Proposed Rule - Air Approval Plans; Texas; Reasonably Available Control Technology in the Houston-Galveston-Brazoria Ozone Nonattainment Area

EPA Docket: EPA–R06–OAR–2020–0165

Proposed: March 10, 2021

Comments of Environmental and Community Groups:

AIR ALLIANCE HOUSTON

EARTHJUSTICE

SIERRA CLUB

TEXAS ENVIRONMENTAL JUSTICE ADVOCACY SERVICES

April 9, 2021

Submitted via regulations.gov and email

<u>Comments of Environmental and Community Groups</u>

These comments are submitted on behalf of Air Alliance Houston, Earthjustice, Sierra Club, and Texas Environmental Justice Advocacy Services ("t.e.j.a.s.") (collectively, "Commenters").

Air Alliance Houston is a non-profit environmental group that seeks to reduce air pollution and other health threats in the Houston region, and to protect public health and environmental integrity through applied research, education, and advocacy, which includes actions to assist our constituents in the area facing this air pollution in their daily lives.

Earthjustice is the nation's largest nonprofit environmental law organization. It fights for a future where children can breathe clean air, no matter where they live, and where all communities are safer, healthier places to live and work.

Sierra Club is one of the oldest and largest national nonprofit grassroots environmental organizations in the country, with more than 820,000 members nationwide, including 28,663 members in Texas, dedicated to exploring, enjoying, and protecting the wild places and resources of the earth; practicing and promoting the responsible use of the earth's ecosystems and resources; educating and enlisting humanity to protect and restore the quality of the natural and human environment; and using all lawful means to carry out these objectives.

t.e.j.a.s. is a non-profit group whose mission is to create sustainable, healthy communities in the Houston Ship Channel region by educating individuals on health impacts from environmental pollution and empowering them to promote the enforcement of environmental laws. In furtherance of this mission, t.e.j.a.s. engages in advocacy and organizing around environmental issues in Texas, including pollution created by refineries and petrochemical facilities along the Houston Ship Channel.

I. Introduction

EPA must not finalize this proposal. Texas's SIP submission to EPA includes no revisions to the state's outdated requirements for reasonably available control technology ("RACT") emission limits for existing sources in the Houston-Galveston-Brazoria ("HGB") nonattainment area. This failure not only contravenes the Clean Air Act and is arbitrary, but it further exacerbates an already egregious environmental justice issue in the HGB area.

Under the Clean Air Act, moderate and higher ozone nonattainment areas must develop plans that require "implementation of reasonably available control technology under [42 U.S.C. §] 7502(c)(1)" for "all…major stationary sources of [volatile organic compounds]" and oxides of nitrogen ("NOx"). 42 U.S.C. § 7511a(b)(2), (f). Revisions to SIPs must incorporate RACT for sources of VOCs covered by EPA-issued control technique guidelines ("CTGs"), as well as for other major sources of VOCs and NOx.

RACT "defines the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility." Memorandum from R. Strelow, Asst. Adm'r, EPA, Office or Air and Waste Management, to Reg'l Adm'rs, EPA Regions I-X, re: *Guidance for Determining Acceptability of SIP Regulations in Non-Attainment Areas* at 2 (Dec. 9, 1976) ("Strelow Memo") (Attachment 1). RACT "means devices, systems, process modifications, or other apparatus or techniques that are reasonably available taking into account: (1) [t]he necessity of imposing such controls in order to attain and maintain a national ambient air quality standard; [and] (2) [t]he social, environmental, and economic impact of such controls" 40 C.F.R. § 51.100(o).

"RACT encompasses stringent, or even 'technology forcing,' requirement[s]." Strelow Memo 2; *accord Sierra Club v. EPA*, 972 F.3d 290, 294 (3d Cir. 2020) ("RACT is a technology-forcing standard designed to induce improvements and reductions in pollution for existing sources."); *see also Whitman v. Am. Trucking Ass'ns*, 531 U.S. 457, 492 (2001) (Breyer, J., concurring) (noting that technology forcing requirements "are still paramount in today's [Clean Air] Act"). "In every case RACT should represent the toughest controls considering technological and economic feasibility that can be applied to a specific situation. Anything less than this is by definition less than RACT and not acceptable for areas where it is not possible to demonstrate attainment." Strelow Memo 3.

Because the HGB area failed to meet its revised attainment deadline for the 2008 ozone National Ambient Air Quality Standards ("NAAQS"), EPA reclassified the area to be in "serious" nonattainment, with a deadline of July 20, 2021. 84 Fed. Reg. 44,238 (Aug. 23, 2019). To remedy its failure to meet its attainment deadlines, Texas is statutorily required to implement RACT-level controls on existing sources in this nonattainment area. But the state has not updated its RACT rules to require more stringent measures to reduce NOx and VOC emissions in the HGB area. And Texas's failure does not fall equally on residents in the HGB area. Instead, as we described below, the state's nonattainment for the HGB area has a disproportionate harm on people of color and low-income populations living near major emission sources. This is particularly true for ozone precursors like VOCs, which are highly concentrated in distinct census tracts.

Texas's failure is inexcusable. And the state's failure to meet its attainment deadlines is proof that additional controls are needed. Despite comments that highlighted potential avenues for additional controls,[1] the state's submission would keep the same RACT determinations used for the 1997 eight-hour ozone NAAQS. EPA's approval of this RACT SIP would be unlawful and contrary to the Clean Air Act. For the reasons outlined below, EPA must reject Texas's RACT SIP submission for the HGB area and require the state issue additional RACT controls.

II. Approving Texas's RACT SIP would be unlawful and arbitrary.

In its submission to EPA, Texas failed to meet its statutory requirements under the Clean Air Act by seeking approval of its existing RACT controls without rationally evaluating additional measures that could reduce emissions in the HGB area. Instead of "determin[ing] whether the existing controls or emissions reduction approach at [existing] source[s] can be updated or improved with reasonably available controls or strategies to achieve increased levels of emission reduction," 81 Fed. Reg. 58,010, 58,037 (Aug. 24, 2016), Texas reflexively relies on its existing controls, which are more than a decade old at this point. EPA's proposal to approve Texas's RACT SIP is unlawful, and contrary to EPA's own rule on implementing the 2008 ozone NAAQS and binding caselaw.

In that implementation rule, EPA emphasized that only in "some cases" would a RACT determination for the 1-hour or 1997 ozone NAAQS be sufficient for the 2008 ozone NAAQS RACT requirement. 80 Fed. Reg. 12,264, 12,279 (Mar. 6, 2015). EPA stated that this decision was based on a belief that in "some cases" "a new RACT determination under the 2008 standard would result in the same or similar control technology as the initial RACT determination under the 1-hour or 1997 standard because the fundamental control techniques, as described in the CTGs and ACTs [alternative control techniques], are still applicable." *Id.* Only in the circumstance where updated RACT would yield only small additional emission reductions at an unreasonable cost would reliance on an existing RACT determination be justified. *Id.* at 12,280. But given that many CTGs and ACTs have not been updated, EPA also emphasized that "in <u>many</u> cases, more recent technical information is available in other forms." *Id.* at 12,278 (emphasis added). This includes "information received during the public comment period." *Id.* at 12,279. Notably, existing regulatory requirements can indicate whether a particular degree of emission limitation does not constitute RACT. *See Sierra Club*, 972 F.3d at 300 & n.69 ("an average of the current emissions being generated by existing systems[] will not usually be sufficient to satisfy the RACT standard."). Thus, a RACT determination is unlawful and arbitrary when other states have RACT requirements that are more stringent. Further, as RACT is technology

[1] Comments on Proposed Houston-Galveston-Brazoria (HGB) Serious Classification Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambien[t] Air Quality Standard (NAAQS) (Oct. 28, 2019) (TCEQ Docket No. 2019-0692-SIP) (Attachment 2).

forcing, existing RACT determinations are not the only relevant criteria in making a RACT determination: EPA has made explicit that best available control technology ("BACT") determinations are relevant, too. EPA, Response to Comments on Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements 102 (Feb. 13, 2015) (EPA-HQ-OAR-2010-0885-0191).

EPA's explanation in its 2008 ozone NAAQS implementation rule is consistent with how EPA has interpreted RACT requirements in the past. EPA has repeatedly stated that states cannot rely on existing RACT determinations from previous ozone standards without explaining how these RACT measures continue to meet the "stringent" RACT standard. Strelow Memo 2; *see* 81 Fed. Reg. 58,037/3. The agency has found that "[p]ast experience has shown that due to ongoing innovation, cost-effective control technologies and process alternatives for many sectors continue to be developed…." 81 Fed. Reg. 58,037/3. And courts have held that "RACT is not designed to rubber-stamp existing control methods." *Sierra Club*, 972 F.3d at 295.

Here, Texas failed to meet the standard outlined by EPA that would allow the state to use its previous RACT determination. Specifically, Texas failed to respond to Commenters' undisputed expert report that outlined how additional controls could result in a large reduction of emissions in the HGB area. *See, e.g.*, *NRDC v. EPA*, 571 F.3d 1245, 1254 (D.C. Cir. 2009) ("If a state is presented with information indicating that a previous RACT determination is inappropriate, the state must consider that information and modify its RACT determinations accordingly.") Commenters' expert, Dr. Ron Sahu, found that many of the largest sources of NOx emissions in the HGB area are associated with electric power generation.[2] And not only did Texas fail to conduct any analysis of the largest NOx source, W.A. Parish station, the state also failed to consider how additional controls could result in NOx and VOC emission reductions at this source. *Id.* at 14-15. For example, Dr. Sahu analyzed the potential NOx reductions for one unit at the largest source of NOx emissions in the HGB area and found that an additional RACT determination, such as requiring a replacement or re-activated Selective Catalytic Reduction ("SCR") catalyst, could have reduced the unit's NOx emissions in 2017 by 1091 tons. *Id.* at 15. Similar reductions could be achieved at other units in the same facility by similar RACT controls for NOx, as well as for VOCs at other facilities. Texas failed to respond rationally to these comments. For example, Texas's only response to these comments about the W.A. Parish station was to claim—without providing any supporting analysis—that it "determined that for all NO_X major sources in the HGB area, current EPA-approved state rules satisfy FCAA NO_X RACT requirements under the 2008 eight-hours ozone NAAQS for the HGB area," pointing to "Table F-4" as containing the determination. TCEQ, Response to Comments 21 (EPA-R06-OAR-2020-0165-0003). Thus, contrary to governing requirements, Texas failed to

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[2] Dr. Ranajit (Ron) Sahu, Comments on the Reasonably Available Control Technology (RACT) and Reasonably Available Control Measures (RACM) for the 2008 Ozone NAAQS Attainment SIP Modifications Proposed by the Texas Commission on Environmental Quality (TCEQ) for the Houston-Galveston-Brazoria (HGB) and Dallas-Fort Worth (DFW) Non-Attainment Areas at 14 (Oct. 28, 2019) ("Sahu Report") (Attachment 3).

rationally address the comments showing more stringent controls were necessary to satisfy RACT.

But instead of an analysis that reviewed whether Texas has properly considered the information before it, EPA states in its Technical Support Document ("TSD") that it "believes" that "any new RACT determinations by the state would be expected to result in the same or similar control technology as the RACT determinations made for the 1-hour or the 1997 ozone standards." TSD 18. EPA's statement is without evidentiary basis and contrary to its own implementation rule for the 2008 ozone NAAQS. To approve Texas's RACT SIP in its current form would be unlawful and arbitrary. As EPA stated in the final rule implementing the 2008 ozone NAAQS, it is only "[a]bsent data or public comments indicating that the previous RACT determination is no longer appropriate" that a state can choose to "not adopt additional SIP controls to meet the new RACT requirement for these sources." 80 Fed. Reg. 12,280. Texas has not met that standard here.

EPA's approval of Texas's submission would rubber stamp Texas's do-nothing-approach to implementing RACT. As such, this action would be arbitrary and contrary to the Clean Air Act.

III. TCEQ's failure to update its RACT regulations exacerbates emissions burdens in the HGB nonattainment area and contravenes EPA's legal obligation to ameliorate environmental justice issues.

The acute harms of ozone and related air pollution in the Houston nonattainment area are not felt evenly. Numerous studies and data demonstrate that low resource communities and communities of color bear a higher burden. For example, in the historic Harrisburg and Manchester neighborhoods in east Houston, 97% of residents are people of color, 90% are low income, and 37% live in poverty.[3] Overall, there is a concentration of major industrial sources of air pollution in such communities.[4] As of 2016, 26 Risk Management Plan industrial facilities—facilities that handle extremely hazardous substances and must report their emissions to the EPA's Toxic Release Inventory—operate in Manchester.[5] These major industrial sources are among the types of existing sources that are subject to RACT requirements in Texas's SIP.

A recent study by Sustainable Systems Research, LLC ("SSR") highlights the extent to which vulnerable communities in the HGB area are put in harm's way by the lack of emissions reductions.[6] By reviewing TCEQ's point source emissions inventory ("PSEI") data in conjunction with U.S. Census data, SSR was able to evaluate the emission burdens of

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[3] Center for Science and Democracy at the Union of Concerned Scientists, Double Jeopardy in Houston, Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities 5-6 (Oct. 2016), https://www.ucsusa.org/sites/default/files/attach/2016/10/ucs-double-jeopardy-in-houston-full-report-2016.pdf (Attachment 4).
[4] *Id*. at 3-6, 13.
[5] *Id*. at 19.
[6] Sustainable Systems Research, LLC, Evaluation of Vulnerability and Stationary Source Pollution in Houston (Sept. 2020) ("2020 Houston Vulnerability Study") (Attachment 5).

communities in the HGB area. Their analysis found that there are widespread disparities in community burdens for pollutants like VOCs, PM_{10}, and $PM_{2.5}$, and that these disparities are "greater for people of color and limited-English households than for households living in poverty."[7] Furthermore, many of these communities are subject to unauthorized emissions of VOCs, especially those living near the vicinity of the Houston Ship Channel.[8]

Texas's failure to implement additional RACT measures exacerbates the burden felt by these communities. As SSR's research shows, VOC emissions in the HGB area are highly concentrated in particularly vulnerable census tracts (see figure 1 below). By failing to enact additional RACT measures, Texas subjects these communities to a disproportionate burden of pollution that threatens their public health. Furthermore, EPA's approval of the state's RACT SIP would contravene Executive Order 13990's commitment to advance environmental justice. As stated in the order, it is the nation's policy to "promote and protect our public health and the environment; … to ensure access to clean air…; [and] to prioritize…environmental justice." 86 Fed. Reg. 7037, 7037 (Jan. 25, 2021) (emphasis added). EPA's proposed approval of this SIP would betray the spirit and letter of the order's commitment to environmental justice.

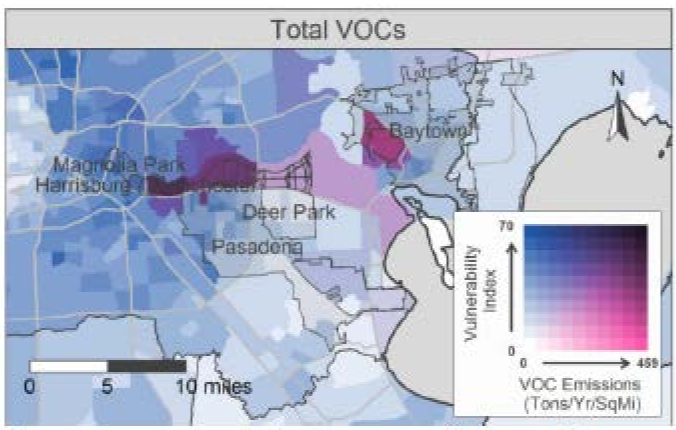

Figure 1, from *2020 Houston Vulnerability Study*, at 31.

IV. If EPA approves some or all of the submittal, EPA must make clear what RACT obligations remain outstanding.

In its proposal, EPA notes that Texas has not updated its RACT for the oil and gas sector to reflect changes to the EPA's Oil and Gas CTG. 86 Fed. Reg. 13,681. This is despite having a 2018 deadline to update its RACT SIP in accordance with the new CTG. While EPA has stated that it is committed to working with Texas to "expedite the development and submission of the required SIP revisions" for the new CTG, it is still unclear if EPA is proposing to approve all of Texas's RACT obligations under the 2008 NAAQS. *Id.* Plainly, EPA cannot lawfully or rationally do so—not just because the RACT SIP submittal has the illegalities and irrationalities discussed above, but also because it does not even purport to

[7] *Id.* at 15*, see also id.* at 17 tbl.2.
[8] *Id.* at 35.

meet the governing requirements established by the Oil and Gas CTG. Thus, if, contrary to law and rationality, EPA chooses to approve any part of this RACT SIP, it must make clear which portions of Texas's RACT SIP fulfill the state's obligations under the 2008 NAAQS remain unfulfilled.

V. Conclusion

For the foregoing reasons, EPA must not approve Texas's RACT SIP submission. By definition, RACT must include the "toughest controls": anything less is not RACT. Strelow Memo 3. Though Commenters provided analysis and highlighted serious gaps in Texas's proposal, Texas's final submission lacks any rational analysis of how the outdated emission limits it submitted to EPA meet RACT, and EPA's proposed approval fails either to engage with Texas's lack of analysis or to undertake its own analysis. Fundamentally, too, EPA's approval of Texas's RACT for the HGB area would contravene the purpose of requiring RACT in SIPs, by allowing the state to rely on outdated controls that fail to meaningfully reduce emissions to achieve attainment.

Attachment List

1. Memorandum from R. Strelow, Asst. Adm'r, EPA, Office or Air and Waste Management, to Reg'l Adm'rs, EPA Regions I-X, re: *Guidance for Determining Acceptability of SIP Regulations in Non-Attainment Areas* (Dec. 9, 1976) ("Strelow Memo")

2. Comments on Proposed Houston-Galveston-Brazoria (HGB) Serious Classification Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambien[t] Air Quality Standard (NAAQS) (Oct. 28, 2019) (TCEQ Docket No. 2019-0692-SIP)

3. Dr. Ranajit (Ron) Sahu, Comments on the Reasonably Available Control Technology (RACT) and Reasonably Available Control Measures (RACM) for the 2008 Ozone NAAQS Attainment SIP Modifications Proposed by the Texas Commission on Environmental Quality (TCEQ) for the Houston-Galveston-Brazoria (HGB) and Dallas-Fort Worth (DFW) Non-Attainment Areas (Oct. 28, 2019) ("Sahu Report")

4. Center for Science and Democracy at the Union of Concerned Scientists, Double Jeopardy in Houston, Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities (Oct. 2016)

5. Sustainable Systems Research, LLC, Evaluation of Vulnerability and Stationary Source Pollution in Houston (Sept. 2020) ("2020 Houston Vulnerability Study")

Attachments

Attachment 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Washington, D.C. 20460

December 9, 1976

MEMORANDUM

SUBJECT: Guidance for determining Acceptability of SIP Regulations in Non-attainment Areas

FROM: Roger Strelow, Assistant Administrator for Air and Waste Management

MEMO TO: Regional Administrators, Regions I-X

The basis for fully approving state-submitted SIP regulations continues to be demonstrated attainment and maintenance of all national ambient air quality standards as expeditiously as practicable. If the plan demonstrates attainment and maintenance, EPA is required to approve the state regulations. EPA cannot disapprove them because they are too stringent or because EPA Considers them not stringent enough (for example, because they are less stringent than a comparable Federal regulation or because they control fewer sources than controlled by Federal regulations), providing the overall SIP shows attainment and maintenance as quickly or quicker than any other available control strategy. If the state plan shows attainment and maintenance, Federal regulations may be revoked at the time of approval.

Especially for oxidant, carbon monoxide, and particulate matter (in areas dominated by urban fugitive dust), control measures required to attain the standards may be technically impossible or socially or economically unacceptable within a short time frame. In this situation, EPA still cannot disapprove state regulations because they are "too stringent," and industry cannot successfully challenge an approval on the ground that the requirements are technologically or economically infeasible. On the other hand, EPA must disapprove the state regulations if they are not stringent enough. The test for approvability of individual regulations is whether they require, at a minimum, all reasonably available controls on a source as expeditiously as practicable. This memorandum seeks to provide guidance as to how to ascertain if state regulations meet these minimum requirements. The use of any given level of control which fails to assure attainment should only be considered to be an interim measure. As control technology improves and as new control measures become feasible for an area, it will be necessary for the SIP to be periodically revised to include these measures until attainment and maintenance can be demonstrated.

1. Reasonably Available Control Measures

a. Stationary Sources

With respect to individual point sources and area sources with defined emission points (i.e., those amenable to the application of "classical" control equipment), reasonably available control technology (RACT) defines the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. Thus, RACT encompasses stringent, or even "technology forcing," requirement that goes beyond simple "off-the-shelf" technology. As noted, RACT is the minimum EPA can accept in non-attainment state plans.

The determination of RACT and the corresponding emission rate, ensuring the proper application and operation of RACT, may vary from source to source due to source configuration, retrofit feasibility, operation procedures, raw materials, and other technical or economic characteristics of an individual source or group of sources. In order to assist the Regions in determining the impact of these variables on RACT, OAQPS is continuing to develop RACT guidance materials (see attached status report). This material describes what can be accomplished with good technology and defines things that should be considered in establishing an emission limit for a specific source of that type. In determining RACT for an individual source or group of sources, the control agency, using the available guidance, should select the best available controls, deviating from those controls only where local conditions are such that they cannot be applied there and imposing even tougher controls where conditions allow. For example, the best available control for a boiler burning coal and bark at a pulp mill is multiclone followed by an electrostatic precipitator (ESP), the two control devices having an overall collection efficiency of 99.5%. However, in areas where the bark or similar fuel has a high salt content as a result of the logs being floated in the estuary portion of the river, it may be that the technological and economic

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* As stated at the outset of this memorandum, the test for approving the entire control strategy – and for EPA thus not having to promulgate any measures – continues to be demonstrated attainment and maintenance of the NAAQS.

problems of installing and operating a large, corrosion resistant ESP may prove unreasonable. More technological and economically feasible controls consisting of a multiclone and ,wet collector designed to withstand the corrosive conditions, and perhaps functioning more effectively on a salt fume than an ESP, depending on the pressure drop employed, may constitute RACT under the conditions cited. In every case RACT should represent the toughest controls considering technological and economic feasibility that can be applied to a specific situation. Anything less than this is by definition less than RACT and not acceptable for areas where it is not possible to demonstrate attainment

As a further assistance to the Regions in defining RACT for the more difficult or the far from textbook situations, OAQPS's Emission Standards and Engineering Division (ESED) will establish a consulting group to support the Regions. This group will include ESED staff but will also include technical expertise from OE and the Regional Offices. In specific instances, the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) may be asked to assist in a RACT determination. The consulting group is being established as a service to the Regions and it should not be looked at as a clearinghouse for regional RACT determinations. These decisions are yours to make. The group is designed to help you as needed on the most difficult cases.

b. Mobile and Area Sources

As with point sources, measures which constitute reasonably available controls for mobile sources and area sources with undefined emission points may represent relatively stringent requirements which in many situations forces the application of measures not previously adopted or implemented in a given area. These measures include vehicle inspection and maintenance, transportation control and land use measures, certain controls on fugitive and reentrained dust, and other measures which may influence customary life styles. They do not include clearly un- reasonable measures such as substantial gasoline rationing. Moreover, what may be reasonable in one area may be un- reasonable in another. For example, while it may be reasonable as a transportation control measure to quickly reduce the number of cars permitted to enter the central business district in a city with a good mass transit system, it would not be reasonable to do this on the same timetable in a city with a poor mass transit system.

2. Documentation

In those situations where the State's control strategy can- not demonstrate attainment it will be necessary for the State to document that their control strategy represents the application of reasonably available control measures to all available source categories. The Region should not approve a control strategy that does not contain sufficient documentation to show that the required control measures are the toughest that are reasonably available for the sources in the area covered by the control strategy.

3. Replacement of Federal Regulation

In some areas the SIPS already contain EPA regulations representing reasonably available controls that generally reflect a national definition of reasonably available controls for that source category and that were arrived at by EPA after proposal and public hearing, (e.g., Stage I and I1 gasoline marketing regulations in 16 AQCRs; transportation control measures in 28 AQCRs).

In these situations there is inherently less flexibility in the definition by the state of reasonably available controls and specific justification will be needed before EPA could ap- prove a regulation which exempts significantly more sources, or which imposes controls significantly less stringent, than the Federal regulations. This justification should document the specific case-by-case economic. technical or other factors which cause the state's regulations, although significantly different from the Federal regulation, to include all that is reasonable for a specific area. (The state regulation would still have to con- form to the criteria outlined for defining reasonable control measures.) Such justification must be provided not only as a basis for approval of the state regulations, but also to protect the enforceability of comparable Federal and state regulations in other areas. In the absence of acceptable justification, the state regulation exempting some sources can be approved as far as it goes and the Federal regulation should remain in effect to cover sources for which the state's regulation does not apply. Of course, nothing should preclude a state from adopting and this Agency approving a regulation which requires more control than the Federally promulgated regulation.

Since it is the Agency's objective to encourage the states to develop and implement regulations to replace EPA regulations, the Agency may approve state regulations that are only marginally different from the Federal regulations without the detailed justification noted above if, in the Regional Administrator's judgment, the impact on emissions differs imperceptibly (less than 5% in cases where it is possible to quantify the difference) from that of the Federal regulations and there is no significant threat of undermining EPA activities elsewhere in the nation. When determining if a state regulation is environmentally equivalent to the Federal regulation, EPA can only look at the particular measure being implemented. In other words, it would be unacceptable to approve a measure requiring significantly less control than the corresponding Federal measure on the basis that other control measures implemented in the same area are significantly more stringent than the comparable Federal measures. In areas where attainment cannot be demonstrated, all reasonable measures on all source categories are needed.

To further encourage states to replace EPA regulations, reasonable additional time generally may be granted to com- ply with replacement regulations providing the new compliance dates (effective dates) are not clearly excessive. We cannot expect a state to adopt regulations which depend upon the prior Federal regulations to alert sources to the steps needed for control, except in those cases where the state regulation is substantially identical to the Federal regulation which it replaces. On the other hand, granting of additional time must be done with care so as not to undermine the action-forcing role of firm deadlines in EPA efforts elsewhere. The use of a "good faith efforts" test will be appropriate in some circumstances

4. Conclusion

In concluding, I would like to reiterate the fact that the air quality standards are not being attained in many of these RACT areas. Therefore, we cannot relax the intensity of the air pollution control effort. We should ensure that all sources contributing to the nonattainment situation are required to implement restrictive available control measures even if it requires significant sacrifices.

cc:`Mr. Tuerk, Mr. Barber, Mr. Legro, Mr. Bonine, Mr. Hidinger.

Attachment 2

Proposed Houston-Galveston-Brazoria (HGB) Serious Classification Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambien Air Quality Standard (NAAQS),

Rule Project No. 2019-077-SIP-NR

TCEQ Docket No. 2019-0692-SIP

Proposed Sept. 11, 2019

Comments of Environmental and Community Groups:

ACHIEVING COMMUNITY TASKS SUCCESSFULLY

AIR ALLIANCE HOUSTON

EARTHJUSTICE

SIERRA CLUB

TEXAS ENVIRONMENTAL JUSTICE ADVOCACY SERVICES

October 28, 2019

Submitted via eComments at https://www6.tceq.texas.gov/rules/ecomments/

Comments of Environmental and Community Groups

These comments are submitted on behalf of Achieving Community Tasks Successfully, Air Alliance Houston, Coalition of Community Organizations, Earthjustice, Sierra Club, and Texas Environmental Justice Advocacy Services (collectively, "Commenters").

Achieving Community Tasks Successfully ("ACTS") is a grassroots community group working for social and environmental justice in the Pleasantville community of east Houston.

Air Alliance Houston is a non-profit environmental group that seeks to reduce air pollution and other health threats in the Houston region, and to protect public health and environmental integrity through applied research, education, and advocacy which includes actions to assist our constituents in the area facing this air pollution in their daily lives.

Earthjustice is the nation's largest nonprofit environmental law organization. It fights for a future where children can breathe clean air, no matter where they live, and where all communities are safer, healthier places to live and work.

Sierra Club is one of the oldest and largest national nonprofit grassroots environmental organizations in the country, with approximately 782,000 members nationwide dedicated to exploring, enjoying, and protecting the wild places and resources of the earth; practicing and promoting the responsible use of the earth's ecosystems and resources; educating and enlisting humanity to protect and restore the quality of the natural and human environment; and using all lawful means to carry out these objectives.

Texas Environmental Justice Advocacy Services ("t.e.j.a.s.") is a non-profit group whose mission is to create sustainable, healthy communities in the Houston Ship Channel region by educating individuals on health impacts from environmental pollution and empowering them to promote the enforcement of environmental laws. In furtherance of this mission, t.e.j.a.s. engages in advocacy and organizing around environmental issues in Texas, including pollution created by refineries and petrochemical facilities along the Houston Ship Channel.

INTRODUCTION

The Texas Commission on Environmental Quality ("TCEQ") must not finalize this proposal. Instead of perpetuating weak ozone protections in one of the most polluted areas of Texas, if not the entire country, TCEQ should be strengthening those protections. The communities and people who have borne the disproportionate burden of toxic ozone precursor emissions of carcinogenic volatile organic compounds ("VOCs") and oxides of nitrogen ("NO_X"), as well as the resulting ozone air pollution have the right to a healthy environment. And in the Houston nonattainment area, it is low resource communities and communities of color who bear the resulting disproportionate health harm from this pollution. The proposed action is a step away from realizing their right to breathe healthy air. As explained below, TCEQ cannot lawfully or rationally finalize the proposed action. In particular, TCEQ fails to demonstrate attainment by the serious area attainment date and the Proposed Rule[1] fails to adequately assess or adopt readily available control technology that is highly cost-effective and could be quickly installed or activated, favoring existing controls that are actually far inferior to reasonably available control technology already in place at other Texas facilities and throughout the nation.

I. The Proposed Rule Perpetuates the Ozone Problem in the Houston Nonattainment Area.

A. Ground-Level Ozone is Harmful to Human Health.

Ozone, the main component of smog, is a corrosive air pollutant that inflames the lungs and constricts breathing, and likely kills people. *See Am. Trucking Ass'ns v. EPA*, 283 F.3d 355, 359 (D.C. Cir. 2002); 80 Fed. Reg. 65,292, 65,308/3-09/1 (Oct. 26, 2015); EPA, *Integrated Science Assessment for Ozone and Related Photochemical Oxidants* 2-20 to -24 tbl.2-1, EPA-HQ-OAR-2008-0699-0405 (Feb. 2013) ("ISA"). It causes and exacerbates asthma attacks, emergency room visits, hospitalizations, and other serious health harms. *E.g.*, EPA, *Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards* 3-18, 3-26 to -29, 3-32, EPA-HQ-OAR-2008-0699-0404 (Aug. 2014) ("PA"); ISA 2-16 to -18, 2-20 to -24 tbl.2-1. Ozone-induced health problems can force people to change their ordinary activities, requiring children to stay indoors and forcing people to take medication and miss work or school. *E.g.*, PA 4-12.

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[1] Proposed Houston-Galveston-Brazoria (HGB) Serious Classification Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambien Air Quality Standard (NAAQS) ("Proposed Rule"), TCEQ Rule Project No. 2019-077-SIP-NR, TCEQ Docket No. 2019-0692-SIP (proposed Sept. 11, 2019).

Ozone can harm healthy adults, but others are more vulnerable. *See* 80 Fed. Reg. 65,310/1-3. Because their respiratory tracts are not fully developed, children are especially vulnerable to ozone pollution, particularly when they have elevated respiratory rates, as when playing outdoors. *E.g.*, *id.* 65,310/3, 65,446/1; PA 3-81 to -82. People living with lung disease and the elderly also have heightened vulnerability. *See* 80 Fed. Reg. 65,310/3. People living with asthma suffer more severe impacts from ozone exposure than healthy individuals and are more vulnerable at lower levels of exposure. *Id.* 65,311/1 n.37, 65,322/3.

Ozone exposure has been linked to the development of asthma, as well as its exacerbation. For individuals already diagnosed with asthma, evidence shows that ozone exposure increases the likelihood of having an asthma attack.[2] Ozone exposure has been shown to have especially significant effects on asthma exacerbation among children. Children living in areas with higher ambient ozone concentrations have been shown to be more likely to either have asthma or to experience asthma attacks compared with children living in areas having lower ambient ozone concentrations.[3]

Additionally, certain "sensitive" groups and individuals are found to have significantly greater susceptibility to ozone-related health impacts. In a 14-year study of 95 U.S. cities, links were found between short-term increases in ozone and premature mortality, even when excluding days exceeding 60 ppb, finding that that "daily changes in ambient O3 exposure are linked to premature deaths, even at very low pollution levels."[4] Other health impacts linked to ozone exposure are related to newborns and the developing fetus.[5] Prenatal exposure to ozone has been linked to reduced birth weight, premature delivery, and birth defects.[6]

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[2] *See, e.g.*, Franze et al., Protein nitration by polluted air, Enviro Sci Technol. 39: 1673-1678 (2005), http://dx.doi.org/10.1021/es0488737; U.S. Environmental Protection Agency, Air quality criteria for ozone and related photochemical oxidants, (EPA/600/R-05/004AF) (2006), http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923.

[3] Akinbami, The association between childhood asthma prevalence and monitored air pollutants in metropolitan areas, United States 2001-2004 (Environ. Res. Apr. 2010), 110(3):294-301, http://dx.doi.org/10.1016/j.envres.2010.01.001.

[4] Bell et al., The Exposure-Response Curve for Ozone and Risk of Mortality and Adequacy of Current Ozone Regulations, Environ Health Perspect. 114:532-536 (2006), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1440776/.

[5] ISA (2013) at 2-20.

[6] Salam et al., Birth Outcomes and Prenatal Exposure to Ozone, Carbon Monoxide, and Particulate Matter: Results from the Children's Health Study, Environ Health Perspec.113: 1638-1644 (2005), http://dx.doi.org/10.1289/ehp.8111.

Ozone also damages vegetation and forested ecosystems, causing or contributing to widespread stunting of plant growth, tree deaths, visible leaf injury, reduced carbon storage, and reduced crop yields. PA 5-2 to -3; ISA 9-1. By harming vegetation, ozone can also damage entire ecosystems, leading to ecological and economic losses. 80 Fed. Reg. 65,370/1-2, 65,377/3.

Currently, approximately half of Texans—over 12 million people—live in areas with air that EPA classified as unsafe to breathe under the 2008 ozone standard.[7] Even more communities violate the more protective 2015 ozone standard.[8] Recent D.C. Circuit decisions regarding the Clean Air Act's Good Neighbor provision mean that Texas is likely to come under obligations to restrict its significant contributions of ozone pollution on downwind states in the near future.[9]

B. Ozone Pollution is a Serious Health Problem in Houston.

Residents of the Houston area are consistently exposed to some of the highest ozone levels in the Central United States. Indeed, air quality monitors in the area consistently exceed the ozone levels current scientific research dictates as necessary to protect human health—especially for sensitive populations such as children, asthmatics, the elderly, and outdoor workers. In fact, the Houston area consistently ranks as one of the most polluted cities in the country for ozone.[10]

For decades, the eight counties making up the Houston area have struggled to attain federal NAAQS for ozone pollution, which are designed to protect human health and welfare. For more than forty years—throughout the implementation of the most recent 2015 ozone standard to the first 8-hour standard in 1997, and further back to the 1-hour standard, and then further back still to photochemical oxidant standards in the

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[7] *Compare* EPA's Greenbook, available at http://www.epa.gov/oaqps001/greenbk/ancl.html (listing Texas counties in nonattainment for the 2008 ozone standards), with U.S. Census Bureau, American FactFinder, 2010 Demographic Profile (search population for each county in the nonattainment areas and Texas population), https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. We incorporate by reference all cited documents into these comments

[8] http://www.epa.gov/oaqps001/greenbk/ancl.html (listing Texas counties in nonattainment for the 2015 ozone standard)

[9] *See Wisconsin v. EPA*, Nos. 16-1406, slip op. (D.C. Cir. Sept. 13, 2019) (finding Clean Air Act's Good Neighbor Provision requires upwind states to eliminate their significant contributions to downwind states' nonattainment problems by respective attainment dates); *see also New York v. EPA*, 2019 WL 4804419 (D.C. Cir. Sept. 30, 2019) (vacating EPA rule partially addressing interstate ozone transport obligations under 2008 NAAQS).

[10] American Lung Association, 2019 State of the Air Report, Most Polluted Cities (ranking the Houston area as the 9th most polluted area in the nation), https://www.lung.org/our-initiatives/healthy-air/sota/city-rankings/most-polluted-cities.html.

early 1970's—the Houston area has consistently failed to meet ozone maximum air quality standards designed to protect human health and welfare. Indeed, the same eight counties in the Houston area—Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller—have been designated "nonattainment" under each of EPA's ozone NAAQS, meaning they have had, or have been contributing to, ozone pollution levels that violate health standards for ozone since the 1970s. 40 C.F.R. § 81.344. And air quality monitors throughout the Houston area regularly report exceedances of federal standards.

The Houston area has a long history of missing attainment dates and seeking extensions, even when the area's history and current data call for stronger ozone control measures. Under the 1-hour 1979 and the 1997 8-hour ozone standards, Houston was classified as "severe"—the second worst classification under the Act. 80 Fed. Reg. 12,264, 12,311 app.B (Mar. 6, 2015) ("Implementation Rule" for the 2008 ozone standard). At the time of the implementation of the 2008 ozone standard, the Houston area had still not complied with either the 1979 or the 1997 standards, though its attainment deadline under the 1979 standard passed in 2007. *Id.*; *see also* 42 U.S.C. § 7511(a)(1) tbl.1. At the time of initial classifications for the 2008 ozone standard, Houston was classified as "marginal" but due to persistent poor air quality, and after receiving a one-year extension and lodging a failing bid for a second one-year extension, EPA reclassified it to "moderate" with an attainment date of July 20, 2018. 80 Fed. Reg. 90,207 (Dec. 14, 2016) (reclassifying Houston area from marginal to moderate); *See also* 77 FR 30,160 (May 21, 2012) (setting moderate area attainment date); *see also* 80 FR 12,264, 12,267/3-68/2 (Mar. 6, 2015) (revising attainment deadlines in light of *NRDC v. EPA*, 777 F.3d 456 (D.C. Cir. Dec. 23, 2014)). Now, the Houston area misses yet another attainment date—the "moderate" area attainment date—and thus must be reclassified to "serious" for the 2008 ozone standard with a new attainment date of July 20, 2021. 84 Fed. Reg. 44,238, 44,244/2 (Aug. 23, 2019).

Texas's failing air quality has serious and well-documented health consequences for the nearly 6 million Texans that live in the Houston area. Scientific research continues to strengthen our understanding of the harm that ozone causes to public health. As discussed above, exposure to ozone is connected to a wide range of significant human health impacts including respiratory and cardiovascular harms, premature deaths, perinatal and reproductive impacts, and central nervous system and developmental harms. Serious health impacts have been demonstrated through controlled human exposure, epidemiologic, and toxicological studies.[11] The physiological impacts of ozone exposure are experienced even by healthy individuals

[11] *See* ISA (2013).

and even at relatively low concentrations of ozone. Moreover, there is a growing body of scientific evidence showing that repeated exposure over time causes additional health impacts, which may be more severe and less likely to be reversible.

For residents of Harris County alone, the consequences of smog are not trivial. Considering the health impacts of smog pollution from oil and gas operations in Harris County between 2016 and 2017, the Clean Air Task force found that children missed 9,954 days of school—over 27 years of education lost—and suffered from 13,600 asthma attacks. Seniors restricted their activities on 25,724 days.[12] These are just quantified examples the many ways quality of life is diminished by poor air quality for the millions of residents of the Houston nonattainment area. And these adverse health consequences are not evenly felt in the population, as discussed below, historically disenfranchised communities suffer the brunt of the health effects from this pollution.

C. Ozone Pollution Disproportionately Harms Low Resource Communities and Communities of Color in the Houston Nonattainment Area.

The acute harms of ozone pollution in the Houston nonattainment area are not felt evenly, numerous studies and data demonstrate that low resource communities and communities of color bear a higher burden. For example, in the historic Harrisburg and Manchester neighborhoods in east Houston, 97% of residents are people of color, 90% are low income, and 37% live in poverty.[13] Overall, there is a concentration of major industrial sources of air pollution in such communities. *Id.* at 3-6, 13. As of 2016, 26 Risk Management Plan industrial facilities—facilities that handle extremely hazardous substances and must report their emissions to the EPA's Toxic Release Inventory—operate in Manchester. *Id.* at 19. Major industrial sources, like those, are among the types of sources that are subject to requirements for Clean Air Act controls in the Texas SIP.

Focusing on unauthorized emissions of VOCs, a recent study finds that these environmental justice communities concentrated around the Houston Ship Channel are disproportionately affected by unauthorized emissions: "unauthorized VOC emissions…are most prevalent in the area around the Ship Channel," and "vulnerable populations experience greater emissions densities (on average) than their more

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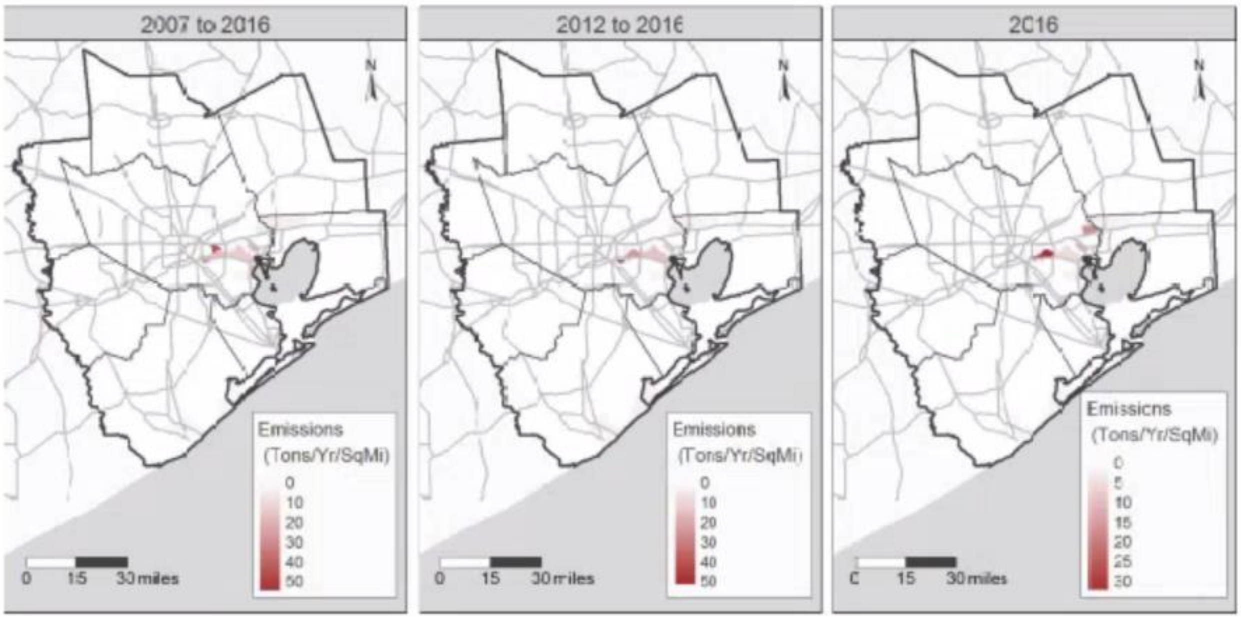
[12] The Oil and Gas Threat Map (search Harris County) (last visited October 28, 2019), https://oilandgasthreatmap.com/threat-map/.

[13] Center for Democracy at the Union of Concerned Scientists, *Double Jeopardy in Houston, Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities* 5-6 (Oct. 2016), https://www.ucsusa.org/sites/default/files/attach/2016/10/ucs-double-jeopardy-in-houston-full-report-2016.pdf (*Double Jeopardy*).

advantaged counterparts…due to the greater severity of emissions burdens that vulnerable populations bear when they live in tracts with emissions."[14] The maps below illustrate the existing disparity:



Unauthorized VOC Emission in the Eight County Houston Region. *Id.* at 25 fig. 5.

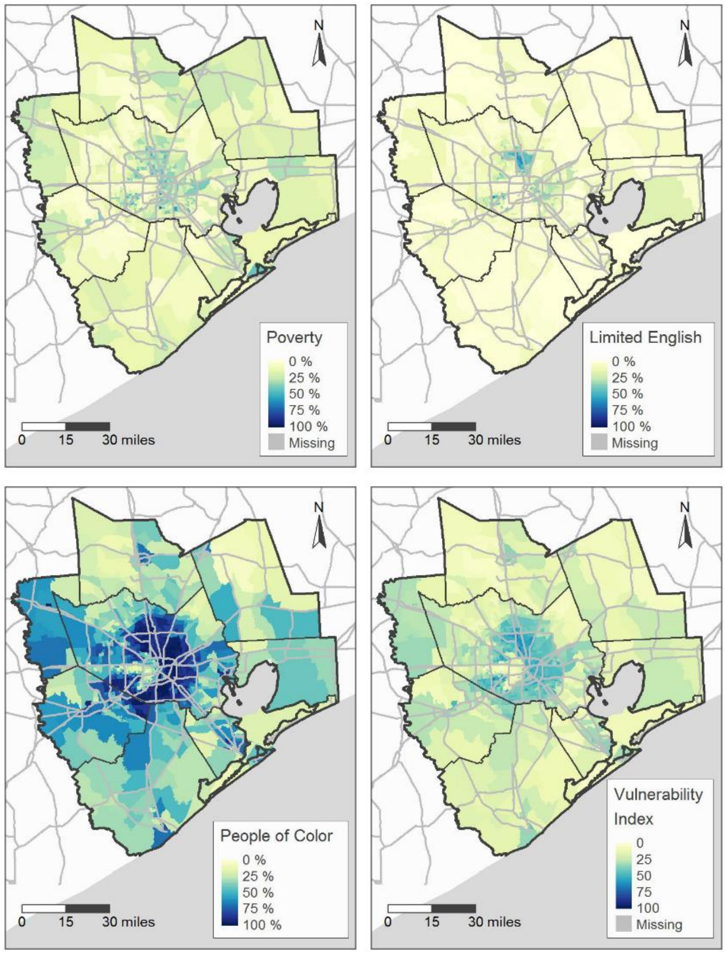
These VOCs include chemicals that are extremely dangerous on their own, like the listed hazardous air pollutants benzene, toluene, and formaldehyde. *See* 40 C.F.R. § 51.100(s) (defining VOC as "any compound of carbon, excluding [certain compounds], which participates in atmospheric photochemical reactions"); EPA, Technical Overview of Volatile Organic Compounds, http://www.epa.gov/indoor-air-quality-iaq/technical-overview-volatile-organic-compounds (discussing benzene, formaldehyde, and toluene as examples of VOCs); 42 U.S.C. § 7412(b)(1) (listing all three compounds as hazardous air pollutants). VOCs are also stored in above-ground storage tanks, the same kind of tanks that recently caught on fire within the nonattainment area at the Deer Park Intercontinental Terminal Company facility and darkened the sky over Houston in a cloud of smoke laced with toxic chemicals like toluene, benzene, and butane.[15]

[14] Sustainable Systems Research, LLC, *Evaluation of Vulnerability and Stationary Source Pollution in Houston* ("2019 Houston Vulnerability Study") at 22 (Feb. 8, 2019), Attachment 1; *see also id.* at 23 tbl.5 (providing statistics).
[15] Letter, Toby Baker, Executive Director, TCEQ to Hon. Ron Reynolds, TX House of Representatives (Apr. 17, 2019), https://www.tceq.texas.gov/assets/public/response/smoke/correspondence/response-letter-to-Representative-Reynolds.pdf.

"The Houston Ship Channel is home to a number of environmental justice communities where long-term exposure to pollution already increases cancer risk by a factor of 1000. Levels of 1,3-butadiene and benzene, both carcinogenic VOCs and other precursor pollutants associated with formation of ground-level ozone, have been monitored for several years along the Houston Ship Channel. In the case of 1,3-Butadiene, a recent epidemiological investigation confirmed a trend of increased incidence of any type of leukemia in children living in parts of Harris County with higher average ambient air 1,3-butadiene concentrations compared to children living in areas of Harris County with lower concentrations of the pollutant. For children living near the Houston Ship Channel, there is a noted increase in the incidence rate of acute lymphocytic leukemia."[16]

And the disproportionate pollution harming Manchester and other Houston Ship Channel communities goes beyond ozone's toxic VOC precursors to particulate matter, and others. For example, spikes from so-called malfunctions of all types of air pollutants contribute to chronic health risks. 2019 Houston Vulnerability Study 22. In the Harrisburg and Manchester communities, "[l]ong-term daily exposures to air pollution can lead to health effects that go unaddressed due to residents' limited financial and health care resources." *Double Jeopardy* at 6. Today, Manchester experiences among the greatest vulnerability from air emissions by surrounding industrial polluters. 2019 Houston Vulnerability Study 25. Other communities of color, especially in eastern portions of Houston-Galveston-Brazoria ozone nonattainment area, bear a similar disproportionate emissions burden, including Pleasantville, Fifth Ward, Pasadena, Clinton Park, Galena Park, Deer Park, and Baytown. The map below illustrates high concentrations of people of color in eastern portions of the nonattainment area and their greater vulnerability to a variety of air pollutants discussed in the attached study.

[16] Brief of Caring for Pasadena Communities as Amicus Curiae p. 14, *Sierra Club v. EPA*, Nos. 15-1465 & 19-1024 (D.C. Cir. filed Jul 22, 2019) (internal citation omitted) (Commenters adopt amici's disproportionality arguments and supporting materials cited), Attachment 2.



Vulnerability in the Eight County Houston Region. *Id.* at 19.

II. THE PROPOSED RULE IS ILLEGAL AND ARBITRARY.

A. The Plan Fails to Demonstrate Timely Attainment as Required by the Clean Air Act.

The attainment demonstration SIP fails to show timely attainment of the 2008 ozone health standard by 2020 as required by the Clean Air and EPA rules. TCEQ's own model shows a 2020 design value of 76 ppb which does not meet the 2008 standard of 75 ppb. TCEQ attempts to use a "weight of evidence" analysis to overcome this modeling result, but that analysis is deficient and simply not credible. The actual monitored design value for the Houston-Galveston-Brazoria (HGB) area as of 2018 was 78 ppb, and monitoring data for 2019 shows continued high ozone levels. According to TCEQ data[17], multiple monitoring locations have already recorded fourth-highest 8-

[17] posted at https://www.tceq.texas.gov/cgi-bin/compliance/monops/8hr_exceed.pl.

hour ozone levels well in excess of 75 ppb this year, with the highest of these being 81 ppb.[18]

Trend data also refutes TCEQ's weight of evidence analysis. Design values show repeated violations of the 2008 NAAQS over recent years, with a value of 81 ppb as recently as the 2015-17 period. Contrary to TCEQ's assertions there is not a downward trend in the most recent years, but rather a repeated recurrence of levels in excess of the standard, alternating between higher and lower exceedances. Three of the past five design value periods have shown values of 80 ppb or higher. The following are design values reported for HGB for the periods 2007-09 through 2016-2018 respectively (in ppb):[19]

84	84	89	88	87	80	80	79	81	78

The data thus do not support a conclusion that the modeling is overpredicting ozone levels for 2020. If anything, the model is likely underpredicting ozone levels.
We also have concerns about TCEQ's use of outdated vehicle registration data to calculate mobile source emission inventories relied on in the model. The vehicle registration data used to calculate attainment and reasonable further progress in these SIPs are from the year 2014. Vehicle registration data is available to the public and is being updated daily by the Texas Department of Motor Vehicles. TCEQ must use the latest available data.

B. The Proposed Rule violates Title VI of the Civil Rights Act of 1964 and EPA's implementing civil rights regulations.

Finalizing a plan without stronger emission control measures where data demonstrate disproportionate harm and an area's air quality data models for NAAQS nonattainment by the attainment date is contrary to Title VI of the Civil Rights Act of 1964. Title VI of the Civil Rights Act of 1964 prohibits recipients of federal funds from discriminating against individuals on the basis of race, color, or national origin. 42 U.S.C. § 2000d. Title VI directs federal agencies granting federal assistance to issue regulations to achieve the statutory objectives. *Id*. § 2000d-1. EPA's implementing regulations state that "[n]o person shall be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving

[18] *See* attached summary sheet, Attachment 3.
[19] Data from EPA, Ozone Design Values, 2018 (XLSX) (973 K, 7/23/2019); https://www.epa.gov/air-trends/air-quality-design-values#report.

EPA assistance on the basis of race, color, [or] national origin[.]" 40 C.F.R. § 7.30. The regulations also provide a non-exclusive list of specific, prohibited discriminatory acts:

> (b) A recipient shall not use criteria or methods of administering its program or activity which have the effect of subjecting individuals to discrimination because of their race, color, national origin, or sex, or have the effect of defeating or substantially impairing accomplishment of the objectives of the program or activity with respect to individuals of a particular race, color, national origin, or sex.

Id. § 7.35. Federal-funding recipients cannot "[r]estrict a person in any way in the enjoyment of any advantage or privilege enjoyed by others receiving any service, aid, or benefit provided by the program or activity." *Id.* § 7.35(a)(3).

The Proposed Rule violates Title VI of the Civil Rights Act of 1964 and EPA's implementing regulations. By TCEQ's own data, the Houston area is set to fail its serious area attainment deadline because its current design value exceeds the 2008 ozone NAAQS.[20] As discussed above, studies and data demonstrate that air pollution, and specifically ozone pollution and ozone precursor pollution, disproportionally harm people of color in the Houston nonattainment area. TCEQ's foot-dragging in implementing stronger emission controls in the face of this persistent smog problem prolongs the disproportionate pollution burden people of color in the Houston area suffer. This means that people of color in the Houston area enjoy the outdoors less and suffer more the health consequences of persistent air quality when compared to white Houston area residents.[21]

There are several measures TCEQ could take through this SIP revision to ameliorate the historic disproportionate harm to people of color. TCEQ should require implementation of available Reasonably Available Control Measures and Reasonably Available Control Measures, as required by the Act and discussed below. The agency could also revoke Texas's affirmative defense provision for startup, shut down, and malfunction events prior EPA's finalization of the proposed withdraw of finding of substantial inadequacy (84 Fed. Reg. 17,986 (Apr. 29, 2019))—a policy that, when in use, allowed polluters to claim the defense and avoid enforcement for approximately 97% of

[20] Proposed Rule ES-1 ("The peak ozone design value for the HGB nonattainment area is projected to be 76 ppb in 2020…").

[21] *See Double Jeopardy* comparing Harrisburg/Manchester to predominantly white neighborhoods in Houston.

unauthorized releases.[22] This would help address some of the disproportionate VOC emissions burden borne by Houston Ship Channel communities, specifically discussed above.

Further, the Commission could extend the comment period, hold another public hearing, and provide *meaningful* opportunities for public participation for the most affected residents of the Houston nonattainment area. The Commission held a public hearing on Monday, October 14, 2019 at 2p.m. at the Houston Texas Department of Transportation office, and another in Arlington on October 17 under similar circumstances. This is hearing did not provide the public a meaningful opportunity to participate. For example, a government-issued identification card is required to enter this building and it is accessible only through very limited public transportation, creating unnecessary roadblocks for elderly residents, disabled persons, youth advocates who must attend school, and undocumented persons who may lack government-issued identification.[23] Using public transportation, it would take someone living in Manchester over an hour and a half to travel to this building. Further, by some measures, Houston has been named the most diverse city in the nation, with over 140 languages spoken by its residents[24], meaning, that TCEQ's English-only public hearing notice is wholly inept at garnering public participation in this part of Texas.[25]

Given the area's history of missing attainment dates and with modeled nonattainment for the serious area attainment deadline, TCEQ failure to implement enhanced emission control measures perpetuates the disproportionate harm borne by people of color in the Houston area in violation of Title VI and EPA's implementing regulations.

C. TCEQ's failure to implement Reasonably Available Control Measures in the Houston area is unlawful and arbitrary under Clean Air Act § 172(c)(1).

TCEQ's failure to implement all reasonably available control measures ("RACM") because it purportedly cannot implement measures by the next ozone

[22] *See* 84 Fed. Reg. 17,986, Docket No. EPA-R06-OAR-2018-0770, Comments of Environmental and Community Group Coalition 1-2.
[23] One's status in this country is irrelevant to participation in SIP revisions or any other environmental permitting or rulemaking action before the TCEQ.
[24] Bryan Kirk, Houston Named the Most Diverse City in the U.S. in Recent Survey (Apr. 10, 2019), https://patch.com/texas/houston/houston-named-most-diverse-city-u-s-recent-survey.
[25] TCEQ, Notice of Public Hearing on Proposed Revisions to 30 Texas Administrative Code Chapters 115 and 117 and to the State Implementation Plan, https://www.tceq.texas.gov/assets/public/legal/rules/hearings/19075115_phn_HGB.pdf.

season plainly violates the Act. Under Act requirements, Texas must implement all available RACM and RACT controls through this SIP revision.[26]

RACM are an independent requirement on all nonattainment areas that that imposes a duty to adopt **all** reasonable available control measures as expeditiously as practicable. 42 U.S.C. § 7502(c)(1); *see also Ober v. Whitman*, 243 F.3d 1190 (9th Cir. 2001). The RACM requirement is an overarching requirement on states to implement reasonable measures as a means of meeting and maintaining standards. *See Sierra Club v. EPA*, 291 F.3d 155, 162 (D.C. Cir. 2002).

RACM determinations submitted to EPA for review must be supported by adequate analysis and data. *See Ober,* 243 F.3d at 1195 (*quoting American Lung Ass'n v. EPA*, 134 F.3d 388, 392–93 (D.C. Cir. 1998)). States must "consider all available control measures and [] adopt and implement such measures as are reasonably available for implementation in the areas as components of the area's attainment demonstration." General Preamble for the Implementation of Title I of the Clean Air Act Amendments of 1990, 57 Fed. Reg. 13,498, 13,560/2 (Apr. 16, 1992). EPA has provided guidance to states on what constitutes RACM. *See* 74 Fed. Reg. 2945, 2951/3 (Jan. 16, 2009) (for the 1997 ozone NAAQS). Here, TCEQ has failed to conduct a thorough review of all available RACMs. It has rejected stronger RACMs without reasoned explanation. TCEQ has also failed to consider all ozone controls adopted in the South Coast Air Quality management District in California, or recommended by the Ozone Transport Commission in the Northeast, or identified in EPA guidance. Nor has TCEQ fully evaluated the transportation control measures identified in Clean Air Act section 108(f) and in EPA guidance elaborating on those measures.

TCEQ's failure to implement even a single new RACM in the Houston area, despite modeling nonattainment, is contrary to the Clean Air Act. Quite simply, TCEQ does not have discretion to delay additional RACM that are needed to timely attain. TCEQ claims that RACM measures "would have to be in place no later than the beginning of ozone season in the attainment year to be considered RACM, or January 1, 2020." Proposed Rule 4-10. But TCEQ has not even tried to show it cannot implement additional RACM in time to produce attainment in the 2020 ozone season. Nor has it demonstrated that timely implementation of sufficient measures is impossible. Even if it could, the claim that Texas cannot implement any new RACM in Houston because of

[26] Dr. Ranajit Sahu, Comments on the Reasonably Available Control Technology (RACT) and Reasonably Available Control Measures (RACM) for the 2008 Ozone NAAQS Attainment SIP Modifications Proposed by the Texas Commission on Environmental Quality (TCEQ) for the Houston-Galveston-Brazoria (HGB) and Dallas-Fort Worth (DFW) Non-Attainment Areas (Oct. 28, 2019) ("Sahu Report"), Attachment 4.

TCEQ's "inability to implement control measures early enough to advance attainment of the 2008 eight-hour ozone NAAQS" impermissibly renders the RACM requirement void. *Id.* By this logic, TCEQ may perpetually short shrifts the Act's RACM requirement — even as the area stands to be reclassified to severe due to persistent smog pollution. Moreover, the claim is simply not credible. As documented in the Sahu Report filed herewith, there are numerous RACM and RACT measures that can be implemented in very short order to curb emissions of ozone precursors.

Texas must implement RACT and RACM as part of this reclassification because it is likely that Houston will fail to meet its serious area attainment date. The Houston area currently models nonattainment of the 2008 ozone NAAQS and there is a strong likelihood that it will fail to meet its serious area attainment deadline, as discussed above. Under this likely scenario, the Houston area is reclassified to severe, and its attainment date is extended by six years to July 20, 2027, 42 U.S.C. § 7511(a)(1) tbl.1, and the last set of air quality data that could be used to demonstrate attainment with this deadline is the ozone season ending on July 20, 2026. Within six months of the passage of the attainment date, or by January 20, 2022, EPA must determine whether the Houston area attained the 2008 ozone NAAQS by the serious area attainment date or reclassify the area to severe. *See* 42 U.S.C. § 7511(b)(2)(A), (B). But EPA is frequently tardy in carrying out this nondiscretionary duty. *See Center for Biological Diversity v. EPA*, 3:19-cv-2462-RS (N.D.C.A.) (case filed May 7, 2019) (lawsuit regarding EPA's failure to finalize attainment determinations by the Act's deadlines). At the time of Houston's serious area reclassification, the EPA Administrator used his discretion to set a SIP revision due date, including RACT measures, of August 3, 2020, approximately one year prior to the serious area attainment date of July 20, 2021 and one year after the effective date of the rule. 84 Fed. Reg. 44,245/3.[27] Without stronger RACM and RACT requirements in this SIP revision, the Houston area will fail to timely attain the serious area attainment deadline, and – under TCEQ's approach – may not see new control measures for the 2008 ozone NAAQS until 2024 or later—where any new measures would provide two-years' worth or less of emission reduction benefits to demonstrate severe area attainment. This outcome is absurd and runs contrary to the carefully designed framework for timely attainment prescribed by the Clean Air Act.

[27] EPA's discretion-based SIP submittal date does not excuse Texas from adopting all RACM and RACT necessary to attain the 2008 standard by the 2020 ozone season. There, Texas cannot wait until August 2020 to adopt and implement all the measures needed to ensure timely attainment in 2020.

D. TCEQ arbitrarily disregards Reasonably Available Control Technology.

TCEQ claims that, based on its flawed framework, RACT measures are simply not available – TCEQ's contentions lack support in the record. The agency claims that existing Texas Administrative Code provisions regarding NOx and VOC controls "continue to fulfill [] RACT requirements for the HGB serious ozone nonattainment area under the 2008 eight-hour ozone NAAQS" and that additional controls for "certain major sources were determined to be either not economically feasible or not technologically feasible." Proposed Rule 4-7 to -8. Yet, based on independent research and TCEQ's own appendices to the Proposed Rule, Commenters' expert was able to identify numerous cost effective RACT measures for NOx and VOC sources that are easily implementable before the next ozone season.[28] TCEQ's reluctance to implement any new RACT measures through this SIP revision arbitrarily disregards this Clean Air Act requirement.

Moderate and higher ozone nonattainment areas must develop plans that implement "reasonably available control technology under [42 U.S.C. §] 7502(c)(1)" for "all…major stationary sources of [volatile organic compounds]" and NO_x. 42 U.S.C. § 7511a(b)(2), (f). Revisions to SIPs must include EPA-issued control technique guidelines ("CTGs") and alternative control techniques ("ACTs") for major sources of VOCs and NOx. RACT "defines the lowest limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility." Memorandum from R. Strelow, Asst. Adm'r, EPA, Office or Air and Waste Management, to Reg'l Adm'rs, EPA Regions I-X, re: *Guidance for Determining Acceptability of SIP Regulations in Non-Attainment Areas* 2 (Dec. 9, 1976) ("Strelow Memo"). RACT "means devices, systems, process modifications, or other apparatus or techniques that are reasonably available taking into account: (1) [t]he necessity of imposing such controls in order to attain and maintain a national air quality standard; (2) [t]he social, environmental, and economic impact of such controls; and (3) [a]lternative means of providing for attainment and maintenance of such standard [for requests for deadline extensions]." 40 C.F.R. § 51.100(o).

