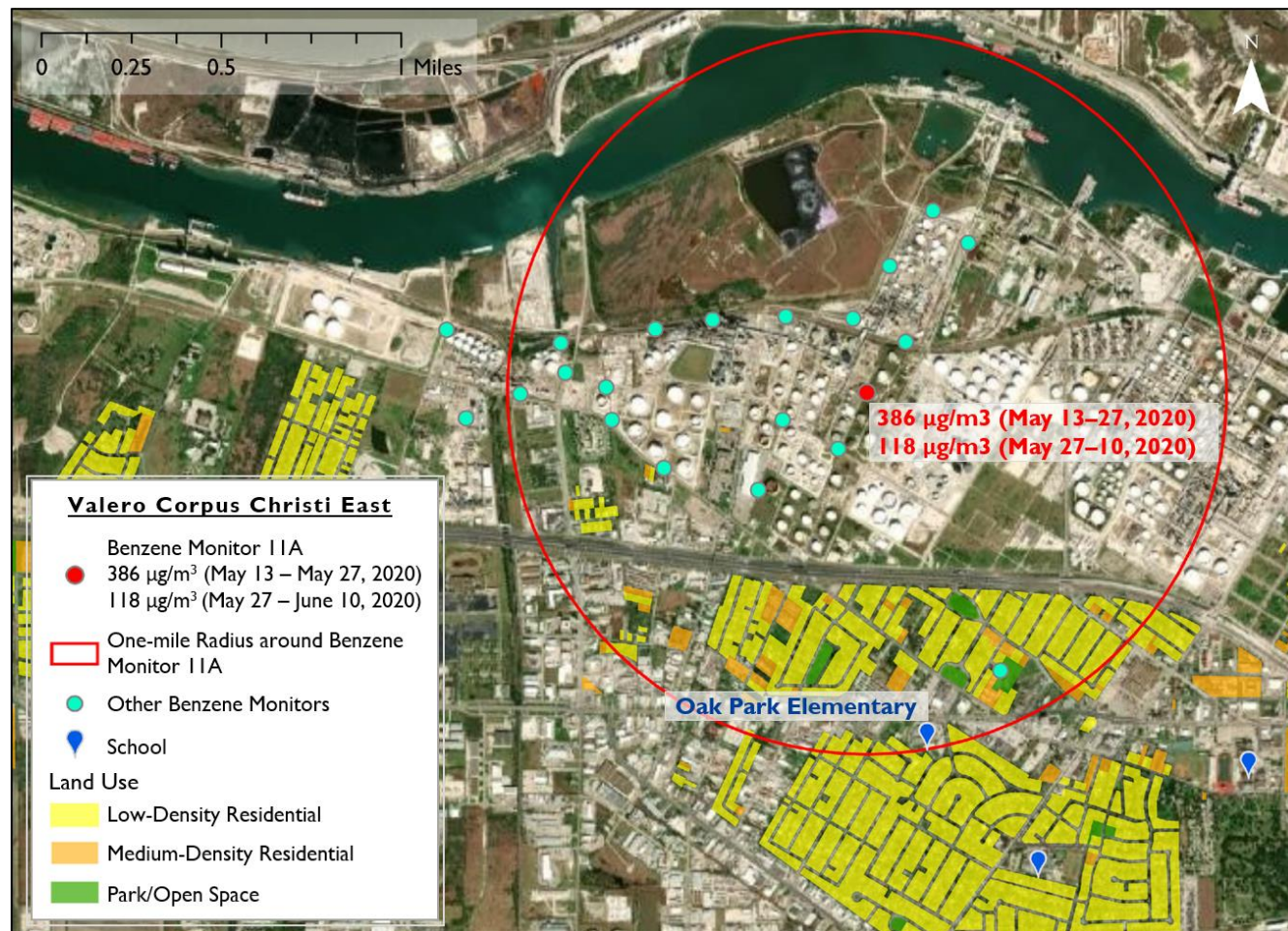
The 2015 Clean Air Act rule requires no response to these short-term events. The action level is triggered only when benzene emissions from sources within the refinery that are subject to the rule result in annual concentrations that exceed “background” levels by nine micrograms. But EPA has plenty of authority – under Section 114 of the Clean Air Act, for example – to investigate these events, require additional monitoring, determine whether the responsible parties are violating any other emission limits that apply to benzene and if so, to order cleanups.

Ground Zero for Environmental Justice

If this broader category of refineries – those with *actual* emissions over the EPA action level – are taken into account, the nearby populations put at risk are even larger than the 530,000 people mentioned earlier. Nearly 700,000 people live within three miles of the 17 refineries reporting actual annual fence-line benzene concentrations above nine micrograms per cubic meter (Table 2).⁹ People of color account for nearly 62 percent of this total, while nearly 45 percent live on incomes below the poverty level (the percentages at each location vary). In contrast, as of 2019 people of color made up about 40 percent of the total U.S. population,¹⁰ while 10.5 percent of the national population earns incomes below the poverty line.¹¹ Many of the surrounding neighborhoods lie less than a mile from some of the largest benzene sources. These are the kinds of communities hit especially hard by COVID-19, where residents who lack affordable health care already suffer from the kind of ailments that make them especially vulnerable to toxic air pollutants like benzene. To get an idea of how close

people live near these pollution hotspots, please consult the maps on pages 18-22, which show how close schools and libraries are to the refineries. An example is in Corpus Christi, below.

Population Surrounding Valero Refinery in Corpus Christi, TX



More than 38,000 people live within three miles of the Valero refinery in Corpus Christi, with 87 percent of them people of color and 59 percent living below the poverty line. As shown with the blue marker, a public school – Oak Park Elementary School – is located one mile south of an air pollution monitor that recorded a dangerous spike in benzene concentrations in May of 2020. Many homes and parks are even closer.

The people who live near plants like the one in Corpus Christi are not necessarily exposed to the benzene levels found at a refinery's property line. Downwind concentrations may vary according to wind direction, weather conditions, emissions from other sources, and other environmental variables. But the presence of benzene in such high concentrations so close to places where so many people live should be a cause for concern. The Biden Administration has pledged to make environmental justice a reality and not just a slogan. The EPA can help keep that promise by doing more to protect the communities that surround these refineries from dangerous and potentially deadly air pollutants.

Benzene and the Fenceline Monitoring Rule

Benzene is a potent carcinogen and one of the most dangerous pollutants released by oil refineries and petrochemical plants. Because it is highly volatile and prone to leak from storage tanks, wastewater impoundments, and other sources where emissions are hard to measure, a 2015 Clean Air Act rule required each refinery to install air pollution monitors (sorber tube monitors) along their plant boundary that measure the average benzene concentrations for each two-week sampling period. That average is determined based on the amount of benzene that has accumulated in the tubes after 14 days.¹²

The benzene levels reported every two weeks reflect the difference between the highest and the lowest concentrations measured anywhere along the fenceline for that sampling period. The lowest measurements are subtracted because they are assumed to represent “background” levels of pollution from outside the refinery. Whenever the resulting net concentrations exceed nine micrograms per cubic meter over any 12-month period, the refinery must investigate the root cause and clean up any emission sources causing the problem. The goal is to identify and repair leaks quickly and to minimize public exposure to benzene and other hard-to-measure toxins that may drift across a plant’s property lines and into neighborhoods that may be right across the street.

Benzene contributes to various forms of leukemia that suppress the formation of healthy blood cells, weaken immune systems, and make people susceptible to other diseases. EPA estimates that inhaling benzene at a concentration as low as 1.3 micrograms per cubic meter over a lifetime could result in up to one additional cancer death per 100,000 people exposed to that level.¹³ As benzene levels rise, those risks increase proportionately. For example, the lifetime exposure to ten times that, or as low as 13 micrograms per cubic meter, can result in one additional cancer death per 10,000 (using EPA’s low-dose linearity concentrations at specified risk levels).

