

# Houston, We Have a Problem

**A Roadmap for Reducing  
Petrochemical Industry Toxic  
Emissions in  
the Lone Star State**

**Executive Summary**

Galveston-Houston Association for Smog Prevention  
Industry Professionals for Clean Air  
Environmental Defense Fund  
Environmental Integrity Project

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#### **GALVESTON-HOUSTON ASSOCIATION FOR SMOG PREVENTION (GHASP)**

GHASP's mission is to persuade government and corporate officials to prevent smog. GHASP seeks to accomplish its mission by being the most credible advocate for clean air in the Houston region; by supporting efforts to educate the public and intensify the political climate; and by directly engaging government officials, community leaders, the media and industry on regional air pollution issues. For more information, visit [www.ghasp.org](http://www.ghasp.org).

#### **INDUSTRY PROFESSIONALS FOR CLEAN AIR (IPCA)**

IPCA is a group of petroleum and petrochemical industry professionals who are concerned about the slow progress toward clean air in the Houston region. We are enlisting like-minded individuals who can offer their expertise in plant operations, economics, design and environmental controls. For more information, visit [www.ipcahouston.org](http://www.ipcahouston.org).

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As the petrochemical capital of the United States, the Houston area is at the center of a toxics storm. Numerous studies have documented dangerous levels of toxic air pollution in the Houston area, including the Milby Park and Galena Park neighborhoods. Communities in other industrialized areas throughout Texas face similar toxic threats. Refineries and chemical plants along the Texas Gulf Coast are major contributors to toxic hotspots in Beaumont, Corpus Christi, Freeport, Port Arthur, Port Neches, and Texas City.

Using Houston as a case study, this report details many of the shortcomings of federal and state toxics regulation, and provides a roadmap for reducing emissions of these harmful pollutants from refineries and chemical plants throughout the state of Texas and beyond.

Unfortunately, Texans cannot count on federal or state laws to protect their health. The U.S. Environmental Protection Agency's industrial toxics program is woefully behind schedule in meeting congressional deadlines. And, even more alarmingly, the federal program does not deal with real-world impacts of toxic pollution, particularly in local toxic hotspots.

To address these deficiencies, a number of states and local governments have adopted their own, more stringent air toxics programs. Texas regulators and politicians, however, have been unable or unwilling to place adequate limits on industrial toxic air emissions to protect the health of Texans.

As a result, Texas industry has not been required to utilize the best available controls and practices for limiting toxic emissions, and cities like Houston have struggled to protect their residents' health.

State and federal government officials can help by improving toxic monitoring and taking into account real-world (cumulative) impacts in heavily industrialized neighborhoods. Texas politicians can also help by adopting legislation to require emission reductions in areas where toxic pollution exceeds safe levels, and encouraging, rather than thwarting, local programs designed to protect public health in toxic hotspots.

Perhaps most importantly, it is time for industry leaders to take responsibility to clean up their toxic emissions. Petrochemical industry executives should make toxic pollution reduction a priority second only to safety. They should support reasonable regulatory measures. And, most of all, petrochemical industry leaders should turn loose their plant managers and engineers to come up with the technical solutions to reduce their toxic emissions and protect public health. At a minimum, industry should adopt controls and practices similar to those discussed in this report, or others that achieve equivalent emission reductions.

# The Federal Toxics Program Does Not Address Hotspots

## Why Federal Regulation Fails to Protect Public Health in Toxic Hotspots

As noted in various governmental reports, EPA's industrial source toxics program suffers from both structural and implementation failings.<sup>1</sup> The program is woefully behind schedule in meeting congressional deadlines and is seriously under funded.<sup>2</sup> Perhaps more importantly, the Clean Air Act's toxic provisions do not address real world impacts of toxic pollution, particularly in local toxic hotspots.

### Toxic Emissions Are Not Monitored and are Under-Reported

EPA evaluates the residual risk from industrial toxic pollutants by modeling the effects of toxic emissions on ambient air. To do this, EPA must estimate how much toxic pollution is released into the air. But, EPA relies largely on industry's self-reported estimates.