"RACT encompasses stringent, or even 'technology forcing,' requirement[s]." Strelow Memo 2; *See also Whitman v. Am. Trucking Ass'ns*, 531 U.S. 457, 492 (2001) (Breyer, J. concurring) (noting that technology forcing requirements "are still paramount in today's [Clean Air] Act"). "In every case RACT should represent the toughest controls considering technological and economic feasibility that can be applied to a specific situation. Anything less than this is by definition less than RACT and not

[28] Sahu Report at 9-20.

acceptable for areas where it is not possible to demonstrate attainment[.]" Strelow Memo 3.

In support of timely attainment, RACT determinations must be made and implemented quickly. *See Miss. Comm'n on Envtl. Quality v. EPA*, 790 F.3d 138, 146 (D.C. Cir. 2015). In SIP revisions, States must submit supporting evidence with their RACT determinations. *NRDC v. EPA*, 571 F.3d 1245, 1254 (D.C. Cir. 2009); *see, e.g.*, 80 Fed. Reg. 12, 264, 12,278/2-80/2 (Mar. 6, 2015). States cannot rely on RACT determinations for previous ozone standards without explanation as to the continued adequacy of the RACT measures. *See* 81 Fed. Reg. 58,010, 58,037/3 (Aug. 24, 2016). The Act provides states with "discretion to require beyond-RACT reductions from any source" because "it may be necessary in some cases for states to achieve 'beyond RACT' reductions in order to demonstrate attainment as expeditiously as practicable." 80 Fed. Reg. 12,279/3.

"Past experience has shown that due to ongoing innovation, cost-effective control technologies and processes alternatives for many sectors continue to be developed…." *Id.* EPA guidance requires states to use information available at the time the RACT SIPs are developed. For example, ACTs, public comments, other relevant information. *See, e.g.,* 80 Fed. Reg. at 12,279/2. Even where ACTs and CTGs may be dated, EPA says that there is other information that is current from which states can provide adequate analysis. *Id.*; 78 Fed. Reg. 34,178, 34,192/2-3 (June 6, 2013). Thus, ACTs and CTGs may not themselves set firm RACT requirements.

Texas must require new RACT in Houston now because the Act so requires, because the area is on track to fail the serious area attainment date and there are stronger RACT measures available. Commenters' expert, Dr. Ranajit Sahu, outlines numerous RACT measures available for implementation that could reduce NOx and VOC emissions, and address the disproportionate burden on environmental justice communities within the nonattainment area. The single largest source of NOx emissions (by a factor of 10) in the Houston area is the W.A. Parish power plant. At this plant, gas-fired units actually emit more NOx than the coal units. Dr. Sahu identifies additional controls, such as "low-NOx burners, or ultra low NOx burners, SNCR, and SCR [selective catalytic reduction]"[29] for these highly polluting units. At the W.A. Parish coal units, new RACT measures appear even more readily accessible, including "properly maintaining and operating already in-place SCIRs for these units" along with other measures.[30]

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[29] Sahu Report at 15.

[30] *Id.*

TCEQ must implement new RACT and RACM measures for refineries because these are readily available. Refineries are large contributors to the ozone problem in Houston and a source of significant disproportionate impacts for environmental communities in the area. Typical reasonably available controls for refineries include "a combination of ultra low NOx burners/FGR/SNCR or ultra low NOx burners/SCR"[31] yet TCEQ does not propose these as RACM or RACT. Measures that do not require long lead times include "better maintenance or proactive replacement of equipment" to prevent and detect leaks of VOCs, also not proposed by TCEQ.[32] There are also readily available RACM and RACT measures for storage tanks at these refineries . Among other things, TCEQ must require all high vapor products "stored in internal floating roof or fixed roof tanks –[be] connected to a vapor recovery or vapor control system with a specified (and verifiable) capture and/or control efficiency of at least 99%."[33] Dr. Sahu demonstrates that there are storage tanks permitted for operation by TCEQ that achieve this level of efficiency; also available are "carbon adsorbers and concentrators (for vapor recovery), and/or catalytic oxidizers and regenerative thermal oxidizers (RTOs) (for destruction of vapors)."[34] TCEQ's RACT and RACM analysis fails to address available NOx and VOC emission reductions available from refinery and storage tank sources.

Additional details for these and other RACT and RACM measures are identified and explained in Dr. Sahu's discussion.

In sum, the Act does not allow TCEQ to disregard and refuse to adopt additional RACM and RACT. Such additional measures are required by the Act, and are necessary to ensure attainment as expeditiously as practicable.

Sincerely,

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[31] *Id.* at 18.
[32] *Id.*
[33] *Id.* at 20.
[34] *Id.*

Attachment 3

Comments on the Reasonably Available Control Technology (RACT) and Reasonably Available Control Measures (RACM) for the 2008 Ozone NAAQS Attainment SIP Modifications Proposed by the Texas Commission on Environmental Quality (TCEQ)

for the

Houston-Galveston-Brazoria (HGB) and Dallas Fort Worth (DFW) Non-Attainment Areas

by

Dr. Ranajit (Ron) Sahu, Consultant[1]

A. Introduction

I have prepared these comments on the proposed Houston-Galveston-Brazoria (HGB) and Dallas Fort Worth (DFW) State Implementation Plan (SIP) modifications by Texas Commission on Environmental Quality (TCEQ) for the as a result of the Serious classification of these areas for the 2008 eight-hour ozone National Ambient Air Quality Standards (NAAQS).

As part of the SIP, the TCEQ was supposed to propose reductions in precursor pollutants NOx and VOCs (which, together with sunlight, form ozone in the atmosphere) in each of these areas pursuant to Reasonably Available Control Technology (RACT[2]) and Reasonably Available Control Measures (RACM[3]) analyses.

I have prepared these focused comments on behalf of Earthjustice and its clients. I focus on the TCEQ's RACT and RACM analyses provided in Appendix F (RACT) and Appendix (G) of the respective SIP modifications.

My focus in these comments pertain to stationary sources only. In summary, for reasons stated in its analyses, the TCEQ has proposed no additional reductions of NOx or VOC emissions

[1] Resume provided in Attachment A.

[2] As noted in the SIPs:

> "RACT is defined as the lowest emissions limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility….RACT requirements for moderate and higher classification nonattainment areas are included in the [Federal Clean Air Act] FCAA to assure that significant source categories at major sources of ozone precursor emissions are controlled to a reasonable extent…"

[3] As noted in the SIPs:

> "[W]hile RACT and reasonably available control measures (RACM) have similar consideration factors like technological and economic feasibility, there is a significant distinction between RACT and RACM. A control measure must advance attainment of the area towards the meeting the NAAQS for that measure to be considered RACM. Advancing attainment of the area is not a factor of consideration when evaluating RACT because the benefit of implementing RACT is presumed under the FCAA."

under either RACM or RACT from any stationary sources in each of these two non-attainment areas, whose ozone problems are clearly getting worse and not better. TCEQ claims, in its analyses that stationary sources, which are already subject to TCEQ's current rules and regulations, cannot provide additional emissions reductions.

In the case of RACM, relying on absurd EPA guidance, TCEQ could not find any additional reductions[4] because these reductions would need to advance the attainment date by one year.[5]

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[4] HGB SIP, Appendix G, Section 4.1

> "[T]he TCEQ determined that no potential control measures met the criteria to be considered RACM."

See also, Section 4.2:

> "[A]dditional NO_X control measures cannot be implemented in time to advance attainment of the 2008 eight-hour ozone NAAQS in the HGB area. For this reason and for the other reasons identified in Table G-1, no NOx control measures are included as RACM for this SIP revision."

See also Section 4.3:

> "Additional VOC control measures cannot be implemented in time to advance attainment of the 2008 eight-hour ozone NAAQS in the HGB area."

DFW SIP, Appendix G, Section 4.1

> "[B]ased on the RACM analysis, the TCEQ determined that no potential control measures met the criteria to be considered RACM. All potential control measures evaluated for stationary sources were determined to not be RACM due to technological or economic feasibility, enforceability, adverse impacts, or ability of the measure to advance attainment of the NAAQS. In general, the inability to advance attainment is the primary determining factor in the RACM analyses."

See also Section 4.2:

> "[A]dditional NO_X control measures will not advance attainment of the 2008 eight-hour ozone NAAQS in the DFW area because it is not possible to implement any significant and cost-effective control measure early enough to advance attainment."

See also Section 4.3:

> "…For this reason and for the other reasons identified in Table G-1, no VOC control measures are included as RACM for this SIP revision."

[5] The absurdity of this constraint is illustrated by the following TCEQ discussion relating to RACM for each non-attainment area. TCEQ first notes that among the criteria that a measure must meet in order to qualify as RACM, is the requirement that the "…control measure can advance the attainment date by at least one year." TCEQ then goes on to state:

> "[T]he EPA did not provide guidance in the *Federal Register* notice on how to interpret the criteria "advance the attainment date by at least one year." Considering the July 20, 2021 attainment date for this attainment demonstration, the TCEQ evaluated this aspect of RACM based on advancing the attainment date by one year, to July 20, 2020….For a control measure to "advance attainment," it would need to be implemented prior to the beginning of ozone season in the attainment year, so suggested control measures that could not be implemented by January 1, 2020 could not be

This is practically impossible, given the typical regulatory calendar. Thus, following EPA guidance for RACM means that RACM, as an emissions reduction tool for stationary sources, would never be applicable – an absurd result.

For RACT, TCEQ also did not find any additional emissions reductions beyond what is already on the books under its current regulations. In turn, some of these regulations reflect EPA's decades-old Control Technology Guidelines (CTG) documents and Alternative Control Technologies (ACT) documents.

TCEQs conclusions are unsupportable and irrational. In the comments below, I show that additional NOx and VOC emissions reductions are available from stationary sources in each of these non-attainment areas. My analysis, as noted above, is not meant to be comprehensive – i.e., I do not provide a detailed analysis of every single opportunity for emissions reductions at every single source of NOx and VOC in these non-attainment areas. Rather, it is focused. Its purpose is to show that additional reductions are available had TCEQ have made reasonable efforts to analyze current, reported emissions.

For all of my analyses below, in the categories I describe, I rely on reported actual emissions by sources in these two non-attainment areas (aggregating the various counties in each of these non-attainment areas) for the year 2017[6] – the most recent year for which actual emissions data are reported.[7] I do not have year 2018 data, which are expected to be released later this year or in early 2020.

> considered RACM because the measures would not advance attainment. To "advance the attainment date by at least one year" to July 20, 2020, suggested control measures would have had to be been fully implemented by January 1, 2019, which has already passed. In order to provide a reasonable amount of time to fully implement a control measure, the following must be considered: availability and acquisition of materials; the permitting process; installation time; and the availability of and time needed for testing."

Therefore, since the time for any measure to be considered as RACM "has already passed," TCEQ's rationale means no measure can be considered under RACM. Clearly, this completely guts RACM as a tool under the SIP. This is a patently absurd result.

[6] TCEQ also relied upon the 2017 inventory for its analysis.

See HGB SIP, Appendix F, Section 2.4. "[T]he TCEQ reviewed the 2017 point source emissions inventory, Title V databases, and NSR databases to identify all major sources of NO_X and VOC emissions….Since the point source emissions inventory database reports actual emissions rather than PTE, the TCEQ used reported actual emissions as low as 25 tpy of NO_X or VOC as the cutoff to develop a preliminary major source list…."

See also DFW SIP, Appendix F, Section2.2. "[T]he TCEQ reviewed the 2017 point source emissions inventory…"

[7] By using the reported actual emissions of NOx and VOC by various sources in these two non-attainment areas, I do not imply that I endorse the reliability or accuracy of the reported emissions. I am simply using the data, as reported.

Given the particular interests of my client, I focused my review of potential emissions reduction opportunities on the following types of sources: (i) reductions of NOx from large sources in each of the two non-attainment areas; (ii) reduction of NOx and VOC from selected refinery source in the HGB non-attainment area; and (iii) reduction of VOC (as associated air toxics) emissions from selected storage tanks located in selected refinery sources in the HGB area.[8] I reiterate that by using these example analyses, I do not mean to imply that the opportunities for emissions reductions are just limited to these sources. These are merely examples.

B. Documents Reviewed

In preparing these comments, I have reviewed the proposed SIP language for each non-attainment area as well as the various Appendices referenced in the SIPs.[9] These include Appendix F and Appendix G for each SIP, dealing, respectively, with the RACT and RACM analyses.

C. Comments – Large NOx Sources

NOx reductions are important in each of the two non-attainment areas. As the respective SIPs state:

> "[D]ue to the abundance of naturally occurring biogenic VOC emissions, the DFW area is primarily NO_X-limited with respect to ozone formation."[10]

and

> "…the HGB area is primarily NO_X-limited with respect to ozone formation due to the abundance of naturally occurring VOC emissions in the area, making additional VOC reductions much less effective than NO_X reductions at lowering ozone levels."[11]

Therefore, it is clear that NOx reductions will translate to lower ozone formation in the atmosphere in each of these areas.

C.1. DFW Non-Attainment Area

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[8] This is particularly relevant not just because of the opportunities for reduction of reactive VOCs from such tanks, which would, of course, assist in reaching ozone attainment. Reductions of such VOCs and associated air toxics would also lead to lower adverse impacts of these emissions on low-income neighboring communities located, in some case, literally adjacent to the selected refineries. Thus, such reductions serve multiple-purposes.

[9] Project Number 2019-077-SIP-NR for the HGB area and Project Number 2019-078-SIP-NR for the DFW area.

[10] DFW SIP Appendix G, Section 4.3.

[11] HGB SIP, Appendix G, Section 4.3.

Table 1 below shows the largest NOx emission sources in the DFW non-attainment area, per the 2017 emissions inventory. I have only included sources that reported actual emissions greater than 40 tons/year.

Table 1 – Large NOx Sources (Dallas Fort Worth Non-Attainment Area)

Company	Site	Source Type	Source Name	2017 Emissions (tpy)
TXI OPERATIONS	MIDLOTHIAN PLANT	KILN	#5 CEMENT KILN STACK	1185.8
HOLCIM TEXAS	MIDLOTHIAN PLANT	KILN	KILN NO. 2 MAIN BAGHOUSE, BYPASS BAGHOUSE, COAL MI	774.9
ASH GROVE CEMENT	MIDLOTHIAN PLANT	KILN	RECONSTRUCTED NO.3 CEMENT KILN SYSTEM	453.1
TEXAS LIME COMPANY	TEXAS LIME	KILN	LIME KILN #6	332.7
HOLCIM TEXAS	MIDLOTHIAN PLANT	KILN	KILN NO. 1 MAIN BAGHOUSE, BYPASS BAGHOUSE, AND SCR	261.4
TEXAS LIME COMPANY	TEXAS LIME	KILN	LIME KILN #5	248.9
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 12	189.0
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 21	186.9
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 13	184.6
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 22	182.7
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 11	178.7
LUMINANT	FORNEY POWER PLANT	TURBINE	COMBUSTION TURBINE 23	175.3
ENNIS POWER	ENNIS PLANT	TURBINE	COMBUSTION TURBINE	88.2
ENLINK MIDSTREAM	HUGHES RANCH COMPRESSOR STATION	I.C. ENGINE	CATERPILLAR G3408TA "UNIT 303572"	81.2
CHAPARRAL STEEL	MIDLOTHIAN PLANT	FURNACE	ARC FURNACE "A"	80.5
CHAPARRAL STEEL	MIDLOTHIAN PLANT	FURNACE	ARC FURNACE "B"	80.5
ELK CORPORATION	ELK CORP	THERMAL OX.	RTO INCINERATOR 2	58.8
BRAZOS ELECTRIC POWER	JOHNSON COUNTY GENERATION	TURBINE	COMBUSTION TURBINE GENERATOR 1	55.6
SMURFIT KAPPA	FORTNEY MILL	BOILER	WOOD FIRED BOILER	49.8
MIDLOTHIAN ENERGY	MIDLOTHIAN ENERGY FACILITY	TURBINE	COMBINED CYCLE GAS COMBUSTION TURBINE	48.4
ENLINK MIDSTREAM	LATERAL H-14 COMPRESSOR STATION	I.C. ENGINE	CATERPILLAR 379NA	47.8
OWENS CORNING	WAXAHACHIE PLANT	FURNACE	"V-1" GLASS FURNACE	44.6
ENLINK MIDSTREAM	LATERAL F-G COMPRESSOR STATION	I.C. ENGINE	CATERPILLAR G3406NA	44.5
ENLINK MIDSTREAM	MEADOWS COMPRESSOR STATION	I.C. ENGINE	COMPRESSOR ENGINE	40.5

The largest sources of NOx, as clearly seen in Table 1 are cement kilns at three companies (TXI, Holcim, and Ash Grove). A lime kiln operated by the Texas Lime Company is also among the top 6 sources. Additional sources include combustion turbines, steel electric arc furnaces, and several engines. But none of these are as large as the cement kilns.

I therefore provide some additional discussions on the potential NOx reductions from the cement kilns. It is useful to start with TCEQ's discussion on the obviously large NOx emissions from these kilns. I quote below from the DFW SIP, Appendix G (RACM Analysis). A somewhat parallel discussion is also provided in Appendix F (RACT Analysis).

> "…[T]hree companies currently operate four kilns in Ellis County. These kilns have been operating well under their ozone season NOx source cap due to low product demand and replacement of higher-emitting wet kilns with dry kilns. No additional rulemaking would be needed to realize these reductions.
>
> TXI Operations, LP (TXI) currently operates one dry preheater/precalciner (PH/PC) kiln. This kiln has emitted…1.63 lb NOx/ton of clinker in 2017….The TCEQ entered into an Agreed Order with TXI to include the 1.95 lb NOx/ton of clinker permit limit as a federally-enforceable addition to the Texas SIP….
>
> Ash Grove Cement Company operated three kilns in Ellis County. However, a 2013 consent decree with the EPA required by September 10, 2014 shutdown of two kilns and reconstruction of kiln #3 as a dry PH/PC kiln with continual SNCR operation, an emission limit of 1.5 lb NOx/ton of clinker…Emissions from this kiln in calendar year 2017 averaged 1.32 lb NOx/ton of clinker…
>
> Holcim U.S., Inc. (Holcim) currently has two dry PH/PC kilns equipped with SNCR…Emissions from Line 1, with the SNCR+SCR-THC system, averaged…1.39 lb NOx/ton of clinker during the 2015 to 2017 ozone seasons. Line 2, with SNCR, emitted an average of 1.38 lb NOx/ton of clinker during the 2017 ozone season…The Holcim SCR-THC installation required more than 12 months from permit application to SCR operation, with additional design time prior to application submittal. Therefore, there is insufficient time to design, permit, construct, and commission an SCR system prior to the March 1, 2020 RACM deadline. For these reasons, SCR or hybrid SCR-SNCR are not RACM for the existing Ellis County cement kilns….
>
> Although the source cap emission specification in §117.3123 could be altered to allow for modeling of lower NOx emissions, the estimated reduction of the source cap is unlikely to result in significant real NOx reductions beyond current operation and will therefore not advance attainment."[12] (emphasis added)

There are several significant issues with TCEQ's statements above.

First, relying on actual emissions staying below source caps "…due to low product demand…" does not provide any reassurance that, should demand increase in future years, that the caps would not be threatened. Counting on lower production in the future is not a proper basis for an attainment demonstration.

Second, as the statements above confirm, none of the kilns have the highest NOx controls (i.e., Selective Catalytic Reduction, SCR).[13] At best, the kilns have Selective Non-Catalytic Reduction (SNCR). Permit limits, as shown above range from around 1.5 to 1.95 lb/ton clinker

[12] DFW SIP, Appendix G, Section 4.2.1.

[13] By SCR, I mean SCR for NOx reduction. Holcim's SCR-THC, which uses a catalyst to reduce hydrocarbon emissions but not NOx, is different.

produced. Yet, as TCEQ is well aware, from its own studies as well as in repeated public comments provided by numerous local and national organizations, SCR technology for NOx reduction is widely applied in cement kilns, especially in Europe, and has been for many years.

Companies engaged in air pollution control have long recognized the application of SCR to cement kilns, via public comments. These include the trade organization, the Institute of Clean Air Companies:

> "Selective Catalytic Reduction (SCR) technology represents a mature NOx abatement technology and is an effective technology for reducing NOx emissions from cement kilns."[14]

Other state regulators have also said the same. This includes the National Association of Clean Air Agencies (NACAA):

> "NACAA believes that EPA's proposed NOx emission limit of 1.5 lb/ton clinker seriously underestimates the reductions that are achievable with SCR technology. If SCR systems are installed, Portland cement facilities will achieve far greater reductions than the 1.5 lb/ton estimated to be achievable with SNCR. In fact, by EPA's own estimate, they will be able to achieve reductions of 0.5 lb/ton clinker with SCR, compared to the 1.5 lb/ton clinker that EPA estimates is achievable with SNCR. Therefore, NACAA recommends that SCR be identified as BDT for this sector. This technology is 'the regulated future" for cement kilns."[15] (emphasis added)

Note the fact that NOx levels would be at 0.5 lb/ton clinker, with SCR – which is considerably lower than the current permit limits (and actual emissions) noted in the TCEQ discussion above.

The TCEQ itself, via a court-ordered study from 2005 (i.e., over 14 years ago) is well aware that SCR is eminently feasible on cement kilns. This study, mandated in 2005 by a court settlement, was conducted by an expert panel of five independent engineering and cement technology experts convened by the TCEQ. They studied the feasibility of a variety of cement plant control technologies, including SCR. The panel's final report, prepared by Eastern Research Group for TCEQ and published in July 2006 concluded:

> "SCR is an available technology for dry kilns," *i.e.* "commercially available and in use on similar types of cement plants" and "transferable technology," because it had been tested and implemented on a full-scale in Europe and had proven effective on similarly fired industrial and utility units in the U.S., like coal-fired power plants and waste incinerators."[16]

[14] www.icac.com.

[15] NACAA comments on the Portland Cement New Source Performance Standards (NSPS), 2008.

[16] ERG, Inc., Assessment of NOx Emissions Reduction Strategies for Cement Kilns – Ellis County, Final Report,

Downwinders at Risk, a local group in the Midlothian area, in comments submitted in July 2014 to the TCEQ provided specific examples of high levels of NOx reduction that were being achieved, back then, using SCR.

> "[E]uropean cement plants using SCR report reductions from 80 to over 90%. The Solnhofer, Germany plant reported an 80% removal rate for NOx pollution when it operated its SCR unit in the early part of this century. The plant manager of the Monselice, Italy cement plant using SCR installed in 2006 has recorded a 95% removal rate of NOx pollution. The Mergelstetten, Germany cement plant reports an 85% removal rate for NOx pollution from an SCR unit installed in 2010. The Rohrdorf, Germany cement plant reports an 88-90% reduction in NOx pollution from an SCR unit installed in 2011. At the Holcim-owned Joppa, Illinois long dry kiln where an EPA pilot project is currently being conducted, operators report an 80% removal rate for a retrofitted SCR system. ("Is SCR Technology Coming (back) to Cement?" John Kline, World Cement, April 2013)."[17]

Engineering companies and SCR catalyst vendors who have experience with cement kilns include Elex, GEA Bischoff, Scheuch, CRI Catalyst Company, Haldor Topsoe, KWH, Lurgi, etc.

SCR has also been successfully demonstrated in the US. In 2015, EPA conducted and completed a pilot test of a full-scale commercial SCR unit on a long dry kiln in Joppa, Illinois. This is similar to the kilns in the DFW non-attainment area. Per the regional EPA office overseeing the test, "the SCR is operating, and results in an emission reduction of about 80%," and the kiln operator is permanently installing the new control technology and seeking a permit for its continued operation.[18]

Finally, additional catalyst-based NOx reduction approaches have also been used, most recently using catalyst-coated bags ("catalytic filter bags") in fabric filters, to reduce NOx.[19]

In other words, there are significant NOx reductions possible from the many cement kilns in the DFW non-attainment area. Dropping NOx rates from the over 1.2 to 1.95 lb/ton clinker to values less than 0.5 lb/ton clinker would result in dramatic reductions of NOx. The TCEQ, which has been well aware of this for over a decade, cannot simply ignore the benefits of the large NOx reduction, while claiming that its current rules and regulations are the best in the

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Cement Kiln Study for the Air Quality Planning Section, Chief Engineer's Office, Texas Commission on Environmental Quality, July 14, 2006.

[17] Comments to TCEQ on the Amendment to State Air Quality Permit Number 8996, Modification to Prevention of Significant Deterioration Air Quality Permit Number PSDTX454M4, July 11, 2014

[18] email from Kushal Som, Environmental Engineer, U.S. EPA Region 5 to Jim Schermbeck, July 21, 2015.

[19] See, Consent Decree lodged in US District Court, District of Nevada, USA v. Nevada Cement Company, Civil Action No. 3:17-cv-00302-MMD-WGC, August 14, 2018.

country – a statement simply at odds with the reality that ozone levels in this non-attainment area are increasing.

TCEQ needs to require SCR as RACT for the cement kilns in the DFW non-attainment area.

C.2. HGB Non-Attainment Area

Table 2 below shows the large (i.e., greater than 40 tons/year actual) NOx emitting sources in the HGB non-attainment area, based on the 2017 inventory.

Table 2 – Large NOx Sources (HGB Non-Attainment Area)

Company	Site	Source Type	Source Name	2017 Emissions (tpy)
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 6 BOILER	1767.7
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 5 BOILER	1140.5
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 8 BOILER	807.9
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 7 BOILER	733.3
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 8 BOILER	404.6
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 4 BOILER	373.5
NRG TEXAS	CEDAR BAYOU STATION	BOILER	UNIT 2 BOILER	271.5
NRG TEXAS	CEDAR BAYOU STATION	BOILER	UNIT 1 BOILER	265.2
EXXONMOBIL	BAYTOWN OLEFINS PLANT	BOILER	BOILER D	156.7
EXXONMOBIL	BAYTOWN REFINERY	FCCU	FCCU 2 FURNACE F1A FLUE GAS TO ATMOSPHER	153.5
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 3 BOILER	148.8
NRG TEXAS	WA PARISH STATION	BOILER	UNIT 3 BOILER	148.8
FREEPORT POWER	OYSTER CREEK COGENERATION	TURBINE	PWR8_GTB_OC8P8GT82_GT-82 GAS TURBINE	139.3
PASADENA COGEN	PASADENA COGENERATION	TURBINE	TURBINE #2 & UNFIRED HRSC	135.6
FREEPORT POWER	OYSTER CREEK COGENERATION	TURBINE	PWR8_GTB_OC8P8GT83_GT-83 GAS TURBINE	127.7
EXXONMOBIL	BAYTOWN OLEFINS PLANT	TURBINE	GAS TURBINE NO. 4	122.8
INEOS	BAYPORT PLANT	HEATER	STEAM SUPERHEATER "HS-201/219"	121.7
TEXAS CITY	TEXAS CITY COGENERATION	TURBINE	G.T. "B" TRAIN	120.8
INEOS	CHOCOLATE BAYOU PLANT	BOILER	NO. 2 OLEFINS BOILER	117.9
INEOS	CHOCOLATE BAYOU PLANT	BOILER	NO. 2 OLEFINS BOILER	113.6
EXXONMOBIL	BAYTOWN REFINERY	TURBINE	GAS TURBINE GENERATOR	105.8
SWEENY COGENERATION	SWEENY COGENERATION FACILITY	TURBINE	GAS TURBINE & DUCT BURNER 1	103.3
ATLANTIC COFFEE	HOUSTON PLANT	BOILER	BOILER 6	100.1
FREEPORT POWER	OYSTER CREEK COGENERATION	TURBINE	PWR8_GTB_OC8P8GT81_GT-81 GAS TURBINE	99.8
SOUTH HOUSTON GREEN	SOUTH HOUSTON GREEN POWER SITE	TURBINE	GP-2 UNIT 801 (UNIT #3)	94.0
PASADENA COGEN	PASADENA COGENERATION	TURBINE	TURBINE #3 & UNFIRED HRSG	93.1
OXYVINYLS	BATTLEGROUND CHLOR-ALKALI PLANT	TURBINE	NO.2 GAS TURBINE (LINKD TO BOILER FIN BGU-005A)	92.6
ENTERGY	LEWIS CREEK PLANT	TURBINE	STEAM GENERATOR NO. 2	92.5
EXXONMOBIL	BAYTOWN OLEFINS PLANT	BOILER	BOILER C	91.1
INEOS	CHOCOLATE BAYOU PLANT	BOILER	NO. 1 OLEFINS BOILER DB 901B	90.4
INEOS	CHOCOLATE BAYOU PLANT	BOILER	NO. 1 OLEFINS BOILER DB 901A	87.9
SOUTH HOUSTON	SOUTH HOUSTON GREEN	TURBINE	GP-2 UNIT 803 (UNIT #1)	87.5

GREEN	POWER SITE			
SOUTH HOUSTON GREEN	SOUTH HOUSTON GREEN POWER SITE	TURBINE	GP-2 UNIT 802 (UNIT #2)	87.1
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE H	86.0
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	84.8
FLINT HILLS	HOUSTON	BOILER	WASTE HEAT BOILER	83.9
BLANCHARD REFINING	GALVESTON BAY REFINERY	FURNACE	ULTRAFORMER NO. 4	83.9
LYONDELL CHEMICAL	CHANNELVIEW PLANT	BOILER	BOILER NO. 1	83.3
AIR LIQUIDE	AIR LIQUIDE BAYPORT COMPL	TURBINE	COMBUSTION GAS TURBINE & H.R. STEAM GENERATOR	82.2
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H2_PYROLYSIS FURNACE 2	81.9
INEOS	BAYPORT PLANT	BOILER	"HB-301S"	80.5
EXXONMOBIL	BAYTOWN OLEFINS PLANT	HEATER	PYROLYSIS FURNACE XE	80.5
PASADENA COGEN	PASADENA COGENERATION	TURBINE	TURBINE & UNFIRED H.R.S.G.	80.2
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE XA	79.7
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE XD	79.1
PHILLIPS 66 COMPANY	SWEENY REFINERY PETROCHEM	FCCU	UNIT 3 PRECIPITATOR STACK	78.7
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE XC	78.2
ASCEND	CHOCOLATE BAYOU PLANT	BOILER	AN7 WASTE HEAT BOILER	78.1
BASF CORPORATION	FREEPORT SITE	INCINERATOR	AAE-3 WASTE LIQUIDS/GAS INCINERATOR	76.7
SWEENY COGENERATION	SWEENY COGENERATION FACILITY	TURBINE	GAS TURBINE & DUCT BURNER 3	76.5
CHANNEL ENERGY CENTER	CHANNEL ENERGY CENTER	TURBINE	TURBINE/HRSG#1	76.1
OPTIM ENERGY	ALTURA COGEN	TURBINE	TURBINE & BOILER SET	76.0
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE J	75.7
ENTERGY TEXAS INC	LEWIS CREEK PLANT	BOILER	STEAM GENERATOR NO. 1	75.3
AIR LIQUIDE	AIR LIQUIDE BAYPORT COMPL	TURBINE	COMBUSTION GAS TURBINE & H.R. STEAM GENERATOR	74.7
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE XB	74.3
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	PS3A-101BB	74.1
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31050:F-P3-1050 FURNACE	74.1
BASF CORPORATION	FREEPORT SITE	OTHER	1260 TRAIN KETTLE	73.9
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC7_FUR_B72L7HH5_H5 FURNACE(TO B72SH5)	72.9
BLANCHARD REFINING	GALVESTON BAY REFINERY	FCCU	FCCU3 WET GAS SCRUBBER	72.4
EIF CHANNELVIEW	CHANNELVIEW COGENERATION FACILITY	TURBINE	GAS TURBINE	72.3
AIR LIQUIDE	AIR LIQUIDE BAYPORT COMPL	TURBINE	COMBUSTION GAS TURBINE & H.R. STEAM GENERATOR	72.2
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 5	72.0
EXXONMOBIL	BAYTOWN REFINERY	HEATER	FCCU3 STEAM GENERATOR 501C TO FCCU3WGS	72.0
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H3_PYROLYSIS FURNACE 3	72.0
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE B	71.7
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	UU3-301BC	71.7
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31130:F-P3-1130 FURNACE	71.6
SWEENY COGENERATION	SWEENY COGENERATION FACILITY	BOILER	UNIT 51 #8 BOILER	71.1
CLEAN HARBORS	CLEAN HARBORS DEER PARK	KILN	HAZARDOUS WASTE INCINERATOR - TRAIN 2	71.0
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31140:F-P3-1140 FURNACE	70.7

EXXONMOBIL	BAYTOWN OLEFINS PLANT	BOILER	BOILER B	70.7
OXYVINYLS	BATTLEGROUND CHLOR-ALKALI PLANT	TURBINE	NO.1 GAS TURBINE/HRSG	70.6
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31110:F-P3-1110 FURNACE	70.4
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 4	70.4
PASADENA REFINING	PASADENA REFINING SYSTEM	HEATER	REFORMER #3 HEATERS	70.2
SWEENY COGENERATION	SWEENY COGENERATION FACILITY	BOILER	UNIT 51 #9 BOILER	70.0
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE A	69.2
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	PS3A-101BA	68.9
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H5_PYROLYSIS FURNACE 5	67.7
CHANNEL ENERGY CENTER	CHANNEL ENERGY CENTER	TURBINE	TURBINE GTG 2	67.7
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	INCINERATOR	KILN_INC_B33INS1_KILN FUEL/WASTEVENTGAS	67.6
EIF CHANNELVIEW	CHANNELVIEW COGENERATION FACILITY	TURBINE	GAS TURBINE	67.3
INEOS	CHOCOLATE BAYOU PLANT	TURBINE	TURBINE	67.0
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 6	67.0
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H6_PYROLYSIS FURNACE 6	66.9
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H1_PYROLYSIS FURNACE 1	66.6
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31120:F-P3-1120 FURNACE	66.3
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31060:F-P3-1060 FURNACE	66.3
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC7_FUR_B72L7HH2_H2 FURNACE(TO B72SH2)	65.9
BASF CORPORATION	FREEPORT SITE	TURBINE	COGENERATION UNIT W/O DUCT BURNER	65.9
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H7_PYROLYSIS FURNACE 7	65.8
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H4_PYROLYSIS FURNACE 4	65.4
EXXONMOBIL	BAYTOWN REFINERY	FURNACE	PIPESTILL 8 FURNACE F801	65.3
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H10_PYROLYSIS FURNACE 10	64.5
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE I	64.3
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE Q	64.3
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC7_FUR_B72L7HH4_H4 FURNACE(TO B72SH4)	64.1
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 8	63.5
DEER PARK ENERGY	DEER PARK ENERGY CENTER	TURBINE	COMBUSTION TURBINE 4	63.4
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	TURBINE	PWR9_GTB_B56P9GT96_GT-96 GAS TURBINE	63.3
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 2	63.3
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 3	63.2
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 7	63.1
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE O	62.8
BAYTOWN ENERGY	BAYTOWN COGENERATION	TURBINE	TURBINE CTG1	62.8
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE XF	62.3
EIF CHANNELVIEW	CHANNELVIEW COGENERATION FACILITY	TURBINE	COGENERATION UNIT 4	62.2
EIF CHANNELVIEW	CHANNELVIEW COGENERATION FACILITY	TURBINE	GAS TURBINE	62.2
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE 1	61.5

CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-1 CRACKING FURNACE	61.4
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	61.3
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	61.1
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-3-CRACKING FURNACE	60.9
OPTIM ENERGY	ALTURA COGEN	TURBINE	TURBINE BOILER SET	60.9
SHELL CHEMICAL	DEER PARK PLANT	HEATER	H1000:PLATFORMER HEATER	60.8
AIR LIQUIDE	AIR LIQUIDE BAYPORT COMPL	TURBINE	COMBUSTOIN GAS TURBINE & H.R. STEAM GENERATOR	60.8
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC7_FUR_B72L7HH1_H1 FURNACE(TO B72SH1)	60.6
SHELL CHEMICAL	DEER PARK PLANT	HEATER	H600:CAT CRACKER HEATER STACK	60.3
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	TURBINE	PWR6_GTB_B246PGT66_GT-66 GAS TURBINE	60.3
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-6-CRACKING FURNACE	60.2
SHELL CHEMICAL	DEER PARK PLANT	BOILER	H87920:STEAM BOILER	60.0
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	59.9
DEER PARK ENERGY	DEER PARK ENERGY CENTER	TURBINE	COMBUSTION TURBINE 3	59.8
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-7-STEAM SUPERHEATER	59.8
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31080:F-P3-1080 FURNACE	59.5
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H8_PYROLYSIS FURNACE 8	59.2
DEER PARK ENERGY	DEER PARK ENERGY CENTER	TURBINE	COMBUSTION TURBINE 2	58.9
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-5 CRACKING FURNACE	58.2
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	UU3-301BD	58.1
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	57.8
JACK A FUSCO	JACK A FUSCO ENERGY CENTER	TURBINE	TURBINE NO. 1	57.7
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNACE F	57.7
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-3 CRACKING FURNACE	57.7
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-4 CRACKING FURNACE	57.6
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	TURBINE	PWR6_GTB_B246PGT63_GT-63 GAS TURBINE	57.6
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	57.4
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	57.2
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-2-CRACKING FURNACE	57.1
EXXONMOBIL	BAYTOWN OLEFINS PLANT	BOILER	BOILER A	57.1
VALERO	TEXAS CITY REFINERY	FCCU	CATALYTIC CRACKING REGENERATOR VENT	57.0
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	TURBINE	PWR6_GTB_B246PGT61_GT-61 GAS TURBINE	57.0
EXXONMOBIL	BAYTOWN REFINERY	FURNACE	PIPE STILL 8 FURNACE F802	56.7
LYONDELL CHEMICAL	CHANNELVIEW PLANT	BOILER	BOILER NO. 3	56.3
ASCEND	CHOCOLATE BAYOU PLANT	BOILER	AN3 INCINERATOR	56.2
SHELL CHEMICAL	DEER PARK PLANT	HEATER	FP31070:F-P3-1070 FURNACE	56.1
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-1-CRACKING FURNACE	56.1
SWEENY	SWEENY COGENERATION	TURBINE	GAS TURBINE & H.R.S.G. 4	56.0

COGENERATION	FACILITY			
DEER PARK ENERGY	DEER PARK ENERGY CENTER	TURBINE	COMBUSTION TURBINE 1	56.0
PHILLIPS 66 COMPANY	SWEENY REFINERY PETROCHEM	HEATER	35 HEATER 1	55.9
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	24F-4-CRACKING FURNACE	55.8
ECO SERVICES	HOUSTON PLANT	INCINERATOR	SPENT ACID REGENERATION UNIT II	55.6
BAYTOWN ENERGY	BAYTOWN COGENERATION	TURBINE	TURBINE CTG2	55.5
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 1 OLEFINS FURNACE	55.1
EQUISTAR CHEMICALS	CHANNELVIEW COMPLEX	HEATER	"F-38304B" OP. 1 STEAM SUPERHEATER "B"	54.9
EQUISTAR CHEMICALS	CHANNELVIEW COMPLEX	HEATER	"F-38001A" OP. 1 STEAM SUPERHEATER "A"	54.8
LYONDELL CHEMICAL	CHANNELVIEW PLANT	BOILER	BOILER NO. 2	54.8
ASCEND	CHOCOLATE BAYOU PLANT	INCINERATOR	NTA INCINERATOR	54.6
NRG TEXAS	SAN JACINTO STATION	TURBINE	UNIT 1 COMBUSTION TURBINE GENERATOR (CTG)	54.5
BLANCHARD REFINING	GALVESTON BAY REFINERY	FURNACE	PREHEAT FURNACE	54.4
SWEENY COGENERATION	SWEENY COGENERATION FACILITY	TURBINE	GAS TURBINE & DUCT BURNER 2	54.0
INEOS	TEXAS CITY PLANT	HEATER	STEAM SUPERHEATER, STY., "HF-201"	53.8
NRG TEXAS	SAN JACINTO STATION	TURBINE	UNIT 2 COMBUSTION TURBINE GENERATOR (CTG)	53.5
EQUISTAR CHEMICALS	LA PORTE COMPLEX	FURNACE	PYROLYSIS FURNACE #9	53.3
JACK A FUSCO	JACK A FUSCO ENERGY CENTER	TURBINE	TURBINE NO. 2	53.2
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	UU3-301BB	53.0
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	52.9
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC7_FUR_B72L7HH3_H3 FURNACE(TO B72SH3)	52.9
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-5-CRACKING FURNACE	52.8
GB BIOSCIENCES LLC	GREENS BAYOU PLANT	OTHER COMBUSTION	IPN - REOXIDIZER	52.4
ENTERPRISE	MONT BELVIEU COMPLEX	FLARE	NORTH PLANT FLARE	52.3
BLANCHARD REFINING	GALVESTON BAY REFINERY	FURNACE	ULTRAFORMER NO. 3	52.3
OPTIM ENERGY	ALTURA COGEN	TURBINE	TURBINE BOILER SET	52.0
EXXONMOBIL	BAYTOWN REFINERY	FURNACE	PIPE STILL 7-FURNACE F701B	51.7
EXXONMOBIL	BAYTOWN REFINERY	FCCU	FURNACE F2A FLUE GAS TO ATMOSPHERE	50.7
OPTIM ENERGY	ALTURA COGEN	TURBINE	TURBINE BOILER SET	50.6
ARKEMA	CLEAR LAKE OPERATIONS	INCINERATOR	INCN_INC_LTO-63IN460INC COMBUST	50.4
BASF CORPORATION	FREEPORT SITE	TURBINE	COGENERATION UNIT WITH DUCT BURNER FIRE	50.3
DOW CHEMICAL	DOW TEXAS OPERATIONS FREEPORT	FURNACE	LHC8_FUR_OC6L8H9_F-9 PYROLYSIS(TO OC6S9)	50.3
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	OTHER COMBUSTION	22C-120-PROPYLENE TURBINE	50.3
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	TURBINE	PWR6_GTB_B246PGT67_GT-67 GAS TURBINE	50.2
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	TURBINE	PWR3_GTB_A123PGT37_GT-37 GAS TURBINE	50.0
ECO SERVICES	BAYTOWN PLANT	FURNACE	FURNACE	49.2
BASF CORPORATION	FREEPORT SITE	INCINERATOR	LIQUID WASTE INCINERATOR	49.0
LONGHORN GLASS	LONGHORN GLASS	FURNACE	GLASS MELTING FURNACE	48.9

TEXAS CITY COGENERATION	TEXAS CITY COGENERATION	TURBINE	G.T. "A" TRAIN	48.8
CHEVRON PHILLIPS	CEDAR BAYOU PLANT	BOILER	BOILER	48.4
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	UU3-301BA	48.0
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	47.8
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-6-CRACKING FURNACE	47.6
BAYTOWN ENERGY	BAYTOWN COGENERATION	TURBINE	TURBINE CTG3	47.5
CHEVRON PHILLIPS	SWEENY OLD OCEAN FACILITIES	FURNACE	33F-2-CRACKING FURNACE	47.0
EXXONMOBIL	BAYTOWN OLEFINS PLANT	FURNACE	PYROLYSIS FURNANCE XG	46.3
EL DORADO NITROGEN	NITRIC ACID MFG FACILITY	OTHER	NITRIC ACID PROCESS UNIT	46.2
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	ULC-104BA	45.5
BLUE CUBE	BLUE CUBE OPERATIONS FREEPORT	BOILER	PHAC_BLR_OC3U3B901_B-901 BOILER	45.3
BLANCHARD REFINING	GALVESTON BAY REFINERY	HEATER	ULC-104BB	45.1
UNION CARBIDE	UCC TEXAS CITY PLANT	BOILER	UTIL_BLR_BOILER NO. 53-E02B53BLR	45.1
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 2 OLEFINS FURNACE	44.4
EXXONMOBIL	BAYTOWN REFINERY	FURNACE	HYDROFORMER 3-FURNACE F1	43.3
NRG TEXAS	CEDAR BAYOU GEN STATION	TURBINE	COMBUSTION TURBINE 41 (COMBINED CYCLE STACK)	43.1
ROHM AND HAAS	DEER PARK PLANT	THERMAL OX.	HT_THO_HT-3_HT-1 A/B TRAIN THOX	42.4
EXXONMOBIL	BAYTOWN OLEFINS PLANT	TURBINE	GAS TURBINE NO. 5	42.1
OPTIM ENERGY	ALTURA COGEN	TURBINE	TURBINE BOILER SET	41.0
INEOS	CHOCOLATE BAYOU PLANT	FURNACE	NO. 1 OLEFINS FURNACE	40.7
BLANCHARD REFINING	GALVESTON BAY REFINERY	FURNACE	ULTRAFORMER NO. 4	40.7

As the top several entries make abundantly clear, many of the largest NOx sources are associated with electric power generation. In particular, the various units at the W.A. Parish station account for either out of the top twelve sources. Collectively, the eight units at the W.A. Parish station collectively are the single largest NOx source in the HGB non-attainment area.

Yet, curiously, the TCEQ's HGB SIP RACT and RACM analysis did not contain any analysis of this large source. I provide some discussion below.

Table 3 below shows the annual NOx rate (in lb/MMBtu, highlighted in yellow) for various years for each of the W.A. Parish units.[20] Units 1-4 (WAP1 through WAP4) are natural gas fired boilers, equipped only with overfire air as the NOx control technology in each case. NOx rates for these gas-fired units are shown for years 2014-2018. Units 5 through 8 (WAP5 – WAP8) are coal-fired units, equipped with SCR, installed around 2003 or 2004 in these units. For the coal-fired units, I have shown the NOx emission rates for the first couple of years when SCR was installed and also the rates for the most recent 5 years (2014-2018). The column next to the individual, annual, NOx rates also shows the average NOx rates for the indicated years: averages for 2014-2018 for the gas-fired units, shown in red font in each case; averages for the two years

[20] Data for this table was obtained from US EPA's Clean Air Markets database, www.epa.gov/ampd. This is data reported by the power plant itself to EPA under Title IV of the FCAA.

right after SCR was installed for the coal units (shown in blue font); and averages for 2014-2018 for the coal-fired units (shown in purple font).

Table 3 also shows the actual NOx emissions (in tons) for each year. Several observations are in order.

First, the NOx rates for the gas-fired units, supposedly using cleaner natural gas are far greater than the coal-fired units. This is simply because gas-firing by itself does not result in lower NOx emissions. Additional controls (even low-NOx burners, or ultra low-NOx burners, SNCR, and SCR) need to be considered and applied in order to reduce NOx rates from these gas-fired units. The annual NOx emissions of these gas-fired units are substantial and rising for several units (see, WAP1 between 2017 and 2018; WAP2 between 2017 and 2018; and WAP3 between 2017 and 2018). Thus, RACT determinations for each of these gas-fired units is in order and would likely result in additional NOx controls. NOx reductions would be substantial.

Second, considering the coal units, even though each is equipped with SCR, note the deterioration in the SCR performance, as reflected in the higher NOx rates for the recent years as compared to the NOx rates in the years immediately after SCR installation. The percent deteriorations are shown below the current average NOx rates in each case. WAP7 had the least deterioration, at roughly 7%, while the others had dramatically lowered performance with levels ranging from 21.9% to 70.2%. This is likely because the SCR catalyst is not being replaced or re-activated in the SCRs for these units. By simply properly maintaining and operating these already in-place SCRs, substantial NOx reductions can be obtained for modest additional cost. The time required to replace and/or re-activate catalysts is also fairly quick. Therefore, I see this as a perfect opportunity for substantial additional NOx reductions, that can in fact be achieved in very little time (i.e., well before the 2020 ozone season), since the SCRs are already installed at units WAP5-WAP8. Replacing catalyst and obtaining post-SCR NOx levels that are similar to original performance is RACM and definitely RACT, even under the irrational constraints imposed on these analyses, as previously discussed.

In order to obtain a sense of the NOx reductions possible with just achieving proper SCR performance, consider WAP6. In 2017, the total NOx from just this unit alone was 1768 tons, as shown in the table below. The NOx rate for that year was 0.0807 lb/MMBtu, also shown in the Table 3. This means that the 2017 heat input for this unit was 43,816,605 MMBtus (i.e., 1768 tons * 2000 lb/ton / 0.0807 lb/MMBtu). Using the same heat input but the 2004 NOx rate (i.e., 0.0309 lb/MMBtu, which the SCR, which was installed in 2003, achieved when the catalyst was new and the SCR was being properly operated), the NOx emissions for 2017 should have been 677 tons instead of 1768 tons. This would have been a reduction of 1091 tons – just from this one unit alone. Of course similarly large reductions would be possible from the three other coal-fired units (or at least from WAP5 and WAP8).

Given the NOx-limited ozone formation in the HGB non-attainment area, previously noted, and these large NOx reductions easily possible at the W.A Parish station, it is clear that TCEQ's RACM and RACT analysis for the HGB is significantly deficient. RACM/RACT for WAP5-WAP8 should simply require SCR performance levels similar to when SCRs were installed for these units. And, for the gas-fired units WAP1-WAP4, RACM/RACT should require additional controls to lower their very high NOx rates, as shown in Table 3. The first NOx Rate column (fourth column from the left) shows the annual NOx rates (for the Year shown in the second column). The second NOx Rate column (fifth column from the left) shows the average of the NOx Rates over several years, as I discuss earlier. For example, for WAP1, 0.1564 lb/MMBtu in the second NOx Rate column is the average of the NOx Rates for years 2014-2018.

Table 3 – W.A. Parish Station Units NOx Analysis

Unit	Year	Load (MW-h)	NOx Rate (lb/MMBtu)		NOx (tons)	Unit Type	Fuel	NOx Control
WAP1	2014	21070	0.1524	0.1564	32	Wall-fired	Nat. Gas.	Overfire Air
WAP1	2015	42126	0.1520		52	Wall-fired	Nat. Gas.	Overfire Air
WAP1	2016	70805	0.1645		88	Wall-fired	Nat. Gas.	Overfire Air
WAP1	2017	49771	0.1444		62	Wall-fired	Nat. Gas.	Overfire Air
WAP1	2018	110983	0.1689		135	Wall-fired	Nat. Gas.	Overfire Air
WAP2	2014	33997	0.0858	0.0955	25	Wall-fired	Nat. Gas.	Overfire Air
WAP2	2015	55613	0.0933		42	Wall-fired	Nat. Gas.	Overfire Air
WAP2	2016	94556	0.1013		74	Wall-fired	Nat. Gas.	Overfire Air
WAP2	2017	51790	0.0903		40	Wall-fired	Nat. Gas.	Overfire Air
WAP2	2018	83396	0.1070		61	Wall-fired	Nat. Gas.	Overfire Air
WAP3	2014	82220	0.1154	0.1739	129	Wall-fired	Nat. Gas.	Overfire Air
WAP3	2015	192194	0.1752		356	Wall-fired	Nat. Gas.	Overfire Air
WAP3	2016	147434	0.1937		276	Wall-fired	Nat. Gas.	Overfire Air
WAP3	2017	172972	0.1808		297	Wall-fired	Nat. Gas.	Overfire Air
WAP3	2018	184226	0.2043		347	Wall-fired	Nat. Gas.	Overfire Air
WAP4	2014	302383	0.0758	0.0928	183	Tangentially-fired	Nat. Gas.	Overfire Air
WAP4	2015	511246	0.0904		334	Tangentially-fired	Nat. Gas.	Overfire Air
WAP4	2016	486987	0.1030		351	Tangentially-fired	Nat. Gas.	Overfire Air
WAP4	2017	452252	0.1082		373	Tangentially-fired	Nat. Gas.	Overfire Air
WAP4	2018	334348	0.0864		220	Tangentially-fired	Nat. Gas.	Overfire Air
WAP5	2004	5252817	0.0309	0.0369	836	Wall-fired	Coal	SCR (since 2003)
WAP5	2005	4926167	0.0429		1057	Wall-fired	Coal	SCR
WAP5	2014	4112463	0.0533	**0.0586 (58.8%)[1]**	993	Wall-fired	Coal	SCR
WAP5	2015	4491326	0.0603		1235	Wall-fired	Coal	SCR
WAP5	2016	3557125	0.0594		989	Wall-fired	Coal	SCR
WAP5	2017	4388738	0.0567		1141	Wall-fired	Coal	SCR
WAP5	2018	4624393	0.0631		1340	Wall-fired	Coal	SCR
WAP6	2004	4617340	0.0328	0.0379	736	Wall-fired	Coal	SCR (since 2003)
WAP6	2005	5519770	0.0430		1130	Wall-fired	Coal	SCR
WAP6	2014	4090727	0.0669	**0.0645 (70.2%)**	1458	Wall-fired	Coal	SCR
WAP6	2015	4105194	0.0520		1121	Wall-fired	Coal	SCR
WAP6	2016	3124670	0.0680		1146	Wall-fired	Coal	SCR
WAP6	2017	4087531	0.0807		1768	Wall-fired	Coal	SCR
WAP6	2018	3790839	0.0548		1086	Wall-fired	Coal	SCR
WAP7	2005	4600575	0.0443	0.0431	1018	Tangentially-fired	Coal	SCR (since 2004)

WAP7	2006	4432909	0.0419		876	Tangentially-fired	Coal	SCR
WAP7	2014	4143520	0.0487	**0.0463 (7.4%)**	941	Tangentially-fired	Coal	SCR
WAP7	2015	3479366	0.0417		668	Tangentially-fired	Coal	SCR
WAP7	2016	2986930	0.0449		604	Tangentially-fired	Coal	SCR
WAP7	2017	3848578	0.0473		733	Tangentially-fired	Coal	SCR
WAP7	2018	4032458	0.0487		756	Tangentially-fired	Coal	SCR
WAP8	2005	4650851	0.0413	0.0397	935	Tangentially-fired	Coal	SCR (since 2004)
WAP8	2006	5375894	0.0380		987	Tangentially-fired	Coal	SCR
WAP8	2014	4481612	0.0473	**0.0484 (21.9%)**	1032	Tangentially-fired	Coal	SCR
WAP8	2015	4046576	0.0472		888	Tangentially-fired	Coal	SCR
WAP8	2016	3792115	0.0450		856	Tangentially-fired	Coal	SCR
WAP8	2017	4297991	0.0560		1213	Tangentially-fired	Coal	SCR
WAP8	2018	3788225	0.0467		901	Tangentially-fired	Coal	SCR

[1] The numbers shown in () for this and each of the other three coal units represent the increase in the NOx Rate in recent years (i.e., 0.0586 lb/MMBtu in this example) as compared to the NOx Rate when the SCR for the unit was first installed (i.e., 0.0369 lb/MMBtu in this example).

As noted in the beginning, I have analyzed NOx emissions from the W.A. Parish station, simply as an example. TCEQ should similarly provide detailed analyses for the large NOx sources in Table 2, showing their current NOx rates as well as feasible NOx rates with various additional controls and work practices.

D. Comments – Large NOx and VOC Sources in Selected Refineries/Chemical Plants (HGB)

Table 4 below shows the large NOx and VOC sources (emissions greater than 40 tons/year) are three selected refineries and chemical plants (Exxon – Baytown Complex; Pasadena Refining; and Valero – Texas City).

As I have noted elsewhere in these comments, refineries and chemical plants, especially the ExxonMobil Baytown Complex, have low-income residential areas very close to the such plants. Reducing NOx and VOC emissions (which also invariably include many toxic pollutants as well) in order to reach ozone attainment from such plants also reduces the pollution on already-burdened populations nearby.

As Table 4 shows, all of the NOx emissions are from fuel-combustion sources such as boilers, heaters, furnaces, turbines, etc. But the HGB SIP RACM and RACT analyses do not, with any particularity at all, address these sources. The analyses simply note the various current TCEQ rules that apply to such sources or note that they are in compliance with decades-old CTG and ACT documents promulgated by EPA. That is insufficient in my opinion. What the SIP must do is: (a) identify the NOx rates for each such large source; (b) identify the current NOx controls if any (such as: low NOx burners, ultra-low NOx burners, flue gas recirculation (FGR), over-fire air, SNCR, or SCR, etc.) that each such source has; (c) identify, based on (a) and (b), the additional NOx reductions that can be obtained if additional or higher/better types of technically feasible NOx controls could be applied; (d) determine cost-effectiveness of the additional controls. Only then can an informed RACT (and RACM) analysis be complete. Typical (i.e., installed in such units at refineries and therefore technical feasible and cost-effective) NOx controls for boilers, furnaces, and heaters would be a combination of ultra-low NOx burners/FGR/SNCR or ultra-low NOx burners/SCR. Similarly, controls for turbines would typically be dry low NOx combustors followed by SCR. It is imperative that TCEQ's RACM/RACT for these combustion controls include these or equally effective NOx controls for the types of refinery NOx sources shown in Table 4.

Similarly, Table 4 below shows a few of the large VOC sources at refineries and chemical plants. Not unexpectedly, several of the large VOC emission sources are fugitive in nature. Here again, it is insufficient for the TCEQ to simply state the applicable TCEQ rule or regulation that applies to such sources. As part of the RACM/RACT analyses, the TCEQ should address each such large VOC source, with applicable options to reduce these VOC emissions. For example, cooling tower VOC emissions reductions can be achieved by enhanced surveillance to ensure that no hydrocarbons leak into cooling water (i.e., via better maintenance, or proactive replacement of equipment). Fugitive emissions from components such as valves, pumps, etc., will require optical gas imaging (OGI) or similar techniques to quickly identify and repair leakers. None of these work practice changes should require long lead times, qualifying them for RACM, even under the "pull forward" constraint imposed on the RACM analysis by poor EPA guidance. It is imperative that TCEQ's RACM/RACT analyses for the types of VOC sources shown in Table 4 include such controls and work practices.

Based on the above, I ask that TCEQ revisit its RACM/RACT analyses for not just these example sources at selected refineries, but for all large VOC sources in the HGB non-attainment area.

Table 4 – Large NOx and VOC Sources Located in Example Refineries and Chemical Plants (HGB Non-Attainment Area)

Company	Plant	Source Name	Source Type	Pollutant	2017 Emissions (tpy)
ExxonMobil	Baytown Olefins Plant	BOILER D	STACK	NOX	156.7
ExxonMobil	Baytown Refinery	FCCU 2 FURNACE F1A	STACK	NOX	153.5
ExxonMobil	Baytown Olefins Plant	GAS TURBINE NO. 4	STACK	NOX	122.8
ExxonMobil	Baytown Refinery	GAS TURBINE GENERATOR	STACK	NOX	105.8
ExxonMobil	Baytown Olefins Plant	BOILER C	STACK	NOX	91.1
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE H	STACK	NOX	86.0
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XE	STACK	NOX	80.5
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XA	STACK	NOX	79.7
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XD	STACK	NOX	79.1
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XC	STACK	NOX	78.2
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE J	STACK	NOX	75.7
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XB	STACK	NOX	74.3
ExxonMobil	Baytown Refinery	FCCU3 STEAM GENERATOR 501C	STACK	NOX	72.0
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE B	STACK	NOX	71.7
ExxonMobil	Baytown Olefins Plant	BOILER B	STACK	NOX	70.7
Pasadena Ref.	Pasadena Refinery	REFORMER #3 HEATERS	STACK	NOX	70.2
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE A	STACK	NOX	69.2
ExxonMobil	Baytown Refinery	PIPESTILL 8 FURNACE F801	STACK	NOX	65.3
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE I	STACK	NOX	64.3
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE Q	STACK	NOX	64.3

ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE O	STACK	NOX	62.8
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE XF	STACK	NOX	62.3
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNACE F	STACK	NOX	57.7
ExxonMobil	Baytown Olefins Plant	BOILER A	STACK	NOX	57.1
Valero	Texas City Refinery	CATCRACKER REGEN VENT	STACK	NOX	57.0
ExxonMobil	Baytown Refinery	PIPE STILL 8 FURNACE F802	STACK	NOX	56.7
ExxonMobil	Baytown Refinery	PIPE STILL 7-FURNACE F701B	STACK	NOX	51.7
ExxonMobil	Baytown Refinery	FURNACE F2A	STACK	NOX	50.7
ExxonMobil	Baytown Olefins Plant	PYROLYSIS FURNANCE XG	STACK	NOX	46.3
ExxonMobil	Baytown Refinery	HYDROFORMER 3-FURNACE F1	STACK	NOX	43.3
ExxonMobil	Baytown Olefins Plant	GAS TURBINE NO. 5	STACK	NOX	42.1
ExxonMobil	Baytown Chem Plant	VARIOUS PROCESSES	FLARE	VOC-Butene	41.0
ExxonMobil	Baytown Refinery	COOLING TOWER NO. 58 FUGITIVES	STACK	VOC-Distillate	57.2
ExxonMobil	Baytown Refinery	MEK DEWAXING PLANT FUGITIVES	FUGITIVE	VOC-MEK	203.4
ExxonMobil	Baytown Refinery	TREATMENT LAGOONS	FUGITIVE	VOC-Methanol	59.1
ExxonMobil	Baytown Refinery	STORMWATER RETENTION BASIN	FUGITIVE	VOC-Methanol	58.7
ExxonMobil	Baytown Refinery	MEK DEWAXING PLANT FUGITIVES	FUGITIVE	VOC-Toluene	58.6

E. Comments – VOC Emissions from Storage Tanks at Selected Refineries (HGB)

Table 5 below shows some of the highest emitting tanks in selected refineries and chemical plants in the HGB non-attainment area. As noted earlier, reductions of VOC emissions from these tanks will not only reduce an ozone precursor but also benefit low-income communities that live very near these plants and are directly impacted by these emissions.

Specifically, each tank shown in Table 5 below contains a high vapor pressure product (as shown in the second to last column). These include gasoline, naphtha, distillates, as well as xylene. Yet, even though these products or intermediates have high vapor pressures, each of the tanks (see the column titled Tank Type) is either an external floating roof tank or a fixed roof tank. There are no indications that the vertical fixed roof tanks are connected to any control devices. External floating roof tanks cannot be connected to control devices.

Table 5 – Emissions from High-Emitting Tanks Located in Example Refineries and Chemical Plants (HGB Non-Attainment Area)

Company	Refinery/Plant	Tank Type	Tank Name	Product / Pollutant	2017 Emissions (tpy)
Valero	Texas City Refinery	EXT FL ROOF: PONTOON DBL SEAL	T-478	GASOLINE	11.7
Valero	Texas City Refinery	EXT FL ROOF: PONTOON DBL SEAL	T-563	GASOLINE	8.9
Valero	Texas City Refinery	EXT FL ROOF: PONTOON DBL SEAL	T-088	NAPHTHA	5.6
Valero	Texas City Refinery	EXT FL ROOF: PONTOON DBL SEAL	T-594	GASOLINE	5.2
ExxonMobil	Baytown Chem Plant	VERTICAL FIXED ROOF TANK	TK3014	META-XYLENE	5.5
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0863	GASOLINE	12.2
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0858	GASOLINE	12.1
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0856	GASOLINE	11.3
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0861	GASOLINE	11.2
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0860	GASOLINE	11.0
ExxonMobil	Baytown Refinery	VERTICAL FIXED ROOF TANK	TK0072	PARA-XYLENE	10.5
ExxonMobil	Baytown Refinery	VERTICAL FIXED ROOF TANK	TK0665	NAPHTHA, etc.	6.0
ExxonMobil	Baytown Refinery	VERTICAL FIXED ROOF TANK	TK1013	DISTILLATE	5.9
ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0850	GASOLINE	5.6
ExxonMobil	Baytown Refinery	VERTICAL FIXED ROOF TANK	TK1084	XYLENE-U	5.4

ExxonMobil	Baytown Refinery	EXT FL ROOF: DBL DECK DBL SEAL	TK0849	GASOLINE	5.4
ExxonMobil	Baytown Refinery	VERTICAL FIXED ROOF TANK	TK1016	DISTILLATE	5.0

In its very generic discussion of tank emissions, the TCEQ states the following:

> "In 2016, 30 TAC Chapter 115, Subchapter B, Division 1, was revised (Rule Project No. 2016-039-115-AI) to increase the control efficiency of control devices, other than vapor recovery units or flares, from 90% to 95% for VOC storage tanks in the HGB area. In addition to increasing the control efficiency for all storage tanks, the rulemaking enhanced inspection, repair and recordkeeping requirements for major source fixed roof crude oil or condensate storage tanks with the uncontrolled VOC emissions of at least 25 tpy in the HGB area. The amendments also expanded the rule applicability to include the aggregate of crude oil and condensate fixed roof storage tanks at pipeline breakout stations in the HGB area. The EPA approved these rule revisions as addressing VOC RACT for both CTG and non-CTG major source storage tanks in the HGB 2008 eight-hour ozone nonattainment area on April 30, 2019 (84 FR 18145)."[21] (emphasis added)

While these rule improvements may be commendable, none of them (emphasized above) pertain to the specific tanks I have listed in Table 5 above – i.e., fixed or external floating roof tanks storing high vapor pressure products. That the TCEQ's current rules allow such storage undercuts its argument that it has some of the best regulations on the books and that no additional rules are required.