The 2015 rule also recognized that significant concentrations of benzene also may signal the presence of a large cloud of other toxins – like formaldehyde, naphthalene, ethyl benzene, toluene, or xylene – that either present their own cancer risks, attack respiratory systems, or contribute to smog formation.¹⁴ The cleanup requirements that are triggered when annual fenceline benzene exceeds nine micrograms are intended to reduce emissions of those associated pollutants as well.

Annual Benzene Concentrations Exceed EPA’s Action Level at 13 Refineries

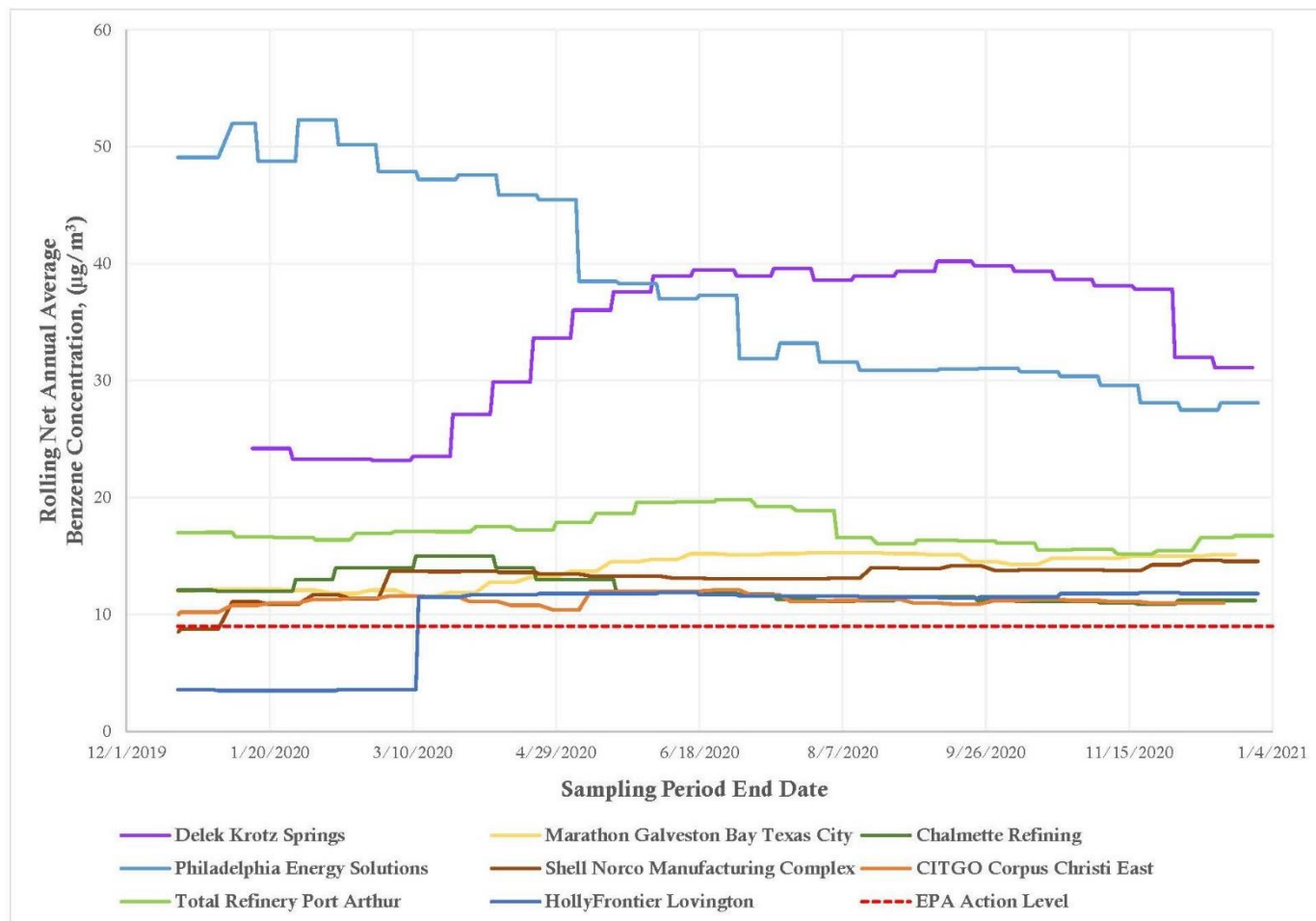
This report identifies refineries where annual benzene concentrations exceeded the nine microgram action level at the end of the 2019 and 2020 calendar years. The 2015 rule set an action level based on a “rolling annual average” that is recalculated every two weeks. For example, the action level would be triggered by annual benzene concentrations averaging 10 micrograms over the 26 two-week sampling periods ending on October 14. Annual concentrations would be recalculated on October 28 and at subsequent fourteen-day intervals, based on the results of the most recent 26 two-week sampling periods.

As discussed on page 5, these are *net* or *adjusted* numbers that do not include background levels of benzene or emissions from storage tanks and nearby facilities. The Delek Refinery in Krotz Spring, Louisiana, had consistently high benzene concentrations. For the 50 two-week sampling periods reported from this facility since early 2019, only ten registered below EPA's action level (nine micrograms per cubic meter of air). It has also had large concentration spikes, registering net benzene concentrations as high as 106.5 and 113.5 micrograms per cubic meter for the sampling periods ending on April 6, 2020 and May 4, 2020, respectively, and peaking at 153 micrograms per cubic meter of air for the sampling period ending on December 17, 2019. Net concentrations decreased in the most recent quarter of 2020, with each sampling period between October through December registering below the nine microgram per cubic meter threshold.

High benzene concentrations have persisted at the former Philadelphia Energy Solutions (PES) refinery in Pennsylvania (shown in **Table 1**), where annual benzene levels were more than three times higher than the action level more than a year the plant closed. Short-term emissions in 2020 peaked in the first quarter with concentrations that averaged 128 and 189 micrograms over the two-week periods ending on January 15 and February 12, respectively. Even after the site was sold to developers last June, one of the monitors recorded a 14-day average of 80 micrograms in late July. These high concentrations are partly the result of emissions released as tanks are drained and gasoline and other petrochemical products are removed from the site.¹⁵

All of the refineries in **Table 1** are required to investigate the source of these high benzene levels and take corrective action, e.g., by identifying and repairing leaks from tanks or other equipment. Yet monitoring data shows that annual concentrations of benzene have continued to exceed the 9 microgram action level for eight of these thirteen refineries at the end of *every* quarter in 2020.¹⁶ As an example, Delek Krotz Springs measured an annual average benzene concentration of 23.5 micrograms at the end of the first quarter of 2020 (the 26 monitoring periods from March 26, 2019 to March 23, 2020), increased up to 39.5 micrograms for the rolling annual average at the end of the second quarter (from July 2, 1990 to June 30, 2020), and had a rolling annual average of 40.2 micrograms at the end of the third quarter (September 24, 2019 to September 21, 2020). These rolling annual average benzene concentrations are shown below in **Figure 1**.

Figure I. Rolling Net Annual Average Benzene Concentration, End of 2019 to End of 2020



The chart above shows refineries whose benzene levels were above the EPA action level (nine micrograms per cubic meter) for every quarter in 2020. The fact that these facilities have benzene levels that stayed high throughout the past year, despite the requirement to investigate and take corrective action, suggests the companies and EPA should have acted more quickly to fix the problems and reduce the emissions.