Recent Houston studies found levels of actual volatile organic compounds (VOCs) from petrochemical facilities to be one to two orders of magnitude (10 to 100 times) higher than reported levels.<sup>3</sup> Monitoring in Canada and Europe has found refinery VOC emissions to be 10 to 20 times higher than reported, with refinery benzene emissions being 18 times higher than calculated emission estimates.<sup>4</sup>

Because reported emissions included in health effects models are likely lower than real world emissions, those health models necessarily under-predict risk.

### EPA Fails to Consider Aggregate or Cumulative Health Risks

When evaluating residual risk, EPA only

looks at the risk from certain pollution sources, or units, at an industrial plant.<sup>5</sup>

The risk analysis does not consider all toxic emissions from the plant. Nor does it consider toxic emissions from surrounding plants. And, it does not address the health impacts from exposure to multiple toxic pollutants at once.

### Current Federal Laws Fail to Address Environmental Justice Impacts

When it comes to toxic air emissions, EPA actually sets a separate, weaker, health standard for industrial fence-line communities. EPA's stated goal is to provide two-tier protection:

(1) To expose the greatest number of persons possible to an individual lifetime cancer risk of no higher than 1 in 1 million, and

(2) To limit, to no higher than 1 in 10,000 [100 in 1 million], the estimated excess cancer risk to persons living near an industrial plant.<sup>6</sup>

### EPA Lacks an Updated List of Air Toxics and Adequate Health Data

The Clean Air Act requires EPA to periodically update its list of hazardous (or toxic) pollutants, but EPA has no process for doing so.<sup>7</sup> Despite the fact that approximately 300 new chemicals enter commerce each year, EPA has yet to add one to the list of regulated air toxics.<sup>8</sup>

## State and Local Governments Must Protect Public Health

### Some State and Local Governments Have Taken Action

In response to ambient monitoring showing elevated levels of air toxics, a number of states and local air pollution control districts

have adopted innovative programs to reduce local public health risks from air toxics.<sup>9</sup> As shown in Table 1 (p. 4), Sample State/Local Air Toxics Programs, various state and local programs improve upon EPA’s regulatory system by:

- regulating more industrial sources than EPA,
- setting more stringent standards than EPA,
- using risk-based approaches for setting priorities,
- considering cumulative impacts,
- identifying and prioritizing new chemicals, and
- requiring standardized, certified, toxic emission reporting.<sup>10</sup>

### Texas Lacks an Enforceable Hotspots Program

Unlike some states, Texas implements the federal toxics program, but does not have its own enforceable toxics standards.<sup>11</sup> The state environmental regulatory agency, the Texas Commission on Environmental Quality (TCEQ), sets target health-based ambient toxics levels, which it refers to as Effects Screening Levels, or ESLs. These ambient toxic goals are designed to ensure a no greater than 1 in 100,000 increase in the risk of cancer from individual air toxics, and are used as guidelines during the permitting process.<sup>12</sup> TCEQ does not, however, treat these health-based ambient toxic goals as enforceable limits, and the agency routinely issues permits for sources whose emissions cause exceedances of the ESLs.

Table 2, TCEQ’s Air Pollutant Watch List, identifies 14 areas of the state where air monitoring shows ambient toxic levels above the health based goals, or ESLs. These areas have been identified as areas of concern for short or long term health effects, and have been placed on the state’s Air Pollutant Watch List.<sup>13</sup>

Unfortunately, there is no formal

mechanism for ensuring that toxic pollution in these areas is reduced to healthier levels (i.e., toxic levels that are lower than the state’s ambient toxic goals, or ESLs). As a result, some areas, such as Port Neches and Corpus Christi, have exceeded the state’s health-based toxic goals for a decade or more.