Simply, all high vapor pressure products (say, above a threshold vapor pressure) should only be stored in internal floating roof or fixed roof tanks – connected to a vapor recovery or vapor control system with a specified (and verifiable) capture and/or control efficiency of at least 99%. Technologies to achieve these are readily available and widely used, including in many Texas plants.[22] These technologies include carbon adsorbers and concentrators (for vapor recovery), and/or catalytic oxidizers and regenerative thermal oxidizers (RTOs) (for destruction of vapors). These would qualify as RACT in my professional opinion.

[21] HGB SIP, Appendix F, Section 3.3.2.

[22] As an example, see the 2017 inventory. A vertical fixed roof tank # V1422 storing butyl acrylate at LBC Houston Bayport Terminal is connected to a vapor oxidizer.

There are numerous other vertical fixed roof tanks in the HGB 2017 inventory whose vapors are connected to flare systems. While a flare is not a preferred VOC control device, at least such vapors are not directly emitted to the atmosphere, as in the case of the tanks shown in Table 5.

ATTACHMENT A

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CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

Dr. Sahu has over twenty nine years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over twenty six years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty five years include various trade associations as well as individual companies such as steel mills, petroleum refineries, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including EPA, the US Dept. of Justice, several states, various agencies such as the California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

In addition to consulting, Dr. Sahu has taught numerous courses in several Southern California universities including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management) for the past seventeen years. In this time period he has also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls) and at California State University, Fullerton (transportation and air quality).

Dr. Sahu has and continues to provide expert witness services in a number of environmental areas discussed above in both state and Federal courts as well as before administrative bodies (please see Annex A).

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.) public sector (such as the US Department of Justice) and public interest group clients with project management, air quality consulting, waste remediation and management consulting, as well as regulatory and engineering support consulting services.

1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.

Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.

1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.

1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.

1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.

1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

1984-1988 Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.

1984 M. S., Mechanical Engineering, Caltech, Pasadena, CA.

1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.

"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.

"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.

"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.

“Thermodynamics and Heat Transfer,” Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.

"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

“Advanced Hazardous Waste Management” University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

“Environmental Risk Assessment,” Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

“Hazardous Waste Remediation” Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

"Air Pollution Controls," University of Southern California, Dept. of Civil Engineering, Fall 1993, Fall 1994.

"Air Pollution Fundamentals," University of Southern California, Dept. of Civil Engineering, Winter 1994.

University of California, Los Angeles

"Air Pollution Fundamentals," University of California, Los Angeles, Dept. of Civil and Environmental Engineering, Spring 1994, Spring 1999, Spring 2000, Spring 2003, Spring 2006, Spring 2007, Spring 2008, Spring 2009.

International Programs

“Environmental Planning and Management,” 5 week program for visiting Chinese delegation, 1994.

“Environmental Planning and Management,” 1 day program for visiting Russian delegation, 1995.

“Air Pollution Planning and Management,” IEP, UCR, Spring 1996.

“Environmental Issues and Air Pollution,” IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

President of India Gold Medal, IIT Kharagpur, India, 1983.

Member of the Alternatives Assessment Committee of the Grand Canyon Visibility Transport Commission, established by the Clean Air Act Amendments of 1990, 1992-present.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-present.

Air and Waste Management Association, West Coast Section, 1989-present.

Professional Certifications

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

Certified Permitting Professional, South Coast AQMD (#C8320), since 1993.

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2019.

Publications (Partial List)

"Physical Properties and Oxidation Rates of Chars from Bituminous Coals," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **67**, 275-283 (1988).

"Char Combustion: Measurement and Analysis of Particle Temperature Histories," with R.C. Flagan, G.R. Gavalas and P.S. Northrop, *Comb. Sci. Tech.* **60**, 215-230 (1988).

"On the Combustion of Bituminous Coal Chars," PhD Thesis, California Institute of Technology (1988).

"Optical Pyrometry: A Powerful Tool for Coal Combustion Diagnostics," *J. Coal Quality*, **8**, 17-22 (1989).

"Post-Ignition Transients in the Combustion of Single Char Particles," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **68**, 849-855 (1989).

"A Model for Single Particle Combustion of Bituminous Coal Char." Proc. ASME National Heat Transfer Conference, Philadelphia, **HTD-Vol. 106**, 505-513 (1989).

"Discrete Simulation of Cenospheric Coal-Char Combustion," with R.C. Flagan and G.R. Gavalas, *Combust. Flame*, **77**, 337-346 (1989).

"Particle Measurements in Coal Combustion," with R.C. Flagan, in "**Combustion Measurements**" (ed. N. Chigier), Hemisphere Publishing Corp. (1991).

"Cross Linking in Pore Structures and Its Effect on Reactivity," with G.R. Gavalas in preparation.

"Natural Frequencies and Mode Shapes of Straight Tubes," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Optimal Tube Layouts for Kamui SL-Series Exchangers," with K. Ishihara, Proprietary Report for Kamui Company Limited, Tokyo, Japan (1990).

"HTRI Process Heater Conceptual Design," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Asymptotic Theory of Transonic Wind Tunnel Wall Interference," with N.D. Malmuth and others, Arnold Engineering Development Center, Air Force Systems Command, USAF (1990).

"Gas Radiation in a Fired Heater Convection Section," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1990).

"Heat Transfer and Pressure Drop in NTIW Heat Exchangers," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1991).

"NOx Control and Thermal Design," Thermal Engineering Tech Briefs, (1994).

“From Purchase of Landmark Environmental Insurance to Remediation: Case Study in Henderson, Nevada,” with Robin E. Bain and Jill Quillin, presented at the AQMA Annual Meeting, Florida, 2001.

“The Jones Act Contribution to Global Warming, Acid Rain and Toxic Air Contaminants,” with Charles W. Botsford, presented at the AQMA Annual Meeting, Florida, 2001.

PRESENTATIONS (PARTIAL LIST)

"Pore Structure and Combustion Kinetics - Interpretation of Single Particle Temperature-Time Histories," with P.S. Northrop, R.C. Flagan and G.R. Gavalas, presented at the AIChE Annual Meeting, New York (1987).

"Measurement of Temperature-Time Histories of Burning Single Coal Char Particles," with R.C. Flagan, presented at the American Flame Research Committee Fall International Symposium, Pittsburgh, (1988).

"Physical Characterization of a Cenospheric Coal Char Burned at High Temperatures," with R.C. Flagan and G.R. Gavalas, presented at the Fall Meeting of the Western States Section of the Combustion Institute, Laguna Beach, California (1988).

"Control of Nitrogen Oxide Emissions in Gas Fired Heaters - The Retrofit Experience," with G. P. Croce and R. Patel, presented at the International Conference on Environmental Control of Combustion Processes (Jointly sponsored by the American Flame Research Committee and the Japan Flame Research Committee), Honolulu, Hawaii (1991).

"Air Toxics - Past, Present and the Future," presented at the Joint AIChE/AAEE Breakfast Meeting at the AIChE 1991 Annual Meeting, Los Angeles, California, November 17-22 (1991).

"Air Toxics Emissions and Risk Impacts from Automobiles Using Reformulated Gasolines," presented at the Third Annual Current Issues in Air Toxics Conference, Sacramento, California, November 9-10 (1992).

"Air Toxics from Mobile Sources," presented at the Environmental Health Sciences (ESE) Seminar Series, UCLA, Los Angeles, California, November 12, (1992).

"Kilns, Ovens, and Dryers - Present and Future," presented at the Gas Company Air Quality Permit Assistance Seminar, Industry Hills Sheraton, California, November 20, (1992).

"The Design and Implementation of Vehicle Scrapping Programs," presented at the 86th Annual Meeting of the Air and Waste Management Association, Denver, Colorado, June 12, 1993.

"Air Quality Planning and Control in Beijing, China," presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

Annex A

Expert Litigation Support

A. Occasions where Dr. Sahu has provided Written or Oral testimony before Congress:

1. In July 2012, provided expert written and oral testimony to the House Subcommittee on Energy and the Environment, Committee on Science, Space, and Technology at a Hearing entitled "Hitting the Ethanol Blend Wall – Examining the Science on E15."

B. Matters for which Dr. Sahu has provided affidavits and expert reports include:

2. Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.

3. Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the United States in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.,* C2-99-1181 (Southern District of Ohio).

4. Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the United States in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

5. Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the United States in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (Middle District of North Carolina).

6. Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the United States in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (Southern District of Ohio).

7. Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.

8. Expert Report and Deposition (10/31/2005 and 11/1/2005) on behalf of the United States in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc*., 5:04-cv-00034-KSF (Eastern District of Kentucky).

9. Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.

10. Expert Report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.

11. Expert Report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.

12. Expert Report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.

13. Expert Report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo's eight new proposed PRB-fired PC boilers located at seven TX sites.

14. Expert Testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of

Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).

15. Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.

16. Expert Report and Deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (Western District of Pennsylvania).

17. Expert Reports and Pre-filed Testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.

18. Expert Report and Deposition (October 2007) on behalf of MTD Products Inc., in connection with *General Power Products, LLC v MTD Products Inc*., 1:06 CVA 0143 (Southern District of Ohio, Western Division) .

19. Expert Report and Deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.

20. Expert Reports, Affidavit, and Deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.

21. Affidavits (May 2010/June 2010 in the Office of Administrative Hearings))/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).

22. Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).

23. Declaration (August 2008) on behalf of the Sierra Club in the matter of Dominion Wise County plant MACT.us

24. Expert Report (June 2008) on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis.

25. Expert Report (February 2009) on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone's proposed Unit 3 in Texas.

26. Expert Report (June 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*

27. Expert Report (August 2009) on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper's proposed Pee Dee plant in South Carolina).

28. Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.

29. Expert Report (August 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

30. Expert Report and Rebuttal Report (September 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

31. Expert Report (December 2009) and Rebuttal reports (May 2010 and June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

32. Pre-filed Testimony (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

33. Pre-filed Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

34. Expert Report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.

35. Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the United States in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (Eastern District of Michigan).

36. Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.

37. Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (District of Colorado).

38. Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

39. Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

40. Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, November 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. Public Service Company of New Mexico* (PNM), Civil No. 1:02-CV-0552 BB/ATC (ACE) (District of New Mexico).

41. Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

42. Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

43. Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (Eastern District of Texas, Texarkana Division).

44. Pre-Filed Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf

Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

45. Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.

46. Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

47. Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority,* Civil Action No. 4:11-cv-00791 (Southern District of Texas, Houston Division).

48. Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

49. Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

50. Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.,* Civil Action No. A-08-CA-648-LY (Western District of Texas, Austin Division).

51. Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.,* Case No. 3:10-cv-747 (TJM/DEP) (Northern District of New York).

52. Declaration (October 2011) on behalf of the Plaintiffs in the matter of *American Nurses Association et. al. (Plaintiffs), v. US EPA (Defendant),* Case No. 1:08-cv-02198-RMC (US District Court for the District of Columbia).

53. Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association,* Case No. 11-417-MJP (Western District of Washington).

54. Expert Report (March 2012) and Supplemental Expert Report (November 2013) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

55. Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency,* Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).

56. Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment,* Case No. 11-105,493-AS (Holcomb power plant) (Supreme Court of the State of Kansas).

57. Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality,* Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).

58. Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) on behalf of the states of New Jersey and Connecticut in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.,* Civil Action No. 07-CV-5298 (JKG) (Eastern District of Pennsylvania).

59. Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project.

60. Expert Report (August 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.

61. Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.

62. Expert Report (October 2012) on behalf of the Appellants (Robert Concilus and Leah Humes) in the matter of Robert Concilus and Leah Humes v. Commonwealth of Pennsylvania Department of Environmental Protection and Crawford Renewable Energy, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2011-167-R.

63. Expert Report (October 2012), Supplemental Expert Report (January 2013), and Affidavit (June 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

64. Pre-filed Testimony (October 2012) on behalf of No-Sag in the matter of the North Springfield Sustainable Energy Project before the State of Vermont, Public Service Board.

65. Pre-filed Testimony (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

66. Expert Report (February 2013) on behalf of Petitioners in the matter of Credence Crematory, Cause No. 12-A-J-4538 before the Indiana Office of Environmental Adjudication.

67. Expert Report (April 2013), Rebuttal report (July 2013), and Declarations (October 2013, November 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

68. Declaration (April 2013) on behalf of Petitioners in the matter of *Sierra Club, et al., (Petitioners) v Environmental Protection Agency et al. (Resppondents),* Case No., 13-1112, (Court of Appeals, District of Columbia Circuit).

69. Expert Report (May 2013) and Rebuttal Expert Report (July 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC,* Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

70. Declaration (August 2013) on behalf of A. J. Acosta Company, Inc., in the matter of *A. J. Acosta Company, Inc., v. County of San Bernardino*, Case No. CIVSS803651.

71. Comments (October 2013) on behalf of the Washington Environmental Council and the Sierra Club in the matter of the Washington State Oil Refinery RACT (for Greenhouse Gases), submitted to the Washington State Department of Ecology, the Northwest Clean Air Agency, and the Puget Sound Clean Air Agency.

72. Statement (November 2013) on behalf of various Environmental Organizations in the matter of the Boswell Energy Center (BEC) Unit 4 Environmental Retrofit Project, to the Minnesota Public Utilities Commission, Docket No. E-015/M-12-920.

73. Expert Report (December 2013) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

74. Expert Testimony (December 2013) on behalf of the Sierra Club in the matter of Public Service Company of New Hampshire Merrimack Station Scrubber Project and Cost Recovery, Docket No. DE 11-250, to the State of New Hampshire Public Utilities Commission.

75. Expert Report (January 2014) on behalf of Baja, Inc., in *Baja, Inc., v. Automotive Testing and Development Services, Inc. et. al*, Civil Action No. 8:13-CV-02057-GRA (District of South Carolina, Anderson/Greenwood Division).

76. Declaration (March 2014) on behalf of the Center for International Environmental Law, Chesapeake Climate Action Network, Friends of the Earth, Pacific Environment, and the Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. the Export-Import Bank (Ex-Im Bank) of the United States*, Civil Action No. 13-1820 RC (District Court for the District of Columbia).

77. Declaration (April 2014) on behalf of Respondent-Intervenors in the matter of *Mexichem Specialty Resins Inc., et al., (Petitioners) v Environmental Protection Agency et al.,* Case No., 12-1260 (and Consolidated Case Nos. 12-1263, 12-1265, 12-1266, and 12-1267), (Court of Appeals, District of Columbia Circuit).

78. Direct Prefiled Testimony (June 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17319 (Michigan Public Service Commission).

79. Expert Report (June 2014) on behalf of ECM Biofilms in the matter of the US Federal Trade Commission (FTC) v. ECM Biofilms (FTC Docket #9358).

80. Direct Prefiled Testimony (August 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of Consumers Energy Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17317 (Michigan Public Service Commission).

81. Declaration (July 2014) on behalf of Public Health Intervenors in the matter of *EME Homer City Generation v. US EPA* (Case No. 11-1302 and consolidated cases) relating to the lifting of the stay entered by the Court on December 30, 2011 (US Court of Appeals for the District of Columbia).

82. Expert Report (September 2014), Rebuttal Expert Report (December 2014) and Supplemental Expert Report (March 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

83. Expert Report (November 2014) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

84. *Declaration (January 2015) relating to Startup/Shutdown in the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.*

85. Pre-filed Direct Testimony (March 2015), Supplemental Testimony (May 2015), and Surrebuttal Testimony (December 2015) on behalf of Friends of the Columbia Gorge in the matter of the Application for a Site Certificate for the Troutdale Energy Center before the Oregon Energy Facility Siting Council.

86. Brief of Amici Curiae Experts in Air Pollution Control and Air Quality Regulation in Support of the Respondents, On Writs of Certiorari to the US Court of Appeals for the District of Columbia, No. 14-46, 47, 48. *Michigan et. al., (Petitioners) v. EPA et. al., Utility Air Regulatory Group (Petitioners) v. EPA et. al., National Mining Association et. al., (Petitioner) v. EPA et. al.,* (Supreme Court of the United States).

87. Expert Report (March 2015) and Rebuttal Expert Report (January 2016) on behalf of Plaintiffs in the matter of *Conservation Law Foundation v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

88. Declaration (April 2015) relating to various Technical Corrections for the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.

89. Direct Prefiled Testimony (May 2015) on behalf of the Michigan Environmental Council, the Natural Resources Defense Council, and the Sierra Club in the matter of the Application of DTE Electric Company

for Authority to Increase its Rates, Amend its Rate Schedules and Rules Governing the Distribution and Supply of Electric Energy and for Miscellaneous Accounting Authority, Case No. U-17767 (Michigan Public Service Commission).

90. Expert Report (July 2015) and Rebuttal Expert Report (July 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

91. Declaration (August 2015, Docket No. 1570376) in support of "Opposition of Respondent-Intervenors American Lung Association, et. al., to Tri-State Generation's Emergency Motion;" Declaration (September 2015, Docket No. 1574820) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors for Remand Without Vacatur;" Declaration (October 2015) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors to State and Certain Industry Petitioners' Motion to Govern, *White Stallion Energy Center, LLC v. US EPA*, Case No. 12-1100 (US Court of Appeals for the District of Columbia).

92. Declaration (September 2015) in support of the Draft Title V Permit for Dickerson Generating Station (Proposed Permit No 24-031-0019) on behalf of the Environmental Integrity Project.

93. Expert Report (Liability Phase) (December 2015) and Rebuttal Expert Report (February 2016) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., Environmental Law and Policy Center, and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

94. Declaration (December 2015) in support of the Petition to Object to the Title V Permit for Morgantown Generating Station (Proposed Permit No 24-017-0014) on behalf of the Environmental Integrity Project.

95. Expert Report (November 2015) on behalf of Appellants in the matter of *Sierra Club, et al. v. Craig W. Butler, Director of Ohio Environmental Protection Agency et al.,* ERAC Case No. 14-256814.

96. Affidavit (January 2016) on behalf of Bridgewatch Detroit in the matter of *Bridgewatch Detroit v. Waterfront Petroleum Terminal Co., and Waterfront Terminal Holdings, LLC.,* in the Circuit Court for the County of Wayne, State of Michigan.

97. Expert Report (February 2016) and Rebuttal Expert Report (July 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

98. Direct Testimony (May 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

99. Declaration (June 2016) relating to deficiencies in air quality analysis for the proposed Millenium Bulk Terminal, Port of Longview, Washington.

100. Declaration (December 2016) relating to EPA's refusal to set limits on PM emissions from coal-fired power plants that reflect pollution reductions achievable with fabric filters on behalf of Environmental Integrity Project, Clean Air Council, Chesapeake Climate Action Network, Downwinders at Risk represented by Earthjustice in the matter of *ARIPPA v EPA, Case No. 15-1180.* (D.C. Circuit Court of Appeals).

101. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

102. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Backus Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

103. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Drakulic Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

104. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Deutsch Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

105. Affidavit (February 2017) pertaining to deficiencies water discharge compliance issues at the Wood River Refinery in the matter of *People of the State of Illinois (Plaintiff) v. Phillips 66 Company, ConocoPhillips Company, WRB Refining LP (Defendants)*, Case No. 16-CH-656, (Circuit Court for the Third Judicial Circuit, Madison County, Illinois).

106. Expert Report (March 2017) on behalf of the Plaintiff pertaining to non-degradation analysis for waste water discharges from a power plant in the matter of *Sierra Club (Plaintiff) v. Pennsylvania Department of Environmental Protection (PADEP) and Lackawanna Energy Center*, Docket No. 2016-047-L (consolidated), (Pennsylvania Environmental Hearing Board).

107. Expert Report (March 2017) on behalf of the Plaintiff pertaining to air emissions from the Heritage incinerator in East Liverpool, Ohio in the matter of *Save our County (Plaintiff) v. Heritage Thermal Services, Inc. (Defendant), Case No. 4:16-CV-1544-BYP*, (US District Court for the Northern District of Ohio, Eastern Division).

108. Rebuttal Expert Report (June 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight (Plaintiffs) v Coyote Creek Mining Company LLC (Defendant),* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

109. Expert Affidavit (August 2017) and Penalty/Remedy Expert Affidavit (October 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant,)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

110. Expert Report (August 2017) on behalf of Appellant in the matter of *Patricia Ann Troiano (Appellant) v. Upper Burrell Township Zoning Hearing Board (Appellee)*, Court of Common Pleas of Westmoreland County, Pennsylvania, Civil Division.

111. Expert Report (October 2017), Supplemental Expert Report (October 2017), and Rebuttal Expert Report (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

112. Declaration (December 2017) on behalf of the Environmental Integrity Project in the matter of permit issuance for ATI Flat Rolled Products Holdings, Breckenridge, PA to the Allegheny County Health Department.

113. Expert Report (Harm Phase) (January 2018), Rebuttal Expert Report (Harm Phase) (May 2018) and Supplemental Expert Report (Harm Phase) (April 2019) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

114. Declaration (February 2018) on behalf of the Chesapeake Bay Foundation, et. al., in the matter of the Section 126 Petition filed by the state of Maryland in *State of Maryland v. Pruitt (Defendant)*, Civil Action No. JKB-17-2939 (Consolidated with No. JKB-17-2873) (US District Court for the District of Maryland).

115. Direct Pre-filed Testimony (March 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of *NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC*, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington.

116. Expert Affidavit (April 2018) and Second Expert Affidavit (May 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power*

Company (Intervenor/Respondent), Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.

117. Direct Pre-filed Testimony and Affidavit (December 2018) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).

118. Expert Report (February 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.

119. Declaration (March 2019) on behalf of Earthjustice in the matter of comments on the renewal of the Title V Federal Operating Permit for Valero Houston refinery.

120. Expert Report (March 2019) on behalf of Plaintiffs for Class Certification in the matter of *Resendez et al v Precision Castparts Corporation* in the Circuit Court for the State of Oregon, County of Multnomah, Case No. 16cv16164.

C. Occasions where Dr. Sahu has provided oral testimony <u>in depositions, at trial or in similar proceedings</u> include the following:

121. Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill.

122. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

123. Trial Testimony (February 2003) on behalf of the United States in the Ohio Edison NSR Cases, *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).

124. Trial Testimony (June 2003) on behalf of the United States in the Illinois Power NSR Case, *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

125. Deposition (10/20/2005) on behalf of the United States in connection with the Cinergy NSR Case. *United States, et* al. *v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (Southern District of Indiana).

126. Oral Testimony (August 2006) on behalf of the Appalachian Center for the Economy and the Environment re. the Western Greenbrier plant, WV before the West Virginia DEP.

127. Oral Testimony (May 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) re. the Thompson River Cogeneration plant before the Montana Board of Environmental Review.

128. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.

129. Oral Testimony (August 2008) on behalf of the Sierra Club and Clean Water re. Big Stone Unit II before the South Dakota Board of Minerals and the Environment.

130. Oral Testimony (February 2009) on behalf of the Sierra Club and the Southern Environmental Law Center re. Santee Cooper Pee Dee units before the South Carolina Board of Health and Environmental Control.

131. Oral Testimony (February 2009) on behalf of the Sierra Club and the Environmental Integrity Project re. NRG Limestone Unit 3 before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

132. Deposition (July 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al*.

133. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coleto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

134. Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

135. Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

136. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).

137. Oral Testimony (November 2009) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

138. Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

139. Oral Testimony (February 2010) on behalf of the Environmental Defense Fund re. the White Stallion Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

140. Deposition (June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

141. Trial Testimony (September 2010) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (Western District of Pennsylvania).

142. Oral Direct and Rebuttal Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

143. Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

144. Oral Testimony (October 2010) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

145. Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

146. Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

147. Deposition (December 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

148. Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).

149. Oral Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

150. Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

151. Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

152. Oral Testimony at Hearing (March 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC,* 09-CV100-RET-CN (Middle District of Louisiana).

153. Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

154. Oral Testimony at Hearing (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

155. Deposition (March 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

156. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

157. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

158. Deposition (February 2014) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

159. Trial Testimony (February 2014) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

160. Trial Testimony (February 2014) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC,* Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

161. Deposition (June 2014) and Trial (August 2014) on behalf of ECM Biofilms in the matter of the *US Federal Trade Commission (FTC) v. ECM Biofilms* (FTC Docket #9358).

162. Deposition (February 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

163. Oral Testimony at Hearing (April 2015) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

164. Deposition (August 2015) on behalf of Plaintiff in the matter of *Conservation Law Foundation (Plaintiff) v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

165. Testimony at Hearing (August 2015) on behalf of the Sierra Club in the matter of *Amendments to 35 Illinois Administrative Code Parts 214, 217, and 225* before the Illinois Pollution Control Board, R15-21.

166. Deposition (May 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

167. Trial Testimony (October 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

168. Deposition (April 2016) on behalf of the Plaintiffs in *UNatural Resources Defense Council, Respiratory Health Association, and Sierra Club (Plaintiffs) v. Illinois Power Resources LLC and Illinois Power Resources Generation LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (Central District of Illinois, Peoria Division).

169. Trial Testimony at Hearing (July 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

170. Trial Testimony (December 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

171. Trial Testimony (July-August 2016) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

172. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

173. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Backus Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

174. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Drakulic Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

175. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Deutsch Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

176. Deposition Testimony (July 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight v Coyote Creek Mining Company LLC (Defendant)* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

177. Deposition Testimony (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

178. Deposition Testimony (December 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

179. Deposition Testimony (January 2018) in the matter of National Parks Conservation Association (NPCA) v. State of Washington Department of Ecology and British Petroleum (BP) before the Washington Pollution Control Hearing Board, Case No. 17-055.

180. Trial Testimony (January 2018) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

181. Trial Testimony (April 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington.

182. Deposition (June 2018) (harm Phase) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

183. Trial Testimony (July 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.

184. Deposition (January 2019) and Trial Testimony (January 2019) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).

185. Trial Testimony (March 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.

Attachment 4

Double Jeopardy in Houston

Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities

Center for Science and Democracy at the Union of Concerned Scientists

t.e.j.a.s

Texas Environmental Justice Advocacy Services

Introduction

There is compelling evidence that people of color and those living in poverty are exposed to higher levels of environmental pollution than whites or people not living in poverty (Cushing et al. 2015; Bullard, Johnson, and Torres 2011; Mohai, Pellow, and Roberts 2009; Bullard 2000). The health impacts on these populations from environmental degradation are amplified by other negative socioeconomic and health factors such as the lack of access to health care, healthy foods, and public transportation, along with stress from poverty, unemployment, and crime, among other factors (Prochaska et al. 2014; O'Neill et al. 2003). This disproportionate exposure to toxic pollution, and the associated health impacts, underscores the need to address environmental justice. Environmental justice is defined by the Environmental Protection Agency (EPA) as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA 2016a).

Recent reports by the Environmental Justice and Health Alliance for Chemical Policy Reform (EJHACPR 2014) and the Center for Effective Government (CEG 2016) found that, compared with national averages, a significantly greater percentage of African Americans, Latinos, and people in poverty live near industrial facilities that use large quantities of toxic chemicals and present a risk of major chemical disasters. A 2004 study found that larger, more chemical-intensive facilities tend to be located in counties with larger black populations and in counties with high levels of income inequality. It also found a greater risk of chemical accidents and spills at facilities in counties with larger African American populations (Elliott et al. 2004).

The release of toxic chemicals from industrial sources into surrounding communities is all too common. The EPA's Risk Management Plan (RMP) program encompasses the nation's most high-risk industrial facilities that produce, use, or store significant quantities of toxic and flammable chemicals. Among other requirements, these facilities must prepare plans for responding to a worst-case incident such as a major fire or explosion in which toxic chemical pollution is released into the surrounding community. The EPA estimates that approximately 150 catastrophic accidents occur each year in regulated industrial facilities. The EPA notes that these accidents "pose a risk to neighboring communities and workers

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Due to a lack of comprehensive zoning laws in Houston, many fenceline communities lie directly next to chemical facilities, and hence are exposed to high levels of air pollution and risk of catastrophic accidents. Compared with the Houston urban area, neighborhoods such as Harrisburg/Manchester and Galena Park comprise a larger percentage of African Americans, Latinos, and people living at or near poverty levels.

because they result in fatalities, injuries, significant property damage, evacuations, sheltering in place, or environmental damage" (EPA 2016b). Less severe accidents happen regularly—425 chemical accidents occurred in the little more than two years between the explosion in April 2013 at the West Texas fertilizer facility and August 2015 (CPCD 2015), and many others likely went unreported.

Communities closest to these hazardous facilities are likely to experience the greatest impacts from an explosion or chemical release—and would have the least amount of time to escape these dangers (USCSB 2016; Lezon 2016; Zaveri and Dempsey 2016). Therefore, while the "vulnerability zone" that would be impacted by a worst-case accident from some of these RMP facilities extends as far as 25 miles or more, this report focuses on the demographics and health risks for people living within one mile of these facilities—the fenceline zone.

THE HOUSTON CONTEXT

In addition to the acute risk of a catastrophic chemical accident, people in fenceline communities—those in close proximity to these facilities—face the "double jeopardy" of living with daily chronic exposure to high levels of toxic pollution in their air, water, and soil. Exposure to toxic air pollution in the Houston metropolitan area has long been a concern, especially for low-income communities and communities of color along the Houston Ship Channel, home to a large concentration of oil refineries and other heavy industry. An analysis of air pollution risks in the greater Houston area conducted in 2005 to 2006 for the Mayor's Task Force on Health Effects of Air Pollution, which also focused on several east Houston communities, found that air pollution in the Harrisburg/Manchester community exceeded safe levels for seven of the 12 air pollutants deemed "definite risks," the most of any of the communities. In assessing the results of air pollution on east Houston communities, the task force concluded that "east Houston neighborhoods that face a number of vulnerabilities based on their marginal social and economic standing also carry a heavier burden of health risks from breathing pollutants in their air. They tend to be located

[The accidental release of toxic chemicals from industrial sources into surrounding communities is all too common.]

closer to major point sources than most other neighborhoods in the greater Houston area and to be nearer to major transportation corridors. The burden of these risks taken together poses special needs in these neighborhoods" (Mayor's Task Force 2006).

Other studies of the Houston area's air pollution have found similar disproportionate impacts on people of color and the poor. A 2008 study found a disproportionate cancer risk especially for Hispanics living in poverty and with other indicators of social disadvantage (Linder, Marko, and Sexton 2008). A recent study of the Houston area examined residents'

[425 chemical accidents occurred in the little more than two years between the explosion in April 2013 at the West Texas fertilizer facility and August 2015.]

acute risks from potential chemical facility accidents as well as chronic risks from exposure to air pollution, finding that "neighborhoods with a higher percentage of Hispanic residents, lower percentage of homeowners, and higher income inequality are facing significantly greater exposure to both chronic and acute pollution risks. . . . Households isolated by language—those highly likely to face evacuation problems during an actual chemical disaster—tend to reside in areas facing significantly greater exposure to high-impact acute events"(Chakraborty et al. 2014).

This report builds on that past work, analyzing chronic exposure and health risks from toxic air pollution as well as potential acute exposures from unplanned chemical releases from neighboring chemical facilities included in the EPA's RMP program. We compare the risks and exposures facing residents of two predominantly Hispanic and low socioeconomic east Houston communities, Harrisburg/Manchester and Galena Park, with two primarily white and wealthier west Houston communities, West Oaks/Eldridge and Bellaire (see methodology section below).

Cities, towns, and neighborhoods composed predominantly of low-income people of color—such as those of Galena Park and Harrisburg/Manchester—with high densities of commercial and industrial spaces that pose serious health and societal impacts on their residents often go unnoticed, unappreciated, and even justified as acceptable by people

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The Houston neighborhoods of Harrisburg/Manchester and Galena Park, whose residents are predominantly African American, Hispanic, and low income, face far greater health risks than the members of more white and affluent communities like West Oaks/Eldridge and Bellaire, given their proximity to chemical facilities that pollute the surrounding air, water, and soil.

who have little experience with the circumstances of these communities. In his classic study of landfills and dumps in black neighborhoods in Houston, *Dumping in Dixie*, Dr. Robert Bullard asks, "Are environmental inequities a result of racism or class barriers or a combination of both? After more than two decades of modern environmentalism, the equity issues have not been resolved" (Bullard 2000). He also notes that, "poor whites and poor blacks [and brown communities] do not have the same opportunities to vote with their feet. Racial barriers to education, employment, and housing reduce mobility options available to the black [and brown] underclass and the black [and brown] middleclass."*

As a result of the multiple constraints on low-income residents, their relocation away from these polluting sources is not a realistic option without assistance. Cycles of poverty, institutionalized racism, hopelessness, fear, and complacency are the products of failed attempts to push for change. These factors call for a deeper understanding of and respect for the issues facing environmental justice communities—not only regarding the intersection of race and disproportionate impacts of pollution but including a broader look at the societal systems that allowed these situations to develop.

While Galena Park and Harrisburg/Manchester are no longer dotted by oil derricks, they now house facilities that store and produce large amounts of chemicals, oil, and other toxic products, posing disproportionate risks of catastrophic chemical spills and chronic air-pollution emissions on people of color. They are just two of many frontline environmental justice communities throughout the nation that pay the environmental and human price for rampant industrial growth.

Political Realities

Congressional and state legislative districts have a history of disenfranchising minority and low-income communities by drawing district lines to reinforce favorable voting patterns (Bush v. Vera 1994). While US House of Representatives District 29, which encompasses Galena Park, Manchester, Pasadena, and a handful of other environmental justice communities, is a majority Hispanic district established to diversify representation in Congress, it has yet to achieve this goal. Fortunately, a recent Texas voter-identification requirement was struck down in federal court, in part because it would disproportionately discourage Latino and black residents from voting (Veasey v. Perry 2014).

Further weakening the protection of east Houston communities is the lack of citywide zoning in Houston. The city officials maintain that its patchwork of ordinances and restrictions fills this gap. These include municipal management districts, ordinances, deed restrictions, historic designations, de facto locally controlled zoning, and developer-master-planned

* *Bullard added the inclusion of brown communities in personal communication with the report's authors (Bullard 2016).*

Congressional and state legislative districts have a history of disenfranchising minority and low-income communities.

communities. Such bodies have restricted motels, industrial facilities, and cell phone towers. Bodies such as the 22 municipal management districts that overlap with tax increment reinvestment zones in Houston can be effective at exerting influence over land use, and municipal management districts can use tax increment reinvestment zones to fund community improvement projects (Kiger 2015). Unfortunately, these land use efforts have not been as effective in marginalized communities as in other communities.

In recent years, Texas has frequently opposed national environmental protection efforts, having sued the EPA 23 times since the start of the Obama administration (Wray 2016a). To improve environmental conditions in their communities, local organizations such as Texas Environmental Justice Advocacy Service have communicated with the EPA, the Texas Commission on Environmental Quality, local and state officials, and industry players and have utilized the legal system to press their concerns about environmental conditions and health impacts (Selle 2013). Although working groups and strategy plans have been established to address these environmental issues, most of these bodies not only add a bureaucratic layer to communication between residents and agencies, but also create lengthy response times.

History and Community Characteristics

HARRISBURG/MANCHESTER

Harrisburg/Manchester sits beneath the 610 Ship Channel Bridge on a 5.81-square-mile plot of land and was once a booming shipping and oil town. Originally intended to be a wharf, since the 1860s Harrisburg/Manchester has been occupied by commercial industry—first, cotton and grains, followed by oil, petrochemical products, and plastics (Magnolia Park Land Company n.d.). Formerly predominately white, by the 1980s the population of Harrisburg/Manchester was predominantly Hispanic (CHPDD 2014; Kleiner 2010). While Houston, called the energy capital of the nation, experienced economic expansion fueled by the world's energy consumption and reliance on petrochemical products, Manchester and other east Houston communities bore the brunt of this growth.

Hartman Park, the only public green space in Harrisburg/Manchester, exemplifies what it means to be a fenceline community where industries such as Valero Refining and Westway Chemicals can be spotted from residents' doorsteps. These are large industrial plants. Valero Houston Refining has a throughput capacity of 160,000 barrels per day of a range of petroleum products including gasoline, kerosene, jet fuel, ultra-low sulfur, liquefied petroleum gases, propylene, no. 6 oil, and sulfur. Westway Chemical Terminals and Storage handles a wide variety of products from fertilizers to petroleum and houses 93 steel tanks ranging from 4,100 to 74,500 barrels with a total capacity of 2,059,512 barrels; additional railcar storage expansion is underway (Westway Terminal Group n.d.).

Located at the mouth of the 52-mile Houston Ship Channel, Harrisburg/Manchester is home to numerous polluting industrial facilities, including oil refineries and other heavy industry. Looming over the community to the east is the 610 Ship Channel Bridge, which casts a shadow on Harrisburg/Manchester as one of the busiest highways in the city, releasing an unbroken stream of diesel emissions. Beneath the bridge is Texas Port Recycling, a facility with the largest metals shredder in southeast Texas, specializing in ferrous and nonferrous scrap metal recycling, railcar dismantling, car crushing, torch processing, container dismantling, and other processes (Texas Port Recycling n.d.). There are more than 30 industrial emitters of wastewater, air contaminants, and hazardous waste in Harrisburg/Manchester that report to the EPA, in addition to many more facilities that handle hazardous materials but are not required to report to the agency. On the south end of this community are more than 26 lanes of Union Pacific rail tracks. Industries in neighboring communities also add to the cumulative exposures that affect this community.

Some older residents who at one point worked at nearby plants often share concerns over the workplace safety practices. If disaster struck one of these facilities, it would start a catastrophic domino effect leading to an evacuation. However, all possible exits, except for one, are crossed by rail tracks with the potential for trains blocking their use. The Bernie Guerra Bridge, named after a man who lost his life because an emergency vehicle could not reach him, provides the sole escape route and has just two lanes, one in and one out. An evacuation of Harrisburg/Manchester would require more than 3,000 people to use one road, consisting of a single lane, out of town.

Ninety-seven percent of the population in this economically depressed neighborhood is made up of people of color;

90 percent are low income and 37 percent live in poverty. Long-term daily exposures to air pollution can lead to health effects that go unaddressed due to residents' limited financial and health care resources. Residents of fenceline communities such as Harrisburg/Manchester are unable to relocate because of low home values, a product (paradoxically) of being so close to polluting industry. Residents lack access to public transportation: in March 2016 the public transportation authority stopped serving the area. They also lack sufficient access to healthy food, health care, and to political representation. This entanglement of issues, coupled with a lack resources and the disproportionate layering of intersecting social issues, epitomizes environmental justice communities like Harrisburg/Manchester.

> ***Long-term daily exposures to air pollution can lead to health effects that go unaddressed due to residents' limited financial and health care resources.***

GALENA PARK

East of Highway 610 and north of Harrisburg/Manchester is the city of Galena Park, originally named Clinton. Formed in 1835, Clinton was a ranching and farming community that benefited economically from being at the mouth of the Houston Ship Channel prior to the construction of the Turning Basin (Ramirez 2010). Due to development of the Houston Ship Channel and the oil industries it began to harbor in the early 1900s, Clinton's economy became less reliant on its agrarian trade and more on industrial development such as oil and synthetic rubber, as well as the movement of goods by water and then by rail (Sibley 2016). Clinton was renamed Galena Park in 1935 after the Galena Signal oil refinery (Siegel and Moretta 2005). Galena Park became an industry town where most of the population worked in oil production in some capacity (Leslie and Edwards 1993). At its inception, Galena Park's population was majority white, due to vast racial segregation in the city. Today, Galena Park is a low-income community of roughly 11,000 residents, of whom 81 percent are Hispanic (Census Bureau 2016).

Like Harrisburg/Manchester, Galena Park is surrounded by the oil, chemical, and supporting industries—the Valero refining stack and Eco Services' candy cane–striped sulfuric acid marker in Harrisburg/Manchester can be seen from homes in Galena Park. Today more than 50 industrial facilities are located in the community, including those owned or operated by Kinder Morgan, Shell, and United States Gypsum. Many sit within one-tenth of a mile from homes and workplaces (EPA 2015a) (see appendix).

Today, rail lines surround the city and intersect with its exits, creating a nightmare for emergency workers traveling to the site of a chemical release. Even though—unlike the city of Houston—Galena Park does have zoning restrictions, it has been on the Texas Commission on Environmental Quality's pollutant watch list for 16 years based on benzene levels that have exceeded screening levels of both the EPA and the Texas Commission on Environmental Quality (Wray 2016b). The toxic air-pollution problem is so extensive that the commission expanded the boundary of the Galena Park air pollutant watch list to include monitoring at additional benzene sources, and the Harris County Pollution Control Services Department added a monitor in 2011 (Capobianco et al. 2013).

BELLAIRE

We selected the west Houston community of West Oaks/Eldridge and the city of Bellaire as comparison communities based on their racial and economic demographics as well as their geographical locations. Both communities are substantially more affluent than the east Houston communities of Harrisburg/Manchester and Galena Park.

The city of Bellaire is a predominantly white (73 percent), upper-class community located within the inner Houston core and has an average income almost five times higher, home values eight times higher, and a poverty rate 7 and 12 times lower than those of Galena Park and Harrisburg/Manchester, respectively. Bellaire ("good air")—so named for its Gulf Coast winds—was founded in 1908 after Southwest Land Company purchased the 9,449-acre Rice Ranch and was incorporated in 1918. Bellaire has zoning for light industrial, commercial, and mixed-use residential and commercial areas. The zoning efforts do not permit open storage facilities such as wrecking, junk, or salvage yards (Bellaire, Texas, code of ordinances 2006). The city has only two allotments for light industrial activity, one of which houses the City of Bellaire Public Works.

WEST OAKS/ELDRIDGE

West Oaks/Eldridge is located in the outer Houston suburbs. Just 30 years ago, this area transitioned from rural sprawling ranches to more residential properties, with energy and business growth. Unlike Harrisburg/Manchester, West Oaks/

> ***Today, rail lines surround the city and intersect with its exits, creating a nightmare for emergency workers traveling to the site of a chemical release.***

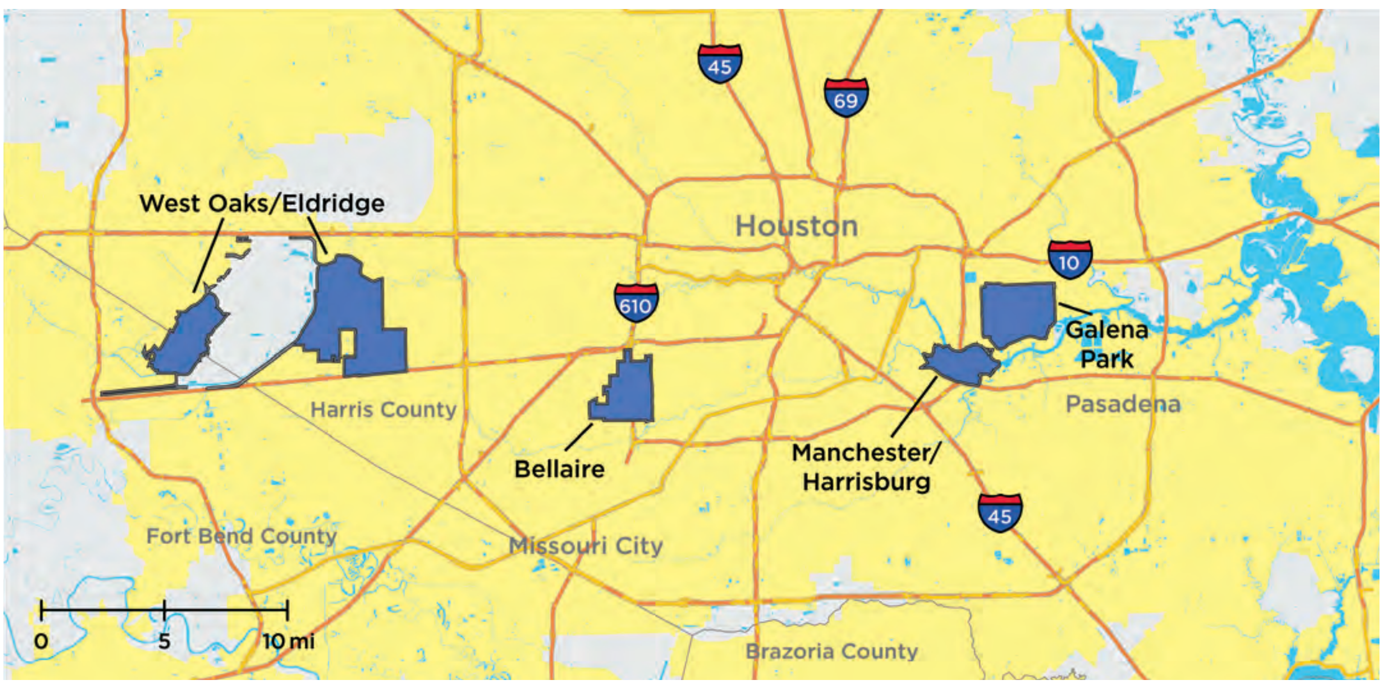
Eldridge has a vast amount of green space, including the Terry Hershey Park trail system that provides walking and bike trails, the George Bush Park west, and the Ray Miller Park with a butterfly garden. Along with several public school districts, several private schools service the area. West Oaks/ Eldridge is also the headquarters of many of the corporations that own facilities in east Houston, including BP America, Citgo, ConocoPhillips, Dow Chemical, and ExxonMobil Chemical. Although the majority of the population is people of color, whites are the predominant individual race, and the poverty rate is one-half to one-third that of the east Houston communities.

Methodology

HOUSTON COMMUNITIES INCLUDED IN THE REPORT

Our analysis of chemical exposures, cancer, and respiratory health risks focused on four communities within the Houston urban area (Census Bureau n.d.a.): Harrisburg/Manchester and Galena Park in east Houston, and Bellaire and West Oaks/ Eldridge in west Houston (Figure 1). West Oaks/Eldridge and Harrisburg/Manchester are both Houston "super neighborhoods," while Bellaire and Galena Park are both classified by the US census as "cities" within the Houston metropolitan area.

FIGURE 1. The Four Houston-area Communities Analyzed for Toxic Chemical Pollution and Health Risks



Toxic air pollution levels and health risks in predominately Hispanic and low-income east Houston communities of Manchester/Harrisburg and Galena Park were compared the wealthier and predominantly white west Houston communities of Bellaire and West Oaks/Eldridge.

SOURCES: HOUSTON URBAN AREA, GALENA PARK, AND BELLAIRE BOUNDARIES, CENSUS BUREAU N.D.A.; MANCHESTER AND WEST OAKS/ELDRIDGE BOUNDAIRES, HOUSTON DATA PORTAL 2013.

The four communities were chosen to allow us to assess any differences in toxic-chemical exposures and potential health risks that may exist between the two types of communities based on demographics (Table 1). The east Houston communities of Harrisburg/Manchester and Galena Park were chosen as examples of Houston frontline communities that are directly impacted by numerous polluting industrial facilities. The west Houston community of West Oaks/Eldridge and the city of Bellaire were selected as comparison communities based on their economic demographics as well as their different geographical locations within the Houston Urban Area. Both communities are substantially more affluent than the east Houston communities of Harrisburg/Manchester and Galena Park. Bellaire is a predominantly white (73 percent), upper-class community located within the inner Houston core with an average income almost five times higher, home values eight times higher, and a poverty rate seven to 12 times lower than those of the east Houston communities. In contrast to the lack of citywide zoning in Houston, Bellaire has zoning for light industrial, commercial, and mixed-use residential and commercial uses. Though West Oaks/Eldridge has a majority of people of color, whites are the predominant individual race, and the poverty rate in that community is one-half to one-third that of the east Houston communities.

With respect to the percentage of people living in poverty in all Houston communities, the Harrisburg/Manchester and Galena Park communities rank in the top 94th and 60th percentiles, respectively, while the Bellaire and West Oaks/Eldridge communities rank in the bottom 4th and 30th percentiles. The two east Houston communities are in the top 92nd and 68th percentiles for percentage of people of color, respectively, and the two west Houston communities are in the bottom 17th and 46th percentiles, respectively (Figure 2, p. 9). Both West Oaks/Eldridge and Bellaire are home to fewer high-risk chemical facilities than the five and eight facilities located within one mile of Harrisburg/Manchester and Galena Park, respectively. Only four such facilities are located within one mile of West Oaks/Eldridge, and just one lies within a mile of Bellaire (see Table 8, p. 15).

DATA COLLECTION AND MAPPING

Publicly available data from the EPA's RMP as provided by the Right-to-Know Network (CEG 2014) were used to determine which RMP facilities were located in the Houston urban area (as defined by the US census) and, more specifically, in the four communities of interest. Facilities' locations were determined based on their self-reported latitude/longitude codes.

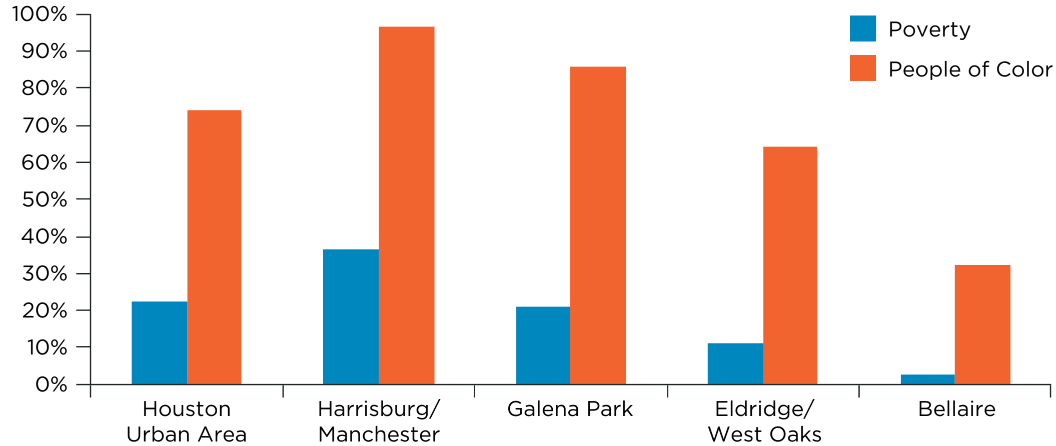
TABLE 1. Wide Demographic Differences Exist Among the Four Houston Communities, including those Populations Living within One Mile of an RMP Facility, and the Houston Urban Area

	Houston Urban Area	Galena Park	Galena Park RMP 1 Mile	Harrisburg/ Manchester	H/M RMP 1 Mile	Bellaire	Bellaire RMP 1 Mile	West Oaks/ Eldridge	West Oaks/ Eldridge RMP 1 Mile
% Population People of Color	67%	86%	86%	97%	97%	32%	34%	64%	76%
% Population in Poverty	17%	21%	21%	37%	38%	3%	4%	11%	11%
Average Home Value	$197,888	$68,118	$71,088	$80,028	$78,159	$647,544	$534,755	$243,912	$177,031
Average Household Income	$82,920	$49,732	$48,233	$45,431	$45,520	$226,333	$191,864	$91,055	$82,178

Demographic data from the US Census Bureau's American Community Survey, accessed via the Census Bureau's "data ferrett" interface (United States Census Bureau n.d.), were used to create census tract–level data tables. This database is updated annually and summarized into three- and five-year spans. The most recent five-year span, 2010 to 2014, was used for this analysis.

SOURCE: CENSUS BUREAU N.D.B.

FIGURE 2. Harrisburg/Manchester and Galena Park Have Substantially Higher Percentages of Poverty and People of Color Compared with West Oaks/Eldridge, Bellaire, and the Houston Urban Area



Using geographic boundaries and racial and poverty statistics from the Census Bureau and Houston government, the population in each of the four communities and the Houston Urban Area were compared to each other.

SOURCE: CENSUS BUREAU, N.D.B.

We obtained data from the EPA's 2011 National Air Toxics Assessment (NATA) cancer risk and respiratory hazard index, as well as specific pollutant risk data, from the NATA website (EPA 2015b), using the census-tract identification codes.

To identify the air pollution burden and chemicals with the greatest health impacts on the four Houston communities, we utilized data from the EPA's Risk Screening Environmental Indicators (RSEI) program (EPA 2016c). In addition, we used the RSEI database to identify industrial sources with the largest toxic air pollution in these communities. The RSEI data were obtained from the EPA and provided to us by Dr. Michael Ash. Dr. Ash is professor of economics and public policy and the chair of the Department of Economics at the University of Massachusetts Amherst. He is affiliated with the Political Economy Research Institute and has access to RSEI microdata. Although these data are publicly available, they are not readily available in the format we required for this analysis. Dr. Ash provided aggregated "toxic concentration" data for the census tracts in the Houston urban area.

The RSEI uses information from the EPA's Toxics Release Inventory (TRI), which tracks toxic chemical releases to the air and water as well as waste management activities for more than 400 chemicals at more than 50,000 industrial and federal facilities across the United States. The RSEI uses simplifying assumptions to fill data gaps and reduce the complexity of calculations. The RSEI toxic concentration scores are unitless numbers that integrate pollution emissions reported to the Toxics Release Inventory weighted by the toxicity of each pollutant and the amount impacting a location. It does not provide a formal risk assessment or describe a specific level of risk, but provides a numeric basis for comparing scores across communities.

Unlike the NATA data discussed previously, which are limited to information on toxic air pollution levels from 2011,

With respect to the percentage of people living in poverty in all Houston communities, the Harrisburg/Manchester and Galena Park communities rank in the top 94th and 60th percentiles.

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In Harrisburg/Manchester and Galena Park, where numerous chemical facilities are located within residential neighborhoods, toxic air pollution levels are much higher than in Bellaire and West Oaks/Eldridge.

the RSEI toxic concentration values for the communities are based on more recent TRI data from 2014. However, it should be noted that while the NATA data are based on toxic air pollution emissions from a broad spectrum of sources (such as large and small industrial facilities, on-road and off-road mobile sources, secondarily formed air pollution), the RSEI data used for this analysis are limited to air pollution emissions from the industrial sources that report to the TRI program.

DEMOGRAPHIC AND TOXIC RISK CALCULATIONS

We used the areal apportionment method to determine the demographics of the neighborhoods and the one-mile zones around the RMP facilities (Mohai and Saha 2007; Mohai and Saha 2006). Thus, demographic characteristics were determined by weighting them based on the proportion of the tract that was captured in the area we studied, then aggregating those data.

NATA risk scores were calculated using the methodology explained in the NATA technical support document (EPA 2015c). We multiplied the "total cancer risk" by the tract population (calculated using the areal apportionment method described above) in the area studied, then aggregated those results and divided that total by the total population in the area. The "cancer risk" and "respiratory hazard index" were calculated for each of the pollutants, and the five chemicals with the highest cancer risk and the five chemicals with the highest respiratory hazard index in each area were identified.

The RSEI "toxic concentration" scores were calculated by multiplying the air pollution toxic concentration by the tract population (as determined using the areal apportionment method described previously) in the area studied, then aggregating those results and dividing that total by the total population in the area. The final values for toxic concentration were also analyzed by chemical and responsible facility in each of the areas studied. Those results were then sorted from highest to lowest values to determine the chemicals and facilities yielding the highest toxic concentration in each area. More information about RSEI can be found at *https://www.epa.gov/rsei/risk-screening-environmental-indicators-rsei-methodology-version-234*.

Results

TOXIC AIR POLLUTION IN HOUSTON

Using the EPA's RSEI data, we found large disparities between the east and west Houston communities in terms of overall toxicity levels from chemical exposures. Our analysis showed that toxicity levels from exposures in Harrisburg/Manchester are 12 and more than three times higher than in West Oaks/Eldridge and Bellaire, respectively, and exposures in Galena Park are 17 and almost five times higher (Table 2).

TABLE 2. Total Toxic Concentration Values in East Houston Communities Are Many Times Higher than West Houston Communities

Community	Total Toxic Concentration
Galena Park	157,653
Harrisburg/Manchester	110,712
Bellaire	32,291
West Oaks/Eldridge	9,233

RSEI data were utilized to derive total toxic concentration values from all of the reporting facility sources that release toxic chemicals into the air in the four Houston communities. By analyzing information from the Toxics Release Inventory together with risk factors, such as each chemical's toxicity, RSEI calculates a toxic concentration numeric score. These scores are then multiplied by the number of affected people in each location and divided by the location population to provide a population-adjusted toxic concentration value.

SOURCES: EPA 2016C; CENSUS BUREAU N.D.B.

POLLUTION SOURCES IMPACTING THE HOUSTON COMMUNITIES

We also analyzed which major industrial facilities contributed the greatest air pollution burden on the communities studied. The high levels of toxic air pollution from major industrial sources in the communities of Harrisburg/Manchester and Galena Park are shown in Table 3. The concentrations in the east Houston communities are 10 to 16 times greater than those in the west Houston communities.

TABLE 3. Top Five Industrial Facilities Impacting the Four Houston Communities

Community	Facility Name	Toxic Concentration	Type of Facility
Galena Park	Ameriforge Corp.	43,358	Iron and Steel Forging
	Targa Downstream LLC–Galena Park Marine Terminal	21,134	Petroleum Bulk Stations and Terminals
	Bayer Materialscience Baytown	16,414	All Other Basic Organic Chemical Manufacturing
	Valero Refining–Texas Lp Houston Refinery	15,180	Petroleum Refining
	Houston Refining LP	6,737	Petroleum Refining
	Total	**102,823**	
Harrisburg/ Manchester	The Goodyear Tire & Rubber Co.	17,191	Synthetic Rubber Manufacturing
	Valero Refining—Texas LP Houston Refinery	14,820	Petroleum Refining
	Ameriforge Corp	13,577	Iron and Steel Forging
	Bayer Materialscience Baytown	8,399	All Other Basic Organic Chemical Manufacturing
	Houston Refining LP	6,254	Petroleum Refining
	Total	**60,241**	
Bellaire	Ellwood Texas Forge	16,172	Iron and Steel Forging
	Ameriforge Corp.	2,167	Iron and Steel Forging
	Ameri-Forge Ltd. dba/Forged Vessel Connections	1,599	All Other Miscellaneous Fabricated Metal Product Manufacturing
	Dixie Chemical Co, Inc.	997	All Other Basic Organic Chemical Manufacturing
	Wyman-Gordon Forgings LP	908	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
	Total	**21,843**	
West Oaks/ Eldridge	Ellwood Texas Forge	2,413	Iron and Steel Forging
	Ameriforge Corp.	1,473	Iron and Steel Forging
	Wyman-Gordon Forgings LP	1,301	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
	Daniel Measurement & Control, Inc.	618	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use
	Hoover Materials Handling Group, Inc.	565	All Other Plastics Product Manufacturing
	Total	**6,370**	

Toxic concentration scores are numbers without units calculated by aggregating the air-pollution toxic concentration for all tracts in each community studied. The toxic concentration numbers were further aggregated by responsible facility in each community. It is important to note that some of the facilities with major chemical-pollution impacts on these communities are not located within the community, but their pollution is transported over longer distances into these communities.

SOURCES: ASH 2016; EPA 2016C.

TOXIC AIR POLLUTION WITH THE GREATEST POTENTIAL FOR HEALTH IMPACTS

We further analyzed the individual chemicals contributing to the toxic concentration levels in the four Houston communities, highlighting the top five chemicals with the greatest concentrations (Table 4). While several of the chemicals with the largest toxic concentrations are consistent across the four communities, there are substantially greater exposures in the Harrisburg/Manchester and Galena Park communities for several of these toxic chemicals. For example, the toxic concentration of 1,3-butadiene, which causes cancer and a host of adverse neurological effects, was 174 times and 29 times greater in Harrisburg/Manchester than the levels in West Oaks/Eldridge and Bellaire, respectively, and levels in Galena Park were 228 times and 38 times greater. The toxic concentration of cancer-causing benzene was almost eight times greater in Harrisburg/Manchester compared with Bellaire. The toxic concentration of cobalt, which can cause respiratory health problems, was 11 and 33 times greater in Galena Park than in Bellaire and West Oaks/Eldridge, respectively.

HEALTH RISKS OF TOXIC AIR POLLUTION EXPOSURE

To compare the cancer risks and potential respiratory hazards from residents' exposure to toxic air pollution in the four Houston communities studied, we used data from the EPA's National Air Toxics Assessment. The NATA was developed primarily as a tool to inform both national and more localized efforts to collect air toxics information and characterize emissions (e.g., to prioritize pollutants or geographical areas of interest for more-refined data collection such as monitoring). The 2011 NATA data, the most recent available, include data for 140 toxic air pollutants from a broad spectrum of sources including large industrial facilities, such as refineries and power plants, and smaller sources, such as gas stations, oil and gas wells, and chrome-plating operations. Other pollution sources include cars, trucks, and off-road sources such as construction equipment and trains, as well as pollution formed by chemical reactions in the atmosphere.

The EPA calculates the amount of air pollution faced by people at the census-tract level and then uses health benchmarks to estimate cancer risks and respiratory health hazards from the combined effect of those exposures. Cancer risks are expressed as the projected number of cancers per million people based on a 70-year lifetime of exposure. The respiratory hazard index represents the ratio of pollutant levels compared with EPA benchmarks established as not likely to cause non-cancer respiratory illnesses based on a lifetime of exposure. An index value greater than 1 indicates the potential for adverse health impacts, with increasing concern as the value increases.

The cancer risk and respiratory hazard values are based on numerous modeled data and therefore should be viewed as estimates of average population risks and hazards rather than exact risk numbers for a particular person. Although NATA estimates cancer risks and non-cancer hazards for numerous toxic air pollutants, additional chemicals might exist that

TABLE 4. Chemicals with the Highest Toxic Concentration Values in Four Houston Communities

Community	Chemical	Toxic Concentration
Galena Park	Chromium and chromium compounds	47,783
	1,3-Butadiene	38,020
	Diaminotoluene (mixed isomers)	16,843
	Cobalt and cobalt compounds	11,975
	Hydrogen cyanide	11,684
Harrisburg/ Manchester	Chromium and chromium compounds	30,817
	1,3-Butadiene	29,083
	Hydrogen cyanide	9,512
	Diaminotoluene (mixed isomers)	8,541
	Benzene	6,795
West Oaks/ Eldridge	Chromium and chromium compounds	7,377
	Nickel and nickel compounds	470
	Cobalt and cobalt compounds	362
	Propyleneimine	187
	1,3-Butadiene	167
Bellaire	Chromium and chromium compounds	23,315
	Nickel and nickel compounds	1,323
	Cobalt and cobalt compounds	1,127
	1,3-Butadiene	992
	Benzene	884

Toxic concentration scores are numbers without units calculated by aggregating the air-pollution toxic concentration for all tracts in each area studied, and then multiplied by the population in each area.

SOURCES: ASH 2016; EPA 2016C.

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Major toxic air pollutants, including those found in high concentrations in Harrisburg/Manchester and Galena Park, are linked to cancers and other serious illnesses affecting the eyes, heart, and respiratory system.

are not identified or for which data on these health impacts are unavailable. Therefore, these risk and hazard estimates represent only a subset of the total potential cancer and non-cancer risks associated with air toxics exposures. It is also important to note that these risk estimates do not consider ingestion or the breathing of indoor sources of air toxics as an additional exposure pathway.

Residents of Harrisburg/Manchester and Galena Park face substantially higher cancer and respiratory health risks than people in West Oaks/Eldridge and Bellaire (Table 5). This finding is not surprising given the concentration of industrial pollution sources in east Houston communities and their proximity to major highways and the Houston Ship Channel.