In some cases, the monitoring and disclosure requirements of the 2015 rule have prompted actions that have substantially reduced benzene levels. For example, the Holly Frontier refinery in Artesia, New Mexico, reported annual benzene concentrations of 290 micrograms in the spring of 2019. While the company took initial steps to clean up the likely emission sources, an inspection in the fall of 2019 by EPA and the state found high leak rates and delayed repairs. EPA followed up in May of 2020 with a notice of violation confirming that Holly Frontier had illegally stored highly volatile products in tanks not designed to contain emissions of benzene and other toxins and had failed to contain vapors released from wastewater drains.¹⁷ Thanks to company action and EPA and state oversight, annual benzene concentrations had dropped to nine micrograms by September 30 of 2020, but increased back up to 11 micrograms per cubic meter by the end of the year.

Other plants, such as Marathon Galveston Bay or Total Port Arthur, show little apparent progress as benzene concentrations averaged over 12 months continue to exceed nine micrograms from one quarter to the next. EPA and states need to step in where these high annual concentrations persist, and they should require refineries to accelerate their efforts to find and fix the emission sources causing this pollution.

The annual benzene levels at the Holly Frontier refinery in Lovington, New Mexico, apparently resulted from a large offsite oil spill in the spring of 2020. Valero Corpus Christi and Houston Refining also reported very high concentrations in 2020 that supposedly reflected emissions from other nearby sources.

Site-Specific Monitoring Plans May Obscure High Benzene Levels

The annual benzene levels at two other Texas refineries (Houston Refining and Valero Corpus Christi East) are far above the nine microgram action level, according to data from their fenceline monitors as seen in Table 2. But so far, both have avoided the investigation and cleanup that would normally follow. This is because they are under “site-specific monitoring plans” approved by EPA that apparently show that most or all of the benzene measured at their property lines comes from off-site sources. For example, the monitors at Valero’s East Refinery in Corpus Christi measured an unadjusted annual average benzene concentration of 26 micrograms at the end of 2020 based on actual fenceline measurements. But under Valero’s site-specific plan, the reported annual results drop to no more than 4 micrograms (far below the action level) after excluding the benzene thought to come from nearby sources.

Annual concentrations at Marathon’s refinery in Galveston Bay averaged 19.6 micrograms for the year of 2020 based on actual measurements from its monitors. While the annual average was adjusted downward to 14.5 micrograms after excluding background and benzene from non-refinery sources, the result was still high enough to exceed the nine microgram action level.

To be fair, the Clean Air Act rule is designed to push refiners to clean up emission sources under their control when they are responsible for elevating benzene concentrations above the action level. No doubt it is challenging to allocate the responsibility for fenceline benzene concentrations in industrial neighborhoods crowded with petrochemical plants. But regardless of who is at fault, it is the government’s obligation to respond quickly when the data demonstrates a potential threat to public health.

Also, although not widely understood, the 2015 rule applies only to benzene released by specific emission sources within refineries that are subject to “Subpart CC” of the regulations that apply to hazardous air pollutants under Section 112 of the Clean Air Act. For example, some refineries also produce benzene that is stored onsite in tanks before it can be sold to chemical manufacturers. While subject to other Clean Air Act rules, such as Hazardous Organic National Emission Standards for Hazardous Air Pollutants,¹⁸ these particular types of storage tanks are *not* covered by the Subpart CC regulations that established the benzene fenceline monitoring requirements.

Not surprisingly, several refineries have proposed reducing the benzene concentrations at their fencelines to account for emissions from these tanks and other sources that are onsite but exempt from Subpart CC. EPA has already approved site-specific monitoring plans that exclude emissions from sources that are managed onsite but exempt from Subpart CC. CITGO's East refinery in Corpus Christi submitted a similar proposal in November of 2020 that is still pending before EPA.¹⁹

These exemptions are the consequence of EPA's approach to regulating hazardous air pollutants, which has established separate standards for each of the industrial categories that may be found within the same petrochemical plant. For example, while Subpart CC regulates emissions from "petroleum refining process units," Subparts F, G, H, and I cover emissions from the manufacturing and storage of chemical products at the same facility. But the fenceline monitoring rules are meant to protect public health by requiring refineries to investigate and clean up emission sources whenever net annual benzene levels exceed nine micrograms. That objective is obviously undercut when refiners can stay below that action level by adjusting monitoring results to exclude any benzene from tanks and other sources that operate within the refinery, but are not regulated under Subpart CC.

Short-Term Benzene Concentrations Dangerously High at Some Refineries

The National Institute of Occupational Safety and Health (NIOSH) recommends that workers limit exposure to no more than 100 parts per billion (ppb) for any 10-hour period unless respirators are in use.²⁰ The Valero Corpus Christi East and Chevron Pasadena monitors show that those limits were exceeded for a full two-week average at each plant. Benzene at one of the Valero monitors averaged 121 ppb (386 micrograms) during the two weeks between May 13 and May 27 of 2020, although Valero adjusted that to zero after concluding that all of that benzene came from sources outside its property line. The Chevron Pasadena Refinery outside of Houston reported that concentrations averaged 178 ppb (567 micrograms) at one of its fenceline monitors between October 16 and October 30 of 2019. Again, these numbers reflect the average benzene concentration over 14 days, whereas the NIOSH limits apply for much shorter periods of time.

People living near refineries are not necessarily exposed to the amount of benzene measured at the plant's boundaries, as that may depend on wind direction, weather conditions, emissions from other sources, and other variables. But when a refinery monitor reports that the average benzene level over two weeks is higher than the amount that workers should be exposed to for more than 10 hours without respirators, that should cause alarm. Keep in mind that the NIOSH recommendations were developed to protect healthy workers, not children, the elderly, or those suffering from ailments made worse by air pollution. Benzene levels can vary widely within a few hours or less. For example, over the course of a two-week sampling period, concentrations could be well over the average for one or more 10-hour periods, then fall to much lower levels in between. Determining the average benzene concentration over a two-week period is not enough to know whether the NIOSH 10-hour limits (or any short-term limit) has been breached.

While the 2015 rule Clean Air Act rule requires refiners to investigate and take corrective action whenever the annual action level is exceeded, no response is required even when benzene concentrations averaged over two weeks are much higher than the amount that workers should not be exposed to for more than 10 hours unless they are wearing respirators. Whether through regulation or by exercising its enforcement authority EPA should, at a minimum, require more frequent, or real-time sampling when two-week benzene averages are exceptionally high.

Where a refinery claims that high benzene levels at its fenceline came from a neighboring facility, EPA should investigate the off-site source to determine whether any laws have been violated or what action can be taken to prevent recurrence. For example, Motiva's refinery in Port Arthur, Texas, reported that benzene levels averaged 122 micrograms at one of its monitors between November 28 and December 12, 2019, due to emissions from an ethylene production facility nearby. That is very likely Motiva's own chemical plant, which disclosed the release of benzene emissions from a "process upset" to the state of Texas within the same 14-day period.

Impact of Short-Term Exposure to Benzene on Vulnerable Populations

The NIOSH standards referenced earlier are designed to protect healthy workers, and not vulnerable populations such as young children, the elderly, those suffering from respiratory diseases or immune disorders and others who may be particularly vulnerable to airborne carcinogens like benzene. The Agency for Toxic Substances Disease Registry (ATSDR) has established a "Minimal Risk Level" of 29 micrograms (9 ppb) for short-term exposures that last no more than fourteen days. This acute inhalation minimal risk level is defined as the exposure to benzene that is likely to be without an appreciable risk of adverse noncancerous effects, which for benzene would pose risks to the immune system.²¹

Appendix A identifies 23 refineries where actual fenceline benzene levels have averaged at least 29 micrograms per cubic meter over one or more two-week periods in 2020. Benzene levels at seven of these plants highlighted in Appendix A have exceeded 90 micrograms per cubic meter, or more than three times the ATSDR Minimal Risk Level. More frequent monitoring at such facilities might identify periods when concentrations exceed the 10-hour NIOSH standard.