### The Houston Example

As the petrochemical capital of the United States, the Houston area is at the center of a toxics storm.<sup>14</sup> Recent studies by the City of Houston, local universities, and medical

TABLE 2. TCEQ’S AIR POLLUTANT WATCH LIST

County	City	Pollutant	Listed Since
Bastrop	Bastrop	hydrogen sulfide	2007
Bowie	Cass	hydrogen sulfide	1999
Brazoria	Freeport	Arsenic	2005
		Cobalt	
		Nickel	
		Vanadium	
Dallas	Dallas	Nickel	2004
El Paso	El Paso	hydrogen sulfide	2004
Galveston	Texas City	Acrolein	2001
		Butyraldehyde	
		propionaldehyde	
		Valeraldehyde	
		Benzene	
Harris	Lynchburg Ferry	hydrogen sulfide	2004
		benzene	
		Styrene	
	Galena Park	Benzene	2000
	Houston	1,3-butadiene	1999
Jasper	Evadale	hydrogen sulfide	2003
Jefferson	Beaumont	hydrogen sulfide	2002
		sulfur dioxide	2003
		Benzene	2004
	Port Arthur	Benzene	2001
	Port Neches	1,3-butadiene	1996
Nueces	Corpus Christi	Benzene	1998

TABLE 1. SAMPLE STATE/LOCAL AIR TOXICS PROGRAMS<sup>15</sup>

State	Program Description	Pollution Thresholds
California Air Resources Board <sup>16</sup>	<p>AB1807 requires identification of toxic air contaminants and exposure levels to protect public health. If necessary to reduce risk CARB must adopt control strategies.</p> <p>Hotspot program requires certain large and small stationary sources to report emissions of air toxics, estimate the public health impact of their emissions, notify neighbors, and take all possible actions to reduce emissions as necessary to meet health-based standards within 5 years.</p>	<p>Threshold for program applicability is the 1-in-1-million risk level.</p> <p>Notice is required to the affected public if risk exceeds 10-in-1-million.</p> <p>Facility risk reduction levels are set by local air district. Sacramento uses 10-in-1-million; Los Angeles 25-in-1-million; San Diego and the Bay Area use 100-in-1-million.</p>
Louisiana <sup>17</sup>	Requires sources to: (1) use Maximum Achievable Control Technology for reducing toxic emissions if the source exceed established Minimum Emission Rates (MERs) and (2) meet ambient toxic air standards. Also requires state toxic emission inventory.	<p>MERs were initially set based on 1-in-a-million risk level.</p> <p>Ambient air standards are set at 1-in-10 thousand risk level.</p>
Louisville, KY <sup>18</sup>	<p>Louisville's program was instituted because levels of 17 Toxic Air Contaminants (TACs) in the area exceeded 1-in-1 million cancer goal.</p> <p>The program includes a general duty to not emit a TAC in an amount or duration that is harmful to the health and welfare of humans, animals or plants.</p> <p>In addition, the program requires large and medium industrial sources to report emissions and determine if toxic emissions exceed health-based thresholds. If thresholds are exceeded, sources must submit plans for reducing emissions of TACs. Reductions in 18 priority TACs must be achieved by 2011.</p> <p>Finally, the program requires a study of whether specific reductions are needed from other sources, such as smaller businesses and cars.</p>	<p>Individual pieces of: (1) existing and (2) new and modified equipment must meet the 1-in-1-million for single TACs.</p> <p>The cumulative emissions of all applicable TACs must not exceed: (1) 3.8-in-1-million from all collective new and modified equipment, and (2) 7.5-in-1-million from all collective existing and new and modified equipment.</p>
New Jersey <sup>19</sup>	<p>Requires facilities seeking permits to apply air toxic emission "state-of-the-art" control technologies.</p> <p>Facilities must estimate the risk posed by their emissions. If benchmarks are exceeded a case-by-case review is conducted and the state may require more stringent controls.</p>	Benchmarks are set at the 1-in-1-million level.
Oregon <sup>20</sup>	<p>"Safety Net" program targets facilities that alone cause exceedances of ambient benchmarks.</p> <p>Geographic hotspots must develop plans to meet the ambient benchmarks within 10 years. Hotspots are designated based on criteria including number and extent of benchmark exceedances and the risk from multiple pollutants and pollutant mixtures.</p> <p>Some source category rules limit emissions from sources that contribute to benchmark exceedances.</p>	Ambient benchmarks are set at the 1-in-1-million level.