Residents of the Harrisburg/Manchester community have a 24 and 30 percent higher cancer risk than those of Bellaire and West Oaks/Eldridge, respectively, with people in fenceline areas of Harrisburg/Manchester facing a 20 and 29 percent greater cancer risk than those in fenceline areas of Bellaire and West Oak/Eldridge. The cancer risk for

TABLE 5. The Harrisburg/Manchester Community Faces Cancer Risks 24 to 30 Percent Greater Than Those in Bellaire and West Oak/Eldridge

	Total Cancer Risk	Cancer Risk Within One Mile of RMP	Total Respiratory Hazard Index	Respiratory Hazard Within One Mile of RMP
Texas	41.07	42.80	1.77	1.90
Houston Urban Area	44.74	47.07	2.09	2.17
Galena Park	57.28	59.05	2.56	2.56
Harrisburg/Manchester	54.44	55.14	2.56	2.55
Bellaire	44.06	45.77	2.06	2.20
West Oaks/Eldridge	42.0	42.9	1.79	1.77

Values for cancer risk and respiratory health hazard for all four communities were calculated from the EPA's 2011 National Air Toxics Assessment, using the census-tract identification codes. Cancer risk is expressed as the incidences of cancer per million people. For the respiratory hazard index, an index value greater than 1 indicates the potential for adverse health impacts, with increasing concern as the value increases.

SOURCE: EPA 2015B.

Harrisburg/Manchester is 22 percent higher than for the overall Houston urban area and is 17 percent higher for people in fenceline areas of Harrisburg/Manchester than for people in fenceline areas of the overall Houston urban area.

Residents of Galena Park face cancer risks that are 30 and 36 percent higher than those in Bellaire and West Oak/Eldridge, respectively, with those in fenceline areas facing a 29 and 38 percent higher risk than fenceline areas of Bellaire and West Oak/Eldridge. Cancer risk for Galena Park is 28 percent greater than that for the entire Houston urban area and 25 percent higher than for people in the Houston urban area living within one mile of an RMP facility.

[***The cancer risk for Harrisburg/Manchester is 22 percent higher than for the overall Houston urban area.***]

The respiratory hazard index for both Harrisburg/Manchester and Galena Park is 24 and 43 percent higher than for Bellaire and West Oaks/Eldridge respectively, indicating that residents in these communities face a comparatively higher potential for developing or worsening lung diseases such as asthma and chronic bronchitis. The respiratory hazard index for Harrisburg/Manchester and Galena Park is 22 percent greater than for the overall Houston urban area. Results for people living within one mile of RMP facilities in each of the four communities are generally similar to those for the entire community, though the respiratory hazard index for people in Bellaire living within one mile of an RMP facility is somewhat higher (7 percent) than that of the entire Bellaire community.

TOXIC AIR POLLUTANTS WITH THE GREATEST POTENTIAL HEALTH IMPACTS

Using NATA data, we analyzed which air pollutants were the greatest contributors to health risks in the four Houston communities (Table 6). Though the chemicals that contribute the greatest to cancer risks and respiratory hazards are generally similar across all four communities analyzed, the substantially higher levels of 1,3-butadiene in Harrisburg/Manchester results in a cancer risk that is 63 percent and 51 percent higher than that of West Oaks/Eldridge and Bellaire, respectively, while risks in Galena Park are 52 percent and 41 percent higher. Benzene-related cancer risks for residents of Galena Park are 46 percent and 25 percent higher in com-parison with West Oaks/Eldridge and Bellaire, respectively, and are 27 percent and nine percent higher in Harrisburg/Manchester. The cancer and non-cancer health effects from these air pollutants are summarized in Table 7. The potential for adverse respiratory impacts from acrolein, which contributed the most to respiratory hazard values for all four communities, was 21 and 43 percent greater in Harrisburg/Manchester compared with Bellaire and West Oaks/Eldridge, respectively, and 19 and 41 percent greater in Galena Park.

DISTRIBUTION OF HIGH-RISK INDUSTRIAL FACILITIES

Industrial facilities included in the EPA's RMP program are those that pose a significant danger from explosions, fires, and other incidents that could result in a release of hazardous chemicals into surrounding communities and disastrously affecting their residents. The Harrisburg/Manchester and Galena Park communities house many more of these RMP industrial facilities than do Bellaire and West Oaks/Eldridge (Table 8). This finding is not surprising given the lack of zoning in Harrisburg/Manchester and the failure to buffer residential areas from industrial facility siting in Galena Park, which does have zoning.

Particularly striking is the difference in populations living within one mile of these facilities: 90 percent of the population of Harrisburg/Manchester and almost 40 percent of those in Galena Park live within one mile of these dangerous facilities in contrast with the 9 and 14 percent of those living in Bellaire and West Oaks/Eldridge, respectively. While the focus of this analysis is on those living within one mile of the chemical facility fence lines, many of the facilities have impact zones for a worst-case accident that extend out three miles or even much farther. The disparity in the number of RMP facilities within three miles in the two sets of communities is especially pronounced, with 28 and 16 facilities in Galena Park and Harrisburg/Manchester, respectively, compared with seven and one in West Oaks/Eldridge and Bellaire, respectively.

Communities in the east Houston area include many RMP facilities that have a history of numerous accidents reported to the EPA. Harrisburg/Manchester and Galena Park have each had two accidents from facilities within one mile of their communities during the five years prior to the facilities' report to the EPA, while facilities in West Oaks/Eldridge and Bellaire have not reported any accidents. For a detailed interactive map of these accidents, as well as demographic data, please visit *www.ucsusa.org/DoubleJeopardy*. It is important to note that these numbers reflect only serious accidents that are required to be reported to the EPA and thus may significantly underestimate the actual number of accidents and chemical releases at these facilities.

SECURING CLEAN AIR AND SAFE FACILITIES FOR ALL HOUSTON RESIDENTS

The communities of Harrisburg/Manchester and Galena Park face disproportionately high levels of toxic air and chemical pollution—and the attendant health effects—from a broad range of sources when compared with the Houston urban area overall as well as two west Houston communities. The east Houston communities contain more high-risk RMP

TABLE 6. Cancer Risks and Respiratory Health Hazards in East Houston Communities from the Top Five Toxic Air Pollutants and Cancer-Causing Chemicals by Total Risk (Cancer Incidence per Million People)

	Galena Park	Harrisburg/Manchester	Bellaire	West Oaks/Eldridge
Cancer-causing Chemicals by Total Risk (Cancers/Million People)				
Formaldehyde	25.76	25.02	23.78	24.44
1,3-Butadiene	7.53	8.03	5.33	4.94
Benzene	5.94	5.18	4.75	4.07
Acetaldehyde	5.49	5.13	3.28	3.28
Carbon Tetrachloride	3.29	3.28	2.47	1.88
Respiratory Hazard Index Chemicals by Hazard Impact				
Acrolein	1.72	1.74	1.44	1.22
Acetaldehyde	0.28	0.26	0.24	0.25
Formaldehyde	0.20	0.20	0.19	0.19
Diesel PM	0.19	0.18	0.13	0.10
Chlorine	0.08	0.06	0.01	0.01

Cancer risk and respiratory health hazard values by chemical for all four communities were calculated from the EPA's 2011 National Air Toxics Assessment, using the census-tract identification code.

SOURCE: EPA 2015B.

TABLE 7. Cancer and Non-Cancer Health Effects of Major Toxic Air Pollutants

Air Pollutant	Cancer	Non-Cancer
Formaldehyde	✔	Respiratory, eyes
1,3-Butadiene	✔	Female reproductive
Benzene	✔	Immune
Acetaldehyde	✔	Respiratory, eyes
Carbon Tetrachloride	✔	Liver, kidney damage
Acrolein	No	Respiratory, eyes
Diesel Particulate Matter (PM)*	✔	Respiratory, heart
Chlorine	No	Respiratory, eyes
Hydrochloric acid/ Hydrogen chloride	No	Respiratory, eyes

Six out of the nine major air pollutants found in the communities studied can cause cancer, and all nine can cause health problems.

* The EPA does not include cancer risks from diesel PM in the NATA.

SOURCES: EPA 2016E; ATSDR 2014; CALEPA 2016.

TABLE 8. High Percentages of People in Harrisburg/ Manchester and Galena Park Live Close to RMP Facilities

Community	# of Facilities (1 Mile)	# of Facilities (3 miles)	% of Total Population Within 1 Mile of at Least One RMP Facility
Harrisburg/ Manchester	5	16	90%
Galena Park	8	28	39%
Bellaire	1	1	9%
West Oaks/ Eldridge	4	7	14%

Publicly available data from the EPA's RMP program obtained from the Right-to-Know Network (CEG 2014) were used to determine which RMP facilities were located in the four Houston communities. Facility locations were based on their self-reported latitude/longitude code.

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Significant improvements in monitoring and regulating chemical exposure are needed to ensure the health and safety of east Houston residents.

> ***In recent years some east Houston monitoring stations have reported increased levels of hazardous pollutants.***

facilities in relatively close proximity to their communities and have a higher proportion of their population within vulnerable zones. In essence, they deal with the "double jeopardy" of stresses and health consequences of potential catastrophic accidents from nearby industrial facilities, as well as the daily, chronic exposure to high levels of toxic pollution. The disproportionate health and safety risks from this concentration of high-risk and heavily polluting facilities underscore the need for environmental justice for these communities.

These risks represent only one of the many factors that influence the health and well-being of the east Houston communities covered in this report. Indoor air pollution; mold and lead from inadequate housing; and lack of access to health care, healthy foods, and public transportation; along with other stresses related to poverty and crime, are just some of the compounding factors that contribute to the cumulative health impacts on residents of environmental justice communities such as those in east Houston (Prochaska et al. 2014; Hynes and Lopez 2007).

Efforts initiated by former Houston mayor Bill White in the mid-2000s to reduce the high levels of toxic air pollutants in east Houston did have some success. In recent years, however, some east Houston monitoring stations have reported increased levels of hazardous pollutants, and concentrations overall seem to be leveling off at these higher levels (Sexton and Linder 2015). A recent assessment of the efforts resulting from the earlier Mayor's Task Force on the Health Effects of Air Pollution concluded that "since White left office in 2010, air quality management in Houston has returned to the way it was before, and today there is scant evidence that his policies have had any lasting impact." This assessment also determined that toxic air-pollution levels are "still not good enough and are not improving fast enough, especially for sensitive and vulnerable populations living in close proximity to major emission sources" (Sexton and Linder 2015).

Recommendations

Significant and expedited improvements in regulatory and public policy are needed at the national, state, and municipal levels to address the health and well-being of at-risk communities in east Houston and elsewhere. The EPA is currently developing revisions to its RMP rule for chemical facilities (EPA 2016d). The program has the potential to improve the safety of chemical facilities and the ability of communities to prepare for—and respond to—accidents at these dangerous facilities (Kothari 2016).

The first four recommendations that follow aim to improve the safety of high-risk industrial facilities, expand communities' access to information about the acute hazards posed by nearby facilities, and improve communities' preparedness for responding to a toxic chemical release. They may have the additional benefit of reducing the daily load of toxic air pollution that affects these communities. The last two recommendations address both the acute risks from chemical facility accidents as well as the risks from daily chronic exposure to toxic air pollution.

Require chemical facilities to use safer chemicals and technologies. Switching to inherently safer chemicals and technologies wherever feasible is the most effective way to prevent deaths and injuries from chemical disasters. In revising its RMP rule, the EPA should require chemical facilities to assess the use of safer processes and adopt them wherever feasible.

Switching to inherently safer chemicals and technologies wherever feasible is the most effective way to prevent deaths and injuries from chemical disasters.

Ensure that facilities share information and their emergency response plans with fenceline communities. The EPA should ensure that communities have access through effective and purposeful outreach to information on hazards and emergency planning under its RMP program and that they have information on facility hazards submitted to states under the Emergency Planning and Community Right-to-Know Act. Local residents, trained health care professionals, emergency responders, and health-care providers need this information to prepare for and effectively respond to a chemical disaster, should one occur. Communities should be

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Communities like Galena Park in east Houston need stronger health and environmental policies at municipal, state, and federal levels to protect residents from toxic air pollution and potential chemical release from nearby chemical facilities.

included in emergency response planning and implementation. Emergency response facilities and the measures devised under these plans should be ready for operation should a chemical release occur.

Require large chemical facilities to continuously monitor and report their fenceline-area emissions and health hazards. Unplanned, smaller releases of toxic chemicals are often a precursor to more serious incidents at chemical facilities and may themselves directly impact the health of people living in fenceline communities. People living in fenceline areas should be able to easily access information (based on validated continuous monitoring) on the toxic emissions coming from industrial facilities, along with information about the chemicals' health hazards. The EPA should expand current requirements for benzene monitoring by oil refineries in fenceline areas to include other toxic air pollutants and other major industrial sources. This information can help communities advocate for vigorous enforcement of regulatory requirements by relevant authorities; push companies to use safer chemicals; alert and educate friends, family members, and community members; and encourage the media to report on polluting facilities in their areas.

Prevent the construction of new or expanded chemical facilities near homes and schools and, conversely, the siting of new homes and schools near dangerous chemical plants. The siting of new chemical facilities or expansion of existing ones in close proximity to homes, schools, or playgrounds significantly increases the possibility that an incident will result in a disaster. Similarly, new homes, schools, and playgrounds should not be sited near dangerous chemical plants. Municipal authorities should adopt and enforce local ordinances that require an assessment of the potential health and safety risks when siting homes, schools, and other public facilities. Requiring a buffer zone between these areas and polluting sources also reduces residents' daily exposure to toxic chemical pollution.

Require publicly accessible, formal health-impact assessments and mitigation plans to gauge the cumulative impact of hazardous chemical exposures on fenceline communities. Environmental and public health agencies in Houston, in Texas, and at the federal level should assess the potential impact of unplanned chemical releases and the cumulative impacts of daily air-pollution exposures on the health of fenceline communities. A focus on cumulative impacts is a cornerstone of environmental justice. Agencies and elected officials should provide the affected communities with the tools and resources they need to fully engage in the assessment process, and the EPA should review hazard assessments of these communities. Emissions permits should be strengthened where necessary to account for the cumulative impact of air-pollution emissions on fenceline communities and provide the reductions in air pollution necessary to protect public health.

Strengthen the enforcement of existing environmental and workplace health and safety regulations. Congress should increase funding to the EPA and the states for expanding inspections and improving the enforcement of environmental and workplace health and safety laws, so that problems in chemical facilities can be identified before they lead to disasters. Better oversight and enforcement will also help agencies and the public hold companies accountable if they fail to address identified hazards and emissions of toxic pollution. Communities facing some of the greatest threats from chemical facility incidents and toxic air pollution need strong governmental policies to protect them, including strict permitting requirements and reliable inspection and enforcement of these requirements. If state and municipal governments are not providing adequate protection, it is essential that the EPA engage to defend these communities' right to a safe environment.

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Industrial Facilities in Harrisburg/Manchester and Galena Park

TABLE A-1. Industrial Facilities in Harrisburg/Manchester

Name of Facility	Location	SIC/NAICS Code	Code Description
Houston, TX #1–Westway Terminals	9325 E. Avenue S Houston, TX 77012	NAICS 424910	Farm supplies merchant wholesalers
Valero Refining	9701 Manchester Houston, TX 77012	NAICS 324110	Petroleum refineries
Echo Distribution Systems	2000 Lawndale Street Houston, TX 77017	SIC 2911	Petroleum refining
SIMS Bayour North WWTP	9500 Lawndale Street Houston, TX 77017	NAICS 221310, 921190, 221320	Water supply and irrigation systems, other general government support, sewage treatment facilities
Quality Carriers	1710 Central St. Houston, TX 77017	NAICS 48412,4841	General freight trucking, long-distance, truckload; general freight trucking
Merichem Company John T Files Technical Center	1503 Central Houston, TX 77012	NAICS 54171, 541712	Research and development in the physical sciences, engineering, and life sciences; research and development in the physical sciences, engineering, and life sciences (except biotechnology)
Solid Waste Lawndale	1502 Central Dr. Houston, TX 77012	NAICS 92119	Other general government support
South Coast Terminals WWTP	Intersection of Loop 610 and HSC Houston, TX	SIC 5171	Petroleum bulk stations and terminals
JHA Environmental Services	8930 Lawndale Street Suite E Houston, TX 77012	NAICS 92411	Administration of air and water resource and solid waste management programs
Texas Port Recycling LP	8945 Manchester St. Houston, TX 77012	NAICS 42393	Recyclable material merchant wholesalers
Solvay - Houston Plant	8615 Manchester St. Houston, TX 77012	NAICS 325180	Other basic inorganic chemical manufacturing
Lone Star Industries	402 Concrete Houston, TX 77012	NAICS 32731	Cement manufacturing
Houston Dynamic Service Inc.	8150 Lawndale Houston, TX 77012	NAICS 333319	Other commercial and service industry machinery manufacturing

TABLE A-1. Industrial Facilities in Harrisburg/Manchester (CONTINUED)

Name of Facility	Location	SIC/NAICS Code	Code Description
Ameritech Inc. (SB)	8315 Manchester Houston, TX 77012	SIC 5051-06 NAICS 423510	Steel distributors and warehouses. Metal service centers and other metal merchant (wholesale)
SIMS Bayour North WWTP	9500 Lawndale Street Houston, TX 77017	NAICS 221310, 921190, 22132	Water supply and irrigation systems, other general government support, sewage treatment facilities
Chevron USA	8001 Lawndale Houston, TX 77012	NAICS 484121	General freight trucking, long-distance, truckload
Comsource Inc.	7412 Manchester St. Houston, TX 77012	NAICS 54138	Testing laboratories
Eddy Refining Company	7401 Manchester Houston, TX 77012	SIC 2911	Petroleum refining
SWS Holdings–Pasadena	8502 Cypress St. Houston, TX 77012	NAICS 336611	Ship building and repairing
Petro-Tech Environmental	8502 Cypress St. Suite B Houston, TX 77012	NAICS 562910	Remediation services
South Coast Terminals	9317 E Ave. S Houston, TX 77012	SIC 5171	Petroleum bulk stations and terminals
Jestex	8107 E. Magnolia Houston, TX 77012	SIC 3441	Fabricated structural metal
Buffalo Marine Service	8201 E Erath St. Houston, TX 77012	SIC 4213-02 NAICS 484230	Fuel, bulk delivery Specialized freight (except used goods) trucking, long distance
CJN Offshore Solutions	7601 Harrisburg Blvd Houston, TX 77012	NAICS 332311	Prefabricated metal building and component manufacturing
Gulf Stream Marine	10000 Manchester Houston, TX 77012	NAICS 488320	Marine cargo handling
Houston Mooring Co.	10000 Manchester Suite C Houston, TX 77012	NAICS 488330	Navigational services to shippings

TABLE A-2. Industrial Facilities in Galena Park

Name of Facility	Location	SIC/NAICS Code	Code Description
Chemical Exchange Industries, Inc. (CXI)	900 Clinton Dr. Galena Park, TX 77547	SIC 2869 NAICS 424690	Industrial organic chemicals, not elsewhere classified Other chemical and allied products merchant wholesalers
Texmark Chemicals, Inc.	900 Clinton Dr. Galena Park, TX 77547	SIC 2899-05 NAICS 325110	Chemicals—manufacturers Petrochemical manufacturing,
GATX Terminals Corp	906 Clinton Dr. Galena Park, TX 77547	SIC 4226	Special warehousing and storage, not elsewhere classified
Kinder Morgan Kansas, Inc.	906 Clinton Dr. Galena Park, TX 77547	NAICS 486210	Pipeline transportation of natural gas
Equilon Enterprises LLC	780 Clinton Dr. Galena Park, TX 77547	SIC 1311 NAICS 211111	Crude petroleum and natural gas Crude petroleum and natural gas extraction
Shell Oil Company	780 Clinton Dr. Galena Park, TX 77547	SIC 2992	Lubricating oils and greases
Shell Lubricants	708 Clinton Dr. Galena Park, TX 77547	NAICS 211111	Crude petroleum and natural gas extraction
National Oilwell Varco, Inc.	210 Magnolia Dr. Galena Park, TX 77547	NAICS 213112	Support activities for oil and gas operations
Mercantile Oil & Gas Producing Corporation	2203 7th St. Galena Park, TX 77547	NAICS 211111	Crude petroleum and natural gas extraction
Enterprise Crude Oil LLC	901 Clinton Dr. Galena Park, TX 77547	SIC 5172	Petroleum and petroleum products wholesalers, except bulk stations and terminals
Texas Mill Supply & Manufacturing Company Inc.	2413 Avenue K Galena Park, TX 77547	NAICS 339999	All other miscellaneous manufacturing
Tri Resources, Inc.–Targa Resources Inc.	12801 American Petroleum Rd. Galena Park, TX 77547	NAICS 211111	Crude petroleum and natural gas extraction
Targa Downstream LLC–Galena Park Marine Terminal	12510 American Petroleum Rd. Galena Park, TX 77547	NAICS 424710	Petroleum bulk stations and terminals
Louis Dreyfus Biofuels Holdings LLC	1500 S Main St. Galena Park, TX 77547	NAICS 523130, 488210	Commodity contracts dealing, Support activities for rail transportation
Galena Park Chevron U.S.A. Inc.	12523 American Petroleun Rd. Galena Park, TX 77547	NAICS 424710	Petroleum bulk stations and terminal
Chevron Marketing Terminal	12523 American Petroleum Rd. Galena Park, TX 77547	SIC 5088-05 NAICS 423860	Ship chandlers Transportation equipment andsupplies (exceptmotor vehicle) merchant

TABLE A-2. Industrial Facilities in Galena Park (CONTINUED)

Name of Facility	Location	SIC/NAICS Code	Code Description
Kinder Morgan Liquids Terminals L.P.	405 Clinton Dr. Galena Park, TX 77547	NAICS 493110	General warehousing and storage
KM Liquids Terminals, L.P	906 Clinton Dr. Galena Park, TX 77547	NAICS 48411, 493110	General freight trucking, local; general warehousing and storage
Green Earth Fuels of Houston LLC	550 Clinton Dr. Galena Park, TX 77547	NAICS 325199	All other basic organic chemical manufacturing
Kinder Morgan Crude and Condensate LLC	407 Clinton Dr. Galena Park, TX	NAICS 32411	Petroleum refineries
Kinder Morgan Inc.	405 Clinton Dr. Galena Park, TX 77547	SIC 4925-01 NAICS 221210	Gas companies Natural gas distribution
Kinder Morgan Inc.	701 Philpot Dr. Galena Park, TX 77547	SIC 4612-01 NAICS 486110	Crude petroleum pipelines Pipeline transportation of crude oil
Kinder Morgan Inc.	906 Clinton Dr. Galena Park, TX 77547	SIC 5171-98 NAICS 424710	Petroleum bulk stations and terminals (wholesale) Petroleum bulk stations and terminals
Oil States Intl Inc.	550 Clinton Dr. Galena Park, TX 77547	NAICS 211111	Crude petroleum and natural gas extraction
Sopus Products	780 Clinton Dr. Galena Park, TX 77547	NAICS 324191	Petro lubricating oil and grease manufacturing
USG Corp. Galena Park	1201 Mayo Shell Rd. |Galena Park, TX 77547	NAICS 322121	Paper (except newsprint) mills
American Plant Food Corp Galena Park	903 Mayo Shell Rd. Galena Park, TX 77547	NAICS 325314	Fertilizer (mixing only) manufacturing
Campbell Concrete & Materials Galena Park	914 Mayo Shell Rd. Galena Park, TX 77547	NAICS 327320	Ready-mix concrete manufacturing
Century Asphalt Ltd. Galena	922 Mayo Shell Rd. Galena Park, TX 77547	NAICS 324121	Asphalt paving mixture and block manufacturing
Vopak Terminal Galena Park Inc.	1500 Clinton Dr. Galena Park, TX 77547	NAICS 42471, 493110, 493190	Petroleum bulk stations and terminals, general warehousing and storage, other warehousing and storage
Magellan Galena Park Laydown Yard	901 Clinton Dr. Galena Park, TX 77547	N/A	N/A
ESI Environmental	902 ½ Holland Ave. Galena Park, TX 77547	NAICS 48411	General freight trucking, local
Burbank Barrel & Drum	1402 Clinton Dr. Galena Park, TX 77547	NAICS 81131 SIC 5093	Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance Scrap and waste materials
Tank Wash of America Inc.	1506 Clinton Dr. Galena Park, TX 77547	NAICS 488999	All other support activities for transportation

TABLE A-1. Industrial Facilities in Galena Park (CONTINUED)

Name of Facility	Location	SIC/NAICS Code	Code Description
Chem-coast Inc.	1609 First St. Galena Park, TX 77547	NAICS 54138	Testing laboratories
Dixie Services	1706 First St. Galena Park, TX 77547	NAICS 54138	Testing laboratories
Pick Instrument Products Co.	102 Eastway Galena Park, TX 77547	SIC 3599	Industrial and commercial machinery and equipment, not elsewhere classified
Pacific Eastern Carriers	2000 Avenue K Galena Park, TX 77547	NAICS 48411	General freight trucking, local
Rescar	2011 Clinton Dr. Galena Park, TX 77547	NAICS 488999	All other support activities for transportation
Container Care International	500 Mayo Shell Galena Park, TX 77547	N/A	N/A
Nov Rig Systems Galena Park	210 Magnolia Dr. Galena Park, TX 77547	NAICS 333132	Oil and gas field machinery and equipment manufacturing
Houston Lube Oil Blending Plant	780 Clinton Dr. Galena Park, TX 77547	NAICS 324191	Petroleum lubricating oil and grease manufacturing
Seaway Galena Park Station	901 Clinton Dr. Galena Park, TX 77547	NAICS 48611	Pipeline transportation of crude oil
Rayco Oilfield Service Inc.	2229 10th St. Galena Park, TX 77547	NAICS 213112	Support activities for oil and gas operations
Cassco Grinding & Machining	2410 Clinton Dr. Galena Park, TX 77547	NAICS 332812	Metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
Cassco Grinding & Machining	300 Mayo Shell Rd. Galena Park, TX 77547	NAICS 332710	Machine shops
Speedy Transportation	202 Eastway St. Galena Park, TX 77547	NAICS 488210	Support activities for rail transportation
Texas Transloaders Inc.	701 Philpot Dr. Galena Park, TX 77547	NAICS 488510	Freight transportation arrangement
Transco Shipping Inc.	1606 Clinton Dr. #2 Galena Park, TX 77547	NAICS 488510	Freight transportation arrangement
Twin Carrier Transportation	806 Sage Dr. Galena Park, TX 77547	NAICS 488210	Support activities for rail transportation
Velasco Logistics Transportation	1902 3rd St. Galena Park, TX 77547	NAICS 488210	Support activities for rail transportation
Watco Transloading LLC	920 Mayo Shell Rd. Galena Park, TX 77547	NAICS 488210	Support activities for rail transportation

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Double Jeopardy in Houston

Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities

[*Harrisburg/Manchester and Galena Park in east Houston face disproportionately high levels of toxic air pollution and risk of chemical spills compared with the two west Houston communities.*]

This report examines the health risks of exposure to toxic air pollution to people living in different Houston neighborhoods that abut high-risk chemical facilities—as well as their potential exposure to unplanned chemical releases. Our analysis compares risks and exposure within two predominantly Hispanic and low income east Houston communities to those within two primarily white and wealthier west Houston communities.

We found that Harrisburg/Manchester and Galena Park in east Houston face disproportionately high levels of toxic air pollution—and risks from their attendant health effects—compared with the two west Houston communities, West Oaks/Eldridge and Bellaire, as well as to the Houston urban area. The east Houston communities also contain more high-risk facilities, and have a higher proportion of their population in close proximity to these dangerous facilities.

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Attachment 5

Evaluation of Vulnerability and Stationary Source Pollution in Houston

Revised September 2020

Prepared by Sustainable Systems Research, LLC

Contents

List of Tables 2

List of Figures 2

List of Appendices 2

Introduction 3

Background: Cumulative Risks, Cumulative Impacts, and Environmental Justice 3

Data and Methods 5

- Emissions Data 6
- Demographic Data 7
- Analysis Areas 8
- Pollutants 8
- Time periods 10
- Data analysis 10

Results 13

- Regionwide 13
- Unauthorized Emissions 23
- The Ship Channel and Communities of Interest 26

Discussion 32

Limitations 32

Conclusions 33

Appendices 35

List of Tables

Table 1: Air Pollutants of Interest 11
Table 2: Average Emissions Burden for Residents of the Eight County Houston Region 16
Table 3: Scope of Emissions in the Eight County Houston Region 17
Table 4: Severity of Emissions Burdens for Residents Living in Tracts with Emissions in the Eight County Houston Region 18
Table 5: Unauthorized VOCs in the Eight County Houston Region: Average Burden, Scope, and Severity 24

List of Figures

Figure 1: Map of the Eight-County Houston, Texas Region and Communities of Interest 9
Figure 2: Vulnerability in the Eight-County Houston Region 20
Figure 3: 2007 to 2016 Emissions in the Eight-County Houston Region 21
Figure 4: 2007 to 2016 Emissions and Vulnerability in the Eight-County Houston Region 22
Figure 5: Unauthorized VOC Emissions in the Eight-County Houston Region 25
Figure 6: Vulnerability in the Ship Channel Area 27
Figure 7: 2007 to 2016 Emissions in the Ship Channel Area 28
Figure 8: Unauthorized VOC Emissions in the Ship Channel Area 29
Figure 9: 2007 to 2016 Emissions and Vulnerability in the Ship Channel Area 30
Figure 10: Vulnerability and Emissions in Communities of Interest 31

List of Appendices

Appendix A: Regionwide Analysis of 19 Pollutants of Concern by Population
Appendix B: Additional Regionwide Maps of Four Pollution Categories
Appendix C: Regionwide Maps of 19 Pollutants of Concern
Appendix D: Additional Ship Channel Maps of Four Pollution Categories
Appendix E: Ship Channel Maps of 19 Pollutants of Concern
Appendix F: Emissions for 2012 to 2016 and 2016 in Communities of Interest
Appendix G: Vulnerability Index and Emissions in Communities of Interest

Introduction

Houston's energy, chemical, and industrial facilities contribute to elevated air pollution levels in the region, including volatile organic compounds (VOCs), particulate matter (PM), and a variety of toxic air pollutants. Much of Houston's industrial activity occurs in the area around the Port of Houston and the Houston Ship Channel, which carries Port traffic from the Gulf of Mexico to and from Houston Port terminals. In areas with numerous pollution sources emitting different types of pollution, the accumulation of risks is of greater concern than the risks posed by each individual pollution source.

Elevated air pollution is of concern when it poses a health risk, particularly in areas where residents are exposed to several sources of pollution, which makes characterizing and mitigating health risks more challenging. In many regions air pollution burdens have been found to disproportionately affect disadvantaged residents, such as people of color and low-income households. This type of environmental injustice is exacerbated when these populations face vulnerability to pollution exposures.

Sustainable Systems Research (SSR) has been asked to characterize the potential for environmental justice concerns associated with stationary source emissions in the Houston area. We first discuss key concepts from cumulative risk assessment and cumulative impacts literature and their intersection with environmental justice concerns. We then evaluate stationary source pollution emissions and demographic vulnerability across the Houston region and the degree to which they converge, posing potential environmental justice concerns. We highlight results in five communities located along the Houston Ship Channel: Manchester, Magnolia Park, Pasadena, Baytown, and Deer Park. We also discuss the potential for environmental justice concerns related to unauthorized air pollution emissions from stationary sources in the Houston area.

Background: Cumulative Risks, Cumulative Impacts, and Environmental Justice

The incremental risks of an activity are of greater concern when the overall risk of many activities in an area is significant. The US EPA's 2003 Framework for Cumulative Risk Assessment defines cumulative risks as "the combined risks from aggregate exposures to multiple agents or stressors."[1] According to the 2003 Framework, cumulative risks can result from exposure to multiple pollutants from multiple sources and may occur over a long period of time. While traditional risk assessment focuses on exposure to one chemical (often from one source), cumulative risk assessments can be helpful in settings where the effects of multiple exposures and multiple sources can result in greater risks to human health or the environment. The evaluation of cumulative risks is not simply the addition of the risks from different chemicals or sources; it includes an assessment of how these

[1] EPA, 2003. "Framework for Cumulative Risk Assessment," May 2003, EPA/630/P-02/001F

stressors interact. Additionally, cumulative risk assessment emphasizes actual people that can be affected, rather than theoretical populations. It can also consider a wider array of stressors (including non-pollutant stressors such as a lack of health care or car crashes) and their interactive effects.

EPA's 2007 Cumulative Health Risk Assessment guidance indicates that one situation which might indicate a need for a health risk assessment is the existence of multiple pollution sources or chemical releases.[2] In order to conduct a cumulative risk assessment in that case, the first step would be to identify all the relevant (present and future) chemical releases and exposure pathways that can affect the population of concern. In particular, chemicals with high potential for health risks and similar effects are of interest. Once the sources and chemicals that will be assessed have been identified, the analysis follows exposure assessment steps of characterizing the sources, determining the spatial scope of analysis, evaluating the fate of emissions, determining who could be exposed, and quantifying their exposures.

Consideration of cumulative risks has become more common in a number of environmental evaluation settings. A handful of states and localities have begun to require cumulative risk assessments. For example, a 2008 Minnesota statute requires that cumulative effects be evaluated and considered before air permits are issued in the Phillips Communities in South Minneapolis.[3] Similarly, under a 2009 ordinance in Cincinnati, Ohio, facilities seeking a new or expanded permit are required to show that they will not have a "cumulative adverse impact" on the environment or the community's health.[4] Health Impact Assessments[5] (HIAs), which have been conducted in a variety of jurisdictions and situations, often include an evaluation of cumulative risks.

An important factor when evaluating cumulative risks is understanding the vulnerability of at-risk populations. EPA outlines four areas of vulnerability that should be assessed in cumulative risk assessments: differential exposure, susceptibility/sensitivity, differential preparedness, and differential ability to recover.[6] Children, the elderly, and people with existing health conditions are

[2] EPA, "Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document," August 2007, EPA/600/R-06/013F
[3] See EPA, "Cumulative Risk Webinar Series: What We Learned," July 2014, EPA/600/R-14/212.
[4] Rachel Morello-Frosch, Miriam Zuk, Michael Jerrett, Bhavna Shamasunder and Amy D. Kyle. Understanding The Cumulative Impacts Of Inequalities In Environmental Health: Implications For Policy. Health Affairs, 30, no.5 (2011):879-887.
[5] For more information about Health Impact Assessments, see http://www.cdc.gov/healthyplaces/hia.htm
[6] EPA, "Framework for Cumulative Risk Assessment," May 2003, EPA/630/P-02/001F; "Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document," August 2007, EPA/600/R-06/013F

particularly vulnerable to exposure to pollution[7, 8]. Additionally, low-income households and people of color can be more vulnerable to the effects of pollution exposure for a number of reasons, including greater rates of preexisting health conditions, greater exposure to a number of environmental hazards, greater social vulnerability (including stress), and limited access to health care.[9, 10]

"Cumulative impacts" are a related concept that is an important part of Environmental Impact Assessments (EIAs) of federal projects conducted under the National Environmental Policy Act (NEPA). Consideration of cumulative impacts in EIAs was first required in 1979. Consideration of a community's vulnerability is also an important part of evaluating cumulative impacts.[11]

Both the cumulative risk and cumulative impact literature point to the importance of understanding the overlap between heightened *exposure* to health risk as a result of multiple stressors and heightened *vulnerability* to that exposure. Populations and communities with this combination of factors can also be examined through the lens of environmental justice. The US EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[12] Concerns about environmental justice have grown out of a number of studies that indicate that in many cases the burdens of environmental harms fall disproportionately onto people of color and low-income populations, while environmental benefits are often unavailable to those people.[13] While environmental justice concerns can stem from pollution of a single chemical or from a single type of pollution source (e.g. landfills), disadvantaged populations and communities often face the cumulative risks caused by numerous pollution sources and chemical exposures. Concepts that underpin cumulative risk assessment and cumulative impacts can broaden our understanding of environmental justice concerns in vulnerable populations and communities.

Data and Methods

In order to better understand the potential for environmental justice concerns related to stationary source pollution in the Houston region, this analysis focuses on three questions:

1. Are total stationary source air pollution burdens in the Houston region greater for vulnerable groups (including people living in poverty, limited-English speaking households, and people of color)?

[7] Morello-Frosch et al., Cumulative Impacts of Inequalities In Environmental Health, 2011.
[8] "Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment of Multiple Chemicals, Exposures and Effects: A Resource Document," August 2007, EPA/600/R-06/013F.
[9] Morello-Frosch et al., Cumulative Impacts of Inequalities In Environmental Health, 2011.
[10] EPA, Concepts, Methods, and Data Sources for Cumulative Health Risk Assessment, 2007.
[11] These factors are outlined in relation to NEPA document evaluation in EPA, "Consideration of Cumulative Impacts in EPA Review of NEPA Documents," May 1999, EPA 315-R-00-002.
[12] See http://www.epa.gov/environmentaljustice/.
[13] Morello-Frosch et al., Cumulative Impacts of Inequalities In Environmental Health, 2011.

2. How do total stationary source emissions burdens and vulnerability in several communities of interest near the Ship Channel compare to the rest of the region?
3. Do unauthorized emissions burdens pose unique concerns (in addition to any concerns that may arise in relation to authorized emissions)?

The focus of this analysis is on pollution *emissions*. This analysis is intended to identify areas where there is potential for elevated and disproportionate pollution emissions in order to identify areas that may be of heightened concern and merit additional scrutiny. This analysis should not be interpreted as an analysis of pollution *exposures* or *health risks*, which would require more in-depth measurements and/or modeling of pollution fate and transport, toxicity, and exposure pathways.

This assessment focuses on where pollution emissions overlap with vulnerable populations. Our approach is similar to the approaches used in screening tools such as US EPA's EJScreen[14] and CalEnviroScreen[15] which overlay environmental burdens and various measures of vulnerability, although it is simplified in its focus on emissions only (rather than concentrations or health risks). Stationary source emissions rates are a result of regulatory and economic decision-making processes (industrial siting decisions, the permitting process, operational or enforcement decisions, etc.), so examining emissions directly may provide insights into patterns that arise in the current decision-making environment.

Emissions Data

All air pollution point sources in Texas that emit or have the potential to emit quantities of criteria pollutants, VOCs, or hazardous air pollutants that exceed reporting requirements (as described in 30-TAC 110.10[16]) are required to report their emissions. Emissions of any pollutant may be reported as *annual emissions*, *emissions events (EE)*, or *scheduled maintenance, startup, and* shutdown *(SMSS)* emissions, depending on how they occur. The Texas Commission on Environmental Quality (TCEQ) tracks reported emissions of over 2000 pollutants and pollutant categories in a point source emissions inventory (PSEI) and provides detailed data upon request.[17] This analysis draws from the TCEQ PSEI data.

TCEQ describes annual emissions as follows:

> "Annual emissions include all of a site's actual annual emissions associated with authorized (routine) operations, maintenance, startup, and shutdown

[14] https://www.epa.gov/ejscreen
[15] https://oehha.ca.gov/calenviroscreen
[16] 30 Tex. Admin. Code §101.10 (2019) (TCEQ, Emissions Inventory Requirements), available at https://texreg.sos.state.tx.us/public/readtac%24ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=101&rl=10
[17] Information about the PSEI is available at https://www.tceq.texas.gov/airquality/point-source-ei/psei.html. A full list of contaminants is available at http://www.tceq.texas.gov/assets/public/implementation/air/ie/pseiforms/contams.xlsx.

activities. It does not include emissions that are defined in 30 TAC Section 101.1 as emissions events or unauthorized scheduled maintenance, startup, and shutdown activities."[18]

We refer to annual emissions as *authorized emissions* in this report.

EE[19] and SMSS emissions [20] are reported for any quantity of emissions that is unauthorized [21]. We refer to EE and SMSS emissions together as *unauthorized emissions* in this report.

Demographic Data

Demographic data are obtained from the US Census[22]. Measures of vulnerability were identified by community partners, and include people of color (POC), people

[18] TCEQ (2017) "TCEQ 2016 Emissions Inventory Guidelines", Publication RG-360/16, p 60, available at https://www.tceq.texas.gov/assets/public/comm_exec/pubs/rg/rg360/rg360-16/rg-360.pdf

[19] According to 30 TAC § 101.1, an emissions event is

> "any upset event or unscheduled maintenance, startup, or shutdown activity, from a common cause that results in **unauthorized emissions [emphasis added]** of air contaminants from one or more emissions points at a regulated entity."

See 30 TAC § 101.1 for definitions of upset events and unplanned maintenance, startup, or shutdown activities. TCEQ also provides guidance on reporting emissions events as follows:

> "...Include the emissions in tons per year from all releases due to emissions events, regardless of whether those releases represent reportable or nonreportable quantities and regardless of whether an affirmative defense is claimed for those emissions...." (TCEQ, 2017, TCEQ 2016 Emissions Inventory Guidelines, page 64).

[20] TCEQ provides guidance on reporting SMSS emissions as follows:

> "Report the emissions in tons from all releases due to scheduled maintenance, startup, and shutdown activities that are **not** authorized by a new source review permit or permit by rule in the "SMSS" category, regardless of whether those releases represent reportable or nonreportable quantities and regardless of whether an affirmative defense is claimed for those emissions..." (TCEQ, 2017, TCEQ 2016 Emissions Inventory Guidelines, page 64-65).

30 TAC § 101.1 defines SMSS activity as follows:

> "For activities with **unauthorized emissions [emphasis added]** that are expected to exceed a reportable quantity (RQ), a scheduled maintenance, startup, or shutdown activity is an activity that the owner or operator of the regulated entity whether performing or otherwise affected by the activity, provides prior notice and a final report as required by §101.211 of this title (relating to Scheduled Maintenance, Startup, and Shutdown Reporting and Recordkeeping Requirements); the notice or final report includes the information required in §101.211 of this title; and the actual **unauthorized emissions [emphasis added]** from the activity do not exceed the emissions estimates submitted in the initial notification by more than an RQ. For activities with **unauthorized emissions [emphasis added]** that are not expected to, and do not, exceed an RQ, a scheduled maintenance, startup, or shutdown activity is one that is recorded as required by §101.211 of this title. Expected excess opacity events as described in §101.201(e) of this title (relating to Emissions Event Reporting and Recordkeeping Requirements) resulting from scheduled maintenance, startup, or shutdown activities are those that provide prior notice (if required), and are recorded and reported as required by §101.211 of this title."

[21] 30 TAC § 101.1 defines unauthorized emissions as

> "Emissions of any air contaminant except water, nitrogen, ethane, noble gases, hydrogen, and oxygen that exceed any air emission limitation in a permit, rule, or order of the commission or as authorized by Texas Health and Safety Code, §382.0518(g)."

[22] https://www.census.gov/

living in poverty (POV), and limited-English households (LEH). The 2010 decennial census provides people of color data (including all Hispanic and/or non-white residents). The population living at or below the poverty level and the number of limited-English households (in which no one age 14 and over speaks English "very well" or speaks English only) are obtained from the 2016 five-year American Community Survey (ACS) data. The total population estimate is also from the 2016 five-year ACS data. Decennial census data were obtained at the block, tract, and place level, and ACS data were obtained at the block-group, tract, and place level for use at different scales of analysis, as described further below. We also present a vulnerability index, calculated as the average of the percent people of color, percent living in poverty, and percent limited-English.

Analysis Areas

This analysis examines emissions, demographic vulnerability, and the potential for environmental justice concerns across the Houston region. In addition, community partners have expressed interest in characterizing vulnerability and emissions in several communities adjacent to the Houston Ship Channel.

In this analysis we evaluate data over two spatial scales as shown in Figure 1:

1. **Eight-County Houston Region:** We evaluate emissions and demographic vulnerability at the Census tract level across the eight-county Houston region. The eight-county area provides a second site for examining larger scale trends, as well as a point of reference to which we can compare the communities of interest. The eight-county area includes Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties. These eight counties are in ozone nonattainment and therefore have more consistent (more stringent) emissions reporting requirements for the TCEQ's PSEI than other counties in the region. This area encompasses the communities of interest.
2. **Communities of Interest:** We also evaluate emissions and demographic vulnerability at the community level for neighborhoods and cities in the region. Community partners have expressed interest in characterizing vulnerability and emissions in several communities that are in the vicinity of the Houston Ship Channel, including the Harrisburg / Manchester and Magnolia Park neighborhoods as well as the cities of Pasadena, Baytown, and Deer Park.

Pollutants

SSR was asked to evaluate emissions of 29 air pollutants in the region that were identified by community partners based on their potential to pose a risk to human health. These include 16 EPA prioritized polycyclic aromatic hydrocarbons (PAHs) and 12 other pollutants identified as of concern based on a recent Union of

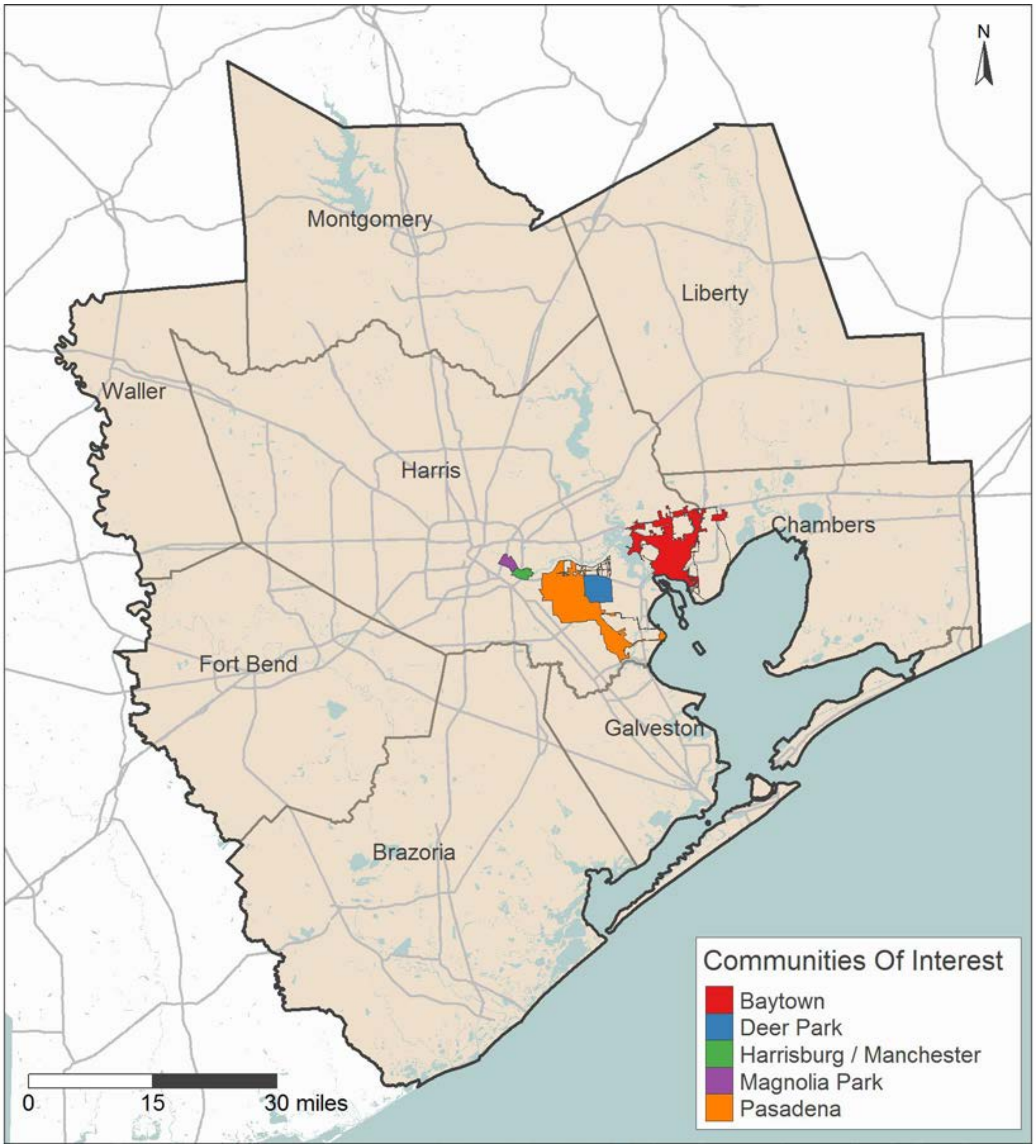


Figure 1: Map of the Eight-County Houston, Texas Region and Communities of Interest

Concerned Scientists / Texas Environmental Justice Advocacy Services Report[23]. One additional pollutant (hydrogen sulfide) was also identified by community partners. Of this list of 29 pollutants, our evaluation includes the 19 pollutants for which PSEI data are available. In order to characterize overall trends, we combine these 19 pollutants into a pollution index. Additionally, we evaluate emissions of three broader categories of pollutants that overlap with several pollutants of concern. Pollutants that are included in this analysis are listed in Table 1.

[23] See Union of Concerned Scientists, "Double Jeopardy in Houston: Acute and Chronic Chemical Exposures Pose Disproportionate Risks for Marginalized Communities," October 2016, https://www.ucsusa.org/resources/double-jeopardy-houston. Pollutants of concern were identified based on the risks indicated in US EPA's Risk-Screening Environmental Indicators (RSEI) and National Air Toxics Assessment (NATA) datasets.

Time periods

We evaluate total emissions over three time periods: the most recently available year (2016), the most recent five-year period (2012 to 2016), and the most recent ten-year period (2007 to 2016). Evaluating all three time periods provides insight into the consistency of emissions over time.

Data analysis

In order to understand the potential for disproportionate emissions burdens in vulnerable populations and communities, this analysis focuses on whether there are patterns of emissions in the region. Thus, this report focuses on broad pollution categories (PM2.5, PM10, VOCs, and an index of the remaining 19 pollutants of concern). The distribution of emissions of any single pollutant may also be of concern, so additional information on each of the 19 pollutant is provided in the Appendices.

We first evaluate each pollutant's emissions density (annual quantity emitted divided by land area) at the census tract level across the eight-county region and for each of the three time periods. We present total emissions (which are the sum of authorized emissions and unauthorized emissions). We then estimate the emissions density as the total emissions per year divided by the tract's land area. Examining emissions density allows us to compare emissions rates across tracts of varying sizes.

We then calculate an index of the 19 pollutants of concern (these are the pollutants listed in the PAH and other pollutants of concern sections of Table 1). The index is a sum of the scaled burden of each of these pollutants.[24] The purpose of the index is to identify areas where emission densities of multiple pollutants of interest are relatively high in order to highlight potential patterns in elevated emissions densities for the 19 pollutants. The index does not capture all pollutants, nor does it indicate pollution concentrations (which depend on the fate and transport of pollutants), pollution exposures, or the magnitude of health risks[25].

[24] We first use a min-max normalization approach to scale the tract-level emissions density of each of the 19 pollutants from 0 to 1. For each pollutant the minimum tract-level emissions density (zero in all cases) is set to 0 and the maximum tract-level emissions density is set equal to 1, with intermediate values scaled by dividing by the maximum tract-level emissions density. These scaled values are estimated for each pollutant and then summed across the 19 pollutants to arrive at the pollution index value for each tract.

[25] The focus of this index is on the density of emissions in each tract rather than the health risk. Because the pollutants of concern were selected based on concerns communities of interest, we also include pollution categories, which reflect a broader number of pollutants. This index does not weight the potential health impacts of each pollutant individually so it does not reflect the magnitude of health risks. A more complex analysis that accounts for the fate and transport of pollution, its toxicological properties, exposures, and population vulnerability would be required to turn emissions data into health risks.

Table 1: Air Pollutants of Interest[26]

Pollutants of interest in study area	Available in TCEQ PSEI data?
Broad pollution categories	
Particulate matter <2.5 µm diameter (PM2.5)	✓
Particulate matter <10 µm diameter (PM10)	✓
Volatile organic compounds (VOCs)	✓
Polycyclic aromatic hydrocarbons (PAHs)	
Naphthalene	✓
Acenaphthene	
Acenaphthylene	✓
Anthracene	✓
Benz[*a*]anthracene	
Benzo[*a*]pyrene	✓
Benzo[*b*]fluoranthene	
Benzo[*ghi*]perylene	
Benzo[*k*]fluoranthene	
Chrysene	
Dibenz[*a,h*]anthracene	
Fluoranthene	✓
Fluorene	
Indeno[1,2,3-*cd*]pyrene	
Phenanthrene	✓
Pyrene	✓
Other pollutants of concern	
Chromium and chromium compounds	✓
1,3-Butadiene	✓
Acetaldehyde	✓
Acrolein	✓
Benzene	✓
Carbon Tetrachloride	✓
Chlorine	✓
Diaminotoluene (mixed isomers)	✓
Diesel Particulate Matter	
Formaldehyde	✓
Hydrogen Chloride	✓
Hydrogen Cyanide	✓
Hydrogen Sulfide	✓

[26] Pollutants that are available in TCEQ PSEI data (https://www.tceq.texas.gov/airquality/point-source-ei/psei.html) are evaluated in this memo. The PAHs and other pollutants of concern are combined in a 19-pollutant index in this report, with detailed results presented in the Appendices.

Once we have tract-level emissions densities for the pollutants and the 19-pollutant index value, we combine these with tract-level measures of vulnerability obtained from the US Census. For each of the three vulnerable populations (people living in poverty, people of color, and limited-English households), we compare emissions densities to the corresponding advantaged populations (people living above poverty, non-Hispanic white people, and English proficient households). We evaluate the emissions density burdens for each population using three metrics:

1. **Average emissions density for the entire population.** This is the average emissions density experienced by the population living in each tract. This is a measure of the average emissions burden on each population.
2. **Percent living near emissions.** This is the share of the population that lives in a tract with an emissions density greater than zero. This is a measure of how widespread the emissions are.
3. **Average emissions density for those living near emissions.** This is the average tract-level emissions density experienced by all individuals of the population that live in a tract with an emissions density greater than zero. This is a measure of how severe the emissions are for those living near them.

We also present maps of the region showing the percent of the population that is vulnerable and emissions densities.

We then evaluate the quantity of emissions that are unauthorized (emissions events and unauthorized scheduled maintenance, startup, and shutdown emissions) for each analysis area and time period for one example pollution category (VOCs). As with total emissions, unauthorized emissions are estimated as an emissions density (tons per year per square mile).

Finally, we examine emissions and vulnerability for communities in the region. We first map emissions and vulnerability at the tract level in the Ship Channel area, highlighting the communities of interest. We then quantify vulnerability and emissions densities at the city and neighborhood scales.[27] Emissions estimates are evaluated as total emissions per year per square mile, as above. Demographic estimates at the city level are obtained directly from the US Census. For the neighborhood-level analysis, demographic data are obtained at the smallest scale available and assigned to the corresponding neighborhood.[28] As part of the

[27] We use 2016 US Census "Place" boundaries to identify city boundaries and City of Houston "Super Neighborhood" boundaries (from https://cohgis-mycity.opendata.arcgis.com/) to identify neighborhoods in the City of Houston, which is the largest city in the region.

[28] Decennial census data is available at the block level while ACS data are available at the block-group level. The block level POC/non-POC population is assigned to the neighborhood in which the block centroid falls. The total number of POC/non-POC is then summed for all blocks in the neighborhood to arrive at the neighborhood-level populations. The block-group level POV/non-POV and LEH/non-LEH populations are assigned to each block they encompass in proportion to the share of the block-group's population that the block comprised in the 2010 decennial Census. These populations are then assigned to neighborhoods based on the block centroid.

community-scale analysis, we also evaluate the vulnerability and emissions densities for three reference areas: the eight-county region, Harris County, and the City of Houston. The eight-county region and Harris County vulnerability estimates are obtained by aggregating tract-level populations to those areas, while the City of Houston estimates are obtained directly from the US Census.

Results

We focus our evaluation of emissions on comparisons of the relative magnitudes of emissions experienced by different populations and communities. This analysis does not represent an evaluation of health risks. The health risks experienced by different groups is a function of the magnitude of emissions in their area (which is presented here), in combination with several other factors that were not evaluated here, including each pollutant's fate and transport, toxicity, the location of potentially exposed populations, and the vulnerability of the population.

Regionwide

We first compare the emissions burdens of vulnerable populations (versus their advantaged counterparts) across the eight-county region.

What is the average emissions burden?

Table 2 shows the average emissions density experienced by each population living in the eight-county Houston region. The "% Difference" columns indicate the percent difference between each vulnerable population (e.g. people of color, or POC) relative to its advantaged counterpart (e.g. non-POC, or non-Hispanic white residents). A percent difference equal to zero indicates that on average the two populations live in areas with the same emissions density. These columns are highlighted to indicate the level of disparity. Bright red highlighting indicates greater levels of disparity for vulnerable populations, white highlighting indicates equal burdens, and bright green highlighting indicates emissions burdens that disproportionately fall on advantaged populations. Note that the values in Table 2 all reflect disparate burdens for vulnerable populations, so they are highlighted in varying degrees of red.

For example, on average, limited-English households live in tracts with 0.81 tons of 2016 PM2.5 emissions per year per square mile, whereas households with some English proficiency live in tracts with 0.4 tons of 2016 PM2.5 emissions per year per square mile. Thus, limited-English households have 101% greater 2016 PM2.5 emissions densities. In other words, on average, limited-English households live in tracts with 2016 PM2.5 emissions densities that are about twice as high as English proficient households.

Looking at the percent difference across demographic groups (which indicates the disparity in average emissions), we see that on average, people of color, people living in poverty, and limited-English households live in tracts with higher emissions densities than their more advantaged counterparts. This finding is consistent across all four pollution categories examined (VOCs, PM10, PM2.5 and the 19-pollutant index) and across all three time periods. Disparities are greatest for VOCs, PM10, and PM2.5 for all vulnerable population definitions. Disparities are also greater for people of color and limited-English households than for households living in poverty. Disparities for PM2.5 and PM10 decrease slightly in more recent time periods for people of color and people living in poverty. Results for each of the 19 pollutants of concern are more mixed, as shown in Appendix A.

Looking at the average emissions burden for each population, we see that emissions for PM2.5, PM10, and VOCs are relatively consistent or modestly decreasing across the three time periods. The 19-pollutant index shows modest reductions in the 2012 to 2016 period and then modest increases in 2016. These trends are similar for vulnerable populations and their more advantaged counterparts.

How widespread are emissions?

Table 3 shows the share of each population living in tracts with emissions that are greater than zero in the eight-county Houston region. As above, the "% Difference" columns indicate the percent difference between each vulnerable population relative to its advantaged counterpart. These columns are again highlighted to indicate the level of disparity, where bright red indicates greater levels of disparity for vulnerable populations and bright green indicates emissions burdens that disproportionately fall on advantaged populations.

For example, on average, 11% of limited-English households live in tracts with 2016 PM2.5 emissions, whereas 12% of households with some English proficiency live in tracts with 2016 PM2.5 emissions. Thus, limited-English households are 8% less likely to live in tracts with 2016 PM2.5 emissions than English-proficient households.

Looking at the percent difference across demographic groups (which indicates the disparity in average emissions), we see that on average people of color, people living in poverty, and limited-English households are less likely to live in tracts with emissions than their more advantaged counterparts, although the differences are modest. This finding is consistent across all four pollution categories examined (VOCs, PM10, PM2.5 and the 19-pollutant index) and across all three time periods. In more recent analysis years (2012 to 2016 and 2016), the modest differences between populations in poverty and limited-English households and their more advantaged counterparts shrink slightly. Results for each of the 19 pollutants of concern are again mixed, as shown in Appendix A.

Looking at the share of each population that lives in a tract with emissions, we see that the scopes of emissions for the three broad pollution categories (PM2.5, PM10, and VOCs) and the 19-pollutant index are modestly decreasing across the three time periods. These trends are similar for vulnerable populations and their more advantaged counterparts.

How severe are emissions for those living near them?

Above we observed that vulnerable populations experience greater emissions densities (on average) than their more advantaged counterparts, although they are also modestly less likely to live in tracts with emissions. These seemingly conflicting accounts of disparity are reconciled when we examine the severity of emissions burdens that vulnerable populations bear when they live in tracts with emissions.

Table 4 shows the severity of the emissions burdens for residents of tracts with emissions. As above, the "% Difference" columns indicate the percent difference between each vulnerable population relative to its advantaged counterpart. These columns are again highlighted to indicate the level of disparity, where bright red indicates greater levels of disparity for vulnerable populations and bright green indicates emissions burdens that disproportionately fall on advantaged populations.

For example, looking at limited-English households living in tracts with 2016 PM2.5 emissions that are greater than zero, we see that these households live in tracts with an average of 7.1 tons of 2016 PM2.5 emissions per year per square mile, versus 3.3 tons of 2016 PM2.5 emissions per year per square mile for English-proficient households. Thus, limited-English households that live in tracts with 2016 PM2.5 emissions have 119% greater 2016 PM2.5 emissions densities.

Looking at the severity of emissions burdens (the average emissions densities experienced by people living in tracts with emissions), we see that people of color, people living in poverty, and limited-English households living in tracts with emissions experience higher average emissions densities when compared with their more advantaged counterparts. This finding is consistent across all four pollution categories examined (VOCs, PM10, PM2.5 and the 19-pollutant index) and across all three time periods. Disparities are generally greater for VOCs, PM10, and PM2.5 for all vulnerable population definitions. Disparities are also greater for people of color and limited-English households than for households living in poverty. Disparities for PM2.5 and PM10 decrease slightly in more recent time periods for all three vulnerable populations. Results for each of the 19 pollutants of concern are again mixed, as shown in Appendix A.

Looking at the severity of emissions for each population we see that emissions for PM2.5, PM10, and VOCs are increasing across the three time periods, particularly for the 19-pollutant index. These trends are similar for vulnerable populations and their more advantaged counterparts.

Table 2: Average Emissions Burden for Residents of the Eight County Houston Region

		Average Burden: Average Emissions Density (tons / year / sq mile estimated at the census tract level)								
Pollutant	Year range	People of Color (POC)	Non POC	% Difference (POC - NonPOC) / NonPOC	People Living in Poverty (POV)	Non POV	% Difference (POV - NonPOV) / NonPOV	Limited English Household (LEH)	Non LEH	% Difference (LEH - NonLEH) / NonLEH
PM2.5	2007 - 2016	0.670	0.331	103%	0.683	0.455	50%	0.845	0.424	99%
	2012 - 2016	0.651	0.322	102%	0.656	0.446	47%	0.828	0.410	102%
	2016	0.625	0.328	90%	0.634	0.436	45%	0.811	0.403	101%
PM10	2007 - 2016	1.02	0.458	122%	1.06	0.665	60%	1.33	0.621	114%
	2012 - 2016	0.953	0.419	127%	0.986	0.617	60%	1.27	0.572	121%
	2016	0.808	0.404	100%	0.831	0.548	52%	1.06	0.512	107%
Total VOCs	2007 - 2016	3.07	1.38	122%	3.07	2.09	47%	3.46	1.91	81%
	2012 - 2016	2.87	1.26	128%	2.83	1.94	46%	3.21	1.76	82%
	2016	2.48	1.17	113%	2.56	1.68	52%	2.90	1.55	87%
19-pollutant index	2007 - 2016	0.0232	0.0198	17%	0.0270	0.0193	40%	0.0278	0.0188	48%
	2012 - 2016	0.0218	0.0170	28%	0.0240	0.0179	34%	0.0274	0.0166	64%
	2016	0.0262	0.0240	9%	0.0279	0.0237	17%	0.0317	0.0222	43%

Table 3: Scope of Emissions in the Eight County Houston Region

		Emissions Scope: Share of Population Living in Tracts with Emissions (%)								
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
PM2.5	2007 - 2016	17.2	18.9	-9%	17.5	18.2	-4%	15	18	-17%
	2012 - 2016	14.8	16.7	-11%	15.2	15.7	-3%	13	15	-14%
	2016	12.6	13.2	-5%	13.1	12.9	2%	11	12	-8%
PM10	2007 - 2016	17.6	19.3	-9%	17.7	18.7	-5%	15	18	-17%
	2012 - 2016	15.4	17.1	-10%	15.6	16.3	-4%	13	16	-15%
	2016	12.8	13.5	-5%	13.4	13.1	2%	12	13	-9%
Total VOCs	2007 - 2016	19.4	21.1	-8%	19.9	20.4	-2%	17	20	-13%
	2012 - 2016	16.8	18.7	-10%	17.5	17.7	-1%	15	17	-12%
	2016	14.7	15.4	-5%	15.4	14.9	3%	13	14	-6%
19-pollutant index	2007 - 2016	14.5	17.6	-18%	14.9	16.4	-9%	12	16	-23%
	2012 - 2016	12.1	15.4	-22%	12.6	13.6	-8%	10	13	-24%
	2016	9.1	11.9	-23%	9.8	10.5	-7%	8	10	-22%

Table 4: Severity of Emissions Burdens for Residents Living in Tracts with Emissions in the Eight County Houston Region

Emissions Severity: Average Emissions Density for People Living in Tract with Emissions (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
PM2.5	2007 - 2016	3.89	1.75	123%	3.89	2.49	56%	5.75	2.40	140%
	2012 - 2016	4.40	1.93	128%	4.32	2.84	52%	6.39	2.71	136%
	2016	4.95	2.48	100%	4.83	3.38	43%	7.15	3.26	119%
PM10	2007 - 2016	5.78	2.37	144%	6.00	3.56	69%	8.88	3.43	159%
	2012 - 2016	6.17	2.45	152%	6.31	3.79	67%	9.51	3.66	160%
	2016	6.31	2.99	111%	6.22	4.18	49%	9.18	4.05	127%
Total VOCs	2007 - 2016	15.9	6.57	141%	15.4	10.3	50%	20.3	9.7	109%
	2012 - 2016	17.0	6.72	153%	16.2	11.0	48%	21.6	10.4	108%
	2016	16.9	7.57	124%	16.6	11.3	47%	21.6	10.8	100%
19-pollutant index	2007 - 2016	0.160	0.113	42%	0.181	0.118	53%	0.229	0.119	93%
	2012 - 2016	0.181	0.111	63%	0.190	0.131	45%	0.272	0.126	116%
	2016	0.286	0.202	42%	0.284	0.226	26%	0.396	0.217	83%

Mapping Vulnerability and Emissions Burdens

To get a better understanding of demographic vulnerability and emissions burdens across the region, we also present maps of tract-level vulnerability and emissions densities. We present 2007 to 2016 emissions burdens in this section. Maps of emissions burdens in the 2012 to 2016 and 2016 time periods show similar spatial patterns and are included in Appendix B. Maps of each of the 19 pollutants of concern are included in Appendix C.