Environmental Justice: Still Waiting

More than 2,600 people live within a mile of the Valero East refinery in Corpus Christi, and nine out of 10 live in households where income falls below the poverty line. Another 1,600 people live less than a mile from the Chevron Pasadena plant, more than half on incomes below the poverty level. Eighty percent of the residents in both of these communities are Latino. Air pollution can further exacerbate environmental justice issues in these fenceline communities. These issues include lack of access to affordable health care, and higher rates of asthma, COVID-19, immune disorders, and other ailments that put the community at risk.

Table 2 identifies characteristics of the population surrounding the 17 refineries where actual annual benzene concentrations exceeded nine micrograms per cubic meter at the end of 2020. As stated previously, nearly 700,000 people live within three miles of these plants, in numbers that range from 120 near the remote HollyFrontier Lovington refinery in New Mexico to the more than 300,000 people surrounding the now-closed Philadelphia Energy Solutions refinery in Pennsylvania.

U.S. Census data tell a familiar story. Overall, nearly two thirds of those living within three miles of these seventeen refineries are people of color, predominately African American or Latino. Nearly half live below the poverty line, compared to the national average of 10.5 percent.²² President Biden has promised to make environmental justice a reality and not just a slogan. These neighborhoods are a good place to start.

Recommendations:

1. As of the end of 2020, at least 13 refineries reported that annual benzene levels exceed EPA's nine microgram action level under federal regulations. Seven of these same plants also exceeded this 12-month action level at the end of 2019. EPA needs to investigate why such high benzene concentrations persist at these plants and take enforcement action if needed to reduce emissions from the sources responsible.
2. Four more refineries that reported actual annual benzene concentrations of more than nine micrograms did not exceed EPA's action level, because some or most of the benzene measured was attributed to "background" or off-site sources of pollution. Many refineries operate in close proximity to other petrochemical plants, which means that some of the benzene that shows up at one refinery's property line may have come from an upwind chemical plant. But in such cases, EPA needs to identify the offsite emission sources and bring them under control.
3. NIOSH recommends that workers wear respirators whenever benzene levels average 100 ppb (or 319 micrograms per cubic meter) over a 10-hour workday. At least two refineries in Texas exceeded these limits at their fencelines for 14 days, including one in the fourth quarter of 2019. EPA should respond immediately when benzene levels are that high, especially when thousands of people who are especially vulnerable to air pollution live nearby.
4. Seven refineries each reported benzene concentrations that averaged more than 90 micrograms over two-week periods in 2020. Benzene is highly volatile and concentrations may fluctuate widely within a few short hours, depending on the wind, weather, emission levels and other variables. At a minimum, EPA should require these refineries to monitor benzene at shorter intervals to determine whether the 10-hour NIOSH advisory or other short-term health-based standards are being exceeded, and to warn nearby communities when these pollution spikes are

happening. The agency should also follow up with enforcement as needed to clean up emission sources causing the problem.

5. The Clean Air Act exempts some refining-related processes and chemical manufacturing from the benzene fenceline monitoring requirements, even though these benzene sources operate within the refinery or on adjacent properties. To protect vulnerable communities downwind, the fenceline benzene monitoring and cleanup requirements should apply to all petrochemical plants and other major sources of benzene.
6. Nearly two-thirds of those living within three miles of the 17 refineries with the highest benzene levels in 2020 are people of color and almost half live below the poverty line. They may lack access to affordable health care and are more likely to be plagued by asthma, COVID-19, or other immune deficiencies that make them especially vulnerable to air pollution. The Biden Administration needs to bring environmental justice to these communities, which have already waited far too long.
7. Anyone who lives near these refineries or who is concerned about the health threats from air pollution can help by emailing or writing EPA Administrator Michael Regan and local Congressional representatives to demand strong EPA action to crack down on benzene emissions.



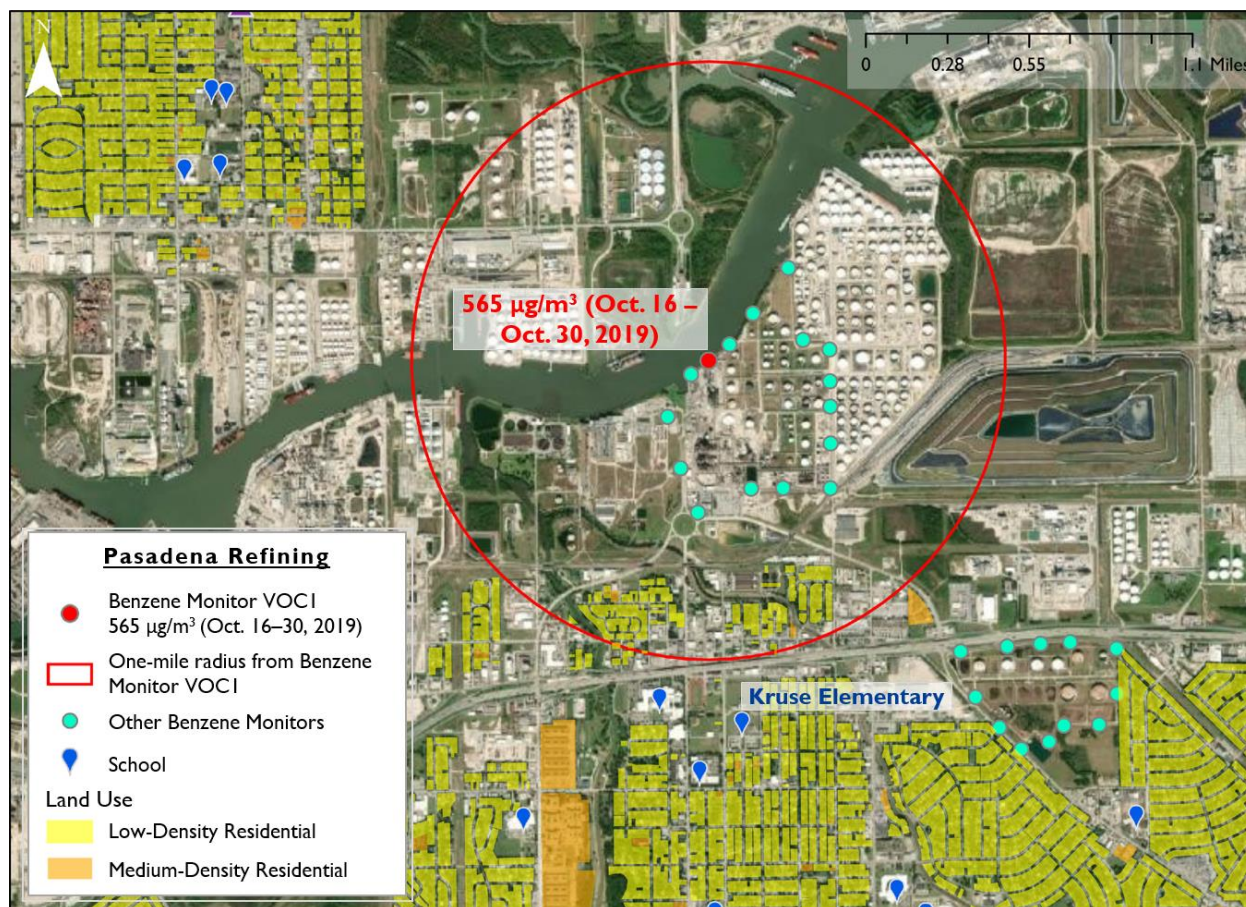
EPA needs to investigate why high benzene concentrations persist at over a dozen refineries across the U.S. and take enforcement actions to reduce emissions.