schools have documented dangerous levels of toxic air pollution in parts of the city. The City of Houston recently identified 12 chemicals that are present in the air at levels that pose a definite health risk.<sup>21</sup>

A study by Rice University, Baylor College of Medicine, Texas Southern University, University of Houston Law Center and the University of Texas Medical Branch at Galveston looked in detail at four pollutants and found:

Mounting evidence demonstrates that the population of Southeast Texas is exposed to disproportionate levels of toxic air pollutants considered to be a health risk to this population.<sup>22</sup>

Houston-area residents pay a price for this toxic pollution. Individuals pay with their health, due to exposure to toxics and to ozone. The general public pays for increased health costs and lowered productivity.<sup>23</sup> In addition, Houston has gained a negative reputation for its air pollution, which makes it harder to attract new companies and the workers Houston needs.

### *The Source of Houston's Problems*

Houston's toxic air pollution comes from many sources, including industry. Benzene, for example, is emitted by industry, as well as mobile sources (i.e., from the tailpipes of cars and trucks). But, because mobile source emissions are dispersed across a wide area, they do not generally cause toxic hotspots. Large industrial facilities, by contrast, are often clustered together, such as along the Houston Ship Channel.

In terms of health risk for an exposed population, it is the concentration of the benzene (or any toxic) exposure that matters, and not the total amount emitted county wide.

There is mounting evidence that industry, not cars, is responsible for Houston's toxic hotspots. For example:

- The areas on the state's Air Pollutant Watch List, where concentrations of toxics exceed the state's health-based goals

(ESLs), are primarily industrial areas, or are directly downwind of industrial areas,<sup>24</sup>

- Monitoring during airplane flyovers has found that benzene levels in downtown Houston are similar to those in Dallas, but that benzene levels rise substantially over the Houston Ship Channel;<sup>25</sup> and
- High benzene levels over the Houston Ship Channel are not associated with high carbon monoxide levels, showing that cars are not the problem. Cars emit carbon monoxide as well as benzene. In locations that do not have industrial complexes, ambient benzene levels rise in proportion to ambient carbon monoxide levels. Along the Houston ship channel, benzene levels rise without associated rises in carbon monoxide, suggesting that the main source of the benzene along the Ship Channel is not cars.<sup>26</sup>

In addition to creating toxic hotspots, emissions of toxics and other VOCs, combine with industrial emissions of nitrogen oxides (NOx), resulting in plumes of high ozone that originate near the Houston Ship Channel and then spread across the city.<sup>27</sup> High ozone levels create a health threat for all of Houston. High ozone can cause chest pain, coughing, and throat and lung irritation. It can also worsen bronchitis, emphysema, and asthma, reduce lung function, and permanently scar lung tissue.<sup>28</sup>

Because toxic industrial emissions have a significant effect on public health, it is important to identify the sources of such pollution. In Harris County, 74 percent of industrial benzene emissions, and 79 percent of 1,3- butadiene emissions, are emitted by the organic chemical, petroleum refining, and petroleum bulk station and terminal industries.

# Texas Refineries and Chemical Plants Can Do More to Reduce Toxic Pollution

It is clear that considerable health risks remain for many Texans exposed to unhealthy ambient concentrations of benzene and other air toxics. While science has only begun to quantify cumulative risks, like those from the variety of toxic chemicals present in the air in many Texas' industrial areas, we do know that public exposure to individual chemicals such as benzene remains too high in parts of the state.

This data, coupled with the inability of many areas to meet the federal air quality standard for ozone, suggest that Texas is a long way from having healthy air.