Figure 2 shows demographic vulnerability across the eight-county Houston region. The share of the population that is in poverty and of color is generally greater in more centrally-located tracts than in outlying areas, with the exception of parts of the west central area. The share of households that are limited-English is greater in the north central and parts of the east and southwest central areas. Accordingly, the vulnerability index (which is an average of the three vulnerability shares) is greater in more centrally-located tracts (with the exception of parts of the west central area).

Emissions densities for the three broad categories of pollutants and the 19-pollutant index are generally greatest in tracts in the vicinity of the Ship Channel (Figure 3). This is consistent across most pollutants and study years (Appendices B and C).

Overlaying emissions densities and the vulnerability index (Figure 4) reveals that the confluence of pollution and vulnerability occurs along the Ship Channel, particularly in centrally-located tracts. This is consistent across the three broad pollution categories and the 19-pollutant index.

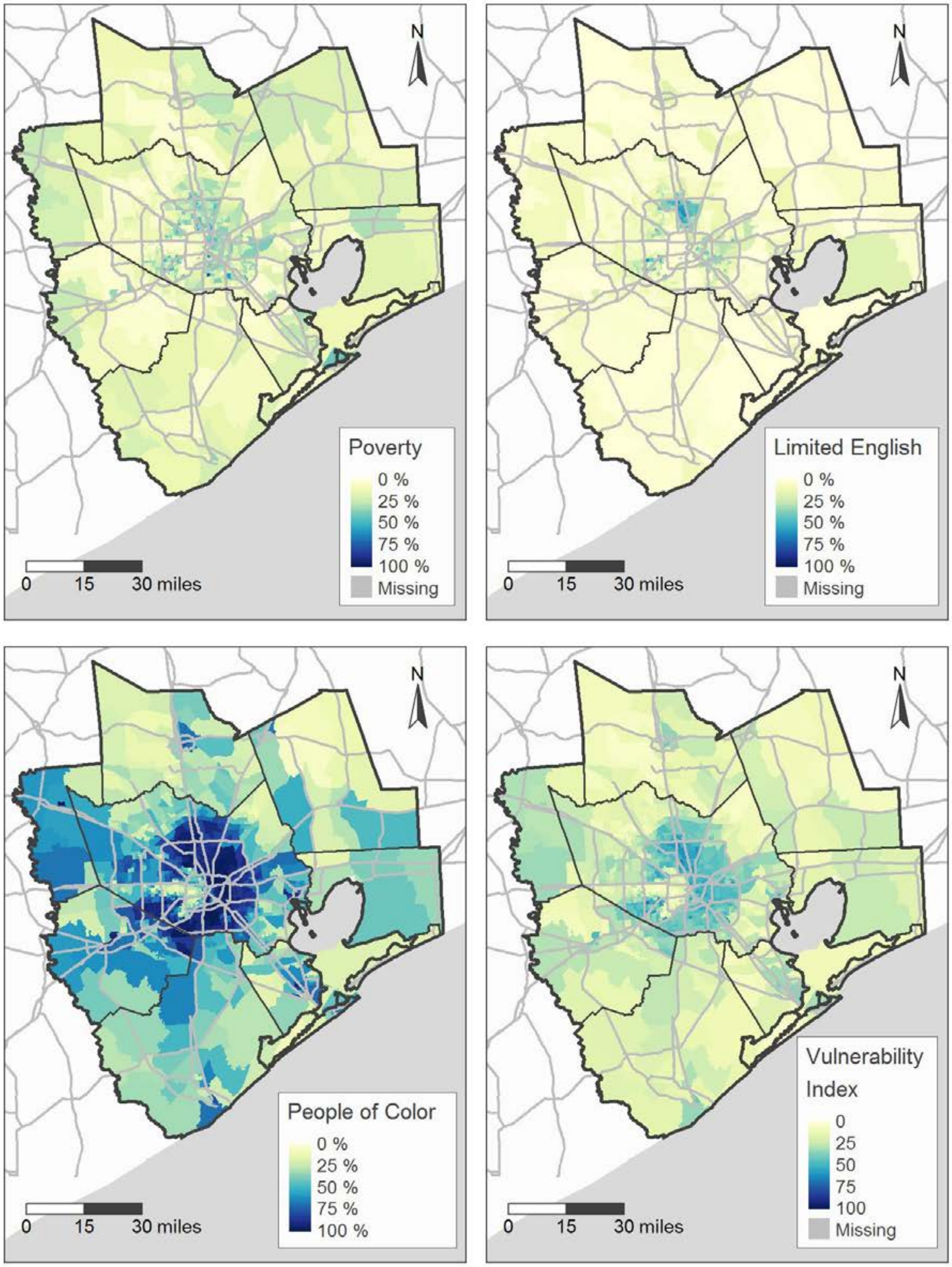


Figure 2: Vulnerability in the Eight-County Houston Region[29]

[29] The Vulnerability Index is an average of % Poverty, % Limited English, and % People of Color.

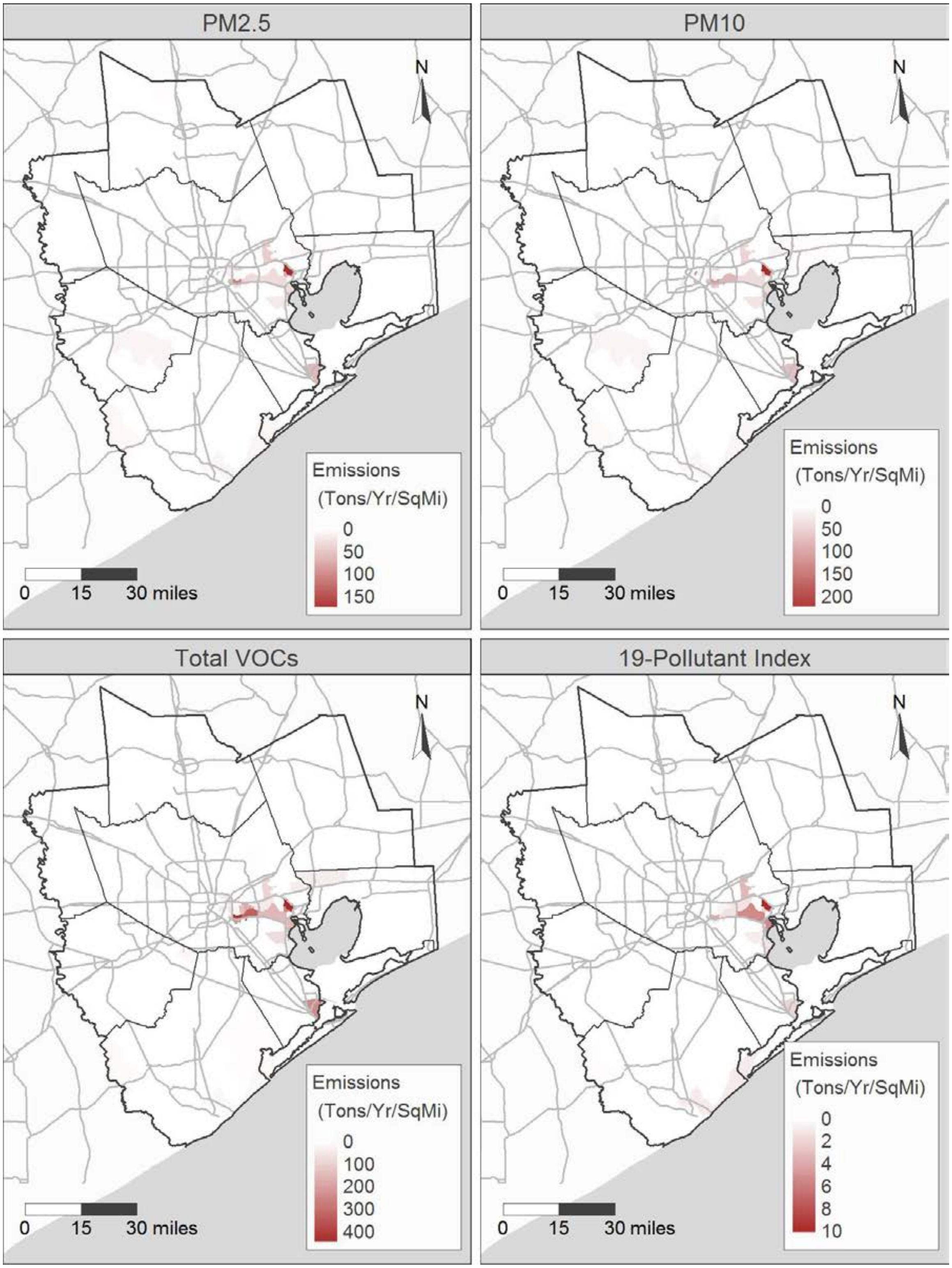


Figure 3: 2007 to 2016 Emissions in the Eight-County Houston Region

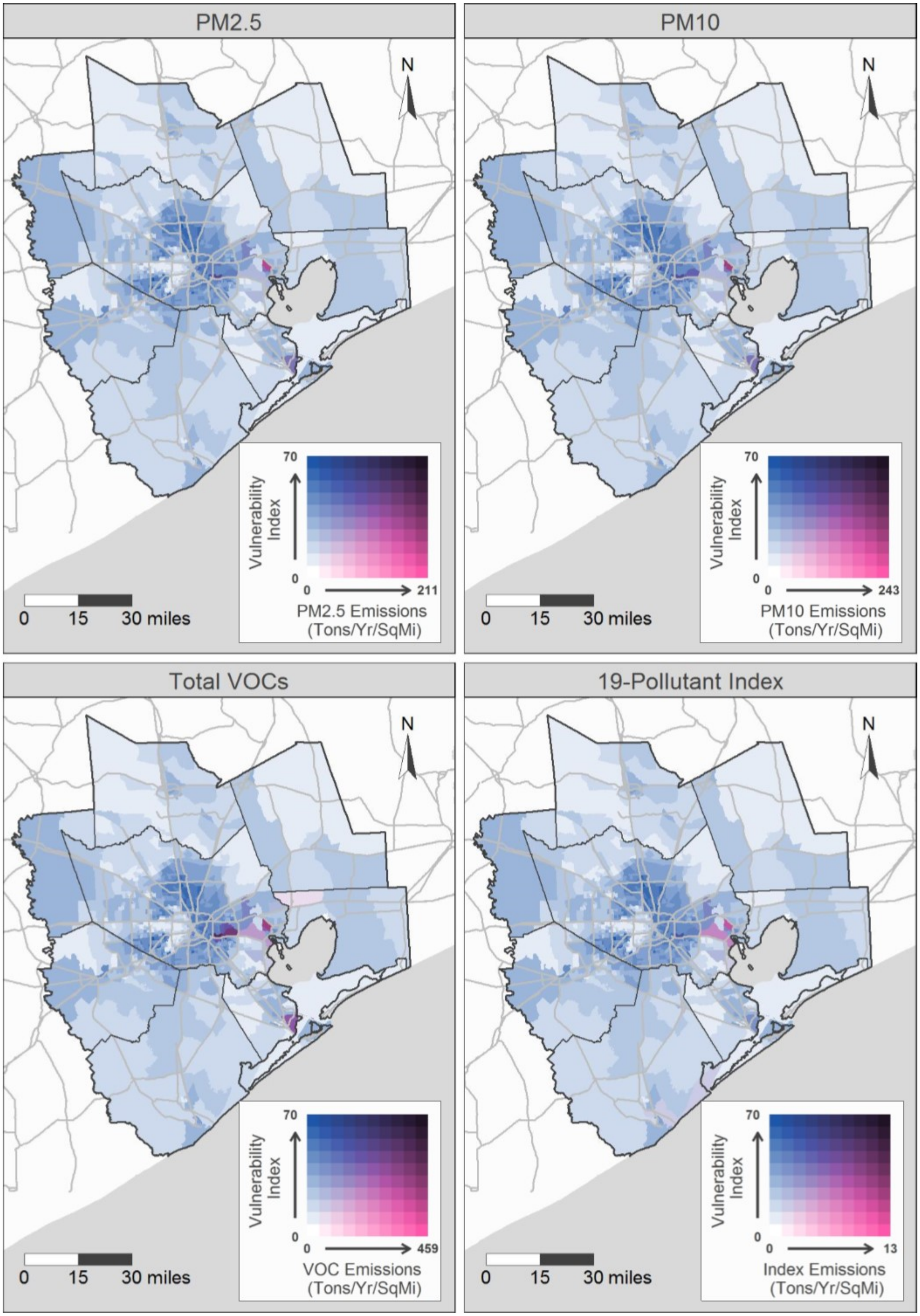


Figure 4: 2007 to 2016 Emissions and Vulnerability in the Eight-County Houston Region

Unauthorized Emissions

The analysis above focuses on total emissions, which include both authorized and unauthorized emissions. Because the unauthorized emissions are not permitted in advance, it is also of interest to examine unauthorized emissions alone. Note that these emissions may be more likely to be uncontrolled, so may occur over short periods of time, potentially leading to spikes in pollution concentrations which have the potential to contribute to acute and chronic health risks.

Table 5 shows the average emissions burden (average emissions density), the scope of emissions (share of population living in tracts with emissions greater than zero), and the severity of emissions for those that are exposed (average emissions density for those that live in tracts with emissions greater than zero). As in Tables 2 to 4, columns are highlighted to indicate the level of disparity, where bright red indicates greater levels of disparity for disadvantaged populations and bright green indicates emissions burdens that disproportionately fall on advantaged populations.

Table 5 shows that vulnerable populations experience greater emissions densities (on average) than their more advantaged counterparts, although they are also modestly less likely to live in tracts with emissions. This is due to the greater severity of emissions burdens that vulnerable populations bear when they live in tracts with emissions. These findings are consistent with emissions of total VOCs (shown in Tables 2 to 4). The average burden and severity of emissions of unauthorized VOCs are approximately an order of magnitude smaller than for total VOCs. At the same time, the shares of the populations living in tracts with unauthorized VOC emissions are approximately half to two-thirds of the shares living in tracts with emissions of total VOCs. Disparities in the severity of emissions experienced by people living in poverty are more modest for unauthorized VOC emissions than for total VOC emissions. Disparities in the average emissions burden and the severity of emissions experienced by people of color and limited-English households are greater for unauthorized emissions in the 2007 to 2016 time period, but these disparities appear to trend downward in the more recent time periods evaluated.

Looking at the magnitude of the average emissions burden and the scope and severity of emissions, we see that emissions burdens and the scope of emissions decrease in more recent time periods when compared with the 2007 to 2016 time period for all populations. The severity of emissions increases slightly for people of color and people living in poverty and decreases for limited-English households, while it increases for all three of the corresponding advantaged populations.

Figure 5 shows the location of unauthorized VOC emissions across the region. These emissions are most prevalent in the area around the Ship Channel, similar to the four pollution categories shown in Figure 3.

Table 5: Unauthorized VOCs in the Eight County Houston Region: Average Burden, Scope, and Severity

Pollutant	Year range	People of Color (POC)	Non POC	% Difference (POC - NonPOC) / NonPOC	People Living in Poverty (POV)	Non POV	% Difference (POV - NonPOV) / NonPOV	Limited English Household (LEH)	Non LEH	% Difference (LEH - NonLEH) / NonLEH
Average Burden: Average Emissions Density (tons / year / sq mile estimated at the census tract level)										
VOCs (unauthorized emissions only)	2007 - 2016	0.192	0.0719	167%	0.170	0.132	29%	0.250	0.103	143%
	2012 - 2016	0.135	0.0587	130%	0.115	0.094	22%	0.175	0.078	126%
	2016	0.106	0.0539	97%	0.103	0.079	30%	0.098	0.071	38%
Emissions Scope: Share of Population Living in Tracts with Emissions (%)										
VOCs (unauthorized emissions only)	2007 - 2016	9.07	11.6	-22%	10.2	9.86	3%	7.82	9.77	-20%
	2012 - 2016	6.90	8.93	-23%	7.90	7.68	3%	5.92	7.60	-22%
	2016	4.97	6.06	-18%	5.73	5.33	8%	4.50	5.27	-15%
Emissions Severity: Average Emissions Density for People Living in Tract with Emissions (tons / year / sq mile estimated at the census tract level)										
VOCs (unauthorized emissions only)	2007 - 2016	2.11	0.621	241%	1.67	1.34	25%	3.19	1.05	203%
	2012 - 2016	1.96	0.658	198%	1.45	1.22	19%	2.96	1.02	190%
	2016	2.14	0.890	140%	1.80	1.49	21%	2.19	1.35	62%

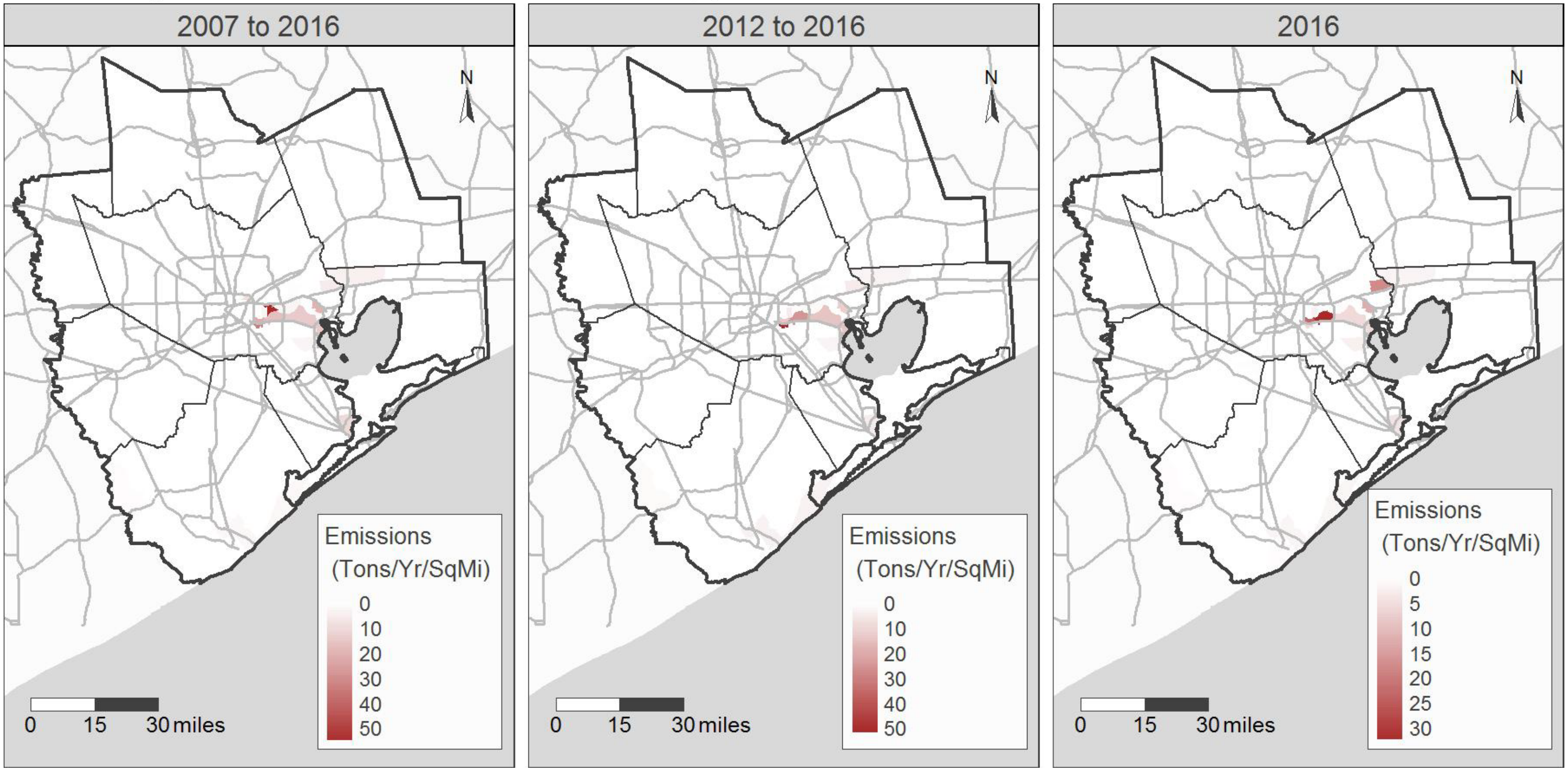


Figure 5: Unauthorized VOC Emissions in the Eight-County Houston Region

The Ship Channel and Communities of Interest

In light of the interest in several Ship Channel communities expressed by community partners and the findings of the previous sections, in this section we examine vulnerability and emissions burdens in the Ship Channel area.

We first zoom in on the vulnerability and emissions maps. Figure 6 shows demographics in the Ship Channel Area, with the communities of interest highlighted. Magnolia Park, Harrisburg / Manchester, and the northwest part of Pasadena exhibit greater vulnerability than outlying areas, particularly in terms of the share of people of color. At the same time, areas along the Ship Channel (including Harrisburg / Manchester, the northern edges of Pasadena and Deer Park, and the southwest of Baytown) exhibit greater total emissions burdens in the 2007 to 2016 period than most other areas (Figure 7). These findings are consistent in the other time periods examined (see Appendix D) and for unauthorized emissions (Figure 8). Additional maps of each of emissions of the 19 pollutants are included in Appendix E. The confluence of vulnerability and emissions burdens is greatest in the Harrisburg / Manchester community and along the northern edges of Pasadena and Deer Park (Figure 9). The differences observed are substantial. For example, the vulnerability measures in Harrisburg / Manchester range from 1.6 to 3.1 times the values for the eight-county region, while the pollution measures shown range from 28 to 61 times the values for the eight-county region for the period from 2007 to 2016.

We then summarize vulnerability and the 2007 to 2016 emissions by community in order to quantify the patterns shown in the maps described above. We also present comparable information for three reference areas: the eight-county Houston area, Harris County, and the City of Houston (Figure 10).[30] Looking at Figure 10a, we see that when compared with the reference areas, Harrisburg / Manchester and Magnolia Park exhibit greater vulnerability, Deer Park exhibits less vulnerability, and Baytown and Pasadena are approximately on par with the reference areas. Figure 10b shows that when compared with the reference areas, Harrisburg / Manchester exhibits far greater emissions density, Baytown, Deer Park, and Magnolia exhibit smaller emissions densities, and Pasadena exhibits emissions densities that are approximately on par with the reference areas. These findings are consistent in the two other time periods evaluated (Appendix F). Detailed tables are provided in Appendix G.

[30] The 19-pollutant index is not included in this part of the analysis because it is not comparable across analysis scales.

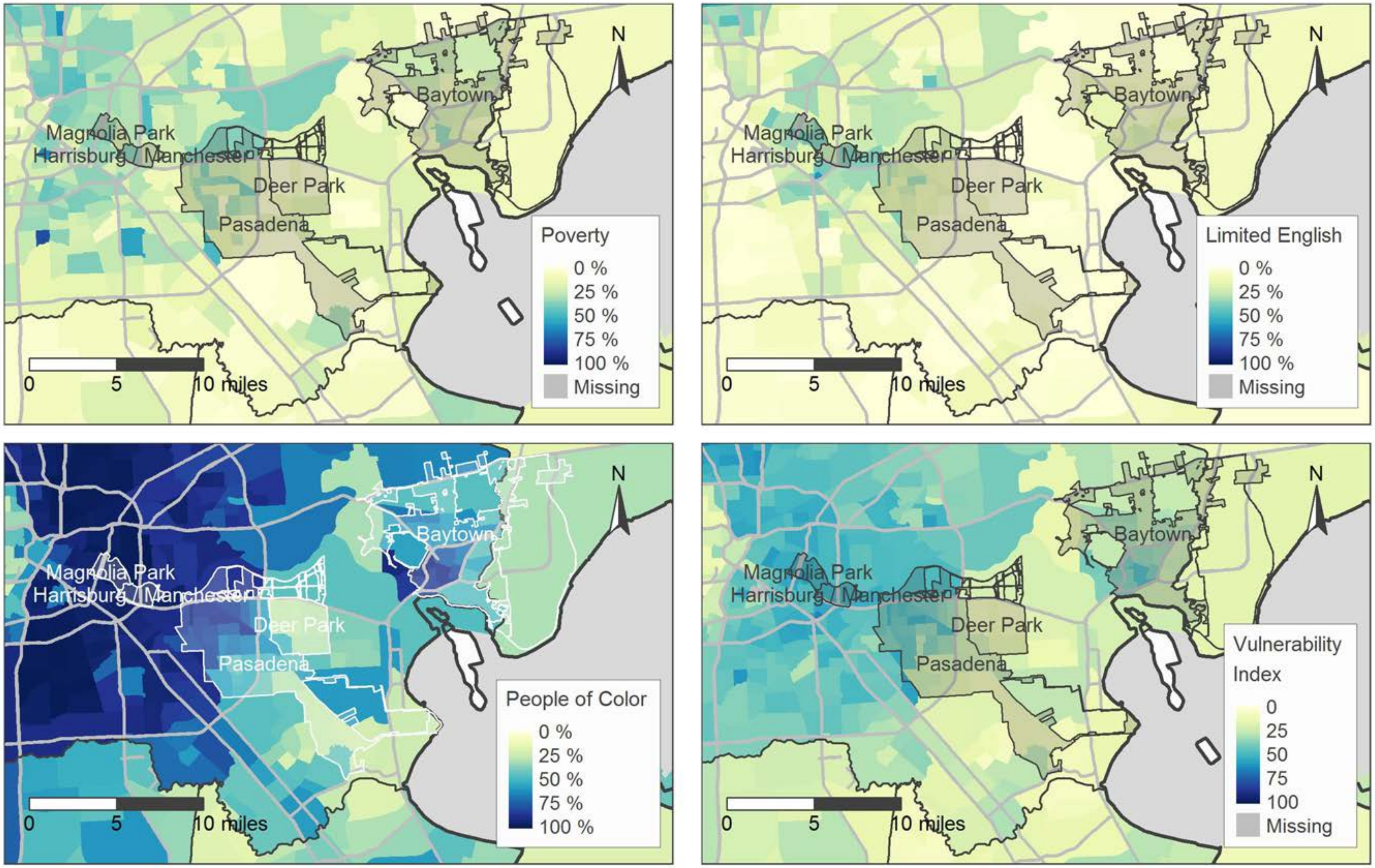


Figure 6: Vulnerability in the Ship Channel Area

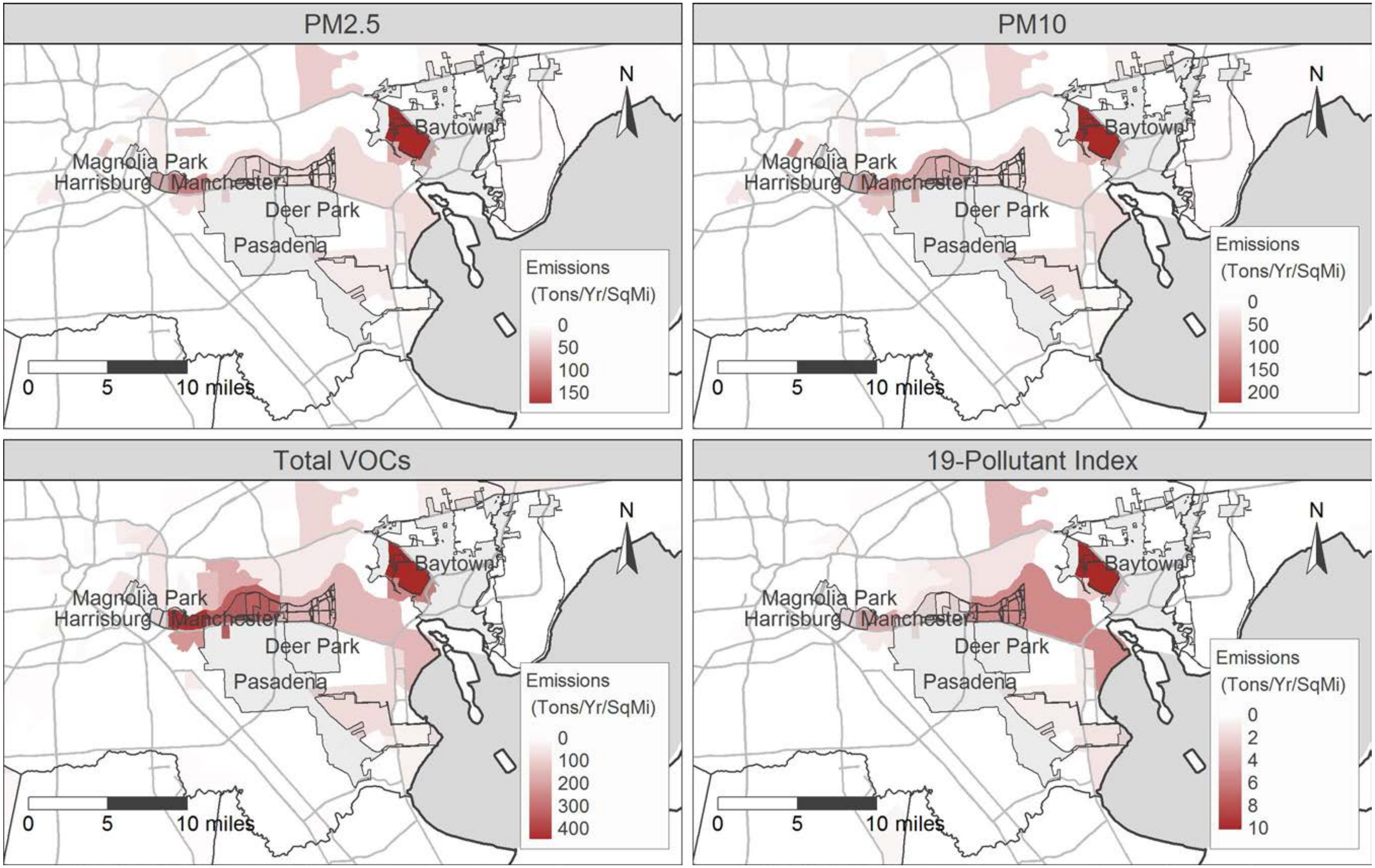


Figure 7: 2007 to 2016 Emissions in the Ship Channel Area

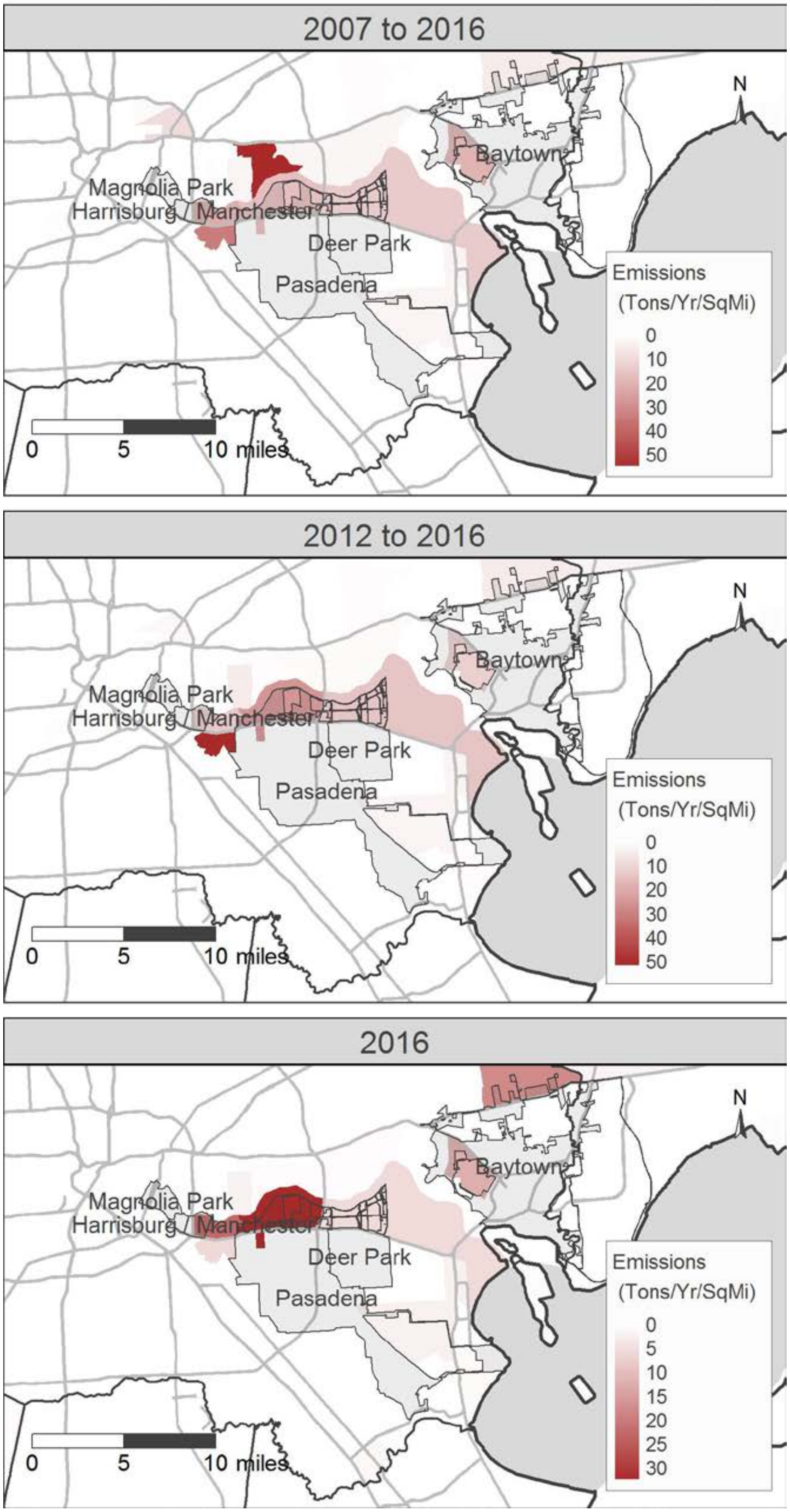


Figure 8: Unauthorized VOC Emissions in the Ship Channel Area

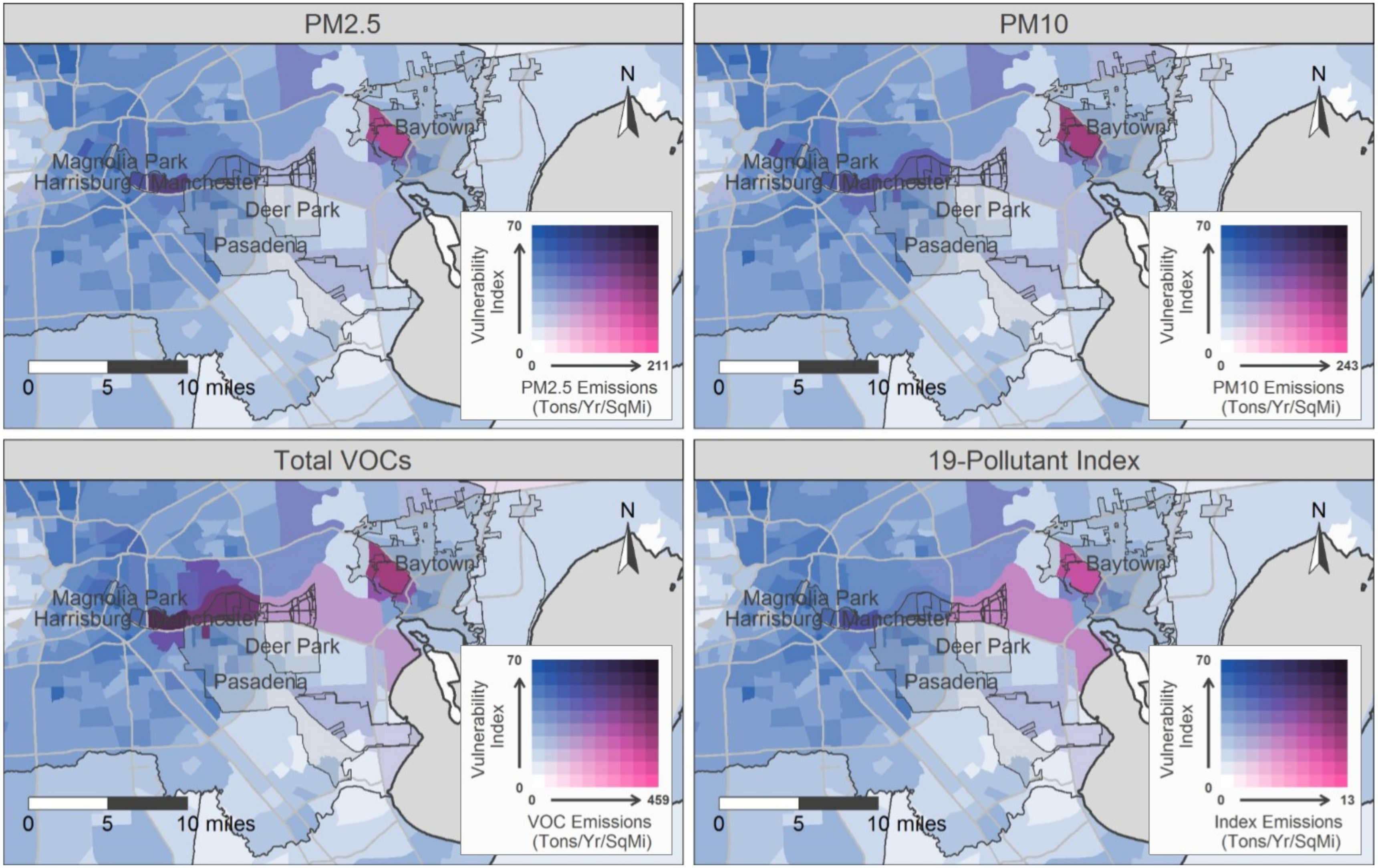


Figure 9: 2007 to 2016 Emissions and Vulnerability in the Ship Channel Area

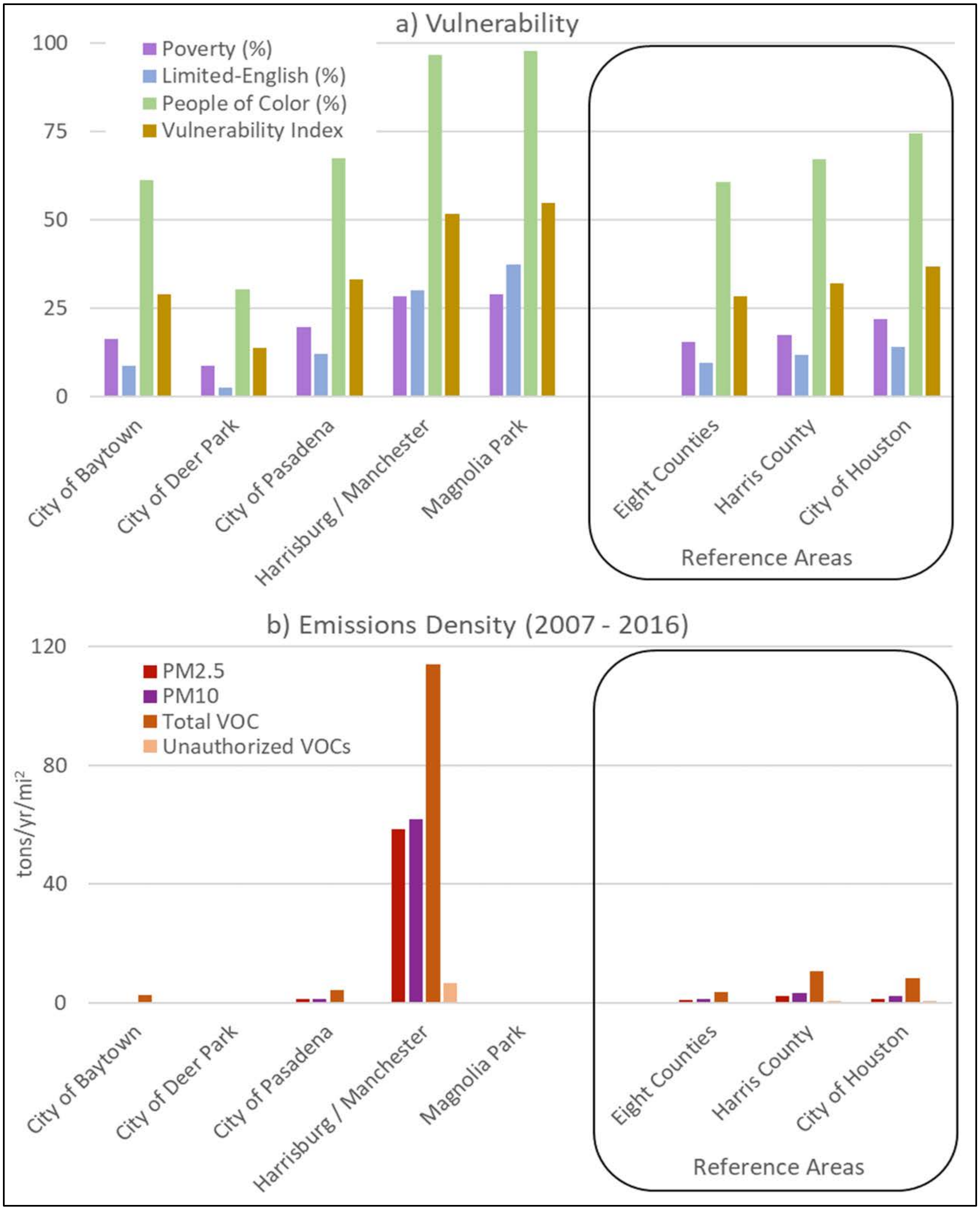


Figure 10: Vulnerability and Emissions in Communities of Interest

Discussion

This analysis evaluates vulnerability and stationary source emissions in the Houston region. Emissions burdens are estimated at the census-tract level, represented as the quantity of pollution emitted per land area. Vulnerability is also evaluated at the tract level, and is estimated based on the share of households that are living in poverty, the share of limited-English households, and the share of the population that are people of color.

The regional-level analysis indicates that the share of vulnerable populations living in tracts where pollution is emitted is modestly smaller than that of more advantaged populations. However, vulnerable populations living in tracts where emissions occur are in proximity to greater densities of pollution emissions than more advantaged populations living in tracts where emissions occur. The overall effect of these two patterns is that the overall average emissions burdens of vulnerable populations are greater than those of more advantaged populations. These findings are consistent for most pollution categories and time periods examined. Disparities are greater for people of color and limited-English households than for people living in poverty.

The regional-scale analysis also points to greater densities of emissions in the Ship Channel area. A closer examination of tracts and communities in that area confirms that many areas along the Ship Channel exhibit greater levels of vulnerability and emissions burdens than the rest of the region. This is particularly true in the Harrisburg / Manchester community.

By examining the density of emissions of different pollutants and pollutant categories experienced by different communities and populations live, we are able to bring attention to areas where emissions burdens and vulnerability intersect. Where and when stationary sources emit different types of pollution is of interest both because of the potential for health risks and because it may provide insight into the regulatory and decision-making context. The authorized emissions included here undergo a permitting process while the unauthorized emissions are reported but are not permitted. In other words, emissions density is closely linked to regulatory and economic decisions.

Limitations

This study focuses on average emissions burdens for different populations and communities. As with any study, this analysis is limited in scope. We evaluated emissions densities but did not evaluate pollution fate and transport in the environment (including chemical reactions that might change the chemical composition of pollutants and the movement of pollutants), residents' exposures to pollution, residents' vulnerability to pollution exposure, or the health risks associated with pollution exposure. Note that this analysis does not account for movement of pollution from adjacent tracts, and it did not include statistical tests of the differences in pollution burdens experienced by different populations and communities.

Comparisons between time periods point to slight to moderate temporal trends for some pollution categories, but the periods of analysis used in this report were not designed to characterize trends over time. Further study would be required to identify trends of increasing or decreasing pollution levels in different populations or communities. Additional avenues for future study include characterizing pollution magnitudes or time trends from different sizes or types of sources, or characterizing the populations that live in areas at these extremes—e.g. those with pollution levels that far exceed the regional average. Additional analysis could also include modeling the fate and transport of pollution in the environment, the population's exposure and vulnerability to pollution, and the health risks borne in different communities and populations.

Conclusions

In this memo we have evaluated demographic vulnerability and point source emissions in the Houston region. This analysis focuses on pollution emissions densities and their relationship with vulnerability in order to identify areas with potential for disparities that may merit additional scrutiny. This analysis should not be interpreted as an analysis of pollution *exposures* or *health risks*, which would require more in-depth measurements and/or modeling of pollution fate and transport, toxicity, vulnerability, and exposure.

Key findings include:

Pollution burdens are disproportionately shouldered by vulnerable populations (people of color, people living in poverty, and limited-English households).

- Vulnerable populations experience greater emissions densities (on average) than their more advantaged counterparts, although they are also modestly less likely to live in tracts with emissions. These seemingly conflicting accounts of disparity are explained by the greater severity of emissions burdens that vulnerable populations bear when they live in tracts with emissions.
- Disparities are substantial, with average burdens for vulnerable populations ranging from 9% to 127% greater than their advantaged counterparts.

Vulnerability and emissions densities vary greatly across the region.

- More centrally-located areas are home to residents with greater vulnerability than are outlying areas, with the exception of the west central part of the region.
- Areas with greater emissions burdens are largely located in the vicinity of the Ship Channel.
- The confluence of pollution and vulnerability occurs along the Ship Channel, particularly in areas that are closer to the center of the region.

- Variation is substantial. For example, the vulnerability measures in Harrisburg / Manchester range from 1.6 to 3.1 times the values for the eight-county region, while the pollution measures range from 28 to 61 times the values for the eight-county region for the period from 2007 to 2016.

Unauthorized emissions of VOCs exhibit similar trends to other pollution categories.
- Vulnerable populations experience greater emissions densities (on average) than their more advantaged counterparts, although they are also modestly less likely to live in tracts with emissions. This is due to the greater severity of emissions burdens that vulnerable populations bear when they live in tracts with emissions.
- Unauthorized emissions of VOCs are largely located in the vicinity of the Ship Channel.

Disparities are consistent across the pollution categories and time periods evaluated.
- Findings of population- and community-level disparities are consistent across the four pollution categories (PM2.5, PM10, total VOCs, and a 19-pollutant index) and the three time periods evaluated (2007 to 2016, 2012 to 2016, and 2016).

Appendices

Contents

Appendix A: Regionwide Analysis of 19 Pollutants of Concern by Population

Appendix B: Additional Regionwide Maps of Four Pollution Categories

Appendix C: Regionwide Maps of 19 Pollutants of Concern

Appendix D: Additional Ship Channel Maps of Four Pollution Categories

Appendix E: Ship Channel Maps of 19 Pollutants of Concern

Appendix F: Emissions for 2012 to 2016 and 2016 in Communities of Interest

Appendix G: Vulnerability Index and Emissions in Communities of Interest

Appendix A: Regionwide Analysis of 19 Pollutants of Concern by Population

Average Burden: Average Emissions Density (1 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Acenaphthylene	2007 - 2016	1.0E-05	1.9E-05	-47%	1.4E-05	1.2E-05	14%	1.3E-06	1.6E-05	-92%
	2012 - 2016	2.3E-07	4.8E-07	-53%	1.8E-07	2.8E-07	-37%	2.9E-07	2.8E-07	4%
	2016	2.7E-07	4.3E-07	-38%	1.3E-07	2.8E-07	-54%	3.5E-07	2.6E-07	31%
Acetaldehyde	2007 - 2016	4.1E-03	3.5E-03	17%	5.5E-03	3.4E-03	60%	5.5E-03	3.3E-03	66%
	2012 - 2016	4.3E-03	3.7E-03	16%	6.0E-03	3.7E-03	63%	6.7E-03	3.5E-03	94%
	2016	6.1E-03	5.2E-03	17%	9.1E-03	5.2E-03	74%	1.1E-02	4.7E-03	137%
Acrolein	2007 - 2016	4.0E-04	5.9E-04	-32%	2.7E-04	5.5E-04	-52%	3.5E-04	4.9E-04	-27%
	2012 - 2016	3.6E-04	5.6E-04	-36%	2.8E-04	5.9E-04	-53%	3.6E-04	5.1E-04	-29%
	2016	3.5E-04	5.3E-04	-33%	2.3E-04	6.5E-04	-64%	3.5E-04	5.4E-04	-34%
Anthracene	2007 - 2016	2.8E-05	2.8E-05	2%	4.4E-05	2.3E-05	86%	5.3E-05	2.2E-05	136%
	2012 - 2016	5.1E-06	5.0E-06	1%	6.7E-06	4.3E-06	56%	7.8E-06	4.2E-06	84%
	2016	3.8E-06	3.6E-06	6%	5.6E-06	3.1E-06	81%	7.7E-06	2.8E-06	176%
Benzene	2007 - 2016	3.0E-02	1.9E-02	57%	3.3E-02	2.2E-02	51%	3.6E-02	2.0E-02	78%
	2012 - 2016	2.4E-02	1.7E-02	48%	2.7E-02	1.9E-02	45%	2.8E-02	1.7E-02	65%
	2016	2.3E-02	1.6E-02	45%	2.4E-02	1.8E-02	29%	2.5E-02	1.7E-02	47%
Benzo[a]pyrene	2007 - 2016	3.7E-07	7.4E-08	406%	2.5E-07	2.0E-07	26%	6.2E-07	1.3E-07	362%
	2012 - 2016	1.1E-07	8.7E-08	30%	4.9E-08	8.2E-08	-40%	1.7E-07	6.8E-08	141%
	2016	9.8E-08	8.3E-08	18%	3.9E-08	7.4E-08	-46%	1.4E-07	6.3E-08	124%
1,3-Butadiene	2007 - 2016	3.0E-02	1.3E-02	129%	2.5E-02	2.1E-02	21%	4.9E-02	1.6E-02	212%
	2012 - 2016	2.7E-02	1.3E-02	114%	2.3E-02	1.9E-02	19%	4.4E-02	1.4E-02	206%
	2016	2.1E-02	1.1E-02	92%	1.9E-02	1.5E-02	21%	3.4E-02	1.2E-02	186%
Carbon tetrachloride	2007 - 2016	5.8E-05	7.0E-05	-17%	1.2E-04	4.7E-05	157%	7.1E-05	5.7E-05	24%
	2012 - 2016	5.1E-05	5.5E-05	-8%	1.0E-04	3.9E-05	167%	6.3E-05	4.5E-05	39%
	2016	1.7E-05	4.8E-05	-64%	3.7E-05	2.7E-05	38%	1.4E-05	3.4E-05	-59%
Chlorine	2007 - 2016	1.6E-03	9.1E-04	79%	2.5E-03	1.1E-03	134%	2.1E-03	1.1E-03	98%
	2012 - 2016	1.3E-03	7.2E-04	83%	2.1E-03	8.2E-04	150%	1.7E-03	8.7E-04	92%
	2016	1.3E-03	7.1E-04	78%	2.0E-03	7.9E-04	146%	1.5E-03	8.6E-04	78%

Average Burden: Average Emissions Density (2 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Chromium and compounds	2007 - 2016	4.5E-05	4.8E-05	-6%	3.4E-05	4.4E-05	-24%	5.0E-05	4.2E-05	18%
	2012 - 2016	3.1E-05	3.2E-05	-4%	1.2E-05	2.6E-05	-53%	3.7E-05	2.4E-05	53%
	2016	4.1E-05	4.6E-05	-10%	1.5E-05	3.5E-05	-57%	5.0E-05	3.3E-05	54%
Diaminotoluene (mixed isomers)	2007 - 2016	2.4E-07	1.1E-06	-78%	6.0E-07	6.1E-07	-2%	1.1E-07	6.6E-07	-83%
	2012 - 2016	4.7E-08	2.7E-08	75%	6.2E-08	3.3E-08	87%	6.2E-08	3.2E-08	96%
	2016	1.5E-09	5.6E-09	-73%	1.8E-09	3.5E-09	-48%	2.6E-09	3.2E-09	-18%
Fluoranthene	2007 - 2016	7.6E-07	1.4E-06	-45%	9.2E-07	8.6E-07	7%	1.9E-07	1.1E-06	-83%
	2012 - 2016	1.4E-07	1.7E-07	-17%	3.8E-08	1.3E-07	-70%	1.9E-07	1.1E-07	61%
	2016	1.5E-07	1.7E-07	-13%	5.0E-08	1.2E-07	-59%	1.8E-07	1.2E-07	57%
Formaldehyde	2007 - 2016	8.4E-03	1.1E-02	-23%	7.4E-03	9.8E-03	-25%	6.6E-03	9.5E-03	-31%
	2012 - 2016	7.4E-03	9.5E-03	-22%	7.0E-03	8.7E-03	-19%	6.1E-03	8.3E-03	-26%
	2016	6.3E-03	8.4E-03	-25%	5.9E-03	8.5E-03	-31%	6.1E-03	7.8E-03	-21%
Hydrogen chloride	2007 - 2016	1.1E-02	4.0E-03	183%	9.6E-03	7.0E-03	38%	6.8E-03	7.0E-03	-2%
	2012 - 2016	1.1E-02	3.6E-03	199%	9.3E-03	6.3E-03	47%	6.6E-03	6.4E-03	3%
	2016	4.8E-03	3.1E-03	54%	4.9E-03	3.5E-03	40%	3.1E-03	3.7E-03	-18%
Hydrogen cyanide gas	2007 - 2016	1.5E-02	3.5E-03	318%	1.1E-02	7.9E-03	43%	2.2E-02	6.1E-03	263%
	2012 - 2016	2.9E-02	6.3E-03	357%	2.2E-02	1.5E-02	43%	4.4E-02	1.2E-02	278%
	2016	3.5E-02	8.1E-03	336%	2.7E-02	1.9E-02	46%	5.3E-02	1.5E-02	259%
Hydrogen sulfide	2007 - 2016	7.4E-03	4.2E-03	77%	6.4E-03	4.8E-03	35%	7.6E-03	4.7E-03	64%
	2012 - 2016	7.3E-03	3.9E-03	87%	6.3E-03	4.7E-03	35%	7.5E-03	4.5E-03	65%
	2016	7.6E-03	3.4E-03	123%	6.6E-03	4.7E-03	41%	8.2E-03	4.5E-03	82%
Naphthalene	2007 - 2016	4.2E-03	2.2E-03	87%	4.7E-03	2.8E-03	69%	5.6E-03	2.6E-03	117%
	2012 - 2016	4.0E-03	2.4E-03	68%	4.4E-03	2.7E-03	64%	5.4E-03	2.5E-03	111%
	2016	2.6E-03	1.9E-03	38%	3.2E-03	1.9E-03	70%	3.9E-03	1.8E-03	117%
Phenanthrene	2007 - 2016	1.5E-04	1.7E-04	-11%	6.2E-05	1.3E-04	-53%	2.0E-04	1.2E-04	68%
	2012 - 2016	2.8E-04	3.3E-04	-14%	9.8E-05	2.4E-04	-60%	3.7E-04	2.2E-04	69%
	2016	2.6E-04	3.0E-04	-14%	9.3E-05	2.3E-04	-59%	3.5E-04	2.0E-04	72%

Average Burden: Average Emissions Density (3 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Pyrene	2007 - 2016	2.1E-06	3.9E-06	-45%	2.7E-06	2.5E-06	10%	4.0E-07	3.2E-06	-87%
	2012 - 2016	2.4E-07	2.9E-07	-18%	5.9E-08	2.1E-07	-72%	3.1E-07	1.9E-07	62%
	2016	2.2E-07	2.7E-07	-18%	5.7E-08	1.9E-07	-70%	2.8E-07	1.8E-07	62%

Emissions Scope: Share of Population Living in Tracts with Emissions (%) (1 of 3)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Acenaphthylene	2007 - 2016	0.07	0.17	-58%	0.10	0.10	-2%	0.04	0.12	-62%
	2012 - 2016	0.03	0.09	-67%	0.04	0.05	-18%	0.04	0.05	-24%
	2016	0.03	0.09	-67%	0.04	0.05	-18%	0.04	0.05	-24%
Acetaldehyde	2007 - 2016	4.36	5.76	-24%	4.58	5.42	-16%	3.71	5.14	-28%
	2012 - 2016	3.83	4.81	-20%	3.78	4.87	-23%	3.17	4.51	-30%
	2016	2.57	2.81	-9%	2.60	3.13	-17%	2.33	2.90	-20%
Acrolein	2007 - 2016	3.39	4.83	-30%	3.47	4.60	-25%	2.79	4.28	-35%
	2012 - 2016	3.05	4.26	-28%	2.99	4.17	-28%	2.45	3.87	-37%
	2016	2.34	2.64	-11%	2.23	2.95	-25%	2.16	2.70	-20%
Anthracene	2007 - 2016	0.62	0.67	-8%	0.63	0.59	6%	0.56	0.59	-6%
	2012 - 2016	0.56	0.66	-16%	0.59	0.56	6%	0.53	0.56	-6%
	2016	0.31	0.40	-23%	0.42	0.29	45%	0.48	0.29	63%
Benzene	2007 - 2016	11.46	14.08	-19%	11.43	13.30	-14%	9.08	12.80	-29%
	2012 - 2016	9.09	11.95	-24%	9.23	10.65	-13%	7.09	10.31	-31%
	2016	6.76	9.09	-26%	7.13	8.14	-12%	5.85	7.87	-26%
Benzo[a]pyrene	2007 - 2016	0.07	0.08	-14%	0.07	0.06	18%	0.09	0.07	39%
	2012 - 2016	0.06	0.02	242%	0.04	0.03	12%	0.09	0.02	307%
	2016	0.06	0.02	242%	0.04	0.03	12%	0.09	0.02	307%
1,3-Butadiene	2007 - 2016	2.59	3.02	-14%	2.70	2.76	-2%	2.34	2.78	-16%
	2012 - 2016	2.05	2.44	-16%	2.09	2.22	-6%	1.90	2.23	-15%
	2016	1.76	1.84	-5%	1.83	1.71	7%	1.78	1.75	2%
Carbon tetrachloride	2007 - 2016	0.61	1.52	-60%	0.99	0.96	3%	0.75	1.05	-28%
	2012 - 2016	0.42	1.07	-60%	0.62	0.69	-10%	0.51	0.71	-28%
	2016	0.35	0.95	-63%	0.54	0.60	-9%	0.47	0.61	-22%
Chlorine	2007 - 2016	1.24	1.60	-23%	1.55	1.32	17%	1.62	1.34	21%
	2012 - 2016	1.12	1.47	-24%	1.36	1.22	11%	1.48	1.18	25%
	2016	0.83	1.37	-39%	1.25	1.00	26%	1.16	0.99	17%

Emissions Scope: Share of Population Living in Tracts with Emissions (%) (2 of 3)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Chromium and compounds	2007 - 2016	1.61	1.07	51%	1.50	1.35	11%	1.38	1.24	11%
	2012 - 2016	0.79	0.67	18%	0.72	0.77	-6%	0.54	0.73	-26%
	2016	0.57	0.54	5%	0.55	0.60	-8%	0.38	0.56	-32%
Diaminotoluene (mixed isomers)	2007 - 2016	0.22	0.72	-70%	0.34	0.44	-23%	0.29	0.44	-34%
	2012 - 2016	0.17	0.48	-65%	0.21	0.31	-33%	0.27	0.29	-5%
	2016	0.13	0.47	-73%	0.15	0.30	-48%	0.22	0.27	-18%
Fluoranthene	2007 - 2016	0.11	0.13	-12%	0.12	0.09	25%	0.07	0.12	-42%
	2012 - 2016	0.07	0.05	42%	0.06	0.05	36%	0.06	0.05	22%
	2016	0.07	0.05	42%	0.06	0.05	36%	0.06	0.05	22%
Formaldehyde	2007 - 2016	9.57	13.30	-28%	9.88	11.51	-14%	7.67	11.14	-31%
	2012 - 2016	8.52	12.12	-30%	8.65	10.51	-18%	6.62	10.13	-35%
	2016	5.75	8.66	-34%	5.99	7.49	-20%	4.79	7.22	-34%
Hydrogen chloride	2007 - 2016	2.89	3.32	-13%	3.07	2.98	3%	2.27	2.98	-24%
	2012 - 2016	2.26	2.53	-11%	2.59	2.22	17%	1.80	2.26	-21%
	2016	1.76	2.16	-18%	2.19	1.81	21%	1.37	1.86	-26%
Hydrogen cyanide gas	2007 - 2016	0.60	0.56	8%	0.69	0.51	36%	0.56	0.55	2%
	2012 - 2016	0.57	0.48	19%	0.69	0.46	50%	0.53	0.49	7%
	2016	0.33	0.41	-20%	0.43	0.30	46%	0.30	0.33	-8%
Hydrogen sulfide	2007 - 2016	3.46	4.48	-23%	3.96	3.69	7%	3.00	3.76	-20%
	2012 - 2016	3.22	4.15	-22%	3.52	3.46	2%	2.48	3.49	-29%
	2016	2.27	3.06	-26%	2.48	2.46	1%	1.85	2.48	-25%
Naphthalene	2007 - 2016	6.29	5.59	13%	6.67	5.70	17%	6.41	5.64	14%
	2012 - 2016	5.31	4.63	15%	5.50	4.76	16%	5.41	4.65	16%
	2016	3.92	3.52	11%	3.97	3.61	10%	4.05	3.51	16%
Phenanthrene	2007 - 2016	0.74	0.74	1%	0.81	0.67	21%	0.79	0.65	22%
	2012 - 2016	0.66	0.49	36%	0.69	0.54	28%	0.68	0.51	35%
	2016	0.60	0.48	26%	0.65	0.51	29%	0.65	0.48	37%

Emissions Scope: Share of Population Living in Tracts with Emissions (%) (3 of 3)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Pyrene	2007 - 2016	0.29	0.19	51%	0.19	0.23	-19%	0.13	0.26	-48%
	2012 - 2016	0.07	0.05	42%	0.06	0.05	36%	0.06	0.05	22%
	2016	0.07	0.05	42%	0.06	0.05	36%	0.06	0.05	22%