Mapping Benzene at Refinery Fencelines:

The Environmental Integrity Project mapped benzene fenceline monitors around five of the refineries that exceeded the nine microgram per cubic meter “action level” using sampling point locations provided in the refinery monitoring reports submitted to EPA. This “hot spot” analysis focused on certain facilities that measured large concentration spikes over two-week sampling periods above 90 micrograms per cubic meter, or ten-times the action level concentration. As noted earlier, the actual exposure to benzene in nearby communities can vary from the concentrations measured at a refinery’s border, depending on factors like proximity, emissions from non-refinery sources, weather conditions, and wind direction. A one-mile radius was drawn around each monitor that recorded benzene concentrations spikes above 90 micrograms one or more times during the fifteen-month period that ended on December 31, 2020.

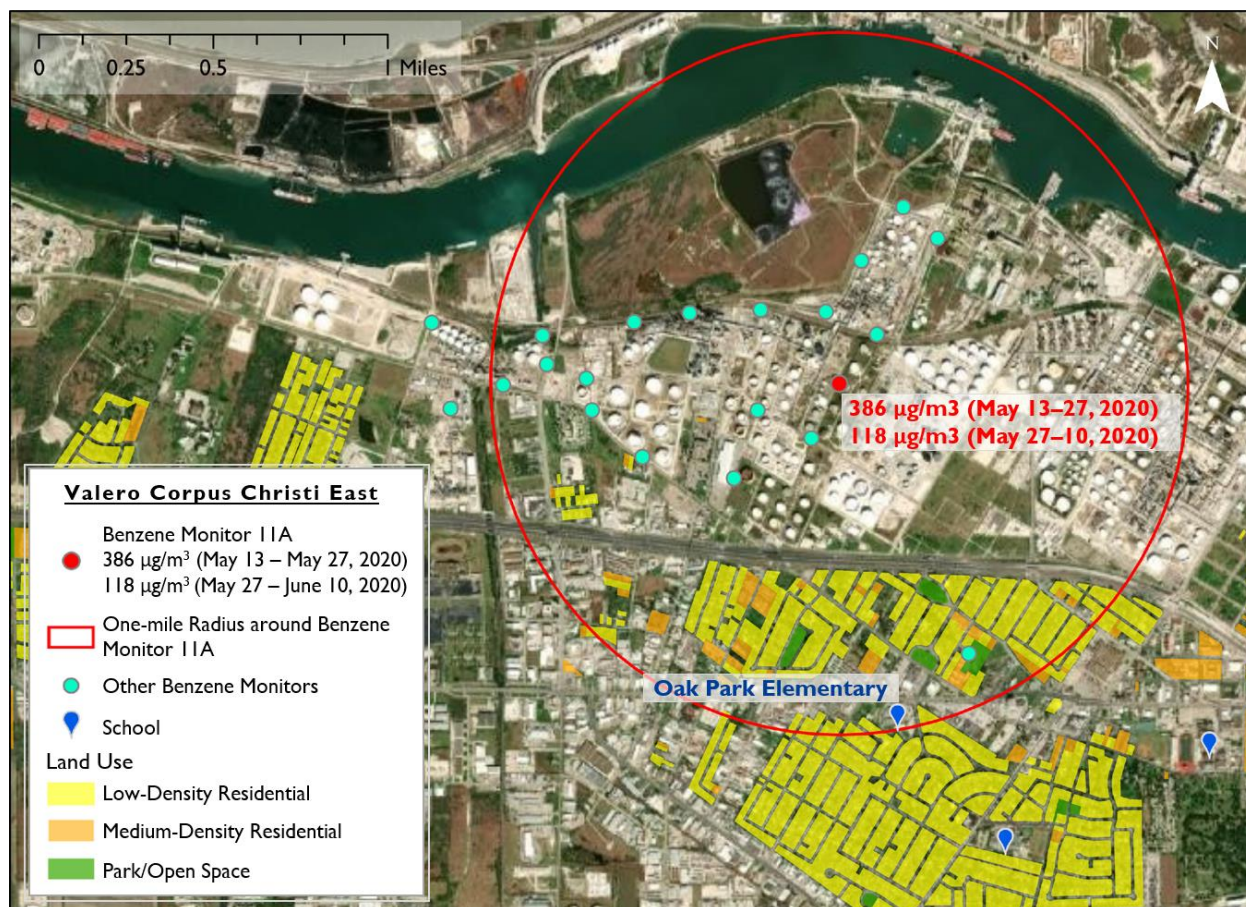
We used regional land use data (sources identified in Appendix C) to identify affected communities living in close proximity to the benzene concentration spikes, which could potentially be exposed to levels of benzene pollution that exceed the federal acute risk level for inhalation. We also mapped potential locations of concern for inhalation exposure – like schools, libraries, and hospitals – where children or those suffering from preexisting medical conditions may have potential inhalation exposure pathways to benzene pollution and other hazardous air pollutants in the air.

Pasadena Refining (Texas)



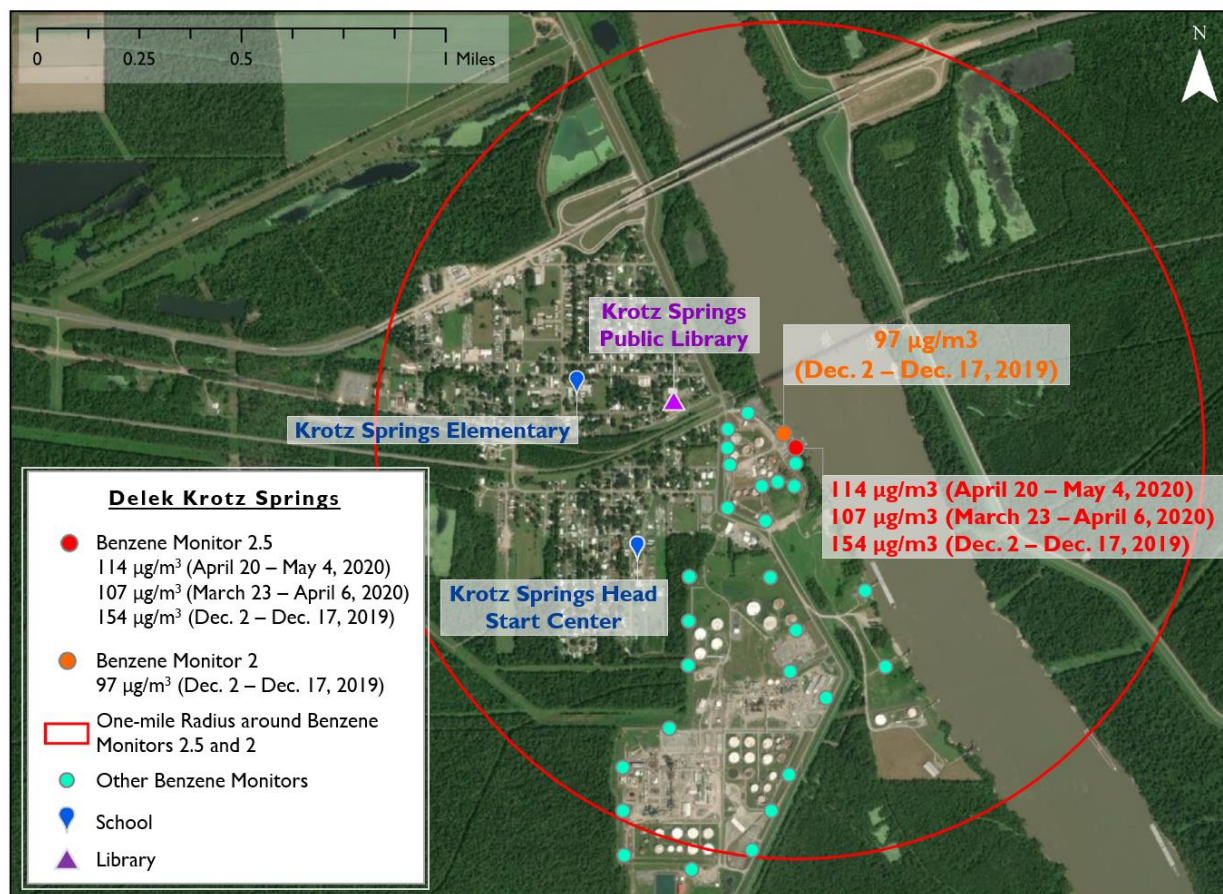
Pasadena Refining, located east of Houston in Pasadena, Texas, measured the largest benzene concentration spike in the year of data examined: 565 micrograms per cubic meter for the monitoring period ending on October 30, 2019. Pasadena Refining was acquired by Chevron in May of 2019.²³ Sampling data indicated the monitor of concern was location VOC1, located on the northern border of the facility adjacent to Buffalo Bayou. Pasadena Refining noted in the monitoring report that as a result of the concentration spike, they would submit a revised corrective action plan. Of the locations of concern mapped, Kruse Elementary School is located three-quarters of a mile south from Pasadena Refining, but lies outside the one-mile radius mapped from the peak benzene concentration at monitor VOC1.