History has shown that industry can rise to meet most challenges. Houston's toxic hotspots persist and ozone levels repeatedly exceed federal standards. And for the air to be safe to breathe for all the state's residents, Texas industry leaders must do their part to clean up toxic emissions.

## Make Pollution Reduction a Corporate Priority Second Only to Safety

Many companies base bonuses on throughput, creating an incentive to increase production at the expense of preventing emissions.<sup>29</sup> If the goals of environmental staff and production staffs are at odds, and production staff are reluctant to temporarily cease operations in order to make repairs, then even those repairs that result in long-term cost savings may not be made.<sup>30</sup>

As Dow Chemical explained when describing its project to reduce startup, shutdown and off-specification product emissions:

One of the main contributors to the overall success of this project was the

adoption of a philosophy that it is an unacceptable practice to flare. This philosophy had to be accepted at all levels. Management (Leadership) supported the project efforts by allowing operations the liberty to slow down the process of upset recovery if the efforts would result in less emissions.<sup>31</sup>

## Increase Monitoring and Verify the Accuracy of Emission Estimates

Relying on inaccurate and outdated emission factors in order to estimate emissions is unacceptable. Numerous studies show that industry estimates dramatically underestimate real emissions. Where continuous monitoring of actual emissions is possible, industry should use such monitoring. Where it is not, companies should verify the accuracy of emission calculations at least every two years, using ambient monitoring technologies that permit site-specific emission estimates, such as Differential Absorption Light Detection and Ranging (DIAL) or Solar Occultation Flux (SOF).

## Use Current Best Controls and Management Practices

Better performing facilities nationwide are implementing technologies and best practices that could be used to minimize toxic emissions in the Houston area. Many of these technologies have been required for years in other jurisdictions or have been required by EPA to resolve enforcement actions.

There are technologies and practices that can be implemented today that will reduce emissions from tanks, fugitives, flares, wastewater systems, cokers,<sup>32</sup> and cooling towers. These include:

- Flare gas recovery to eliminate routine flaring;
- Passive Optical Gas Imaging to support

Leak Detection and Repair (LDAR) programs by identifying unknown sources of leaks, and supplement storage tank and wastewater monitoring programs;

- Venting to control for storage tanks with potentially large toxic emissions;
- Additional speciation requirements for cooling tower monitoring and deadlines for leak repair; and
- Use of fuel gas recovery systems and best management practices to reduce delayed coker emissions.

### *Flare Gas Recovery Virtually Eliminated Flaring at Lion Oil's El Dorado Refinery*

Lion Oil Company's El Dorado Refinery, in Arkansas, installed 2 flare gas recovery systems, which "reduced flaring to near-zero levels, thereby achieving the refinery's emission-reduction objectives and conserving facility resources."

— Hydrocarbon Processing, *Minimize Flaring with Flare Gas Recovery* (June 2002), pp. 83–85.

### *Reducing Flaring Saved Dow Chemical Company \$2.5 Million*

From 2001 to 2003, Dow Chemical Company, in Freeport, Texas, reported a 54 percent reduction in emissions from startup, shutdown and off-specification incidents. The project optimized the use of equipment to re-circulate off-spec hydrocarbons to the front of the plant to be reprocessed. In doing so, Dow documented savings of \$2.5 million.

— Steven Krietenstein, Dow Chemical Co., *Flare Minimization Strategy During Plant Upsets*: Freeport (April 12, 2005).

*Root cause analysis*: California's South Coast and Bay Area Air Quality Management Districts require refineries to conduct root cause analyses of flaring events.<sup>33</sup> EPA has required investigations, reporting, and corrective action for refinery hydrocarbon flaring events in some of its enforcement

actions against Houston area refineries.<sup>34</sup>

### *Inspections and Passive Optical Gas*

*Imaging*: All floating roof tanks and seals should be visually inspected twice per year. Passive Optical Gas Imaging should be used to search for leaks in all fixed and floating roof tanks quarterly and after any repairs. Results should be documented. If leaks are found, inspections should be conducted to determine their source and repairs made.