Emissions Severity: Average Emissions Density for People Living in Tract with Emissions (1 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Acenaphthylene	2007 - 2016	1.4E-02	1.1E-02	26%	1.4E-02	1.2E-02	16%	3.0E-03	1.4E-02	-78%
	2012 - 2016	7.3E-04	5.1E-04	44%	4.3E-04	5.6E-04	-24%	7.3E-04	5.3E-04	37%
	2016	8.6E-04	4.6E-04	88%	3.1E-04	5.5E-04	-44%	8.6E-04	5.0E-04	72%
Acetaldehyde	2007 - 2016	9.3E-02	6.1E-02	54%	1.2E-01	6.3E-02	89%	1.5E-01	6.5E-02	129%
	2012 - 2016	1.1E-01	7.7E-02	45%	1.6E-01	7.6E-02	110%	2.1E-01	7.7E-02	175%
	2016	2.4E-01	1.9E-01	29%	3.5E-01	1.7E-01	110%	4.8E-01	1.6E-01	195%
Acrolein	2007 - 2016	1.2E-02	1.2E-02	-3%	7.6E-03	1.2E-02	-36%	1.3E-02	1.1E-02	11%
	2012 - 2016	1.2E-02	1.3E-02	-11%	9.4E-03	1.4E-02	-34%	1.5E-02	1.3E-02	13%
	2016	1.5E-02	2.0E-02	-24%	1.0E-02	2.2E-02	-53%	1.6E-02	2.0E-02	-18%
Anthracene	2007 - 2016	4.6E-03	4.1E-03	11%	6.9E-03	4.0E-03	75%	9.5E-03	3.8E-03	150%
	2012 - 2016	9.2E-04	7.6E-04	20%	1.1E-03	7.6E-04	48%	1.5E-03	7.5E-04	95%
	2016	1.3E-03	9.2E-04	36%	1.4E-03	1.1E-03	25%	1.6E-03	9.6E-04	69%
Benzene	2007 - 2016	2.6E-01	1.3E-01	93%	2.9E-01	1.6E-01	76%	4.0E-01	1.6E-01	150%
	2012 - 2016	2.7E-01	1.4E-01	95%	2.9E-01	1.7E-01	67%	4.0E-01	1.7E-01	140%
	2016	3.4E-01	1.7E-01	96%	3.3E-01	2.2E-01	48%	4.2E-01	2.1E-01	98%
Benzo[a]pyrene	2007 - 2016	5.4E-04	9.3E-05	487%	3.4E-04	3.2E-04	6%	6.6E-04	2.0E-04	232%
	2012 - 2016	2.0E-04	5.3E-04	-62%	1.4E-04	2.6E-04	-46%	1.8E-04	3.1E-04	-41%
	2016	1.8E-04	5.1E-04	-66%	1.1E-04	2.3E-04	-52%	1.5E-04	2.8E-04	-45%
1,3-Butadiene	2007 - 2016	1.2E+00	4.3E-01	167%	9.3E-01	7.5E-01	24%	2.1E+00	5.6E-01	270%
	2012 - 2016	1.3E+00	5.1E-01	156%	1.1E+00	8.6E-01	27%	2.3E+00	6.5E-01	260%
	2016	1.2E+00	5.9E-01	101%	1.0E+00	9.0E-01	13%	1.9E+00	6.8E-01	181%
Carbon tetrachloride	2007 - 2016	9.6E-03	4.6E-03	107%	1.2E-02	4.9E-03	150%	9.4E-03	5.5E-03	73%
	2012 - 2016	1.2E-02	5.1E-03	133%	1.7E-02	5.6E-03	197%	1.2E-02	6.4E-03	93%
	2016	5.0E-03	5.1E-03	-2%	6.9E-03	4.5E-03	52%	3.0E-03	5.6E-03	-47%
Chlorine	2007 - 2016	1.3E-01	5.7E-02	131%	1.6E-01	8.0E-02	99%	1.3E-01	8.1E-02	63%
	2012 - 2016	1.2E-01	4.9E-02	141%	1.5E-01	6.7E-02	125%	1.1E-01	7.4E-02	53%
	2016	1.5E-01	5.2E-02	193%	1.6E-01	8.0E-02	96%	1.3E-01	8.7E-02	52%

Emissions Severity: Average Emissions Density for People Living in Tract with Emissions (2 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Chromium and compounds	2007 - 2016	2.8E-03	4.5E-03	-38%	2.2E-03	3.3E-03	-32%	3.6E-03	3.4E-03	6%
	2012 - 2016	3.9E-03	4.7E-03	-18%	1.7E-03	3.4E-03	-50%	6.8E-03	3.3E-03	107%
	2016	7.3E-03	8.5E-03	-14%	2.8E-03	5.9E-03	-53%	1.3E-02	5.8E-03	125%
Diaminotoluene (mixed isomers)	2007 - 2016	1.1E-04	1.5E-04	-27%	1.8E-04	1.4E-04	27%	3.8E-05	1.5E-04	-75%
	2012 - 2016	2.8E-05	5.6E-06	398%	3.0E-05	1.1E-05	182%	2.3E-05	1.1E-05	106%
	2016	1.2E-06	1.2E-06	0%	1.2E-06	1.2E-06	0%	1.2E-06	1.2E-06	0%
Fluoranthene	2007 - 2016	6.7E-04	1.1E-03	-37%	7.8E-04	9.1E-04	-14%	2.8E-04	9.4E-04	-71%
	2012 - 2016	2.1E-04	3.5E-04	-42%	6.1E-05	2.7E-04	-78%	2.9E-04	2.2E-04	32%
	2016	2.1E-04	3.4E-04	-39%	8.1E-05	2.7E-04	-70%	2.9E-04	2.2E-04	28%
Formaldehyde	2007 - 2016	8.8E-02	8.2E-02	7%	7.5E-02	8.5E-02	-12%	8.6E-02	8.5E-02	0%
	2012 - 2016	8.7E-02	7.9E-02	11%	8.1E-02	8.2E-02	-2%	9.3E-02	8.2E-02	13%
	2016	1.1E-01	9.7E-02	13%	9.8E-02	1.1E-01	-14%	1.3E-01	1.1E-01	19%
Hydrogen chloride	2007 - 2016	3.9E-01	1.2E-01	224%	3.1E-01	2.3E-01	33%	3.0E-01	2.3E-01	28%
	2012 - 2016	4.7E-01	1.4E-01	235%	3.6E-01	2.8E-01	26%	3.7E-01	2.8E-01	30%
	2016	2.7E-01	1.4E-01	88%	2.2E-01	1.9E-01	16%	2.2E-01	2.0E-01	11%
Hydrogen cyanide gas	2007 - 2016	2.4E+00	6.3E-01	286%	1.6E+00	1.5E+00	5%	4.0E+00	1.1E+00	255%
	2012 - 2016	5.0E+00	1.3E+00	285%	3.2E+00	3.3E+00	-4%	8.3E+00	2.4E+00	253%
	2016	1.1E+01	2.0E+00	442%	6.3E+00	6.3E+00	0%	1.7E+01	4.4E+00	291%
Hydrogen sulfide	2007 - 2016	2.1E-01	9.3E-02	129%	1.6E-01	1.3E-01	26%	2.5E-01	1.2E-01	105%
	2012 - 2016	2.3E-01	9.4E-02	142%	1.8E-01	1.3E-01	33%	3.0E-01	1.3E-01	132%
	2016	3.4E-01	1.1E-01	200%	2.7E-01	1.9E-01	40%	4.4E-01	1.8E-01	145%
Naphthalene	2007 - 2016	6.7E-02	4.0E-02	66%	7.1E-02	4.9E-02	44%	8.7E-02	4.5E-02	91%
	2012 - 2016	7.5E-02	5.1E-02	46%	8.0E-02	5.7E-02	41%	9.9E-02	5.5E-02	81%
	2016	6.7E-02	5.4E-02	24%	8.1E-02	5.2E-02	55%	9.7E-02	5.2E-02	88%
Phenanthrene	2007 - 2016	2.1E-02	2.4E-02	-12%	7.7E-03	2.0E-02	-61%	2.5E-02	1.9E-02	37%
	2012 - 2016	4.2E-02	6.6E-02	-36%	1.4E-02	4.5E-02	-69%	5.4E-02	4.3E-02	25%
	2016	4.3E-02	6.3E-02	-31%	1.4E-02	4.4E-02	-68%	5.4E-02	4.3E-02	25%

Emissions Severity: Average Emissions Density for People Living in Tract with Emissions (3 of 3)

(tons / year / sq mile estimated at the census tract level)

Pollutant	Year range	People of Color (POC)	Non POC	% Difference (POC - NonPOC) / NonPOC	People Living in Poverty (POV)	Non POV	% Difference (POV - NonPOV) / NonPOV	Limited English Household (LEH)	Non LEH	% Difference (LEH - NonLEH) / NonLEH
Pyrene	2007 - 2016	7.4E-04	2.0E-03	-64%	1.4E-03	1.1E-03	36%	3.0E-04	1.2E-03	-76%
	2012 - 2016	3.4E-04	5.9E-04	-43%	9.4E-05	4.5E-04	-79%	4.9E-04	3.6E-04	33%
	2016	3.1E-04	5.4E-04	-42%	9.2E-05	4.2E-04	-78%	4.5E-04	3.4E-04	33%

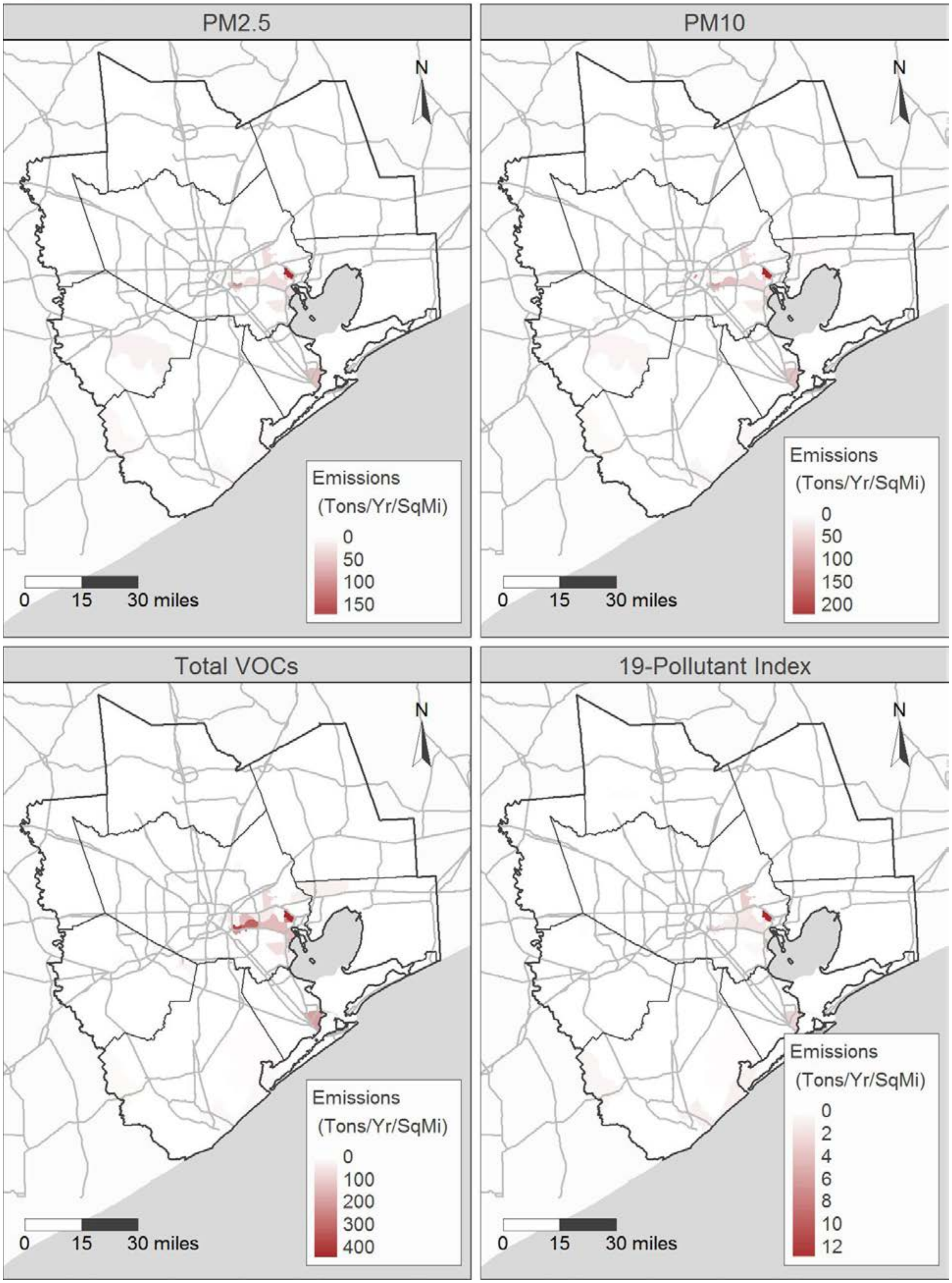
Average Emissions Density for People Living in Tract with Emissions (1 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Acenaphthylene	2007 - 2016	1.4E-02	1.1E-02	26%	1.4E-02	1.2E-02	16%	3.0E-03	1.4E-02	-78%
	2012 - 2016	7.3E-04	5.1E-04	44%	4.3E-04	5.6E-04	-24%	7.3E-04	5.3E-04	37%
	2016	8.6E-04	4.6E-04	88%	3.1E-04	5.5E-04	-44%	8.6E-04	5.0E-04	72%
Acetaldehyde	2007 - 2016	9.3E-02	6.1E-02	54%	1.2E-01	6.3E-02	89%	1.5E-01	6.5E-02	129%
	2012 - 2016	1.1E-01	7.7E-02	45%	1.6E-01	7.6E-02	110%	2.1E-01	7.7E-02	175%
	2016	2.4E-01	1.9E-01	29%	3.5E-01	1.7E-01	110%	4.8E-01	1.6E-01	195%
Acrolein	2007 - 2016	1.2E-02	1.2E-02	-3%	7.6E-03	1.2E-02	-36%	1.3E-02	1.1E-02	11%
	2012 - 2016	1.2E-02	1.3E-02	-11%	9.4E-03	1.4E-02	-34%	1.5E-02	1.3E-02	13%
	2016	1.5E-02	2.0E-02	-24%	1.0E-02	2.2E-02	-53%	1.6E-02	2.0E-02	-18%
Anthracene	2007 - 2016	4.6E-03	4.1E-03	11%	6.9E-03	4.0E-03	75%	9.5E-03	3.8E-03	150%
	2012 - 2016	9.2E-04	7.6E-04	20%	1.1E-03	7.6E-04	48%	1.5E-03	7.5E-04	95%
	2016	1.3E-03	9.2E-04	36%	1.4E-03	1.1E-03	25%	1.6E-03	9.6E-04	69%
Benzene	2007 - 2016	2.6E-01	1.3E-01	93%	2.9E-01	1.6E-01	76%	4.0E-01	1.6E-01	150%
	2012 - 2016	2.7E-01	1.4E-01	95%	2.9E-01	1.7E-01	67%	4.0E-01	1.7E-01	140%
	2016	3.4E-01	1.7E-01	96%	3.3E-01	2.2E-01	48%	4.2E-01	2.1E-01	98%
Benzo[a]pyrene	2007 - 2016	5.4E-04	9.3E-05	487%	3.4E-04	3.2E-04	6%	6.6E-04	2.0E-04	232%
	2012 - 2016	2.0E-04	5.3E-04	-62%	1.4E-04	2.6E-04	-46%	1.8E-04	3.1E-04	-41%
	2016	1.8E-04	5.1E-04	-66%	1.1E-04	2.3E-04	-52%	1.5E-04	2.8E-04	-45%
1,3-Butadiene	2007 - 2016	1.2E+00	4.3E-01	167%	9.3E-01	7.5E-01	24%	2.1E+00	5.6E-01	270%
	2012 - 2016	1.3E+00	5.1E-01	156%	1.1E+00	8.6E-01	27%	2.3E+00	6.5E-01	260%
	2016	1.2E+00	5.9E-01	101%	1.0E+00	9.0E-01	13%	1.9E+00	6.8E-01	181%
Carbon tetrachloride	2007 - 2016	9.6E-03	4.6E-03	107%	1.2E-02	4.9E-03	150%	9.4E-03	5.5E-03	73%
	2012 - 2016	1.2E-02	5.1E-03	133%	1.7E-02	5.6E-03	197%	1.2E-02	6.4E-03	93%
	2016	5.0E-03	5.1E-03	-2%	6.9E-03	4.5E-03	52%	3.0E-03	5.6E-03	-47%
Chlorine	2007 - 2016	1.3E-01	5.7E-02	131%	1.6E-01	8.0E-02	99%	1.3E-01	8.1E-02	63%
	2012 - 2016	1.2E-01	4.9E-02	141%	1.5E-01	6.7E-02	125%	1.1E-01	7.4E-02	53%
	2016	1.5E-01	5.2E-02	193%	1.6E-01	8.0E-02	96%	1.3E-01	8.7E-02	52%

Average Emissions Density for People Living in Tract with Emissions (2 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Chromium and compounds	2007 - 2016	2.8E-03	4.5E-03	-38%	2.2E-03	3.3E-03	-32%	3.6E-03	3.4E-03	6%
	2012 - 2016	3.9E-03	4.7E-03	-18%	1.7E-03	3.4E-03	-50%	6.8E-03	3.3E-03	107%
	2016	7.3E-03	8.5E-03	-14%	2.8E-03	5.9E-03	-53%	1.3E-02	5.8E-03	125%
Diaminotoluene (mixed isomers)	2007 - 2016	1.1E-04	1.5E-04	-27%	1.8E-04	1.4E-04	27%	3.8E-05	1.5E-04	-75%
	2012 - 2016	2.8E-05	5.6E-06	398%	3.0E-05	1.1E-05	182%	2.3E-05	1.1E-05	106%
	2016	1.2E-06	1.2E-06	0%	1.2E-06	1.2E-06	0%	1.2E-06	1.2E-06	0%
Fluoranthene	2007 - 2016	6.7E-04	1.1E-03	-37%	7.8E-04	9.1E-04	-14%	2.8E-04	9.4E-04	-71%
	2012 - 2016	2.1E-04	3.5E-04	-42%	6.1E-05	2.7E-04	-78%	2.9E-04	2.2E-04	32%
	2016	2.1E-04	3.4E-04	-39%	8.1E-05	2.7E-04	-70%	2.9E-04	2.2E-04	28%
Formaldehyde	2007 - 2016	8.8E-02	8.2E-02	7%	7.5E-02	8.5E-02	-12%	8.6E-02	8.5E-02	0%
	2012 - 2016	8.7E-02	7.9E-02	11%	8.1E-02	8.2E-02	-2%	9.3E-02	8.2E-02	13%
	2016	1.1E-01	9.7E-02	13%	9.8E-02	1.1E-01	-14%	1.3E-01	1.1E-01	19%
Hydrogen chloride	2007 - 2016	3.9E-01	1.2E-01	224%	3.1E-01	2.3E-01	33%	3.0E-01	2.3E-01	28%
	2012 - 2016	4.7E-01	1.4E-01	235%	3.6E-01	2.8E-01	26%	3.7E-01	2.8E-01	30%
	2016	2.7E-01	1.4E-01	88%	2.2E-01	1.9E-01	16%	2.2E-01	2.0E-01	11%
Hydrogen cyanide gas	2007 - 2016	2.4E+00	6.3E-01	286%	1.6E+00	1.5E+00	5%	4.0E+00	1.1E+00	255%
	2012 - 2016	5.0E+00	1.3E+00	285%	3.2E+00	3.3E+00	-4%	8.3E+00	2.4E+00	253%
	2016	1.1E+01	2.0E+00	442%	6.3E+00	6.3E+00	0%	1.7E+01	4.4E+00	291%
Hydrogen sulfide	2007 - 2016	2.1E-01	9.3E-02	129%	1.6E-01	1.3E-01	26%	2.5E-01	1.2E-01	105%
	2012 - 2016	2.3E-01	9.4E-02	142%	1.8E-01	1.3E-01	33%	3.0E-01	1.3E-01	132%
	2016	3.4E-01	1.1E-01	200%	2.7E-01	1.9E-01	40%	4.4E-01	1.8E-01	145%
Naphthalene	2007 - 2016	6.7E-02	4.0E-02	66%	7.1E-02	4.9E-02	44%	8.7E-02	4.5E-02	91%
	2012 - 2016	7.5E-02	5.1E-02	46%	8.0E-02	5.7E-02	41%	9.9E-02	5.5E-02	81%
	2016	6.7E-02	5.4E-02	24%	8.1E-02	5.2E-02	55%	9.7E-02	5.2E-02	88%
Phenanthrene	2007 - 2016	2.1E-02	2.4E-02	-12%	7.7E-03	2.0E-02	-61%	2.5E-02	1.9E-02	37%
	2012 - 2016	4.2E-02	6.6E-02	-36%	1.4E-02	4.5E-02	-69%	5.4E-02	4.3E-02	25%
	2016	4.3E-02	6.3E-02	-31%	1.4E-02	4.4E-02	-68%	5.4E-02	4.3E-02	25%

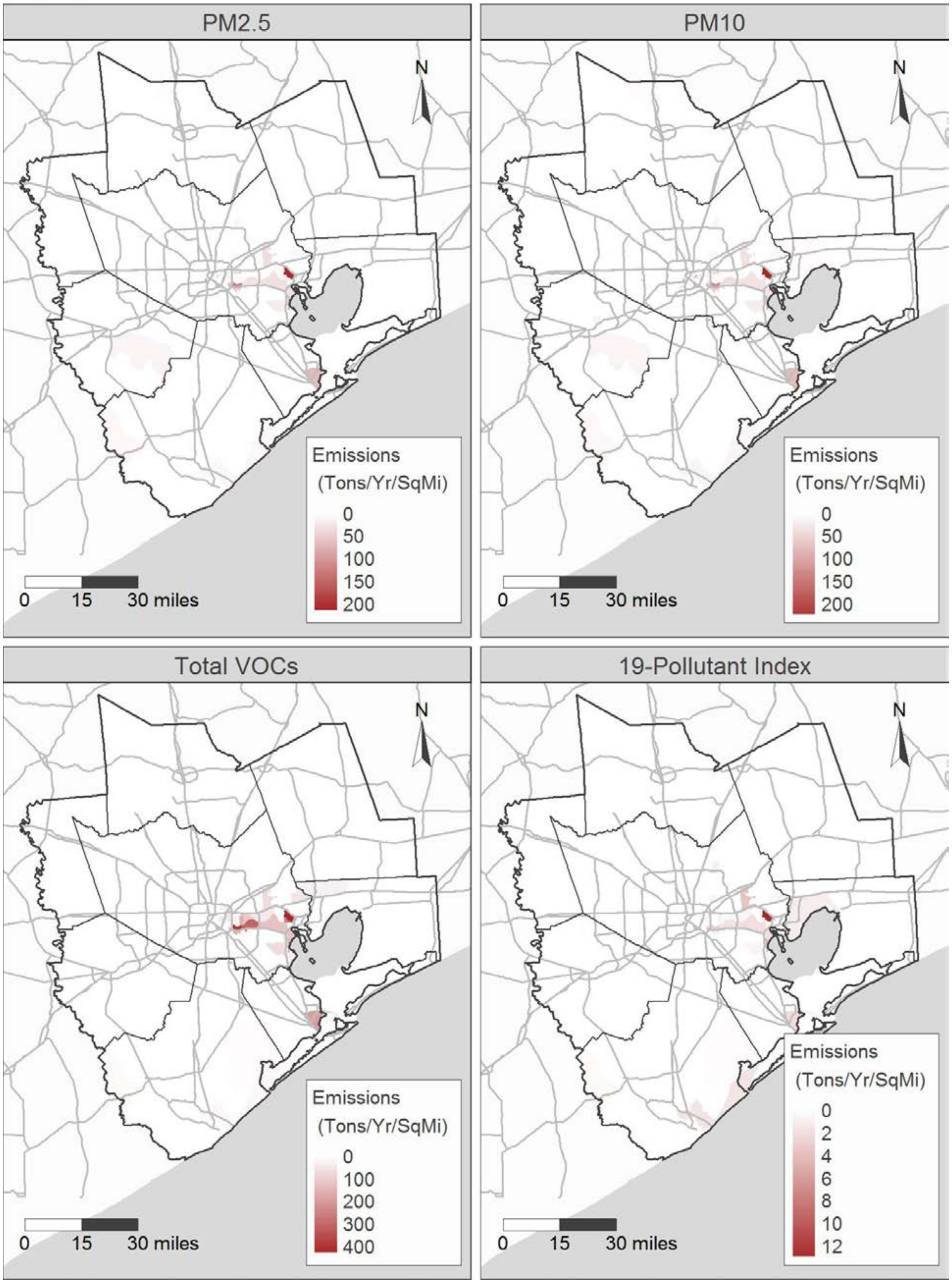
Average Emissions Density for People Living in Tract with Emissions (3 of 3) (tons / year / sq mile estimated at the census tract level)										
Pollutant	**Year range**	**People of Color (POC)**	**Non POC**	**% Difference (POC - NonPOC) / NonPOC**	**People Living in Poverty (POV)**	**Non POV**	**% Difference (POV - NonPOV) / NonPOV**	**Limited English Household (LEH)**	**Non LEH**	**% Difference (LEH - NonLEH) / NonLEH**
Pyrene	2007 - 2016	7.4E-04	2.0E-03	-64%	1.4E-03	1.1E-03	36%	3.0E-04	1.2E-03	-76%
	2012 - 2016	3.4E-04	5.9E-04	-43%	9.4E-05	4.5E-04	-79%	4.9E-04	3.6E-04	33%
	2016	3.1E-04	5.4E-04	-42%	9.2E-05	4.2E-04	-78%	4.5E-04	3.4E-04	33%

Appendix B: Additional Regionwide Maps of Four Pollution Categories

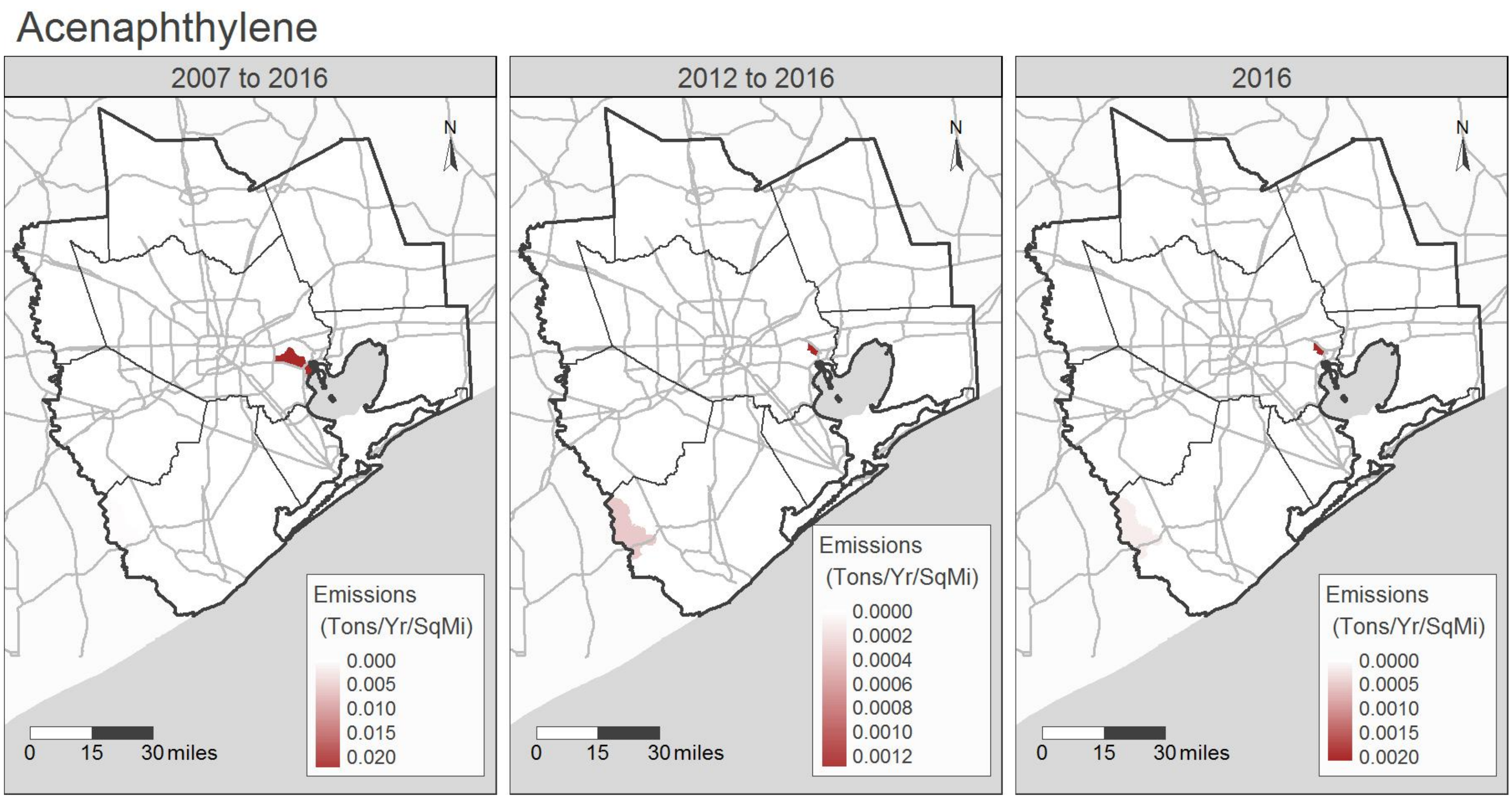
2012 to 2016


PM2.5
PM10
Total VOCs
19-Pollutant Index
N
Emissions
(Tons/Yr/SqMi)
0
50
100
150
200
0
100
200
300
400
0
2
4
6
8
10
12
0 15 30 miles

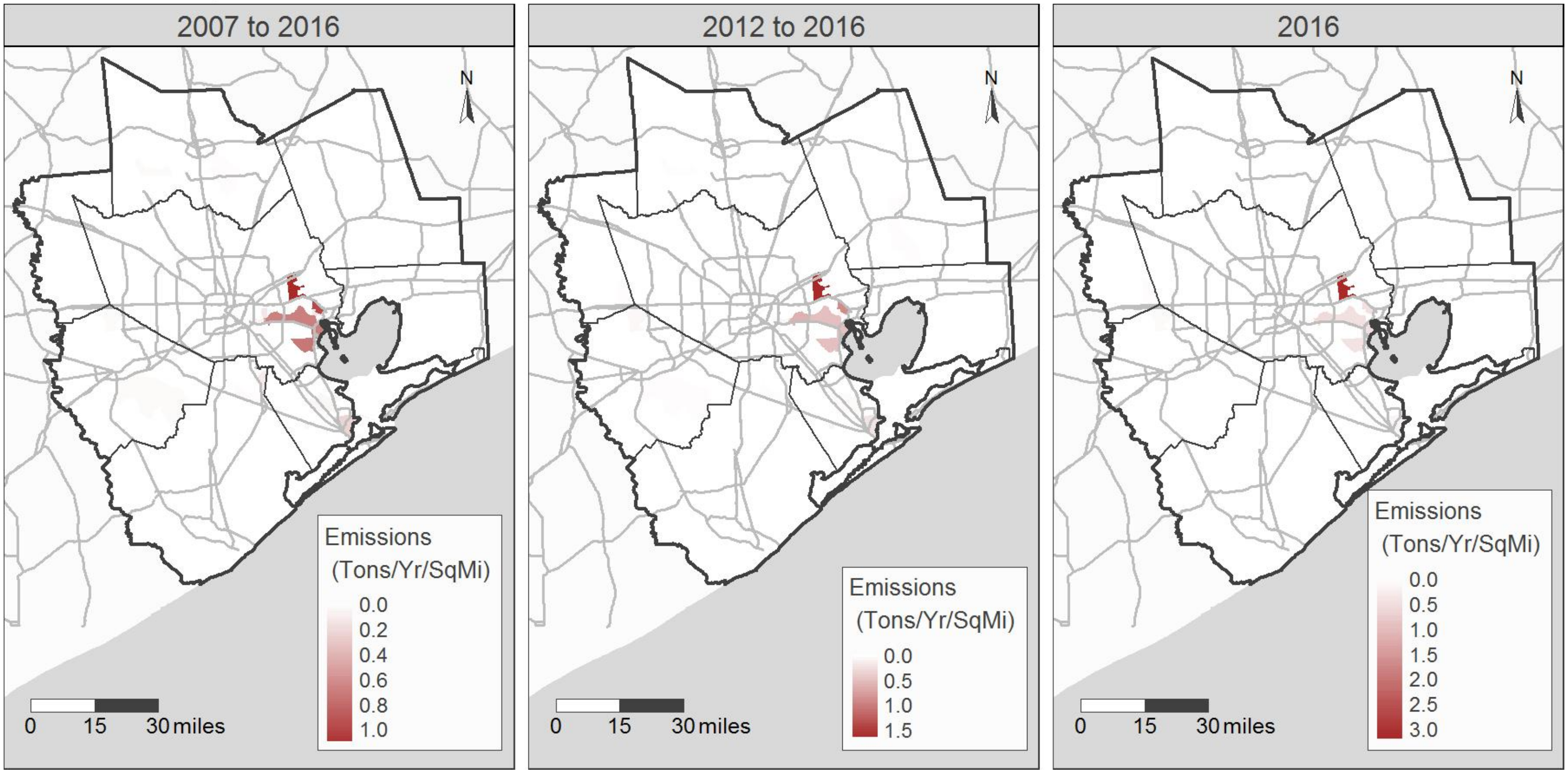
2016


PM2.5
N
Emissions
(Tons/Yr/SqMi)
0
50
100
150
200
0 15 30 miles
PM10
N
Emissions
(Tons/Yr/SqMi)
0
50
100
150
200
0 15 30 miles
Total VOCs
N
Emissions
(Tons/Yr/SqMi)
0
100
200
300
400
0 15 30 miles
19-Pollutant Index
N
Emissions
(Tons/Yr/SqMi)
0
2
4
6
8
10
12
0 15 30 miles

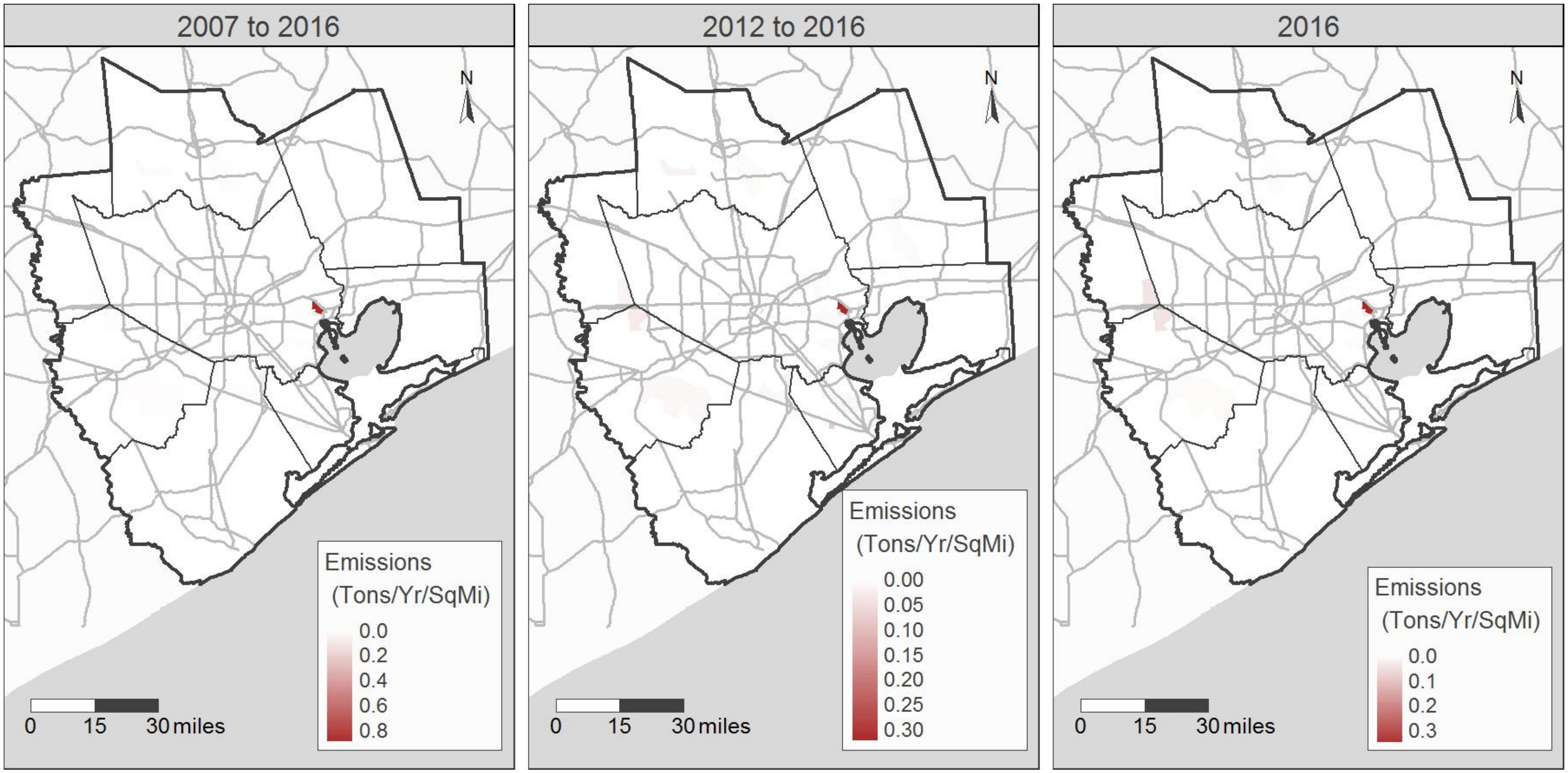
Appendix C: Regionwide Maps of 19 Pollutants of Concern


Acenaphthylene
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0.000
0.005
0.010
0.015
0.020
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012
0.0000
0.0005
0.0010
0.0015
0.0020
0
15
30 miles

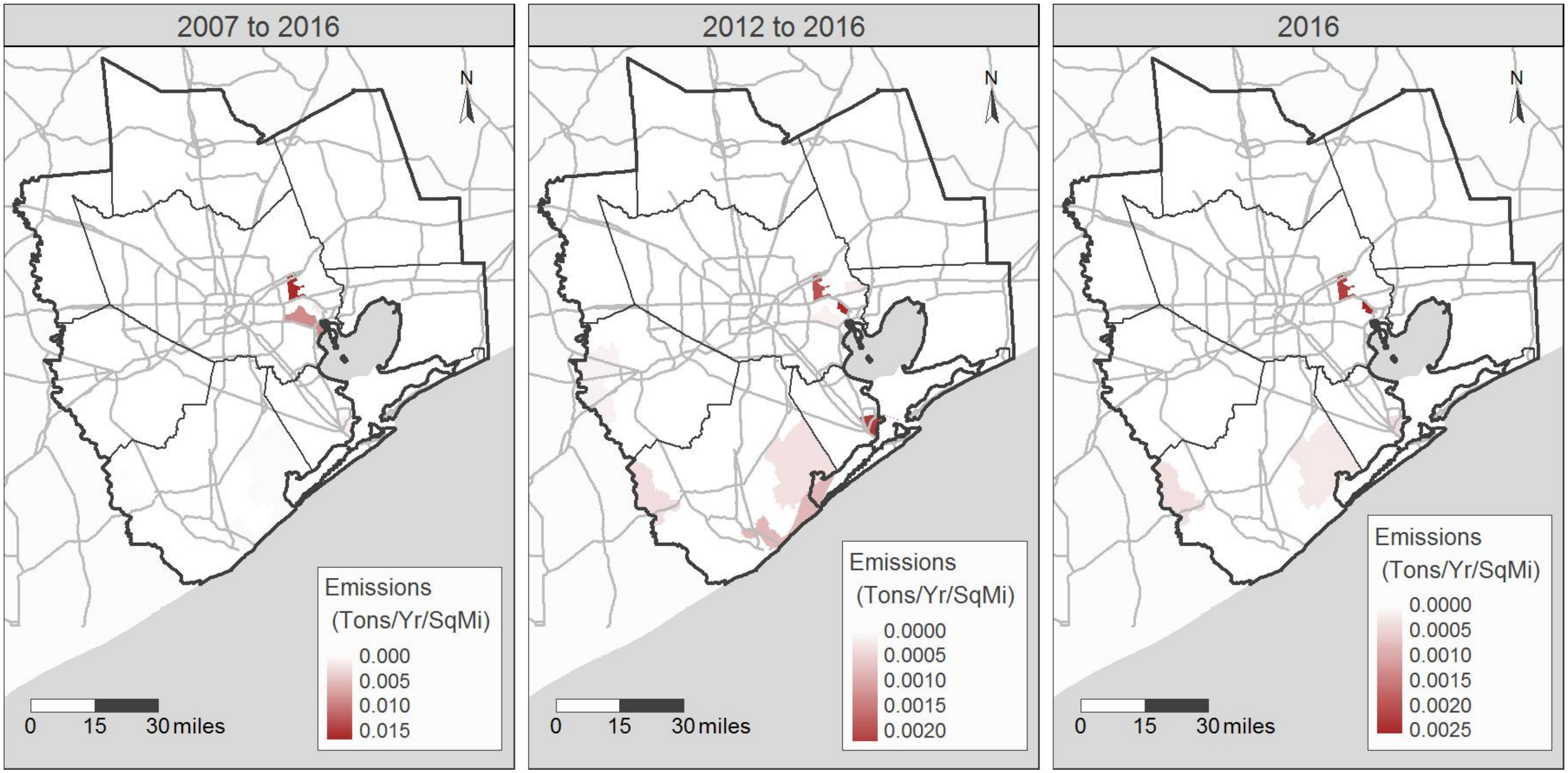
Acetaldehyde



Acrolein

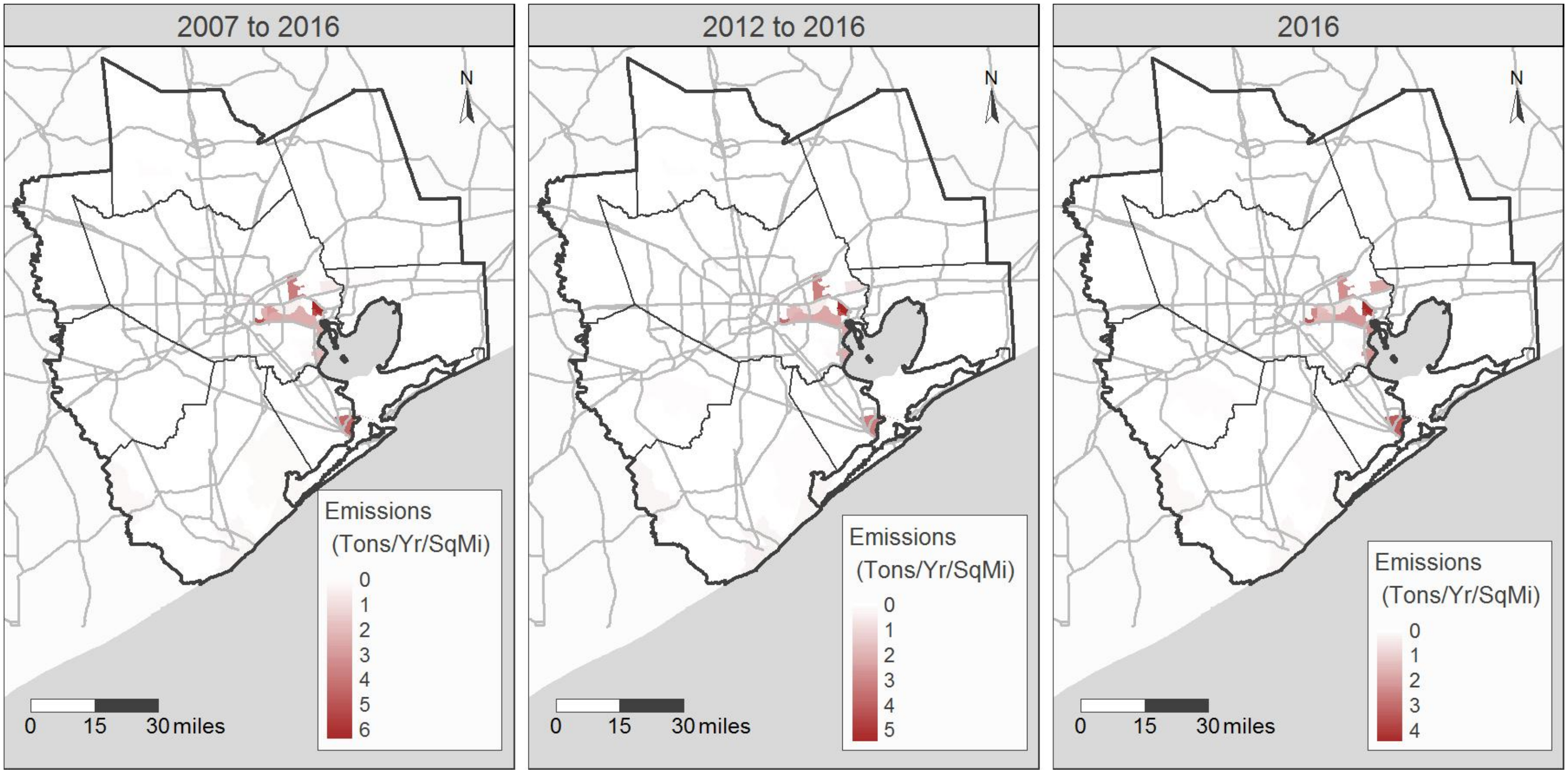

2007 to 2016
N
Emissions
(Tons/Yr/SqMi)
0.0
0.2
0.4
0.6
0.8
0 15 30 miles
2012 to 2016
N
Emissions
(Tons/Yr/SqMi)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0 15 30 miles
2016
N
Emissions
(Tons/Yr/SqMi)
0.0
0.1
0.2
0.3
0 15 30 miles

Anthracene

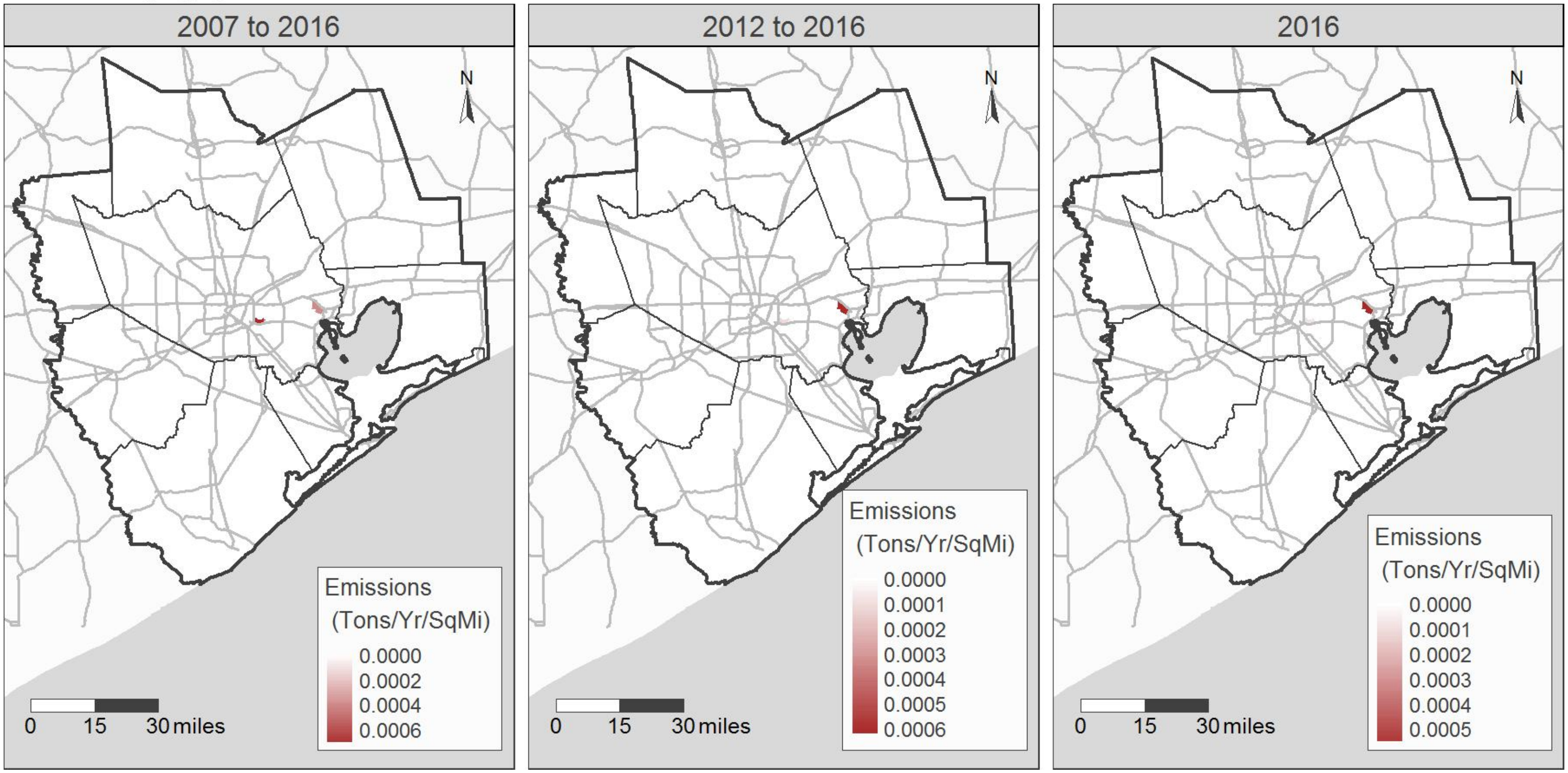


2007 to 2016
N
Emissions
(Tons/Yr/SqMi)
0.000
0.005
0.010
0.015
0
15
30 miles
2012 to 2016
N
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0020
0
15
30 miles
2016
N
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0
15
30 miles

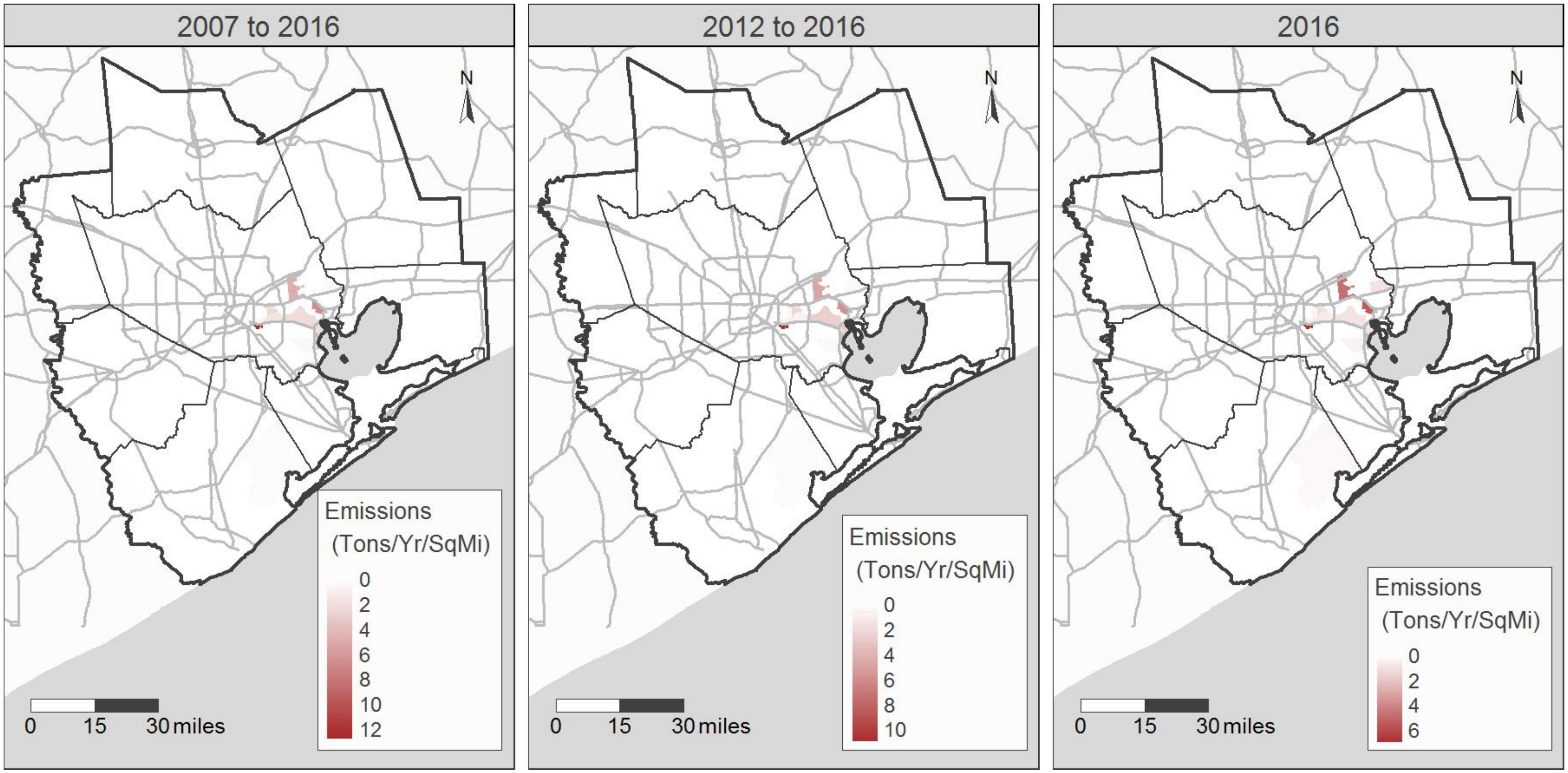
Benzene


2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0
1
2
3
4
5
6
0
15
30 miles