Valero Corpus Christi East (Texas)



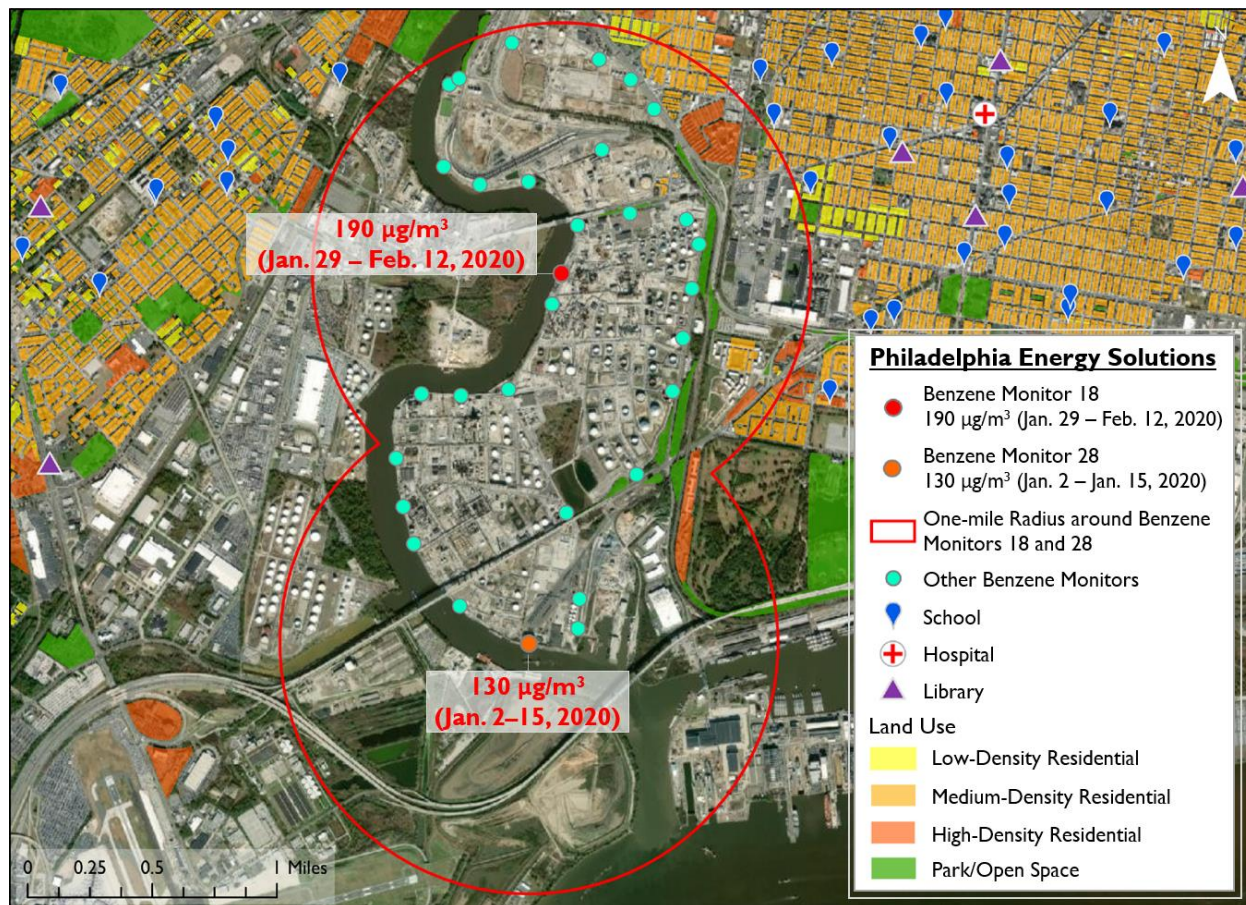
Valero Corpus Christi East Refinery, located in Corpus Christi, Texas, measured multiple concentration spikes in 2020, peaking at 386 micrograms per cubic meter for the monitoring period ending on May 27, 2020. Sampling data indicated that both concentration spikes were located at monitoring location CCEP 11A, located on the eastern edge of the facility bordering Citgo Corpus Christi East and in close proximity to Williams Magellan Corpus Christi. However, both concentration spikes were excluded as zero in Valero's submitted reports, and have not been factored into the annual-average action level evaluation. This facility had a site-specific monitoring plan approved by EPA in January of 2018, and routinely include corrections for non-covered sources and potential off-site emissions. Oak Park Elementary, located at the border of the one-mile radius, is located in the community south of the Valero Refinery, and is relatively close to Valero monitoring location CCEP BG at Woodlawn Park, which is also included in the facility's fenceline monitoring reports.

Delek Krotz Springs (Louisiana)



Delek Krotz Springs, located in Krotz Springs, Louisiana, measured the highest annual average benzene concentration for the twelve-month period that ended on September 30, 2020. As seen above, many of the large concentration spikes at this facility were measured at monitors 2 and 2.5, located at the refinery boundary along the Atchafalaya River. Monitor 2.5 registered three concentrations above 90 micrograms per cubic meter, peaking at 154 micrograms the monitoring period ending December 17, 2019. Nearby are the Krotz Springs Head Start Center, located a quarter mile due west of the refinery fenceline, as well as Krotz Springs Public Library, located a quarter mile north-west of the refinery fenceline and approximately one-third of a mile from monitoring locations 2 and 2.5.

Philadelphia Energy Solutions (Pennsylvania)



As noted in EIP's February 6, 2020 report,²⁴ high benzene concentrations have persisted at the former Philadelphia Energy Solutions refinery in Pennsylvania, where annual benzene levels were more than three times higher than the EPA action level. Not only has the facility had difficulty decreasing below the action level, the refinery site continued to report large concentration spikes. For example, in January 2020, Monitor 18 detected a concentration of 190 micrograms per cubic meter and Monitor 28 measured a concentration of 130 micrograms per cubic meter. In its monitoring report, Philadelphia Energy Solutions stated that the elevated monitoring results were due to leaks that occurred while emptying benzene tanks.

Houston Refining (Texas)



Houston Refining, located in Houston, Texas, has reported large concentration spikes but has not technically reported an exceedance of the action level concentration. Located just upriver from Pasadena Refining, this facility has a site-specific monitoring plan to adjust for off-site sources. This facility saw a large concentration spike of 98 micrograms per cubic meters for the monitoring period ending on March 18, 2020. However, the refinery excluded the concentration from its rolling net annual average, because the refinery claims that the benzene came from a leak at a neighboring facility. Similar to Pasadena Refining, these facilities are in locations that lack comprehensive zoning laws, which can result in fence-line communities living nearby or directly next to refineries, increasing the potential for exposure to air pollution.²⁵ As seen in the map, though the concentration spike was not included in the annual average, several low and medium-density residential communities are located within a one-mile radius of the peak monitoring location.