### *EPA Touts Benefits of Vapor Recovery for Crude Oil Storage Tanks*

"VRUs (Vapor Recovery Units) are relatively simple systems that can capture about 95% of the Btu-rich vapors for sale or for use onsite as fuel. Currently between 8,000 and 10,000 VRUs are installed in the oil production sector, with an average of four tanks connected to each VRU. Natural Gas STAR partners have generated significant savings from recovering and marketing these vapors while at the same time substantially reducing methane and HAP emissions. Partners have found that when the volume of vapors is sufficient, installing a VRU on one or multiple crude oil storage tanks can save up to \$260,060 per year and payback in as little as three months."

— U.S. EPA, *Lessons Learned: Installing Vapor Recovery Units on Crude Oil Storage Tanks*, (Oct. 2003). [www.epa.gov/gasstar/pdf/lessons/11\\_final\\_vap.pdf](http://www.epa.gov/gasstar/pdf/lessons/11_final_vap.pdf)

*Improved Monitoring*: Coker emissions, including VOC and benzene emissions, should be monitored during drilling. Drilling is part of the coking process during which pressure water jets are used to fracture the coke bed in a drum and allow it to fall into the receiving area.

## Conclusion: A Roadmap for Reducing Industrial Toxic Emissions

Existing ambient air monitoring data confirms that toxic hotspots warrant immediate action in urban areas such as Houston. These hotspots are the result of inadequate public health consideration by environmental regulators, and the absence of concerted remedial action by industry and government to reduce ambient toxics to safe levels.

Federal, state and local governments, as well as industry, should implement these steps in order to protect people from the health threats posed by toxic air pollution.

The federal government should:

- Improve toxic monitoring and reporting requirements, including requiring the use of new technologies for measuring facility-wide emissions;
- Consider aggregate and cumulative impacts of toxic emissions in regulatory determinations;
- Require information regarding the health impacts of chemicals before they are released to the market; and
- Adopt legislation to identify and assist in the cleanup of local toxic hotspots.

The State of Texas should:

- Adopt enforceable ambient toxic standards;
- Adopt hotspots legislation requiring state or local governments to identify and clean up local areas with unsafe ambient levels of air toxics; and
- Encourage local governments to implement programs to protect residents from adverse health effects due to toxic

air pollution.

Industry should:

- Make toxic pollution reduction a company priority, second only to safety;
- Increase toxics monitoring and verify the accuracy of emissions estimates through the use of LIDAR or similar facility-wide monitoring;
- Use current best available technologies and management practices to reduce toxic emissions, including:
  - Flare gas recovery to eliminate routine flaring;
  - Passive Optical Gas Imaging to support LDAR programs by identifying unknown sources of leaks, and supplement storage tank and wastewater monitoring programs;
  - Venting to controls for storage tanks with potentially large toxic emissions; Additional speciation requirements for cooling tower monitoring and deadlines for leak repair; and
  - Use of fuel gas recovery systems and best management practices to reduce delayed coker emissions; and
- Support reasonable regulatory proposals, instead of using publicly unaccountable lobbying firms and trade associations to fight toxic control requirements.

### Eliminating Leaks Often Pays for Itself

In the process of focusing on pollution sources, owners of industrial facilities often find they ultimately save money by locating leaky equipment. In the Shoreacres investigation, once the emissions problem was resolved, the company was no longer losing valuable raw product. In these cases, the pollution control equipment pays for itself in short order.

— TCEQ, Forecast for Houston: Air Quality Improving, Natural Outlook (Spring 2008).