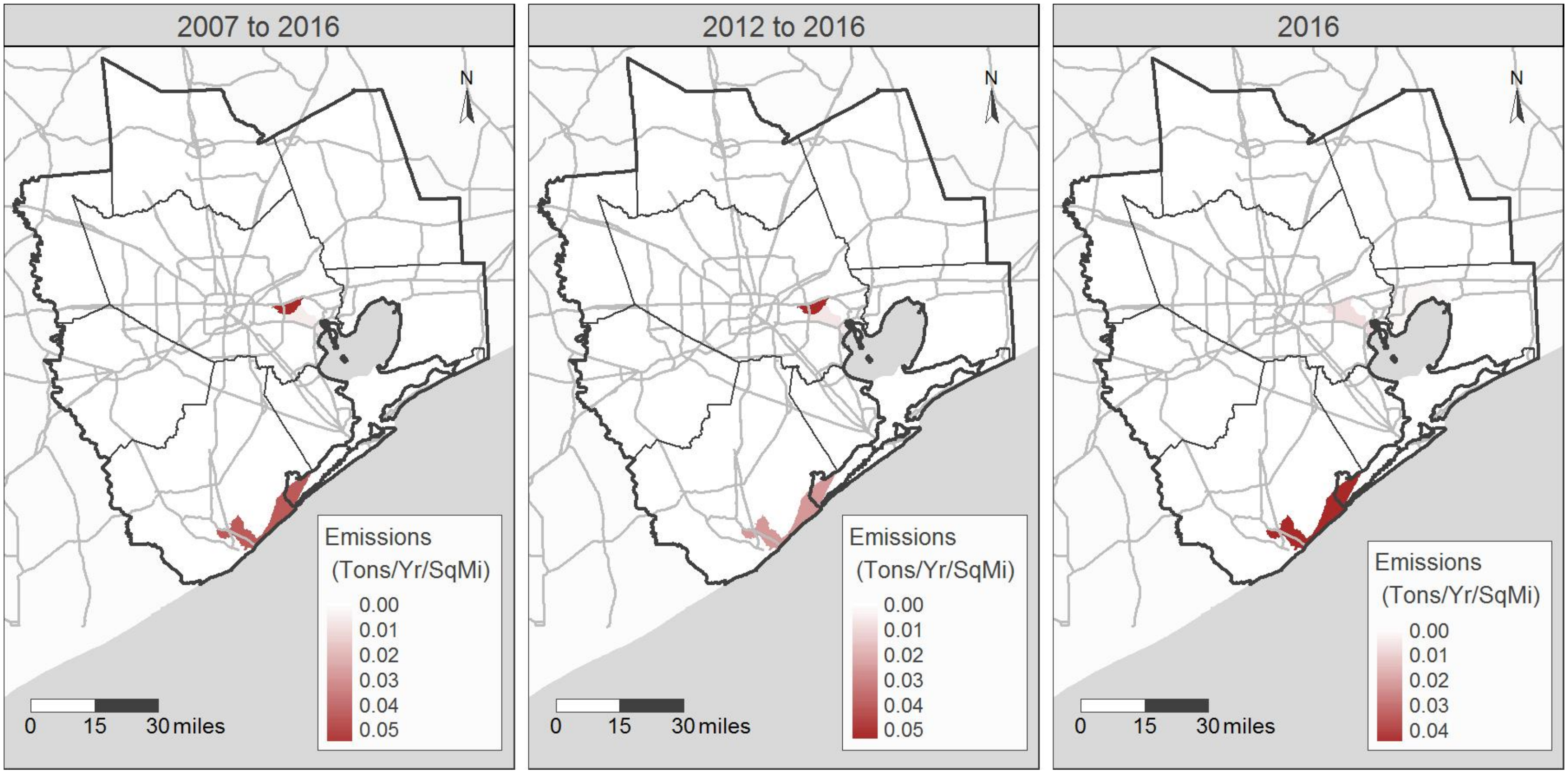
Benzo[a]pyrene

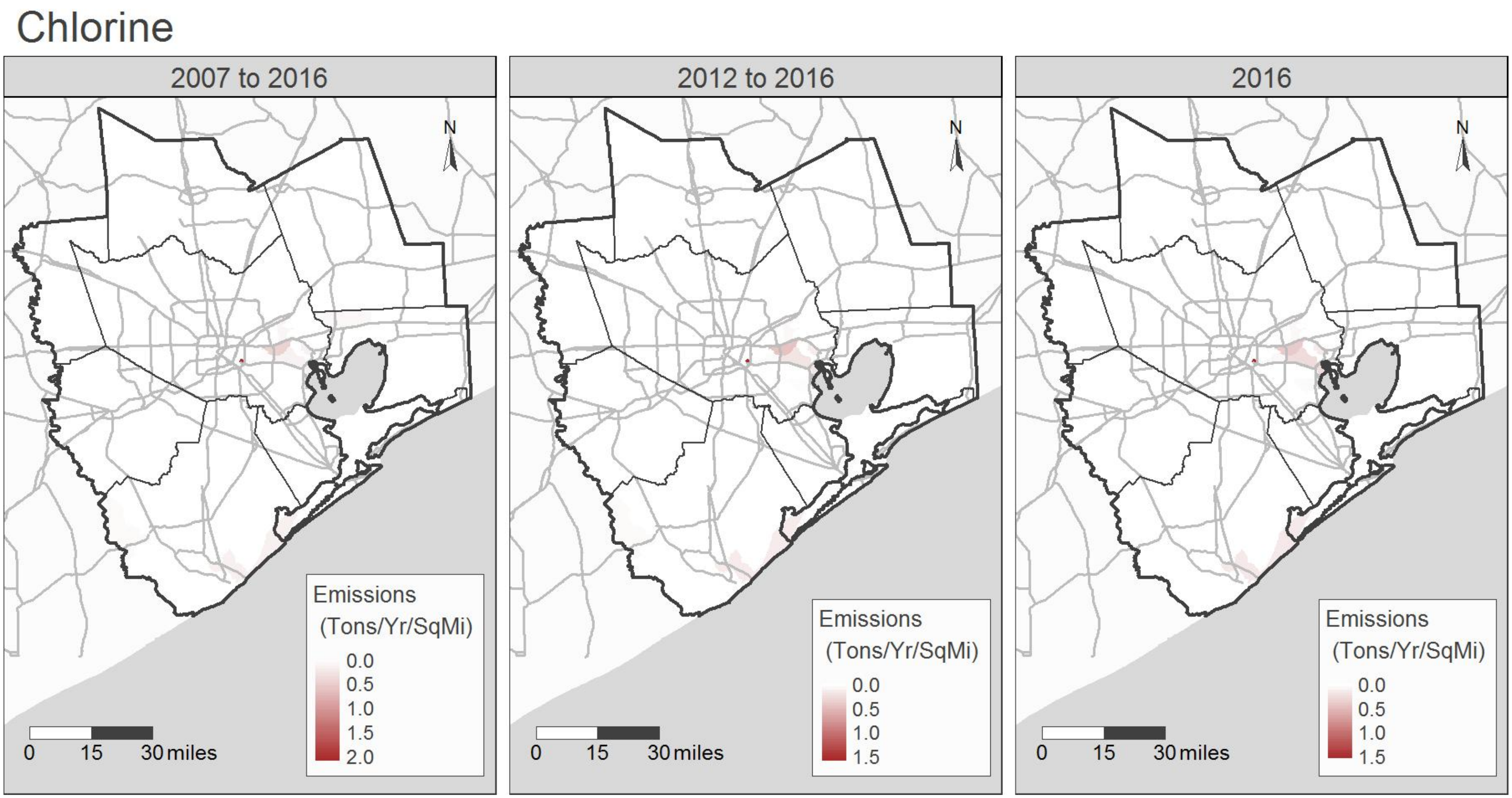


1,3-Butadiene

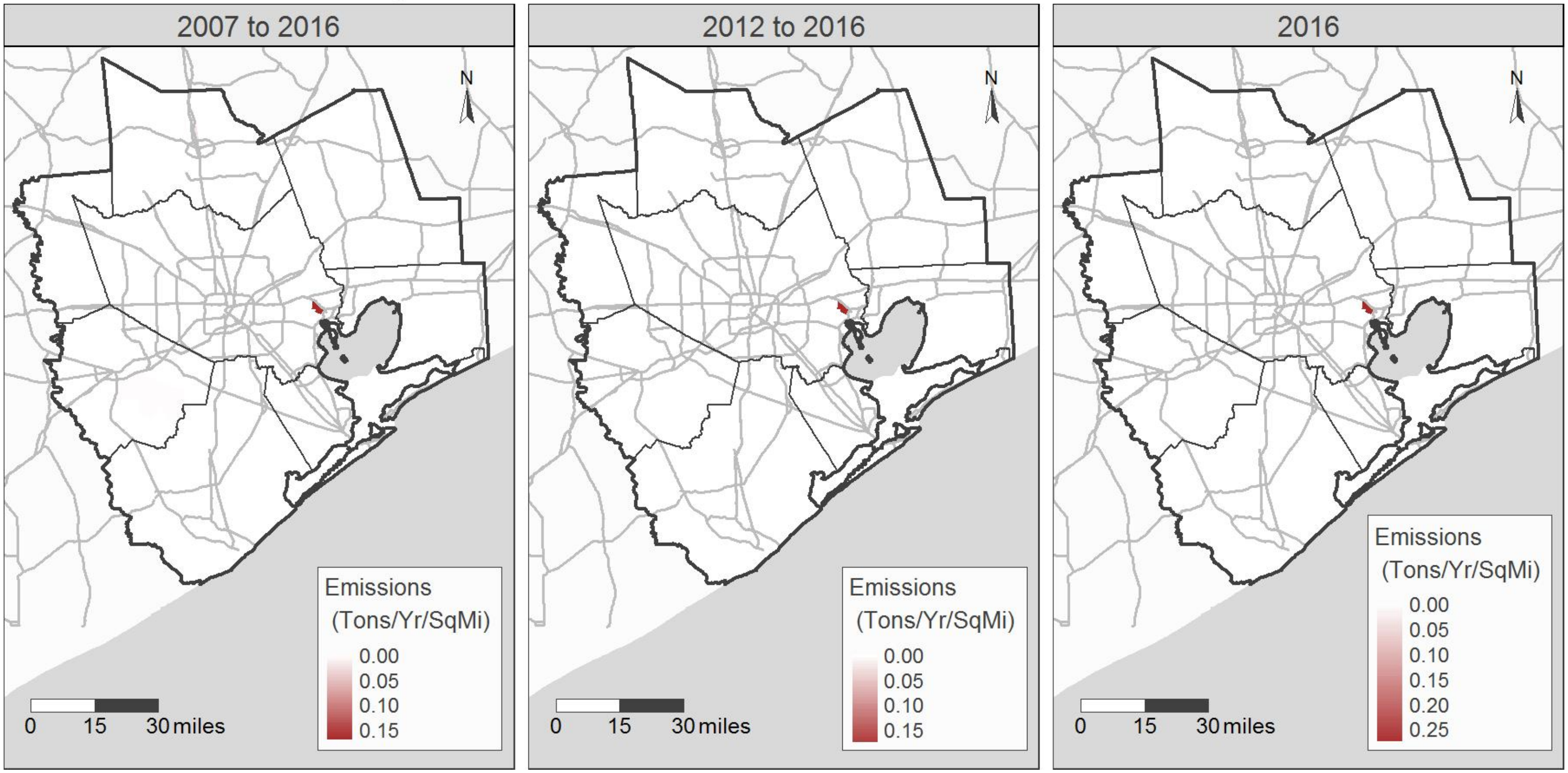


Carbon tetrachloride

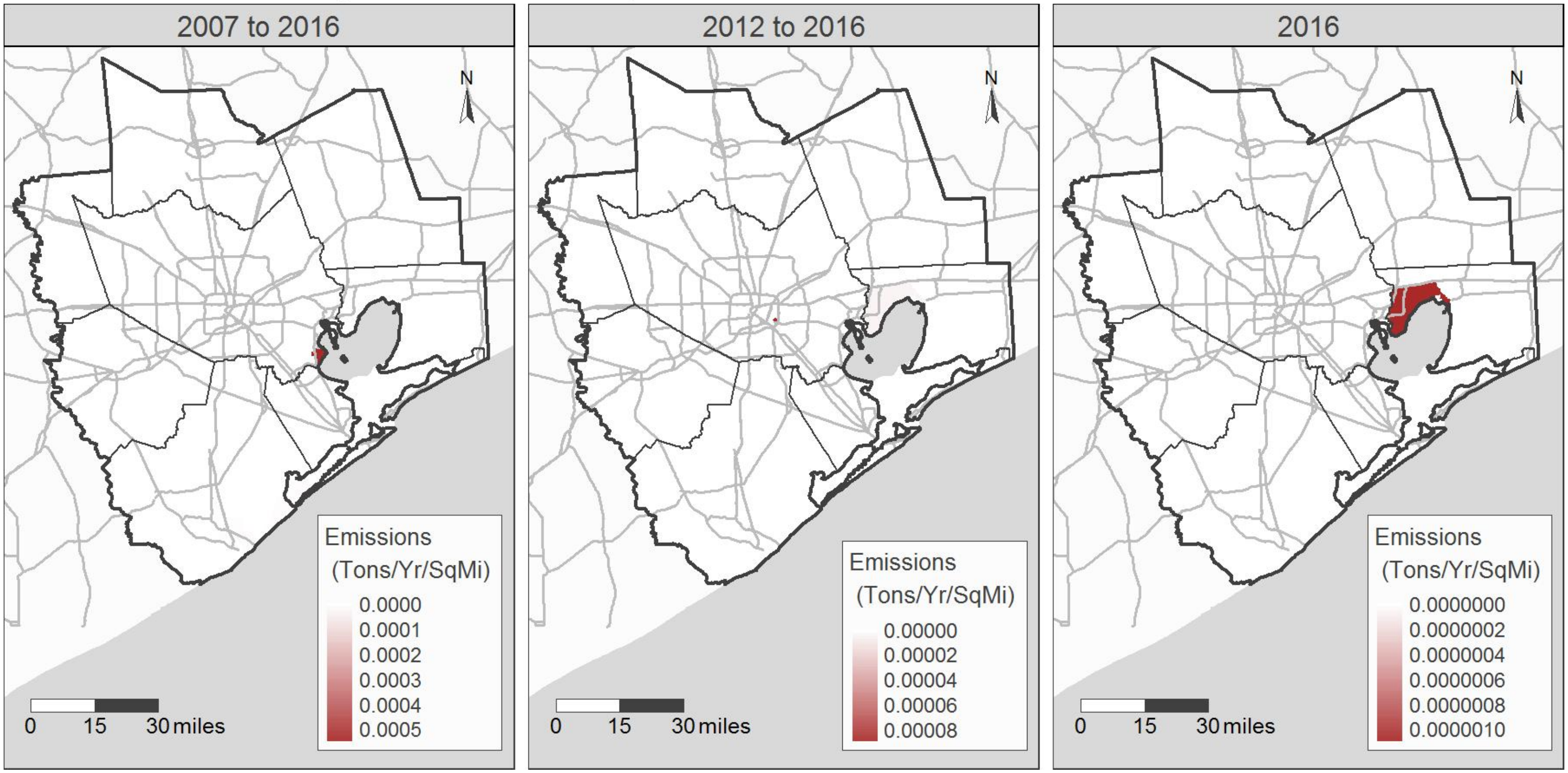


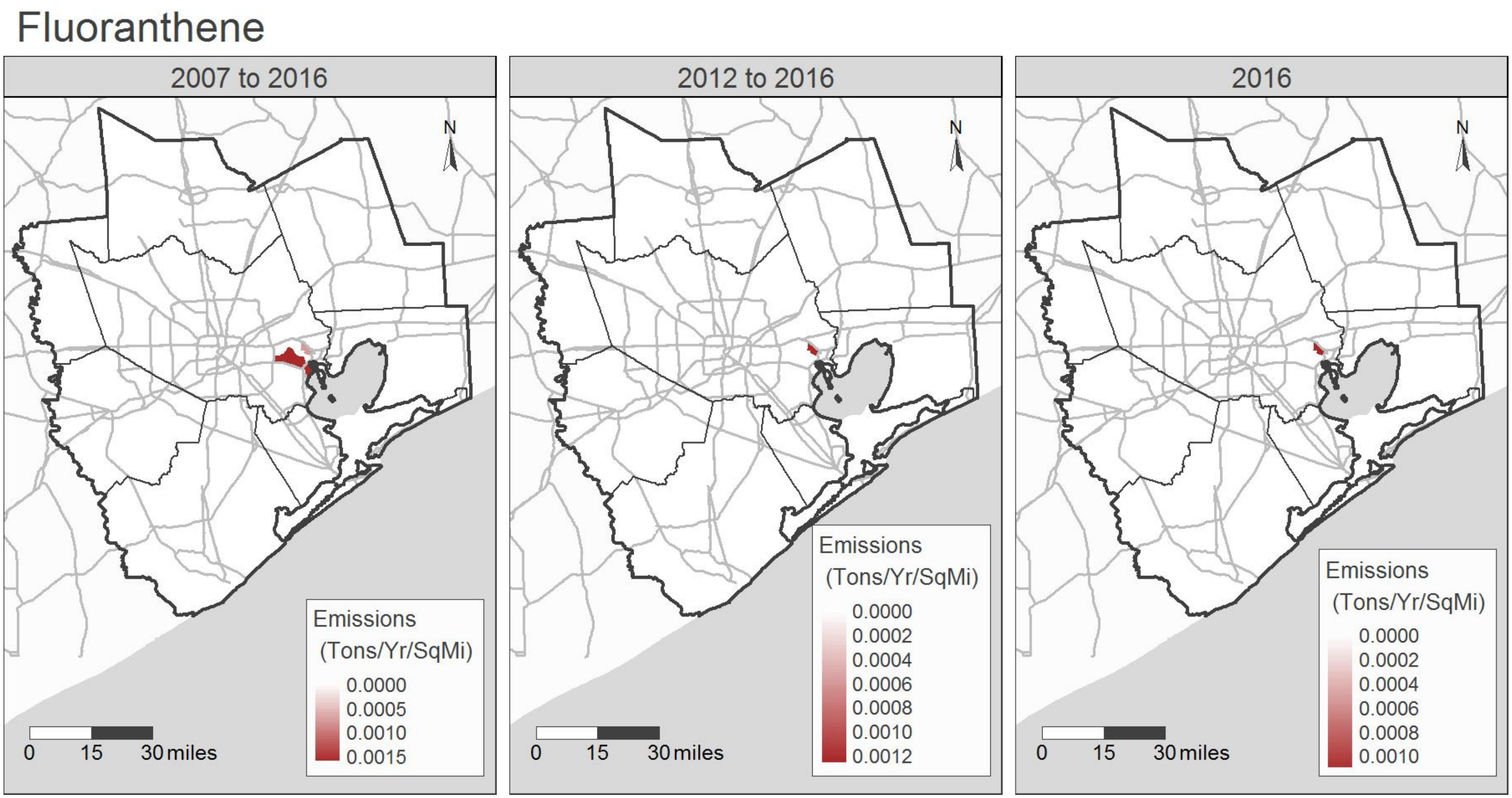

Chlorine
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
2.0
0
15
30 miles

Chromium and compounds

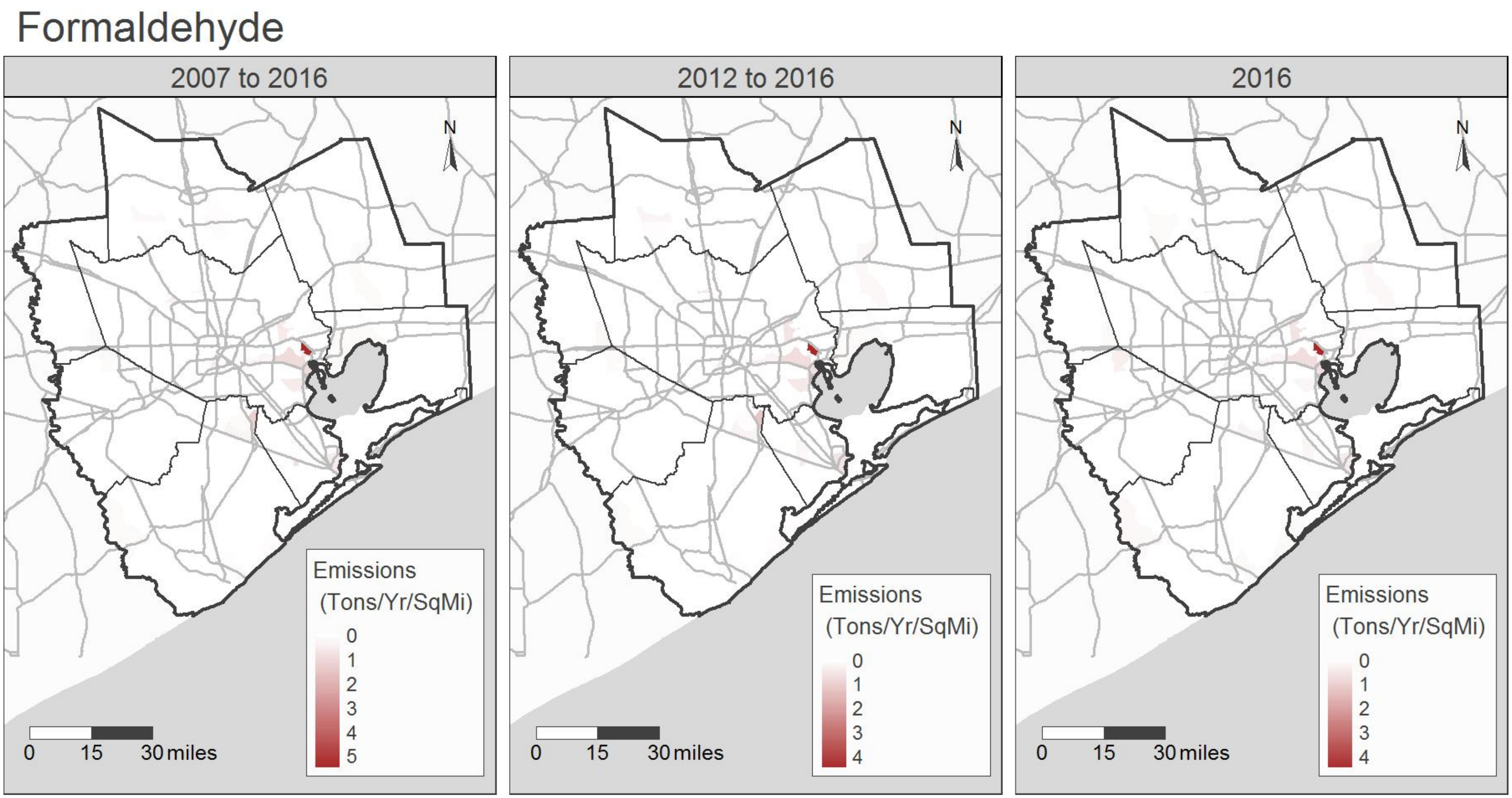


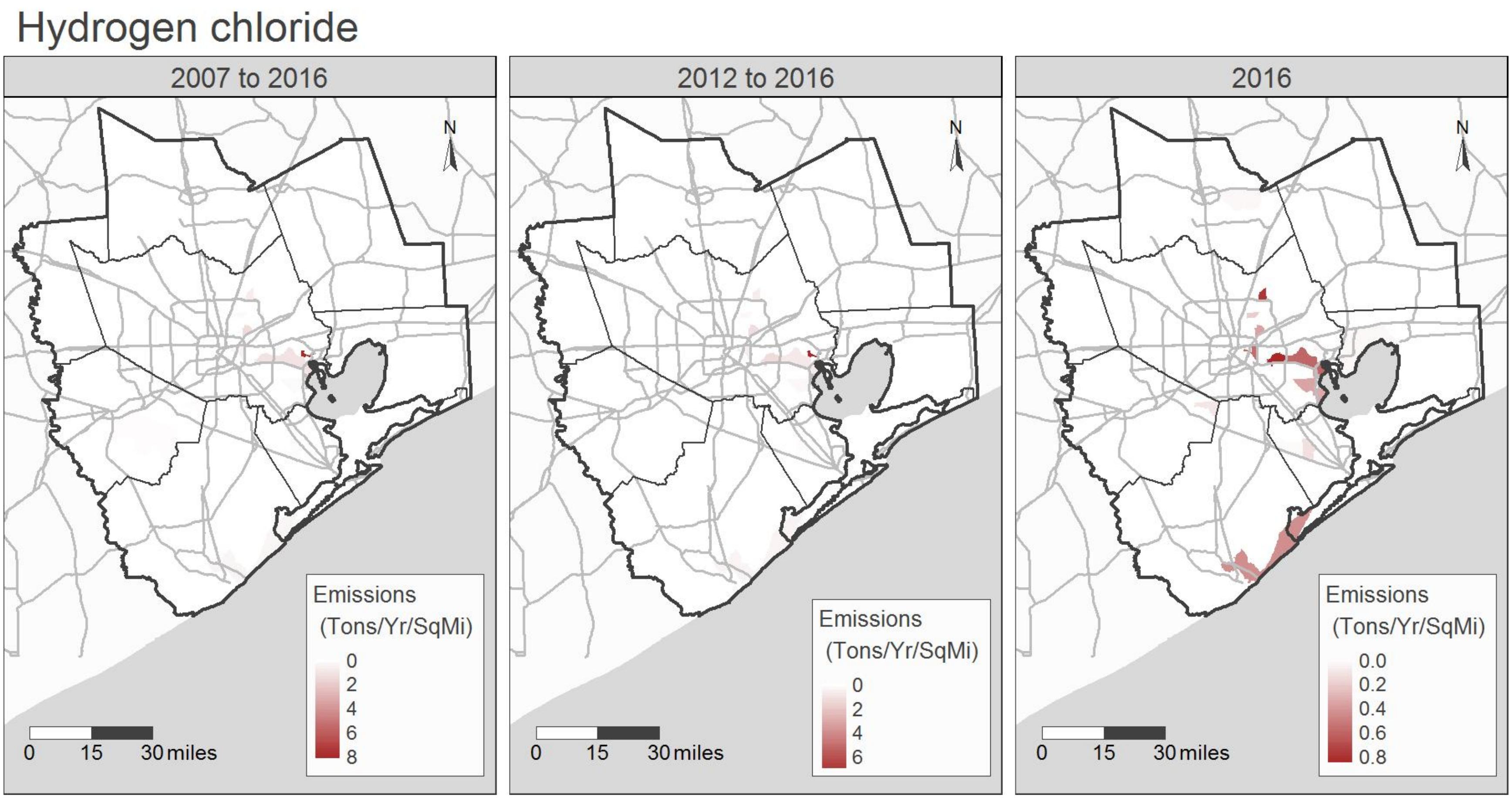
Diaminotoluene (mixed isomers)



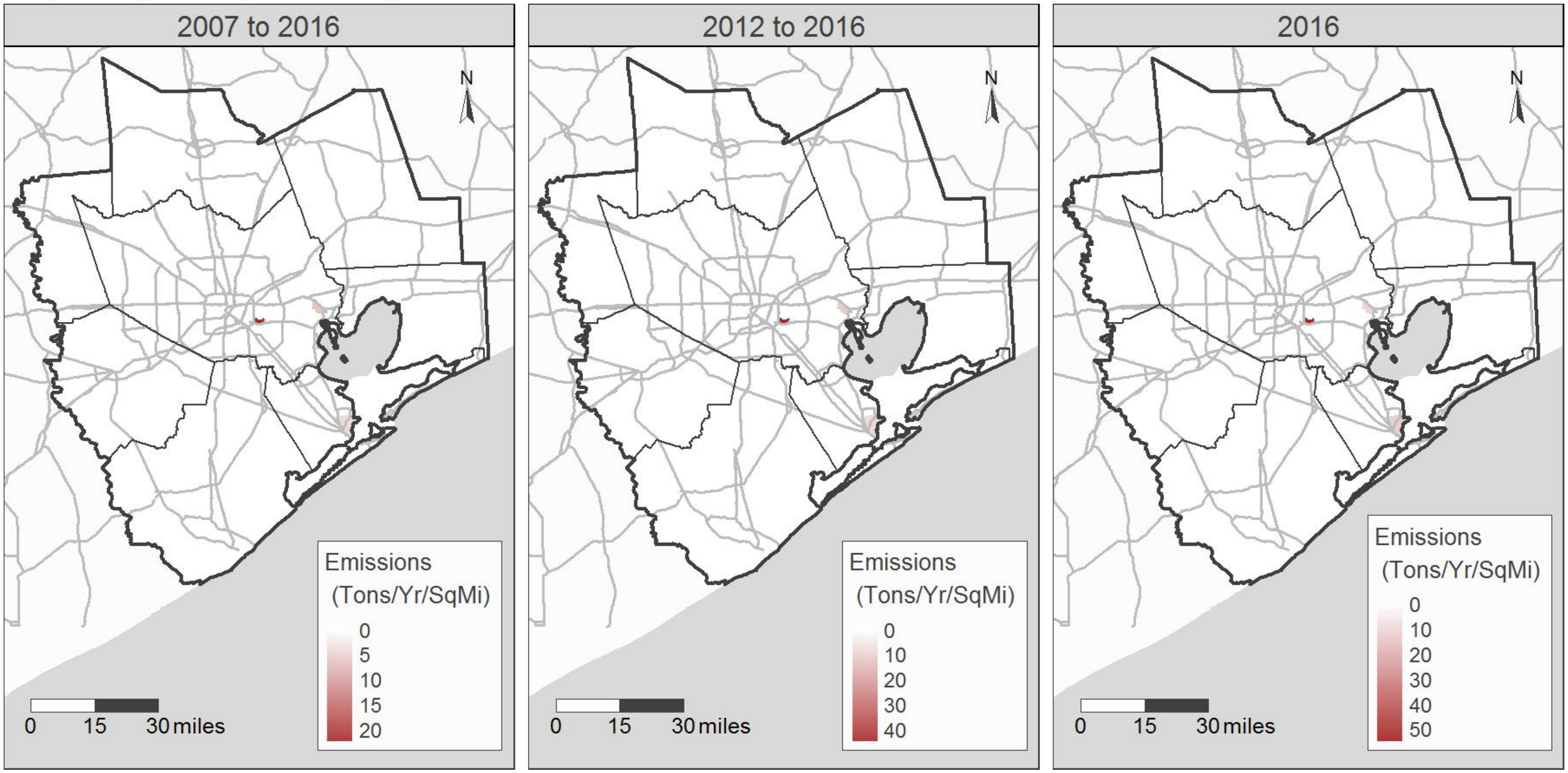


Fluoranthene
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0 15 30 miles

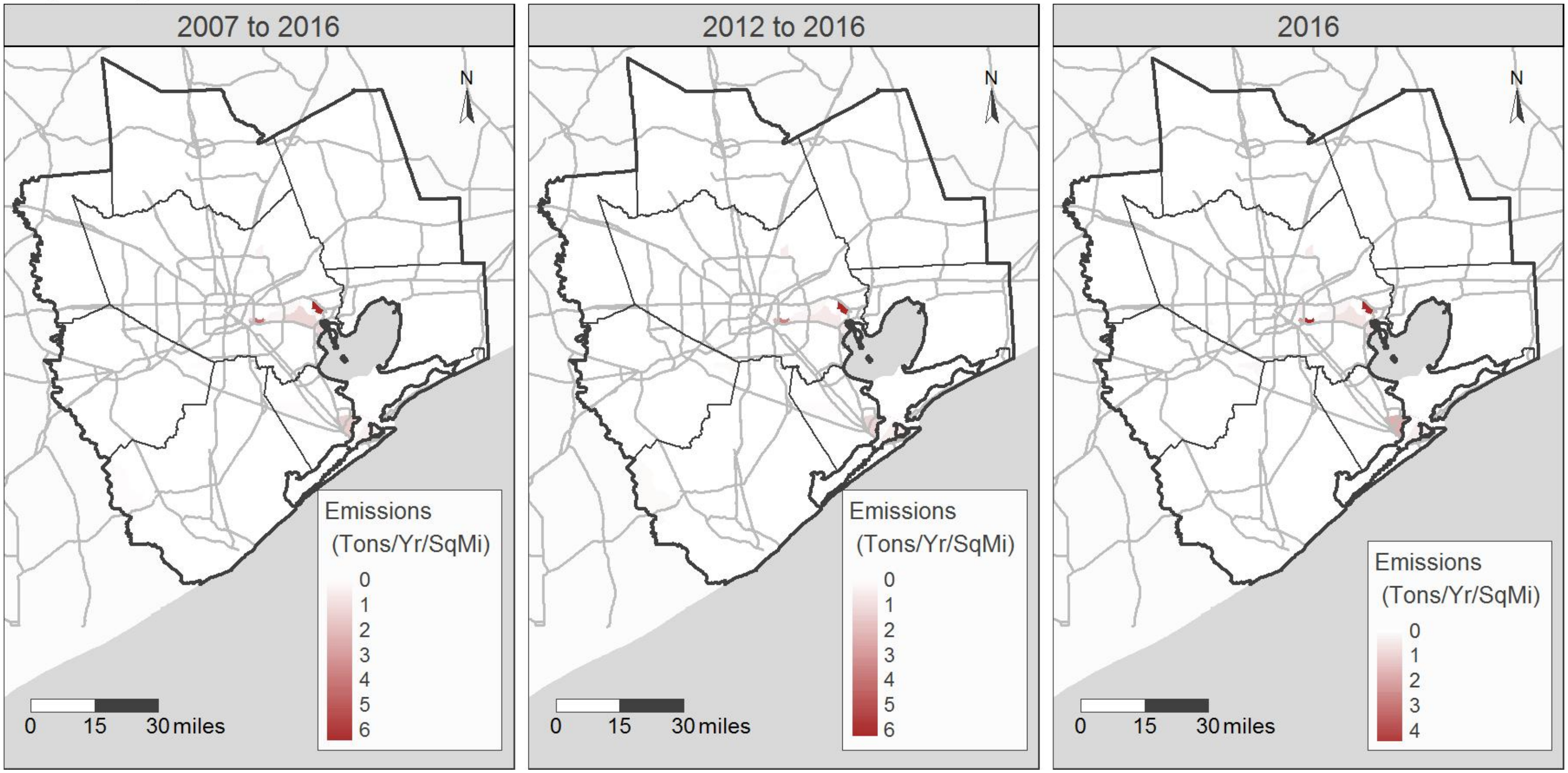

Formaldehyde
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0
1
2
3
4
5
0 15 30 miles


Hydrogen chloride
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0
2
4
6
8
0
2
4
6
0.0
0.2
0.4
0.6
0.8
0
15
30 miles

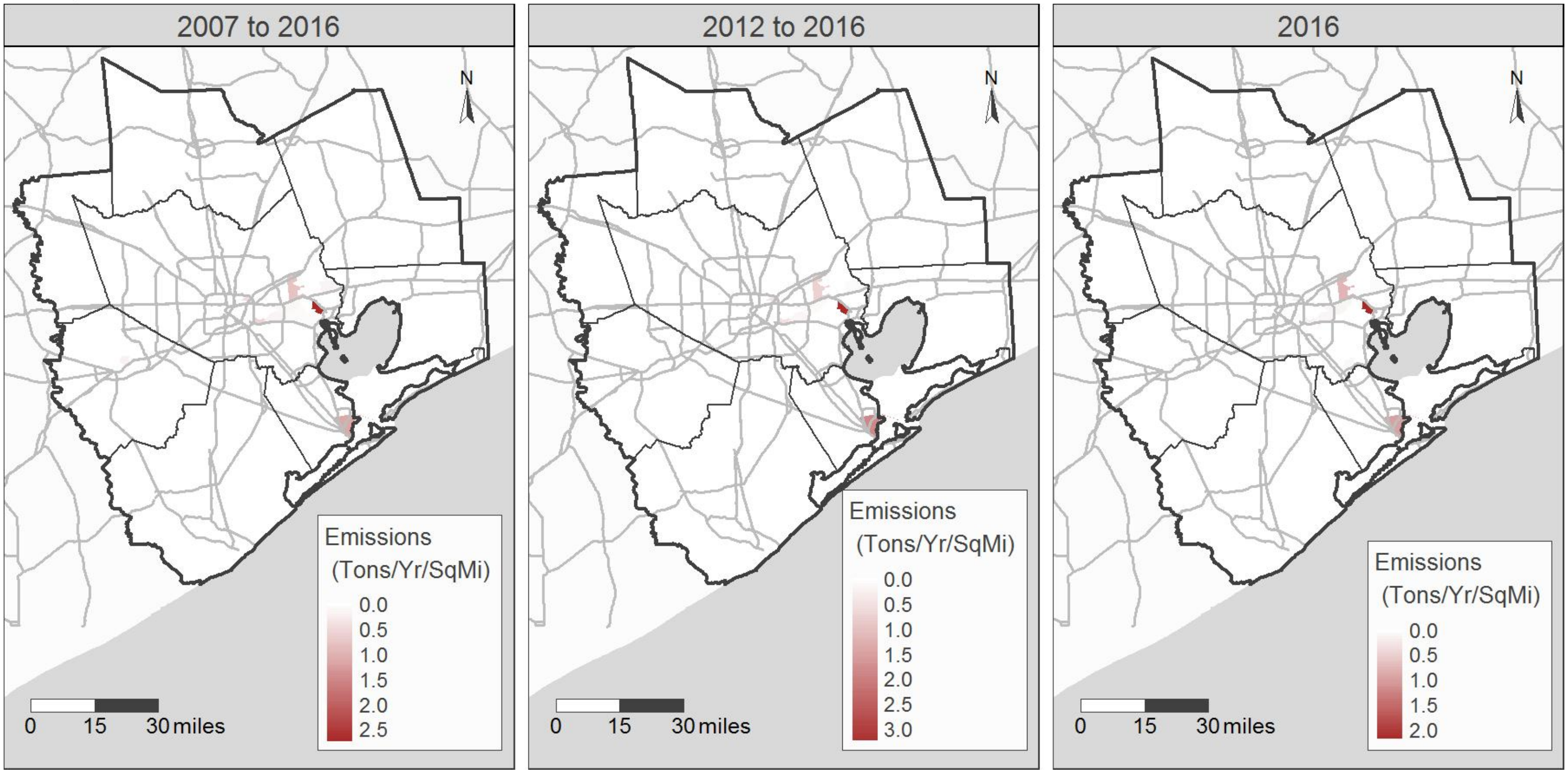
Hydrogen cyanide gas

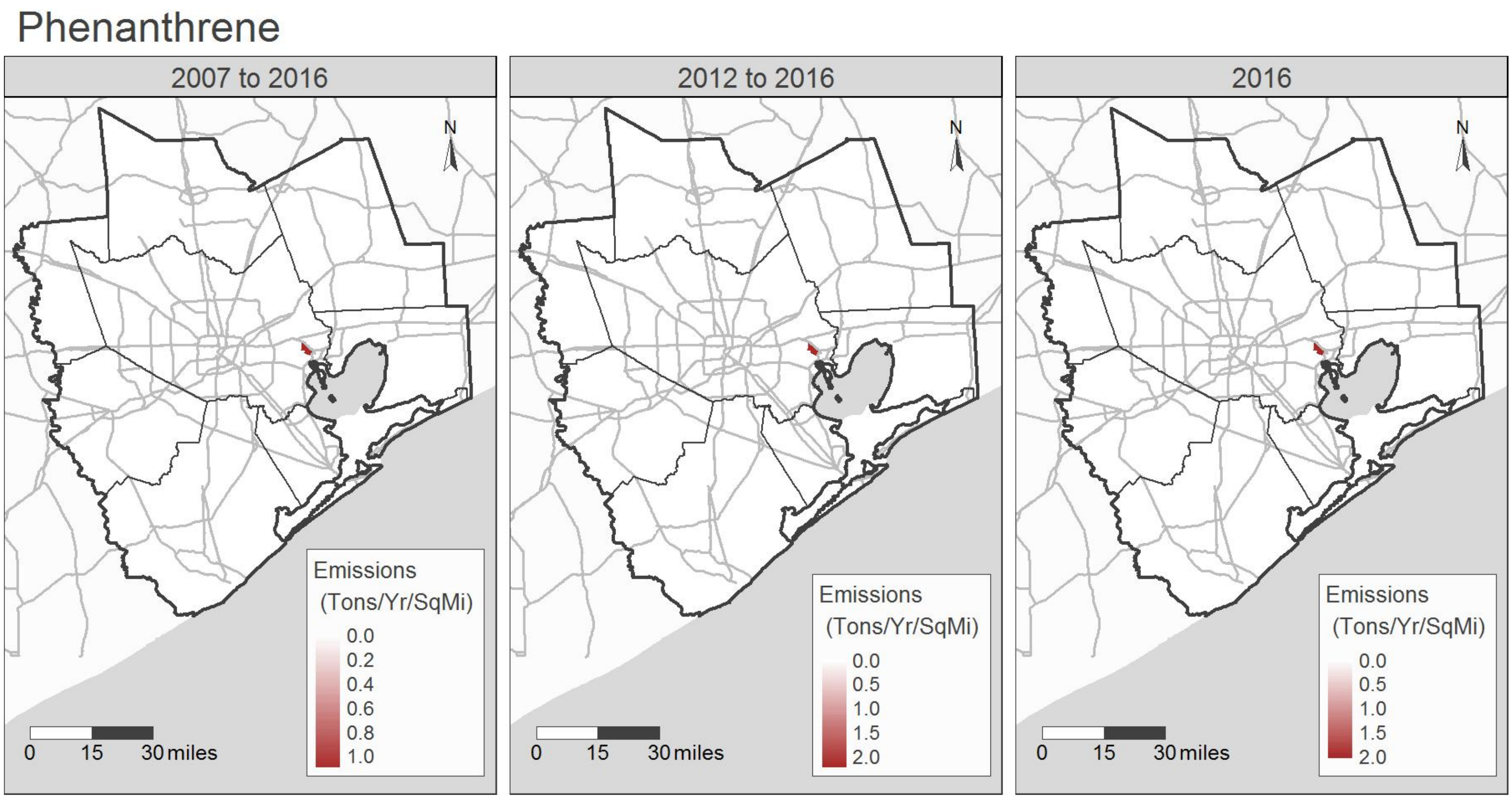


Hydrogen sulfide

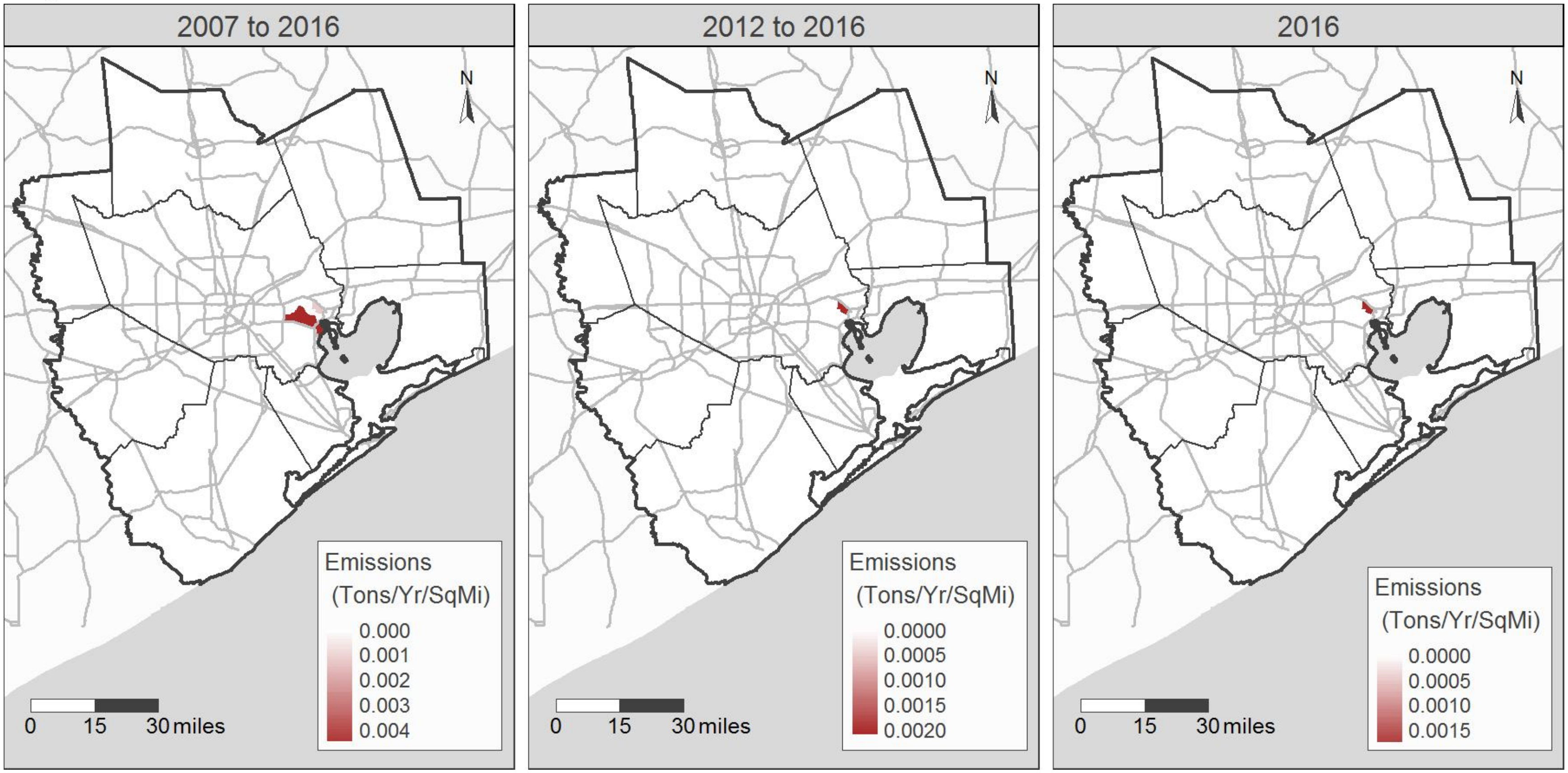


Naphthalene




Phenanthrene
2007 to 2016
2012 to 2016
2016
N
Emissions
(Tons/Yr/SqMi)
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.5
1.0
1.5
2.0
0
15
30 miles

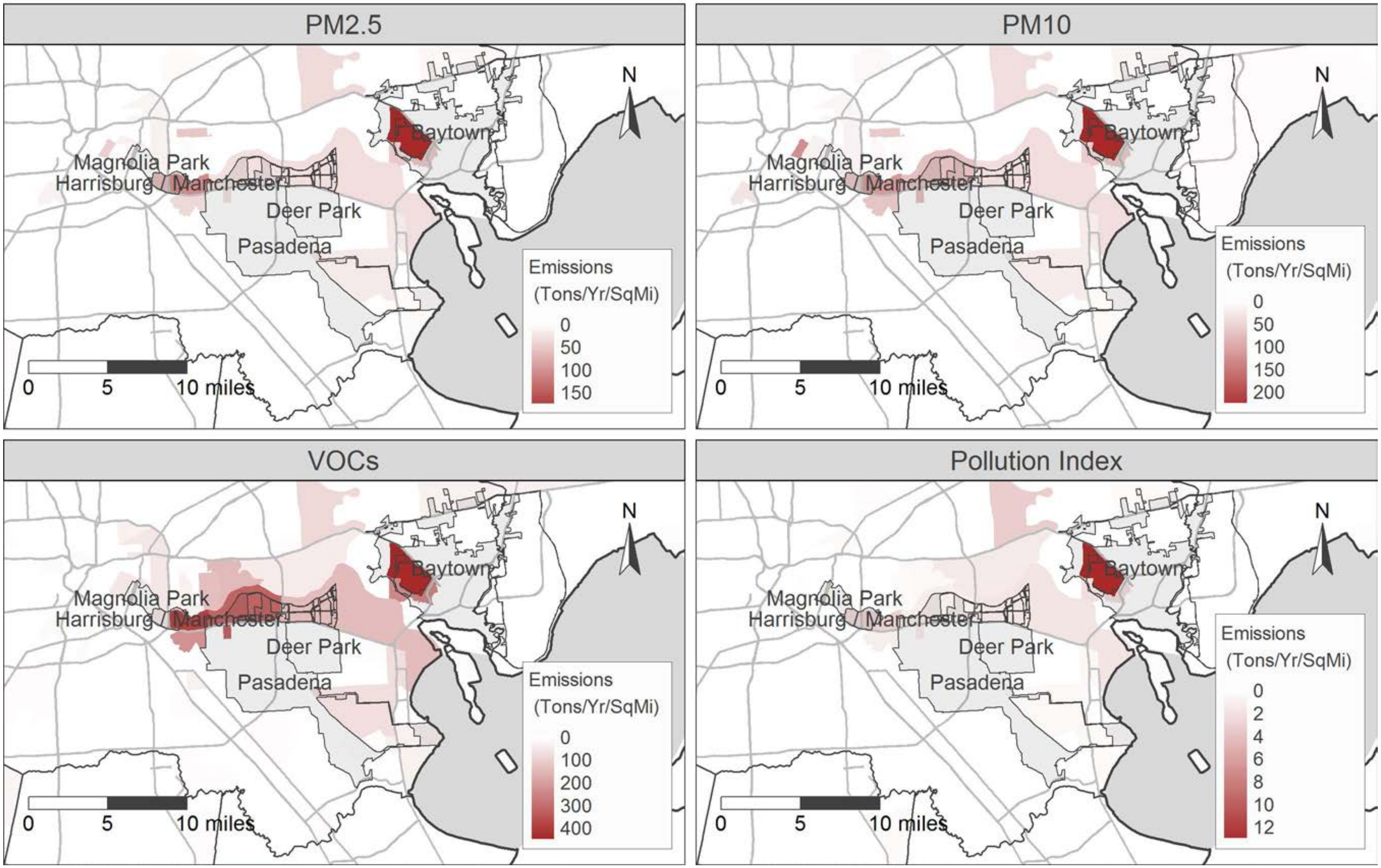
Pyrene



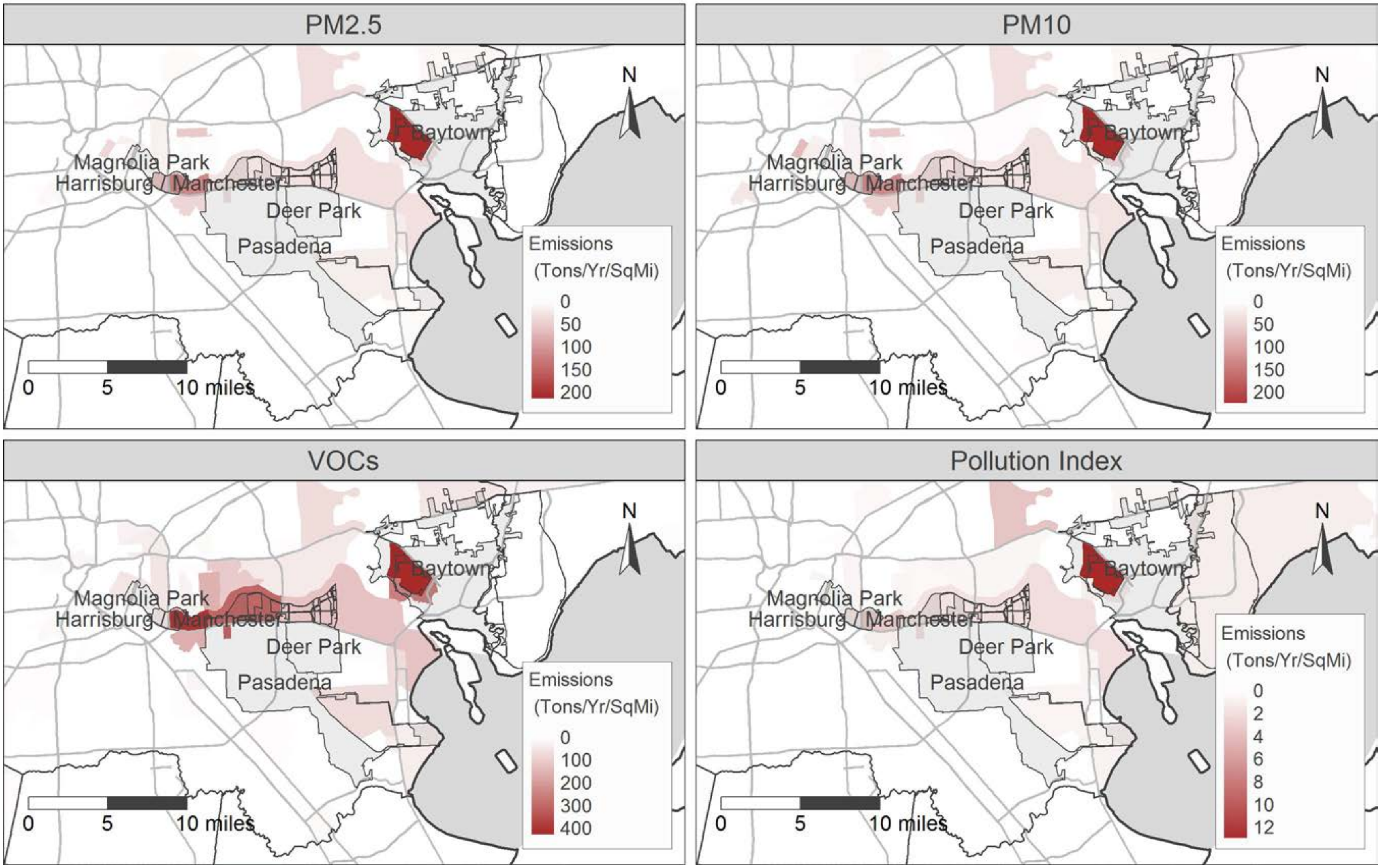
2007 to 2016
2012 to 2016
2016
N
Emissions (Tons/Yr/SqMi)
0.000
0.001
0.002
0.003
0.004
0.0000
0.0005
0.0010
0.0015
0.0020
0.0000
0.0005
0.0010
0.0015
0 15 30 miles

Appendix D: Additional Ship Channel Maps of Four Pollution Categories

2012 to 2016

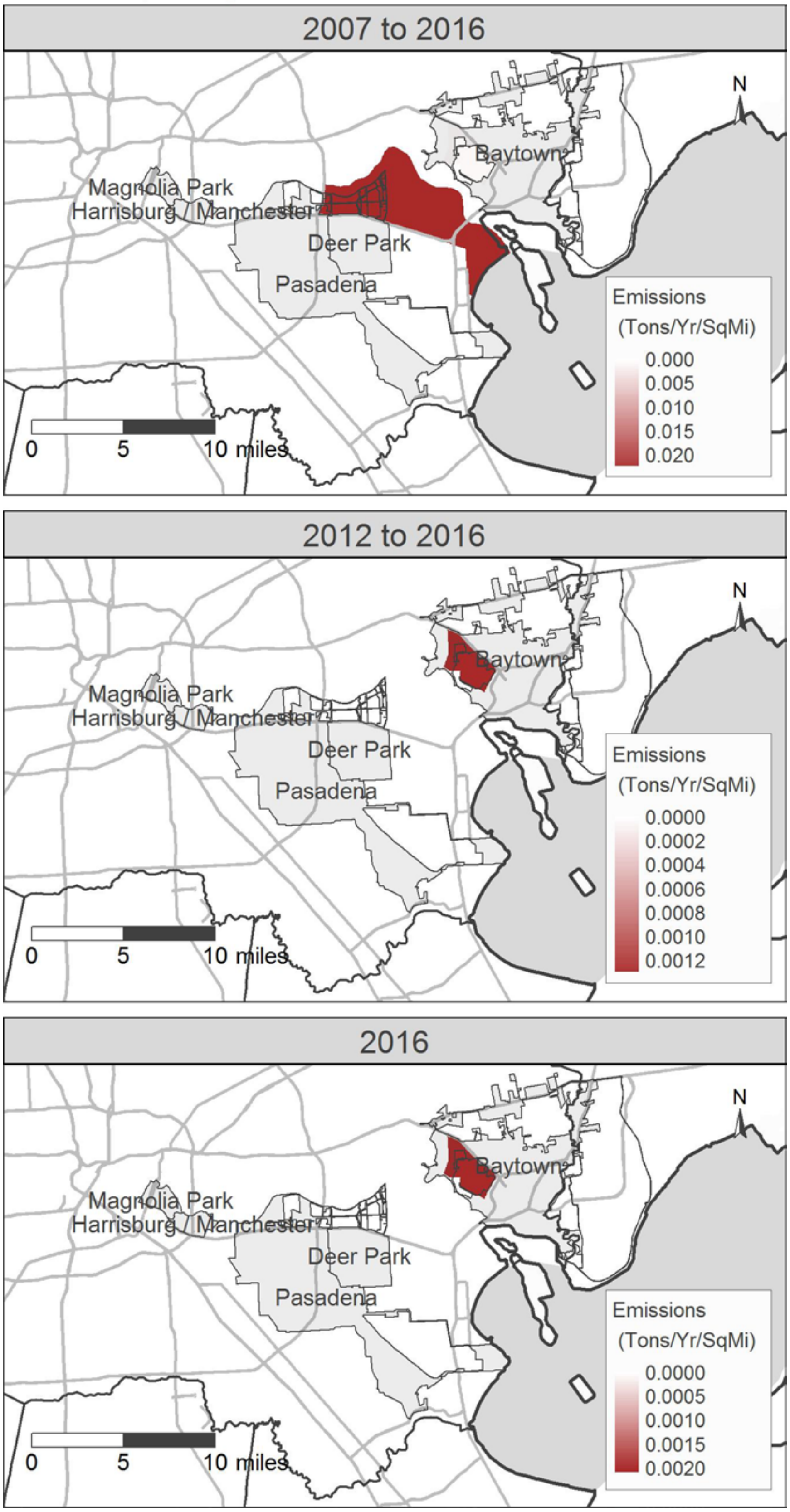

PM2.5
PM10
VOCs
Pollution Index
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0
5
10 miles
Emissions
(Tons/Yr/SqMi)
0
50
100
150
200
300
400
2
4
6
8
10
12

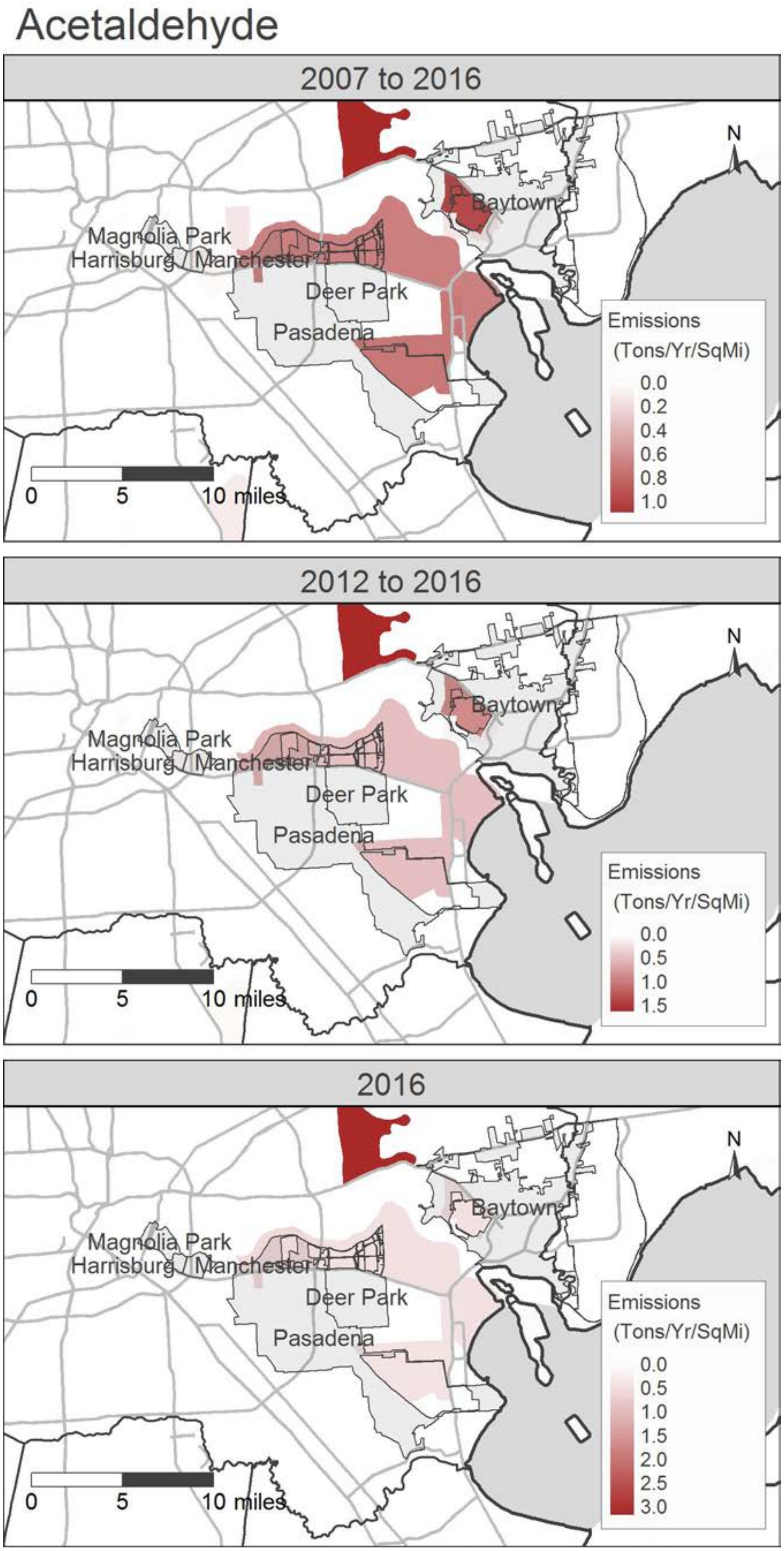
2016


PM2.5
PM10
VOCs
Pollution Index
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
0
5
10 miles
Emissions
(Tons/Yr/SqMi)
0
50
100
150
200
0
100
200
300
400
0
2
4
6
8
10
12

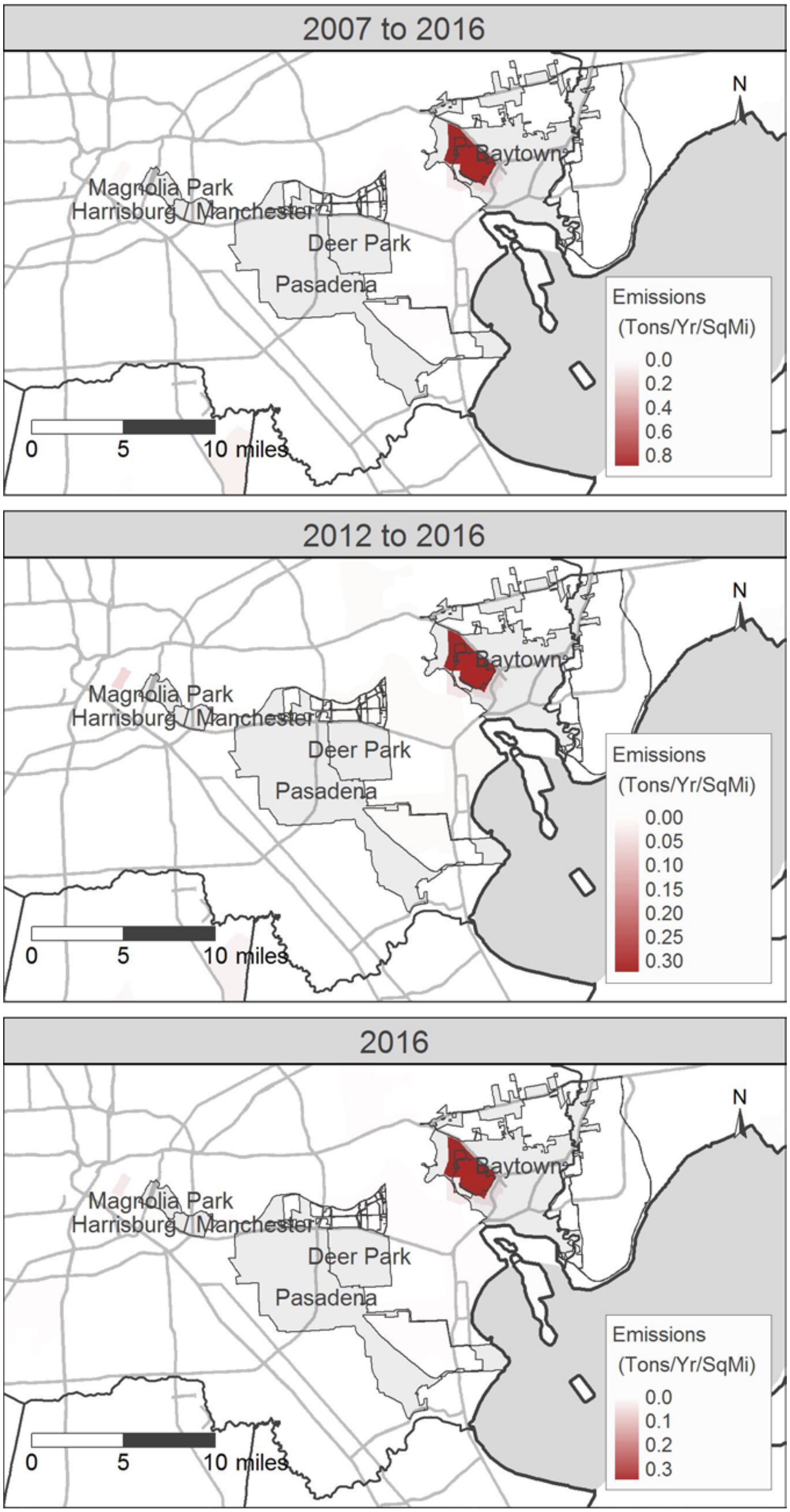
Appendix E: Ship Channel Maps of 19 Pollutants of Concern

Acenaphthylene

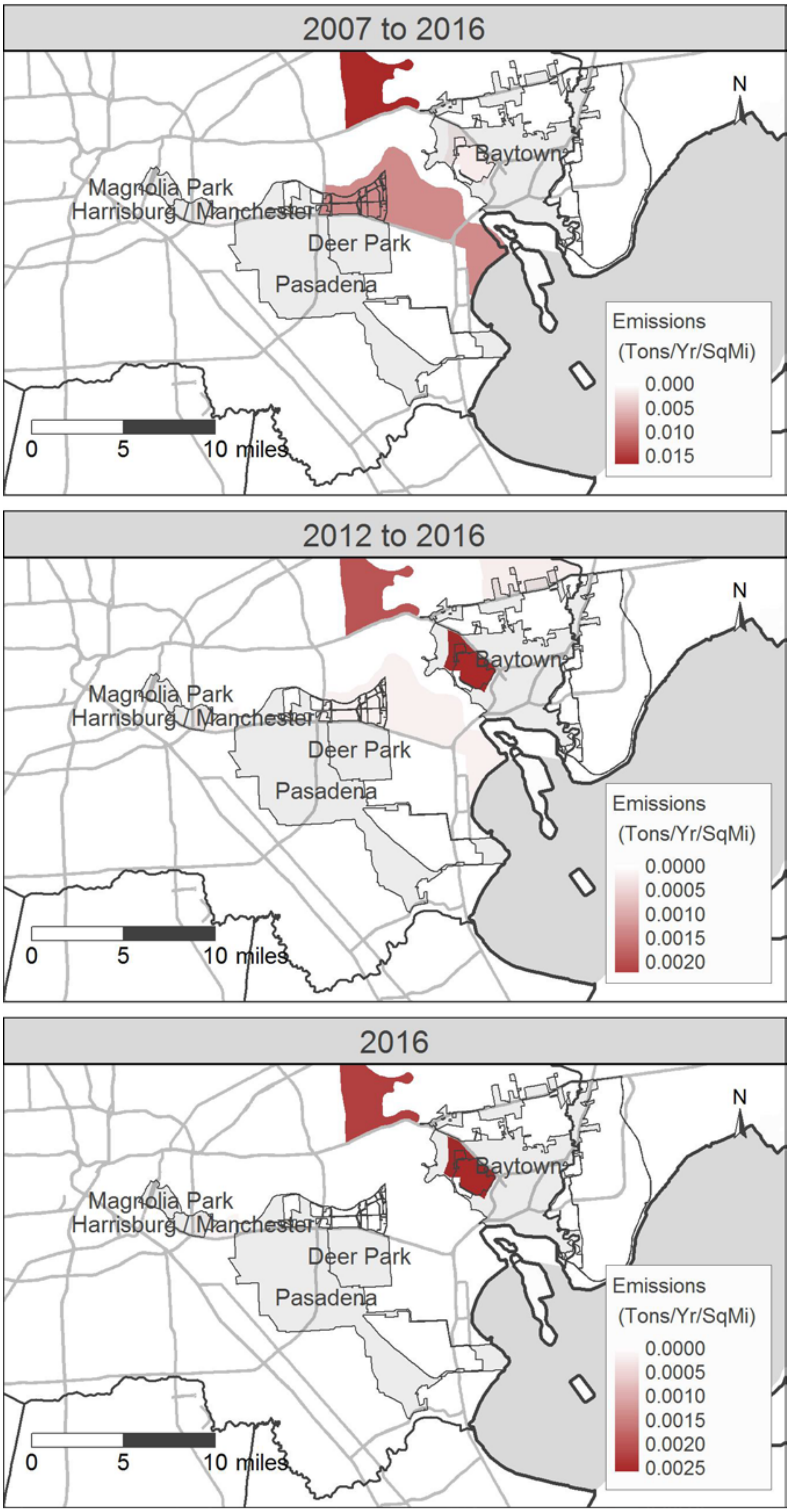



Acetaldehyde
2007 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.2
0.4
0.6
0.8
1.0
N
0
5
10 miles
2012 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
N
0
5
10 miles
2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
N
0
5
10 miles

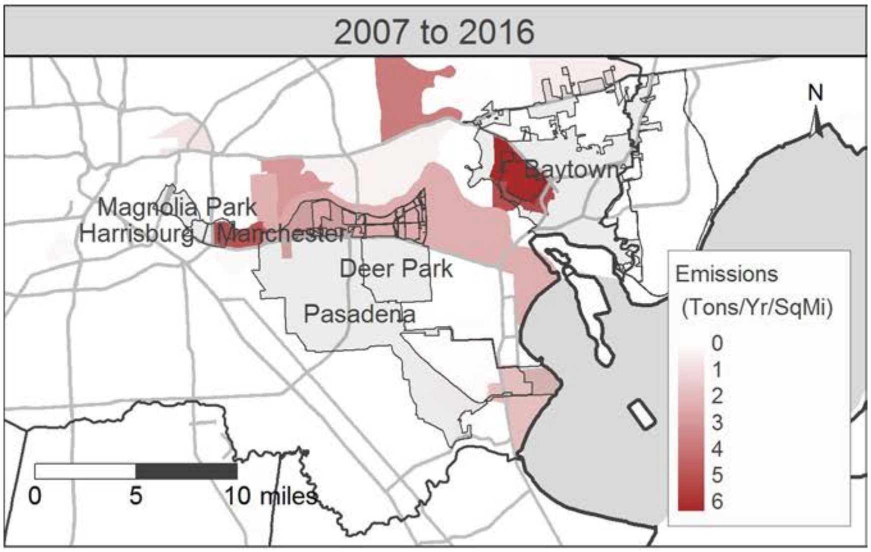
Acrolein

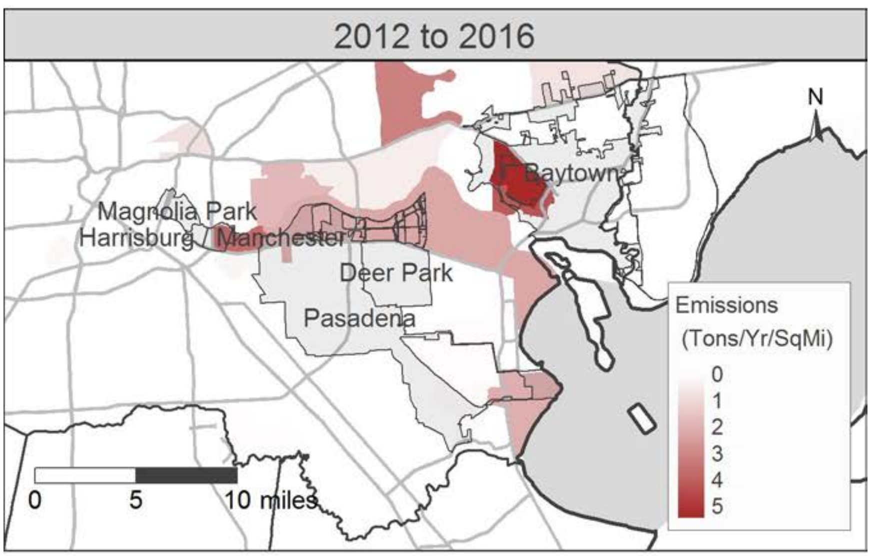

2007 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.2
0.4
0.6
0.8
0
5
10 miles
2012 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
5
10 miles
2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.1
0.2
0.3
0
5
10 miles