Appendix A. Two-Week Actual Benzene Concentrations Above ATSDR Minimal Risk Level (MRL), 2020

Facility	City	State	2-week Sampling Period End Date	# of locations above MRL (29 micrograms/ cubic meter)	Range of benzene concentrations over MRL (micrograms/ cubic meter)
Shell Chemical Mobile	Saraland	AL	4/22/2020	1	37
			5/6/2020	1	34.2
			5/20/2020	1	41.1
			6/3/2020	3	31-76
			7/1/2020	1	92.4
			8/12/2020	1	48.1
			10/21/2020	1	65.6
Par Hawaii East	Kapolei	HI	10/5/2020	1	46.4
Marathon Catlettsburg Refining	Catlettsburg	KY	3/11/2020	1	134
			10/21/2020	1	166
Chalmette Refining	Chalmette	LA	2/11/2020	2	35-57.5
			2/26/2020	2	29
CITGO LCMC Westlake	Westlake	LA	9/8/2020	4	42-78
			10/6/2020	1	29
Delek Krotz Springs	Krotz Springs	LA	3/23/2020	1	29.1
			4/6/2020	1	107
			4/20/2020	1	83.9
			5/4/2020	1	114
			5/18/2020	1	79.7
			6/1/2020	1	62.9
			6/15/2020	1	63.1
			6/30/2020	1	30.3
			7/27/2020	1	31.2
			9/8/2020	1	35.2
			9/21/2020	1	41.9
Phillips 66 Alliance	Belle Chasse	LA	2/5/2020	1	29
			8/19/2020	1	54.5
			9/2/2020	1	37.5
			9/30/2020	1	35
Phillips 66 Lake Charles	Westlake	LA	8/24/2020	1	49
			9/15/2020	1	43
Shell Norco Manufacturing Complex	Norco	LA	1/16/2020	1	65.5
			2/13/2020	1	37.8
			3/12/2020	1	79.3
Chevron Pascagoula	Pascagoula	MS	2/5/2020	1	58
HollyFrontier Artesia	Artesia	NM	12/1/2020	2	30-31

Appendix A, Continued

Facility	City	State	2-week Sampling Period End Date	# of locations above MRL (29 micrograms/ cubic meter)	Range of benzene concentrations over MRL (micrograms/ cubic meter)
HollyFrontier Lovington	Lovington	NM	3/26/2020	1	210
Monroe Trainer Refinery	Marcus Hook	PA	3/3/2020	1	34.9
Philadelphia Energy Solutions	Philadelphia	PA	1/15/2020	2	36-130
			2/12/2020	1	190
			4/8/2020	1	42
			7/1/2020	1	55
			7/15/2020	1	48
			7/29/2020	3	30-80
CITGO Corpus Christi East	Corpus Christi	TX	5/21/2020	1	47
CITGO Corpus Christi West	Corpus Christi	TX	7/16/2020	1	42
Flint Hills Resources Corpus Christi West Refinery	Corpus Christi	TX	9/1/2020	1	37.5
			1/5/2021	1	51.8
Houston Refining LP	Houston	TX	3/18/2020	2	44.8-98
			12/9/2020	1	35.8
Marathon Galveston Bay Texas City	Texas City	TX	2/5/2020	1	31.6
			3/18/2020	1	29.8
			4/1/2020	1	40.6
			4/15/2020	1	32.4
			5/27/2020	1	38.5
Pasadena Refining	Pasadena	TX	4/1/2020	1	32.8
Shell Deer Park	Deer Park	TX	9/29/2020	1	32.1
Total Refinery Port Arthur	Port Arthur	TX	5/26/2020	1	38.1
			6/9/2020	1	37.6
			8/4/2020	1	35.7
			12/21/2020	1	34.3
Valero Corpus Christi East	Corpus Christi	TX	5/27/2020	1	386
			6/10/2020	3	29.6-118
			7/8/2020	1	35.8

Duplicate samples from the same sampling period and location have been averaged. ATSDR Minimal Risk Level (MRL) defined as 9 parts per billion, or approximately equivalent to 29 micrograms benzene per cubic meter. The numbers above are actual readings of air monitors, not "net" or adjusted numbers.

Appendix B. Guide for Accessing EPA Benzene Reports

Below is a guide for journalists, researchers or other citizens who want to check EPA records for benzene levels monitored at the fencelines of a local refinery.

The refinery reports available on EPA site:

<https://cfpub.epa.gov/webfire/reports/eseach2.cfm>

- a. Enter Search terms for “CEDRI Submission Date” starting 01/01/2018 to the present date.
 - b. For “Regulatory Part and Subpart, select Part 63 – NESHAP and CFR Subpart CC: Petroleum Refineries.
 - c. If desired, add additional search terms to limit results, such as facility state.
 - d. Submit search.
2. Downloading the report
 - a. Submission date will typically be 45 days or less after the conclusion of the sampling quarter.
 - b. EPA notes that there may be up to a 30-day delay after submittal to appear on the website.
 - c. After locating the desired record, click the icon under the “Document” tab to initiate download.
 - d. Locate and unzip file from downloads.
3. Navigating the report
 - a. “Welcome” and “Background” tabs contain information on the rule and reporting.
 - b. “Facility information” contains necessary facility name, address, sampling year and sampling quarter information. Both facility name and quarter worth checking to ensure reviewing the desired report.
 - c. “Period Identifications” contains crucial data for assessing compliance with the action level. Column E “Sampling Period Change (Δc)” are the individual maximum two-week difference, while Column F is the Annual Average (of the previous 26 Sampling Period Δc) which is assessed against the action level.
 - d. Individual sampler locations and results found in “Sampler Information” and “Sample Results” tabs.

Appendix C: Mapping Data Sources

1. Oak Ridge National Laboratory (ORNL) Geographic Information Science and Technology (GIST) Group; National Geospatial-Intelligence Agency (NGA); Homeland Security Infrastructure Program (HSIP) Team. Public Schools, ESRI Feature Service Feature Class. Available at:
https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/Public_Schools/FeatureServer
2. Oak Ridge National Laboratory (ORNL) Geographic Information Science and Technology (GIST) Group; National Geospatial-Intelligence Agency (NGA); Homeland Security Infrastructure Program (HSIP) Team. Private Schools, ESRI Feature Service Feature Class. Available at:
https://services1.arcgis.com/Hp6G80Pky0om7QvQ/arcgis/rest/services/Public_Schools/FeatureServer
3. Harris County Land Use, ESRI Feature Service Feature Class. (8/18/2016). Available at:
<https://mycity2.houstontx.gov/pubgis02/rest/services/HoustonMap/Landuse/MapServer>
4. City of Philadelphia Planning Commission. City of Philadelphia Land Use, ESRI Feature Service Feature Class. Available at:
https://services.arcgis.com/fLeGjb7u4uXqeF9q/arcgis/rest/services/Land_Use/FeatureServer
5. Enriched PLS_FY2016_Outlet_puout16a, ESRI Feature Service Feature Class. Available at:
https://services1.arcgis.com/4yjifSiIG17X0gW4/arcgis/rest/services/Enriched%20PLS_FY2016_Outlet_puout16a/FeatureServer
6. Definitive Healthcare Bed Locations. ESRI Feature Service Feature Class. Available at:
https://services7.arcgis.com/LXCny1HyhQCUSueu/arcgis/rest/services/Definitive_Healthcare_USA_Hospital_Beds/FeatureServer
7. City of Corpus Christi. Land Use, Nueces County, ESRI Feature Service Feature Class. Available at:
<https://services.arcgis.com/0J4ZNc4NaTguvRy0/ArcGIS/rest/services/OpenData/FeatureServer>

Endnotes

¹ Benzene; CASRN 71-43-2,” Chemical Assessment Study, Integrated Risk Information System, National Center for Environmental Assessment, US Environmental Protection Agency, Section II.C.2, p. 33, available online at

https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0276_summary.pdf#nameddest=cancerinhal

² 43 CFR § 63.658.