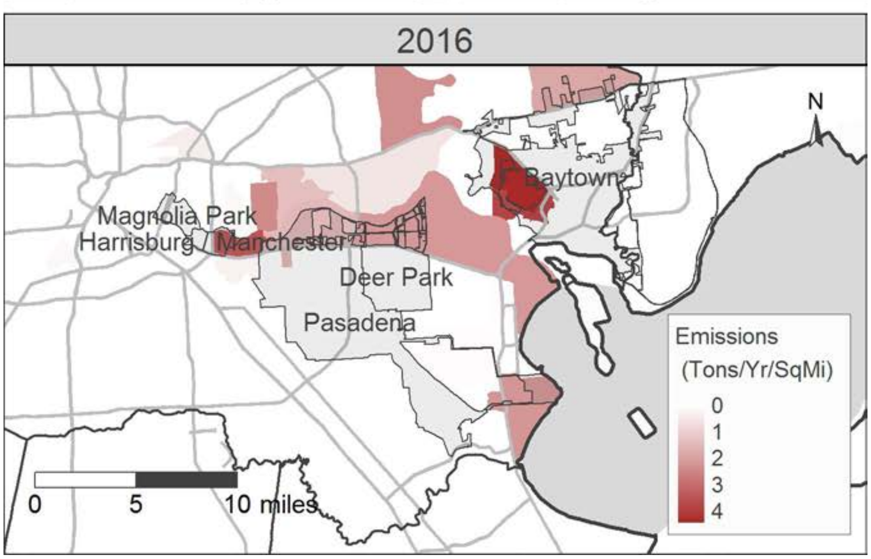
Anthracene

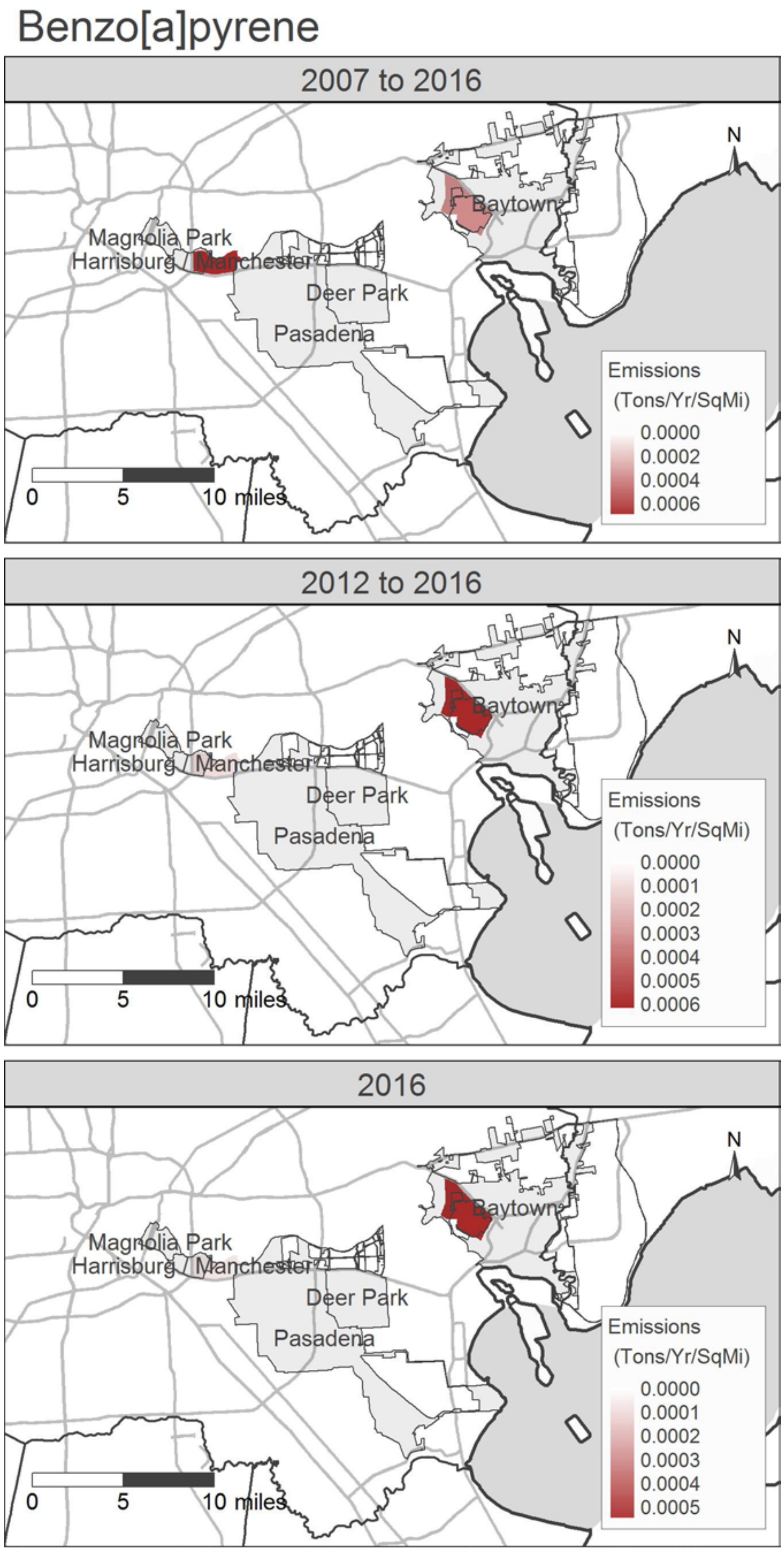

2007 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0 5 10 miles
Emissions
(Tons/Yr/SqMi)
0.000
0.005
0.010
0.015
2012 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0 5 10 miles
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0020
2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0 5 10 miles
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025

Benzene

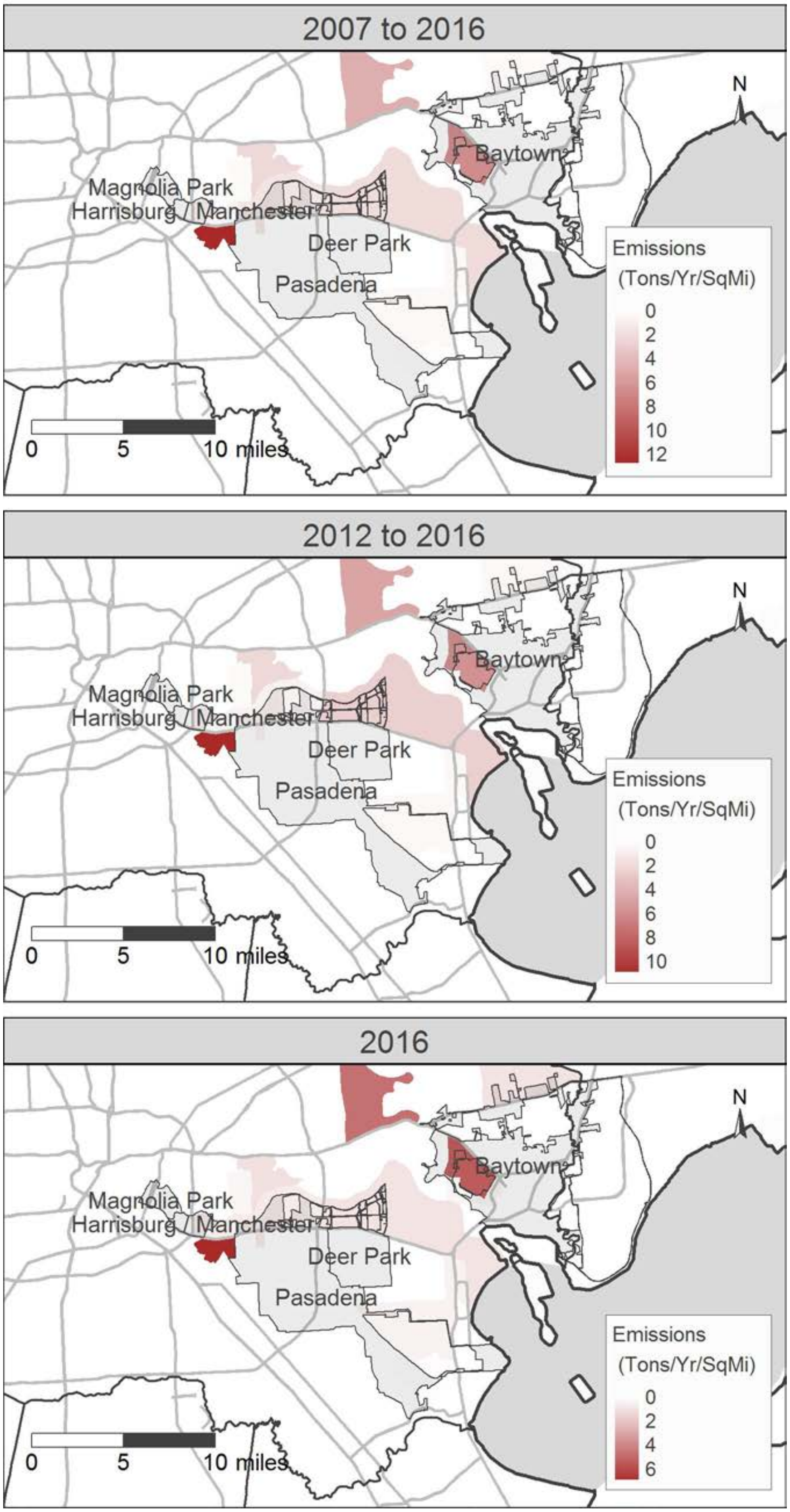

2007 to 2016
Magnolia Park
Harrisburg / Manchester
Baytown
Deer Park
Pasadena
N
Emissions
(Tons/Yr/SqMi)
0
1
2
3
4
5
6
0
5
10 miles


2012 to 2016
Magnolia Park
Harrisburg / Manchester
Baytown
Deer Park
Pasadena
N
Emissions
(Tons/Yr/SqMi)
0
1
2
3
4
5
0
5
10 miles

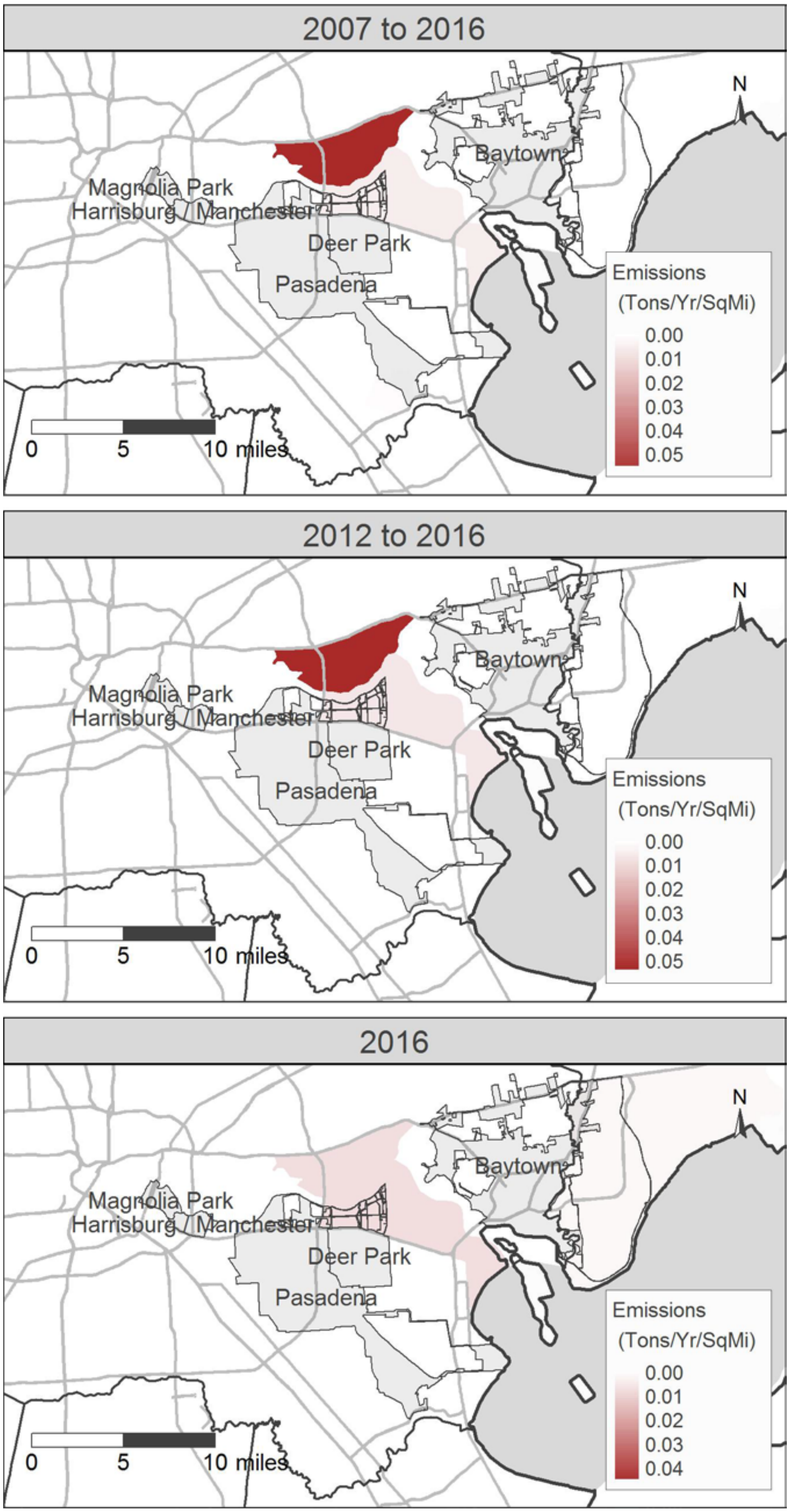

2016
Magnolia Park
Harrisburg / Manchester
Baytown
Deer Park
Pasadena
N
Emissions
(Tons/Yr/SqMi)
0
1
2
3
4
0
5
10 miles


Benzo[a]pyrene
2007 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0000
0.0002
0.0004
0.0006
0
5
10 miles
2012 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0
5
10 miles
2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0
5
10 miles

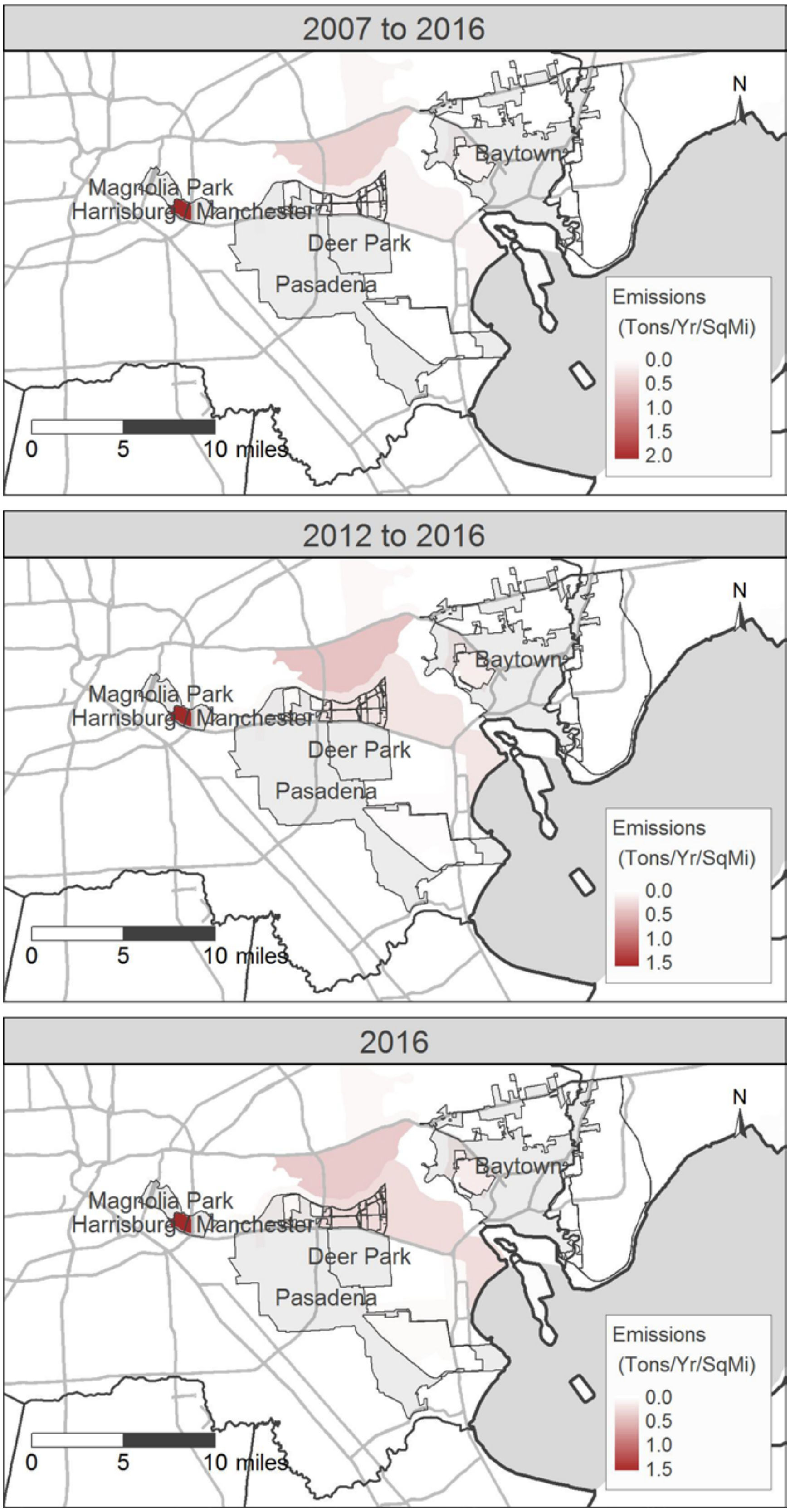
1,3-Butadiene



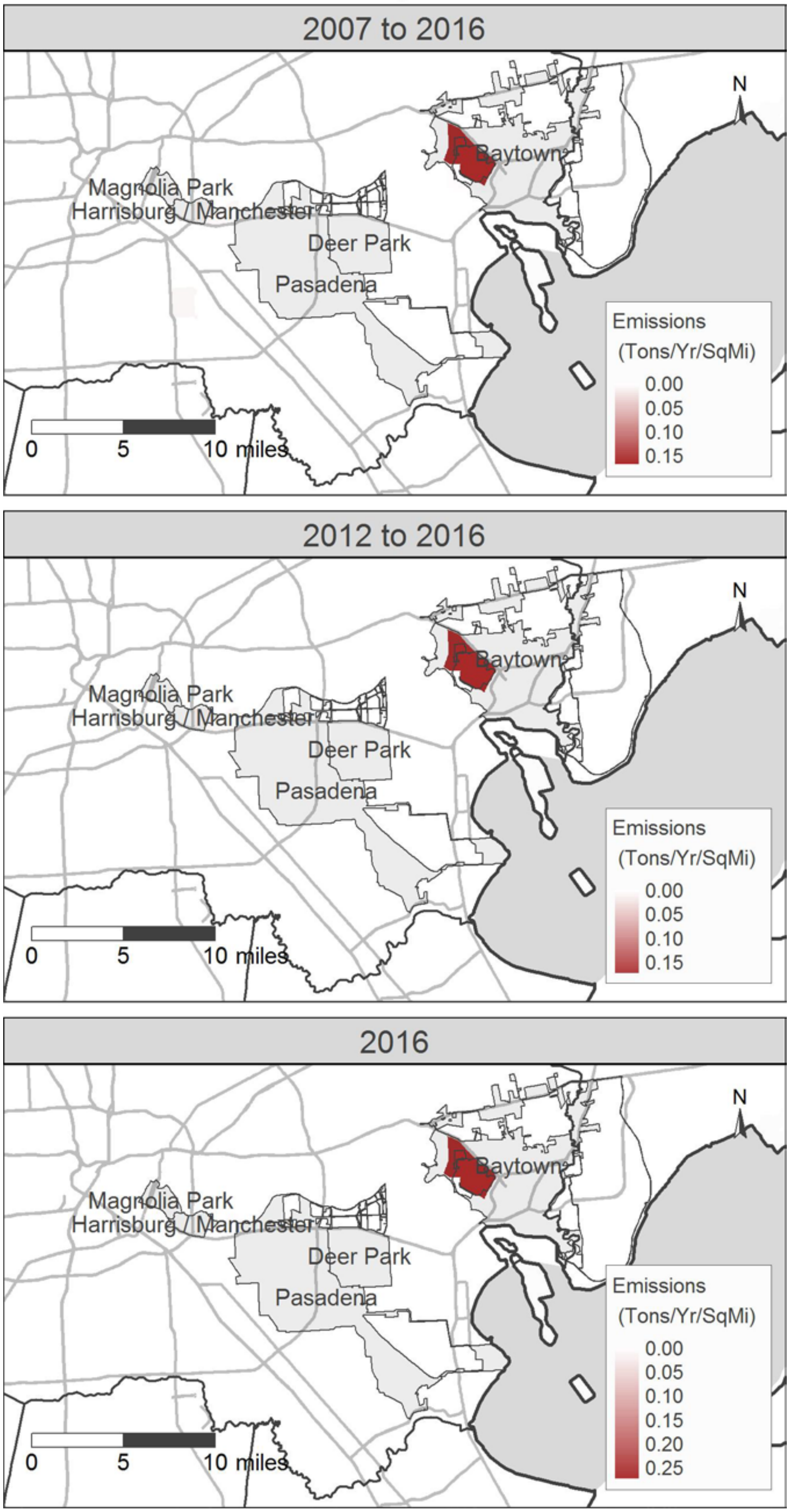
Carbon tetrachloride



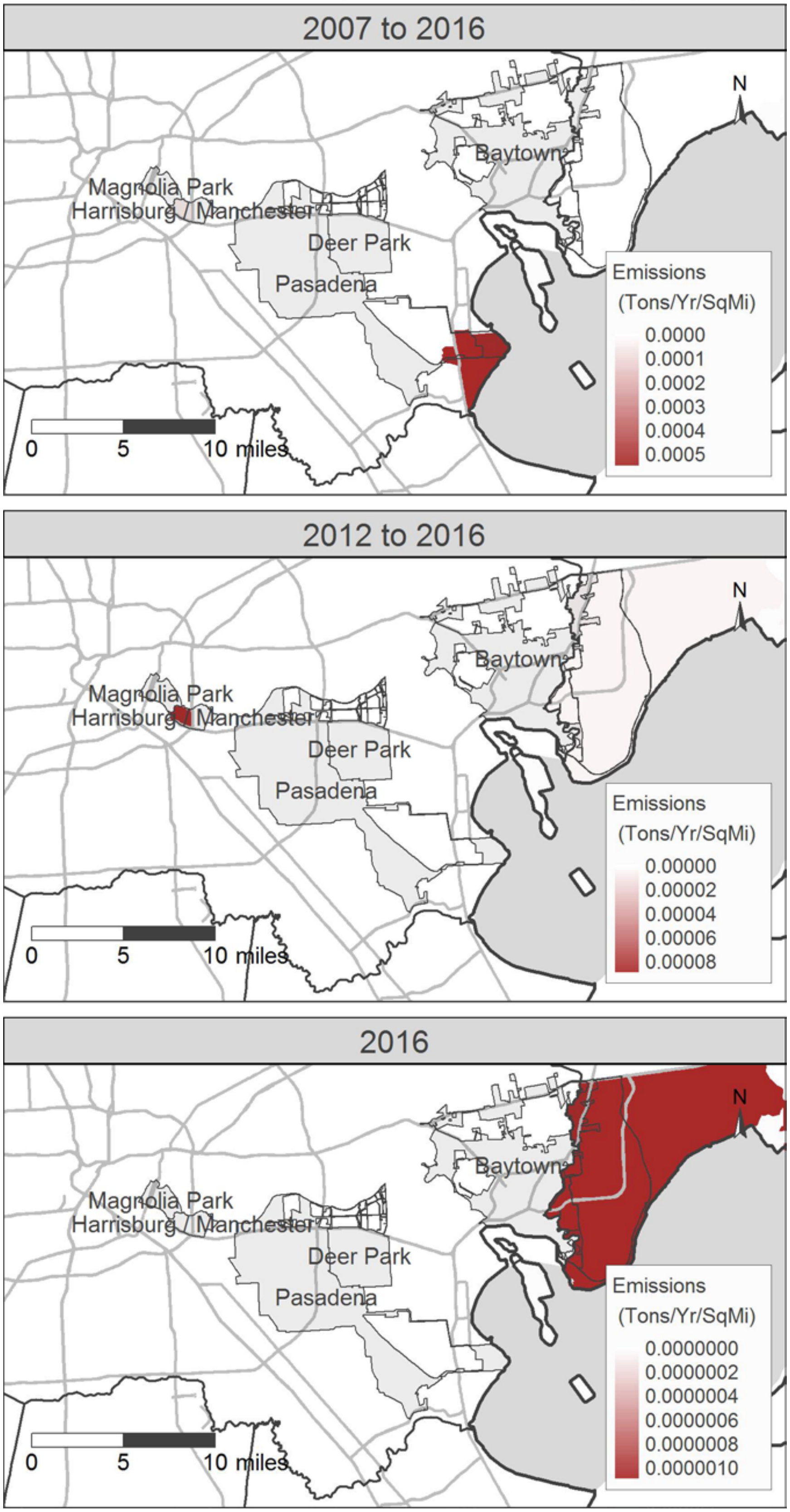
Chlorine


2007 to 2016
N
Baytown
Magnolia Park
Harrisburg
Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
2.0
0
5
10 miles
2012 to 2016
N
Baytown
Magnolia Park
Harrisburg
Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
0
5
10 miles
2016
N
Baytown
Magnolia Park
Harrisburg
Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
0
5
10 miles

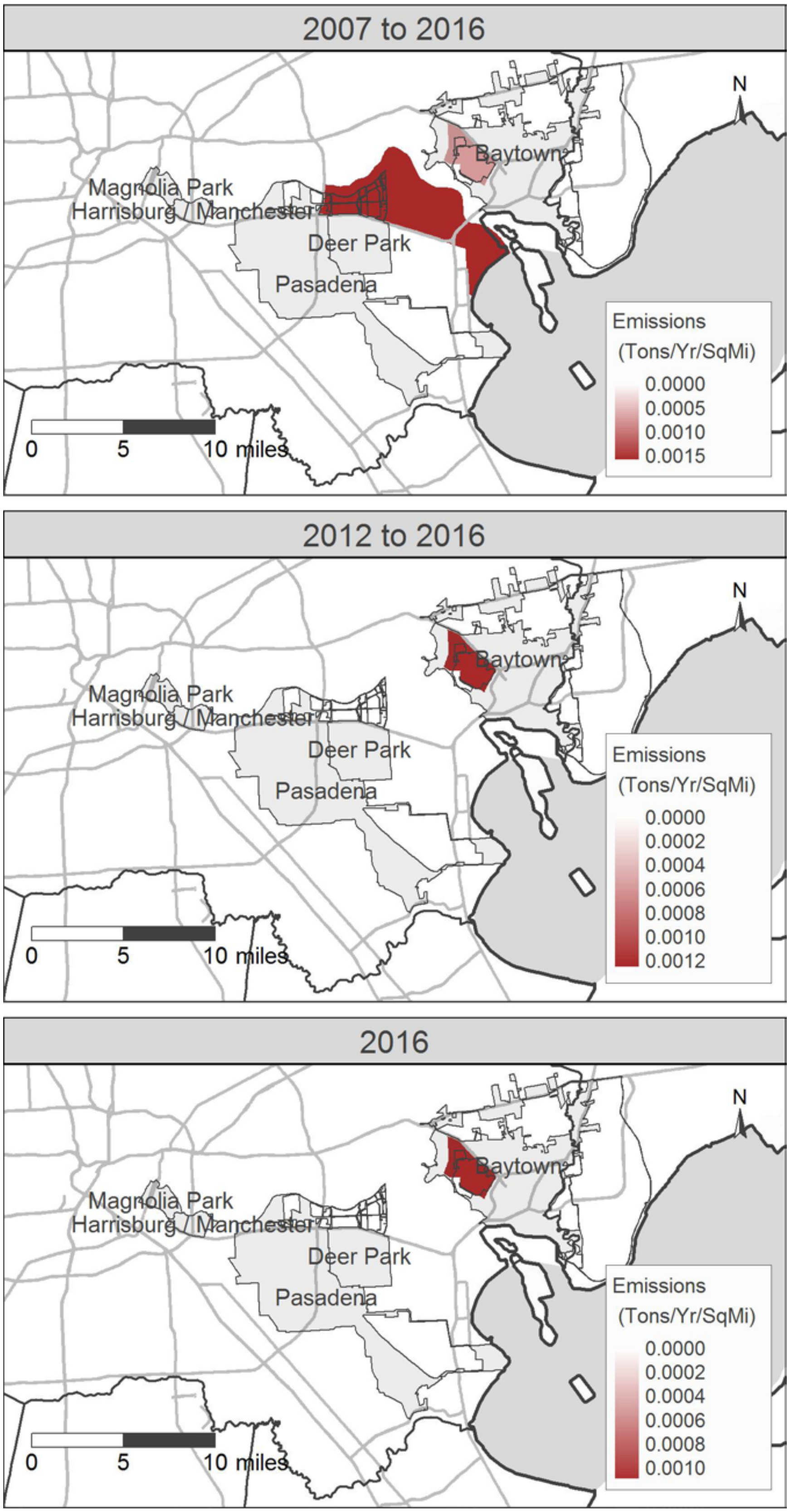
Chromium and compounds



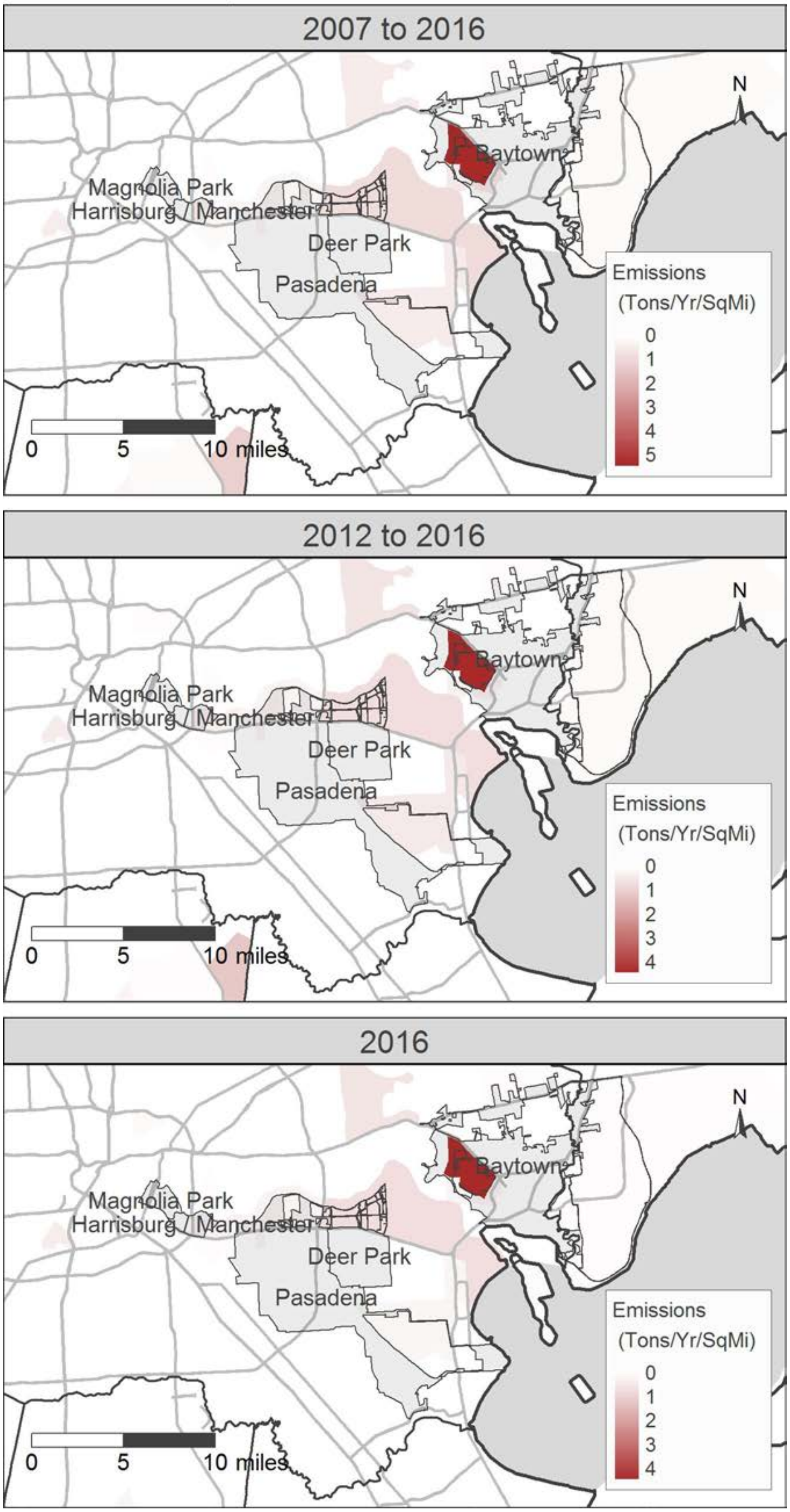
Diaminotoluene (mixed isomers)



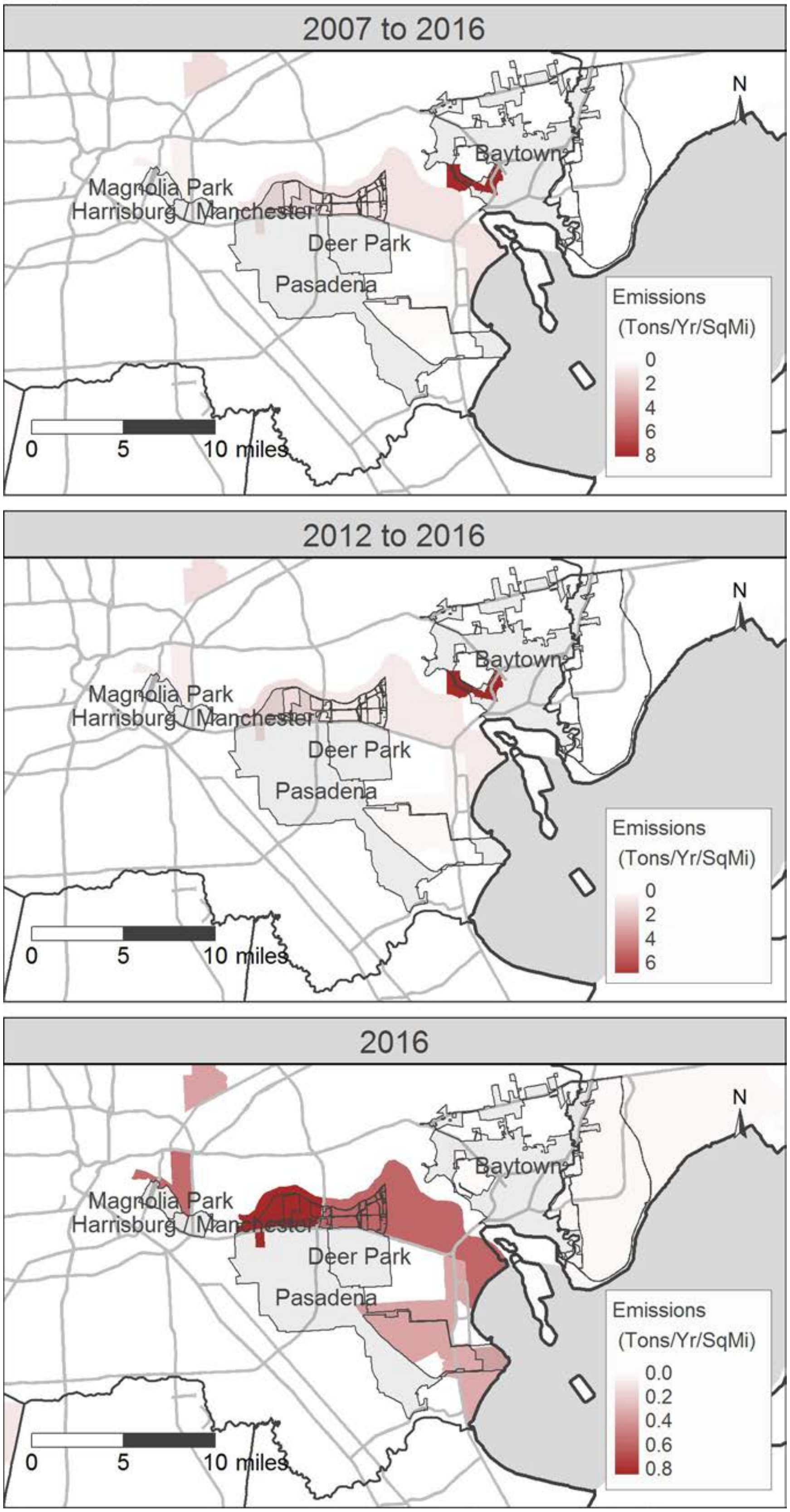
Fluoranthene



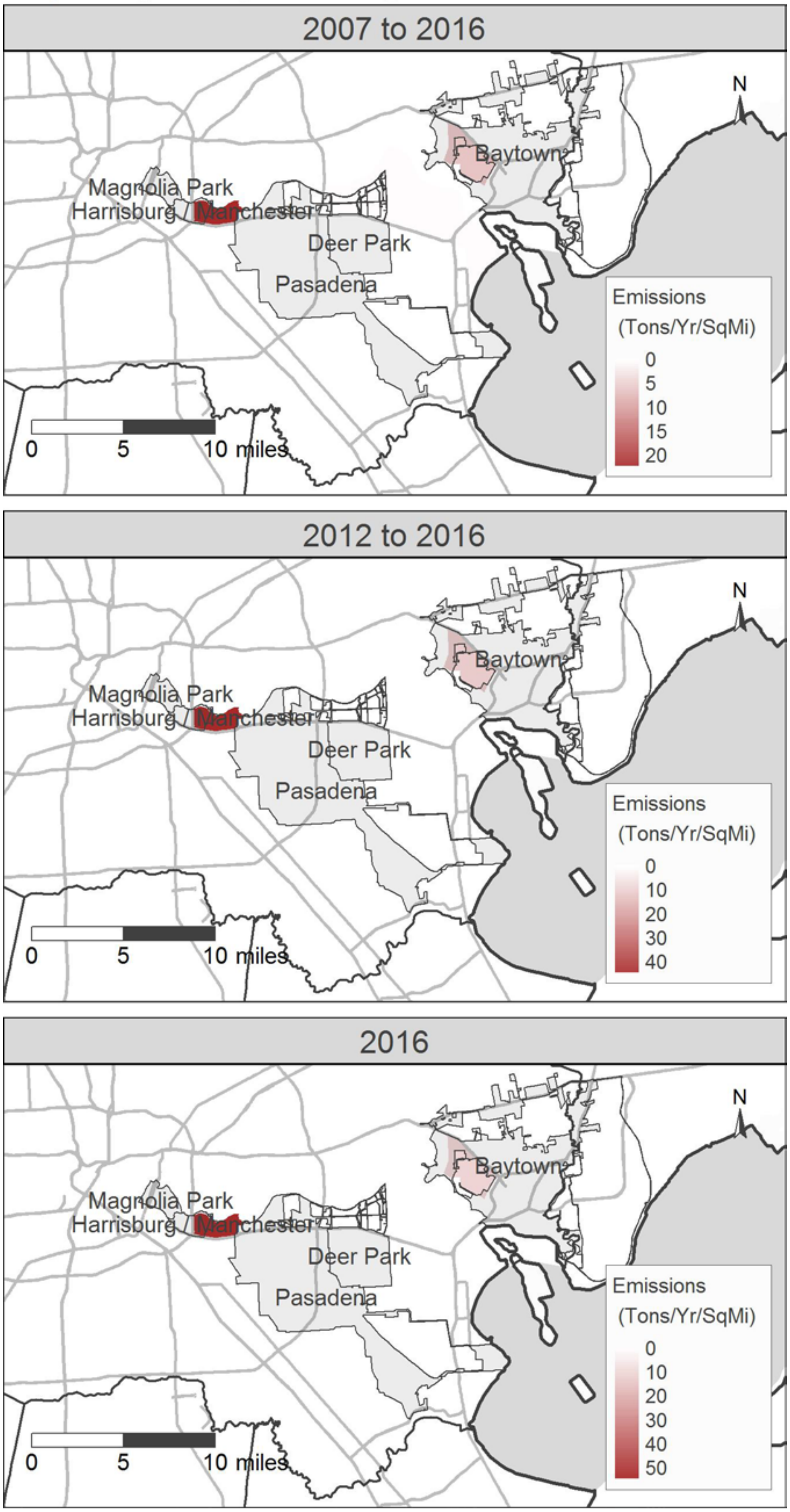
Formaldehyde



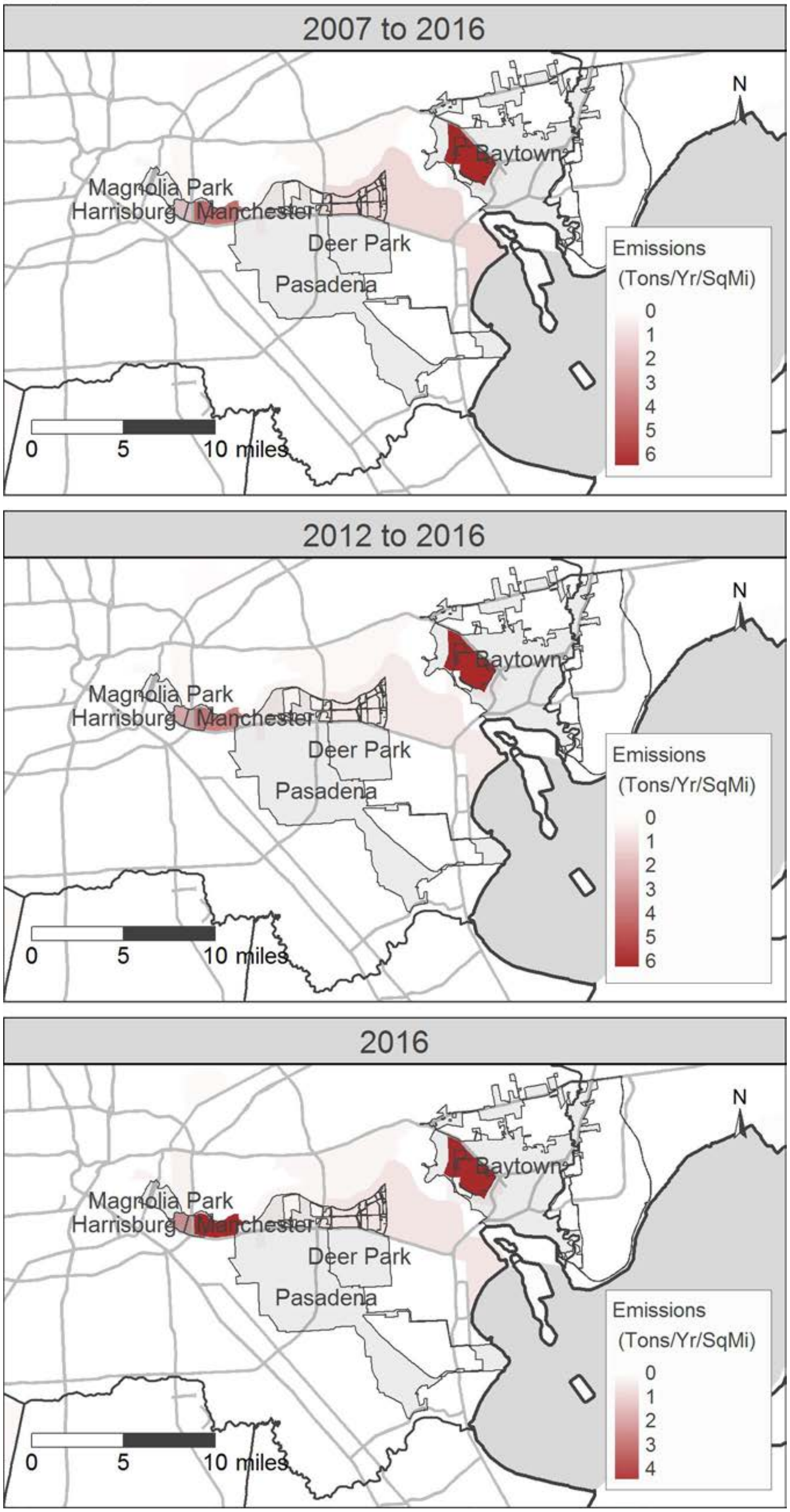
Hydrogen chloride



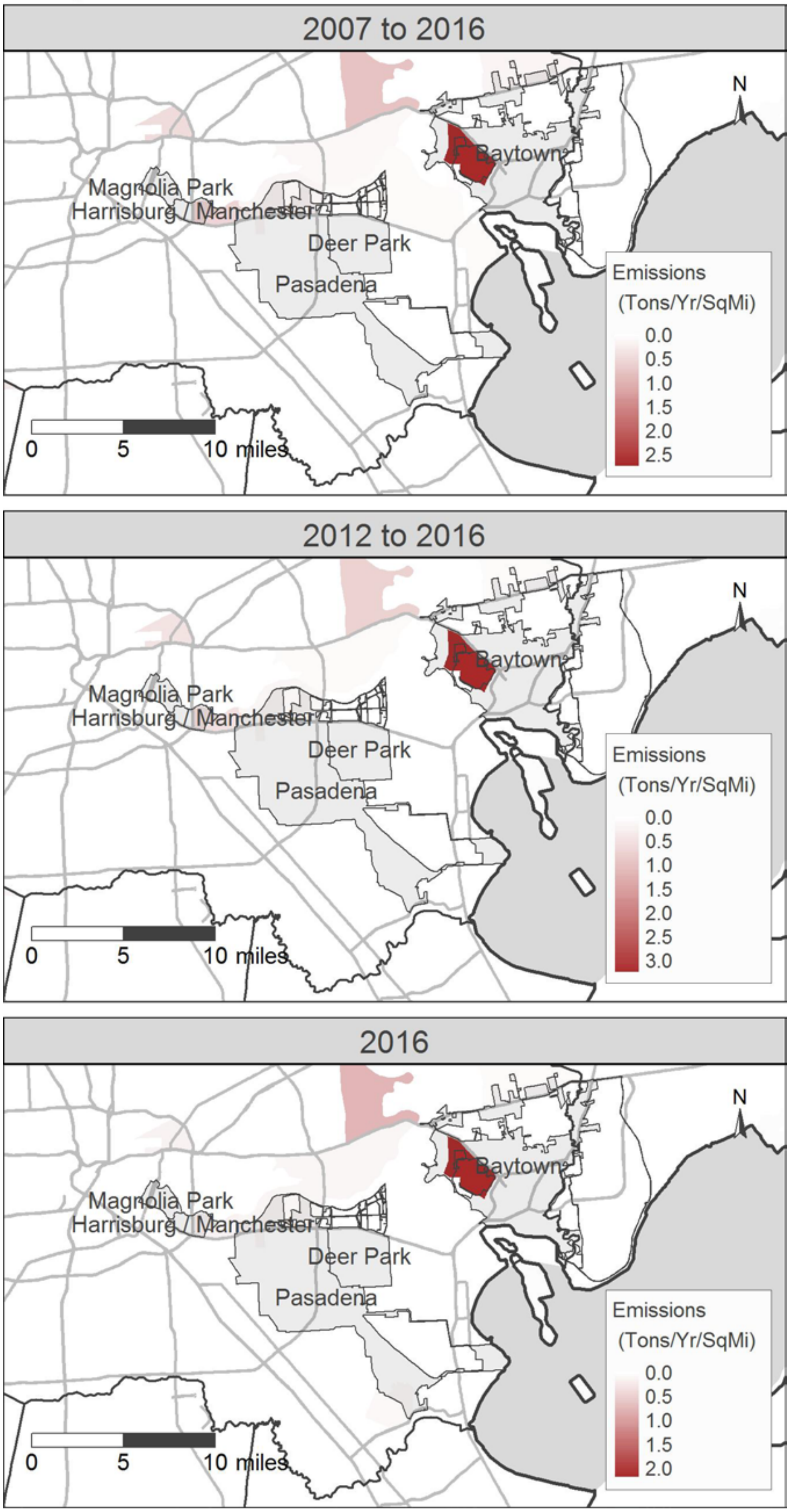
Hydrogen cyanide gas

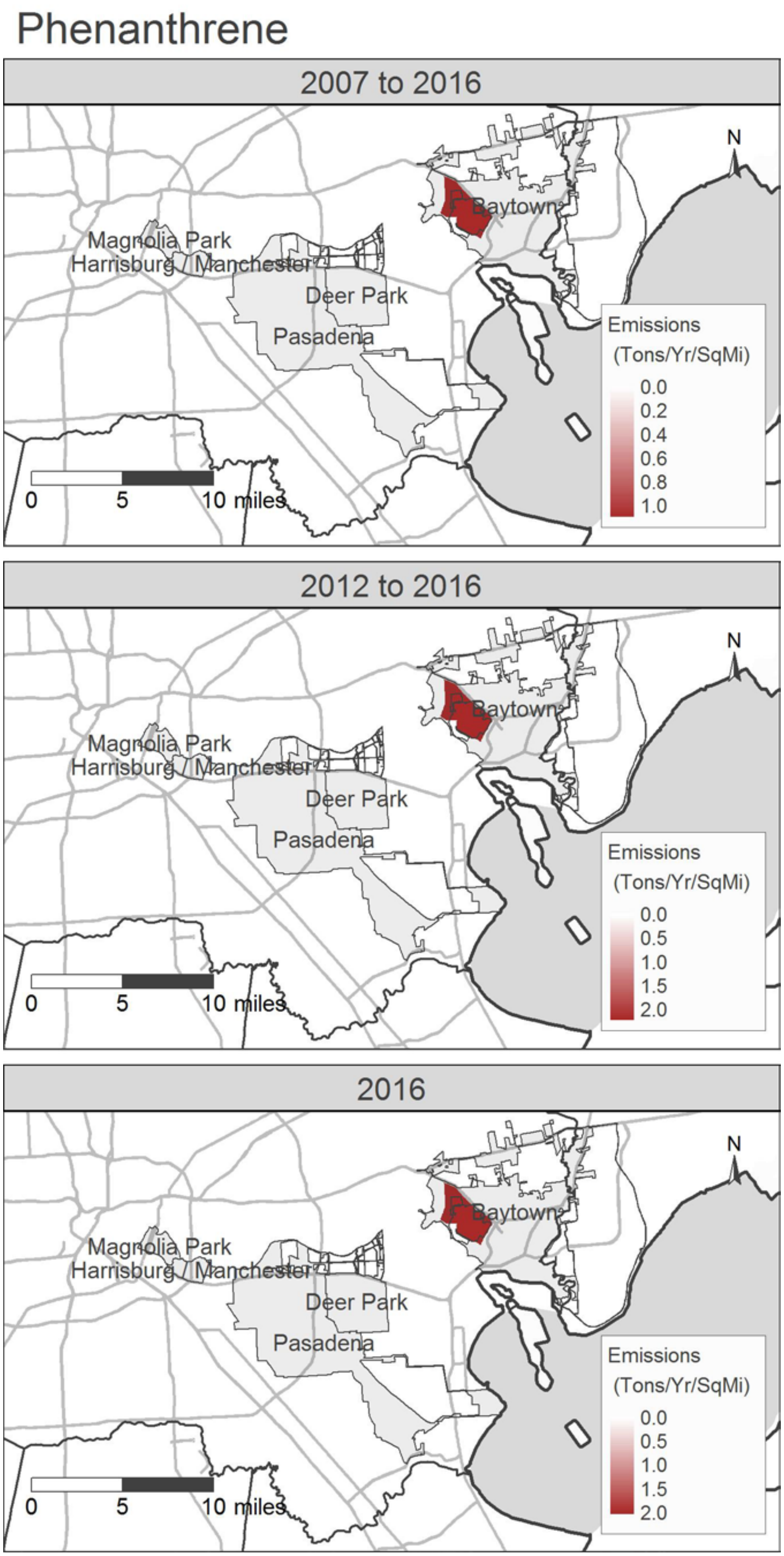


Hydrogen sulfide

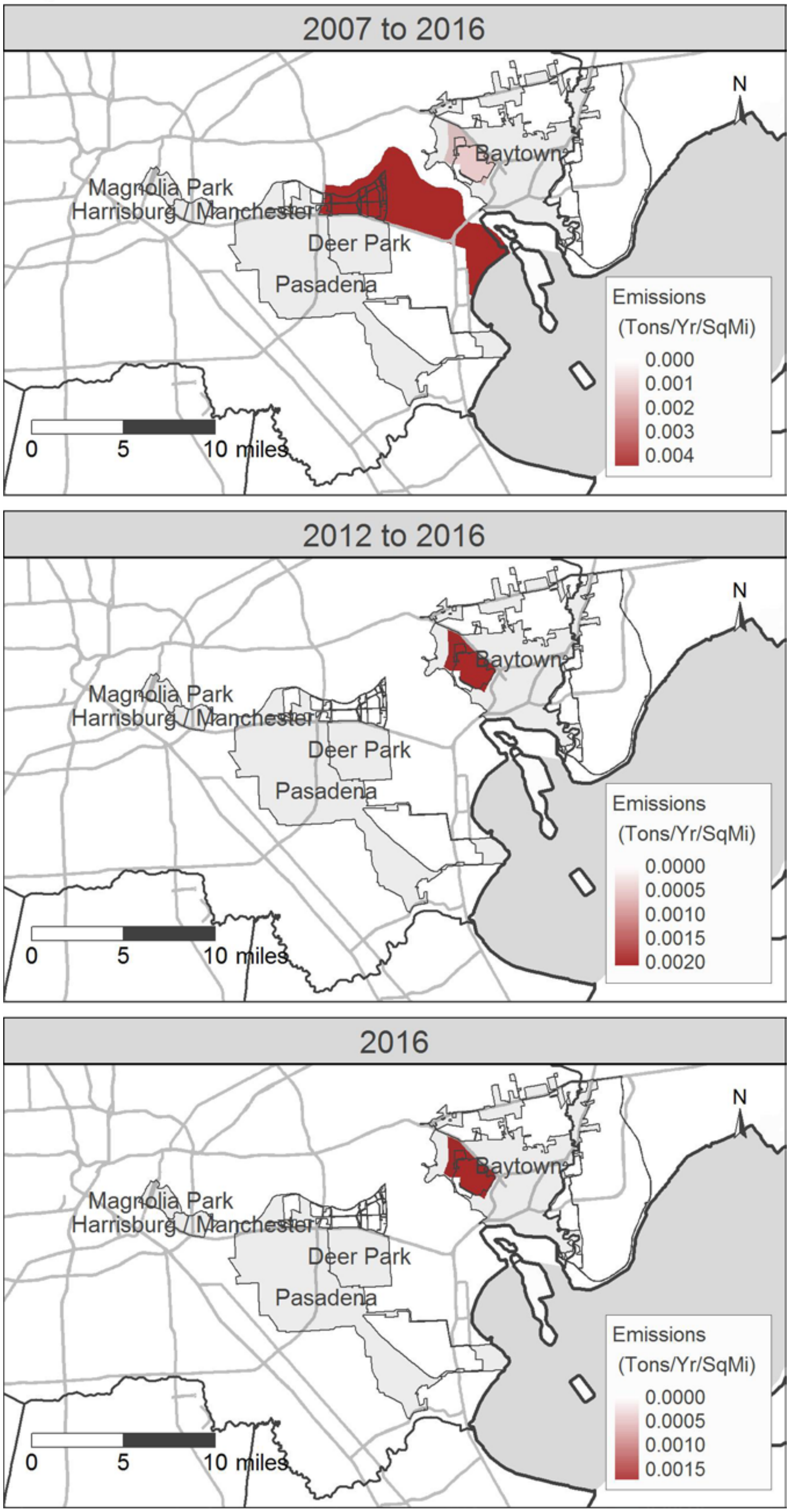


Naphthalene

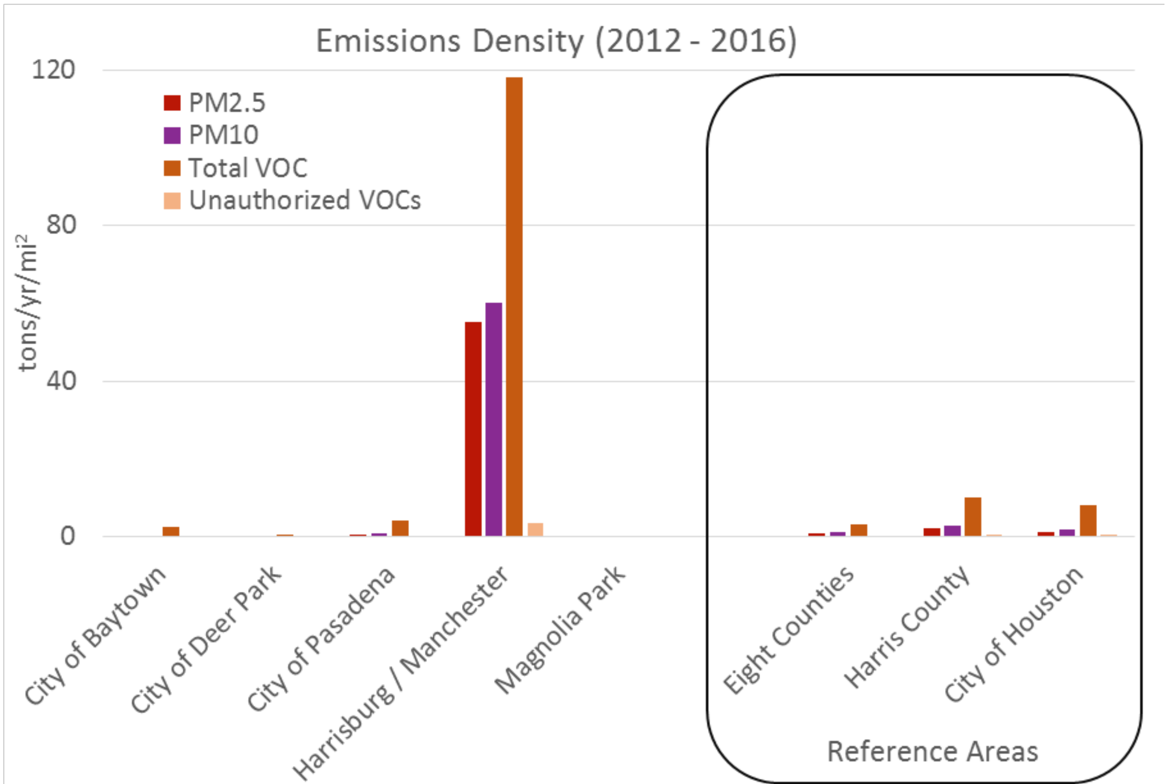


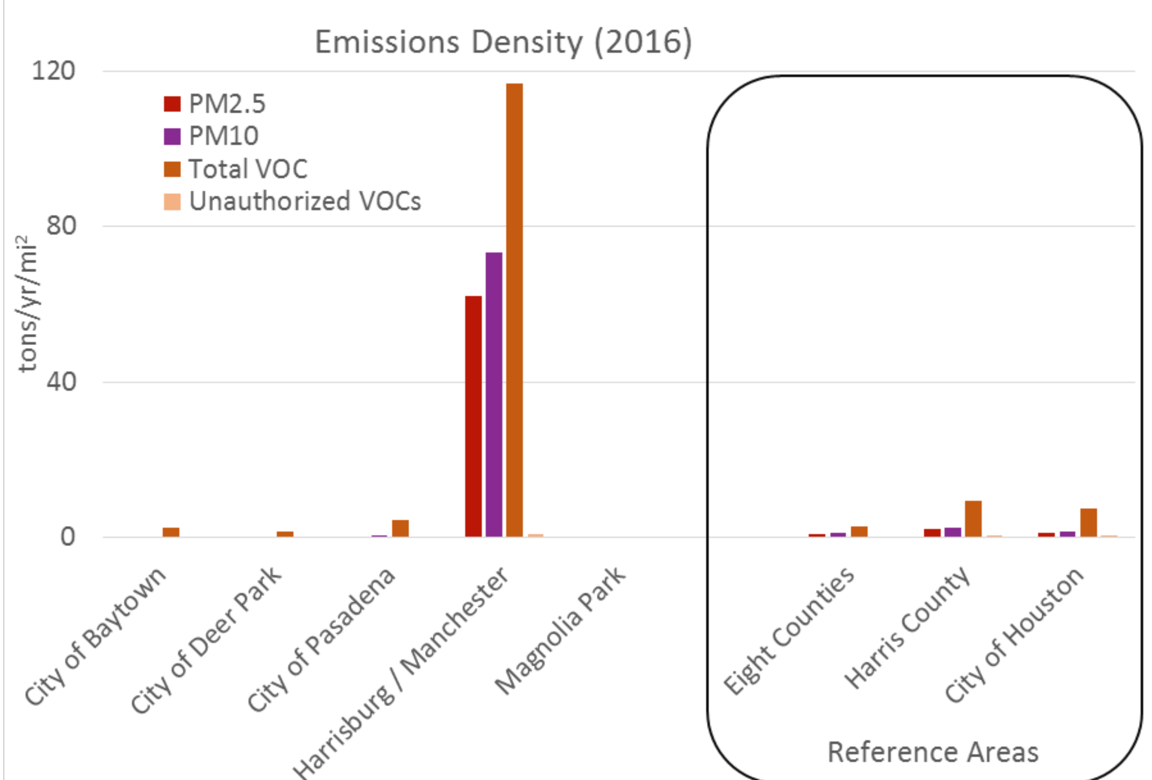

Phenanthrene
2007 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10 miles
2012 to 2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
2.0
0
5
10 miles
2016
N
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
Emissions
(Tons/Yr/SqMi)
0.0
0.5
1.0
1.5
2.0
0
5
10 miles

Pyrene


2007 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0
5
10 miles
Emissions
(Tons/Yr/SqMi)
0.000
0.001
0.002
0.003
0.004
2012 to 2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0
5
10 miles
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015
0.0020
2016
Baytown
Magnolia Park
Harrisburg / Manchester
Deer Park
Pasadena
N
0
5
10 miles
Emissions
(Tons/Yr/SqMi)
0.0000
0.0005
0.0010
0.0015

Appendix F: Emissions for 2012 to 2016 and 2016 in Communities of Interest


Emissions Density (2012 - 2016)
120
80
40
0
tons/yr/mi²
PM2.5
PM10
Total VOC
Unauthorized VOCs
City of Baytown
City of Deer Park
City of Pasadena
Harrisburg / Manchester
Magnolia Park
Eight Counties
Harris County
City of Houston
Reference Areas


Emissions Density (2016)
120
80
40
0
tons/yr/mi²
PM2.5
PM10
Total VOC
Unauthorized VOCs
City of Baytown
City of Deer Park
City of Pasadena
Harrisburg / Manchester
Magnolia Park
Eight Counties
Harris County
City of Houston
Reference Areas

Appendix G: Vulnerability Index and Emissions in Communities of Interest

Demographics and Vulnerability Index in Communities of Interest				
Location	**Poverty (%)**	**Limited-English (%)**	**People of Color (%)**	**Vulnerability Index**
City of Baytown	16.4	8.7	61.3	28.8
City of Deer Park	8.6	2.4	30.5	13.8
City of Pasadena	19.6	12.2	67.3	33.0
Harrisburg / Manchester	28.4	30.1	96.6	51.7
Magnolia Park	28.9	37.2	97.8	54.7
Eight Counties	15.3	9.6	60.6	28.5
Harris County	17.4	11.8	67.0	32.1
City of Houston	21.9	14.0	74.4	36.8

Emissions in Communities of Interest
(tons / year / sq mile estimated at the census tract level)

	2007 to 2016				2012 to 2016				2016			
Location	**PM2.5**	**PM10**	**Total VOC**	**Unauthorized VOCs**	**PM2.5**	**PM10**	**Total VOC**	**Unauthorized VOCs**	**PM2.5**	**PM10**	**Total VOC**	**Unauthorized VOCs**
City of Baytown	0.11	0.14	2.5	0.052	0.12	0.15	2.6	0.06	0.13	0.16	2.6	0.00022
City of Deer Park	0.000010	0.000010	0.31	NA	0.000021	0.000021	0.62	NA	0.000095	0.000095	1.4	NA
City of Pasadena	1.1	1.31	4.1	0.16	0.58	0.83	4.1	0.2	0.37	0.38	4.4	0.066
Harrisburg / Manchester	58	62	114	6.5	55	60	118	3	62	73	117	0.72
Magnolia Park	0.15	0.15	0.12	NA	0.16	0.16	0.11	NA	0.17	0.17	0.13	NA
Eight Counties	1.0	1.3	3.7	0.24	1.0	1.2	3.3	0.20	0.95	1.1	3.0	0.14
Harris County	2.4	3.4	11	0.71	2.3	3.0	10	0.56	2.3	2.6	9.4	0.49
City of Houston	1.1	2.1	8.1	0.45	1.1	1.9	8.0	0.56	1.2	1.5	7.3	0.53

*NA indicates no reported emissions of this type in this location.