³ All benzene values reported by refineries under 43 CFR §63.658 based on records obtained by searching the US EPA “WEBFIRE” site at <https://cfpub.epa.gov/webfire/reports/eSearchResults.cfm>.

⁴ Demographic data for each facility obtained from U.S. Environmental Protection Agency’s “Environmental Compliance History Online (ECHO)” at <https://echo.epa.gov/>. EPA demographic statistics of surrounding area based on 2010 U.S. Census and 2006-2010 American Community Survey 5-Year Summary data.

⁵ Annual average net concentration numbers obtained from refinery benzene reports, publicly available on the EPA website. Standard procedure is to take annual average from refinery report, under the “Period Identifications” tab and the last reported value under the “Annual Average Δc” in column F. For facilities with rounding in the reported average, the annual average is checked and calculated as specified by rule, using the past 26 weeks of “Sampling Period Δc” data in column E. Substantial differences were seen for the calculated average from Marathon Catlettsburg and HollyFrontier Lovington, and the table reflects the calculated value from the past 26 sampling results. Pasadena Refining also provided rounded values within column E, and each two-week sampling period Δc was calculated from subtracting the lowest benzene concentration from the highest in the “Sample Results” tab. Since Delek Krotz Springs first submitted reports in 2020, the 2019 net concentration reflects the first annual average reported for this facility once 26 weeks of sampling were completed, which was an average of 24.2 micrograms for the period ending on 1/27/2020.

⁶ People of color based on percent identified as “minority” population in ECHO database, and includes African-American, Hispanic, Asian/Pacific Islander and American Indian residents.

⁷ CDC. Occupational Safety and Health Guideline for Benzene, p. 1, <https://www.cdc.gov/niosh/docs/81-123/pdfs/0049.pdf>. NIOSH recommended exposure limit given as 0.1 ppm as an 10-hour time weighted average, which is equivalent to 100 ppb or 319 μg/m³ using the conversion equivalent of 1 ppm benzene=3.19 mg/m³ given at: <https://www.cdc.gov/niosh/npg/npgd0049.html>. Definition for NIOSH recommended exposure limits (RELs) and time-weighted average concentration given in NIOSH Pocket Guide to Chemical Hazards, available at <https://www.cdc.gov/niosh/npg/pgintrod.html>.

⁸ “Toxicological Profile for Benzene, Agency for Toxic Substances Disease Registry, US Department of Health and Human Services (2007), p. A-3, available at <https://www.atsdr.cdc.gov/toxprofiles/tp3.pdf>. ATSDR minimal risk level (MRL) for inhalation of benzene given as 9 ppb, which can be converted to approximately 29 μg/m³ using the conversion equivalent of 1 ppm benzene=3.19 mg/m³ given at: <https://www.cdc.gov/niosh/npg/npgd0049.html>.

⁹ Demographic data for each facility obtained from US EPA’s “Environmental Compliance History Online (ECHO)” at <https://echo.epa.gov/>.

¹⁰ US Census Bureau. QuickFacts, Population estimates as of 2019. People of color estimated as those not included in “White alone, not Hispanic or Latino, percent” category, which was 60.1% in 2019. Available at: <https://www.census.gov/quickfacts/fact/table/US/PST045219>.

¹¹ US Census Bureau. Income and Poverty in the United States: 2019. September 15, 2020. Report Number P60-270. At Table B-5. Available at:

<https://www.census.gov/content/dam/Census/library/publications/2020/demo/p60-270.pdf>.

¹² *Supra*, n. 1.

¹³ EPA Integrated Risk Information System (IRIS). Benzene; CASRN 71-43-2. At 33. Available at: https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0276_summary.pdf

¹⁴ EPA. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards Final Rule, 80 Fed. Reg. 75,181 (December 1, 2015). Available at:

<https://www.govinfo.gov/content/pkg/FR-2015-12-01/pdf/2015-26486.pdf>.

¹⁵ Philadelphia Energy Solutions benzene report to EPA includes comments under sample result data. For example, the sampling period ending on 1/2/2020 noted at Sampler 7 “Related to fugitives during benzene

tanks de-inventory operations (non-routine). De-inventory is part of shut down of refinery processing operations.” Available at <https://cfpub.epa.gov/webfire/reports/eseach2.cfm> under Part 63, subpart CC.

¹⁶ Facilities exceeding the action level at the end of each quarter of 2020 include Delek Krotz Springs, Shell Norco, Chalmette Refining, HollyFrontier Lovington, Philadelphia Energy Solutions, Total Port Arthur, Marathon Galveston Bay, and Citgo Corpus Christi East. HollyFrontier Artesia began and ended 2020 above the action level, though briefly dipped below the 9 microgram threshold at the end of the third quarter of 2020.

¹⁷ EPA. HollyFrontier Navajo Artesia Refinery Inspection Report. 10/1/29-10/4/29. Redacted version available at: [https://www.documentcloud.org/documents/6792943-](https://www.documentcloud.org/documents/6792943-insprptairhollyfrontierartesiarefinery20191001.html#document/p12/a554557)

[insprptairhollyfrontierartesiarefinery20191001.html#document/p12/a554557](https://www.documentcloud.org/documents/6792943-insprptairhollyfrontierartesiarefinery20191001.html#document/p12/a554557)

¹⁸ EPA “Synthetic Organic Chemical Manufacturing Industry: Organic National Emission Standards for Hazardous Air Pollutants (NESHAP) - 40 CFR 63 Subparts F,G,H,I,” available at:

<https://www.epa.gov/stationary-sources-air-pollution/synthetic-organic-chemical-manufacturing-industry-organic-national>, accessed April 9, 2021.

¹⁹ CITGO Petroleum Corporation. “Site-Specific Benzene Fenceline Monitoring Plan (Proposed). November 12, 2020. Available at <https://cfpub.epa.gov/webfire/reports/eseach2.cfm> under Part 63, subpart CC.

²⁰ NIOSH Benzene REL available at: <https://www.cdc.gov/niosh/npg/npgd0049.html>. TWA of 0.1 ppm (100 ppb) defines guidance for 10-hour workday exposure.

²¹ “Toxicological Profile for Benzene, Agency for Toxic Substances Disease Registry, US Department of Health and Human Services (2007), p. A-3, available at <https://www.atsdr.cdc.gov/toxprofiles/tp3.pdf>. ATSDR minimal risk level (MRL) for inhalation of benzene given as 9 ppb, which can be converted to approximately 29 µg/m³ using the conversion equivalent of 1 ppm benzene=3.19 mg/m³ given at: <https://www.cdc.gov/niosh/npg/npgd0049.html>.

²² US Census Bureau. Income and Poverty in the United States: 2019. September 15, 2020. Report Number P60-270. At Table B-5. Available at:

<https://www.census.gov/content/dam/Census/library/publications/2020/demo/p60-270.pdf>.

²³ See Chevron Pasadena History. Available at: <https://pasadena.chevron.com/about/history>

²⁴ Environmental Integrity Project, “Monitoring for Benzene at Refinery Fencelines,” February 6, 2020. Link: <https://environmentalintegrity.org/wp-content/uploads/2020/02/Benzene-Report-2.6.20.pdf>

²⁵ See Union of Concerned Scientists and Texas Environmental Justice Advocacy Services (t.e.j.a.s). “Double Jeopardy in Houston: Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities.” October 1, 2016. At 3. Available at: <https://www.jstor.org/stable/resrep17254>.