- (GAO 06-669).
- 1 See U.S. General Accounting Office, *Air Pollution: EPA's Strategy and Resources May Be Inadequate to Control Air Toxics*, (June 26, 1991); *Air Pollution: Progress and Problems in Implementing Selected Aspects of the Clean Air Act Amendments of 1990* (Oct. 29, 1993); *Air Pollution: Reductions in EPA's 1994 Air Quality Program's Budget* (Nov. 29, 1994); and *Clean Air Rulemaking: Tracking System Would Help Measure Progress of Streamlining Initiatives* (Mar. 2, 1995). See also, U.S. Government Accountability Office, *EPA Should Improve the Management of its Air Toxics Program* (June 26, 2006). See also, EPA Office of Inspector General, *Progress Made in Monitoring Ambient Air Toxics, But Further Improvements Can Increase Effectiveness*, (March 2, 2005); *Improvements in Air Toxics Emissions Data Needed to Conduct Residual Risk Assessments* (Oct. 31, 2007).
  - 2 U.S. Government Accountability Office, *EPA Should Improve the Management of its Air Toxics Program* (June 26, 2006) (Report No. GAO-06-669).
  - 3 TexAQS II Rapid Science Synthesis Team, *Final Rapid Science Synthesis Report: Findings from Second Texas Air Quality Study (TexAQS II)* (Aug. 31, 2007), p. 7 Finding C2. <http://www.esrl.noaa.gov/csd/2006/rss/rsstfinalreport083107.pdf>. VOCs are chemical compounds that have high enough vapor pressures under normal conditions to significantly vaporize and enter the atmosphere or to participate in a photoreaction.
  - 4 EPA, *Technical Memorandum: Potential Low Bias of Reported VOC Emissions from the Petroleum Refining Industry* (July 27, 2007), p. 1. (EPA Docket No. EPA-HA-OAR-2003-0146).
  - 5 In fact, EPA does not even consider all emissions from the units it is reviewing. It does not include in its consideration impacts from non-routine events, such as unit startup, shutdown, or malfunction.
  - 6 EPA, Office of Air Quality Planning and Standards, *Residual Risk Report to Congress*, (March 1999), p. ES-11.
  - 7 <http://www.epa.gov/ttn/atw/orig189.html>. See also, U.S. Government Accountability Office, *EPA Should Improve the Management of its Air Toxics Program* (June 26, 2006), p. 19. (GAO 06-669).
  - 8 GAO 06-669, at p. 19.
  - 9 A 1995 survey by STAPPA ALAPCO found that 60% of respondents had risk-based air toxics programs, 50% of which addressed both new and existing sources.
  - 10 U.S. Government Accountability Office, *EPA Should Improve the Management of its Air Toxics Program* (June 26, 2006), p. 6–7.
  - 11 Some Texas rules for reducing ozone levels, however, require reductions in VOCs, including toxics.
  - 12 TCEQ, *Guidelines to Develop Effects Screening Levels, Reference Values, and Unit Risk Factors* (Nov. 2006), p. 3–5.
  - 13 See, <http://www.tceq.state.tx.us/implementation/tox/AirPollutantMain/APWL.html>.
  - 14 <http://www.houston.org/industryGuide/petrochemical.asp>.
  - 15 For detailed information regarding other state toxics programs, see Rice University, Baylor College of Medicine, Texas Southern University, University of Houston Law Center and the University of Texas Medical Branch at Galveston, *The Control of Air Toxics: Toxicology, Motivation and Houston Implications* (Sept. 2006), p. 116-154.
  - 16 CA Assembly Bill 1807, Tanner 1983. CA Assembly Bill 2588, Connelly 1987. Health & Safety Code, Div. 26, Part 6.
  - 17 LAC33:III.Chapter 51, Subchapter A.
  - 18 Louisville APCD Regs. Part 5.<sup>1</sup>
  - 19 N.J.A.C. 7:27–17.
  - 20 OR Dept. Env. Quality Rules 340-246-0010 through 0230.
  - 21 City of Houston, *Mayor's Task Force on the Health Effects of Air Pollution, A Closer Look at Air Pollution in Houston: Identifying Priority Health Risks* (June 2006), p. 13.
  - 22 Rice University, Baylor College of Medicine, Texas Southern University, University of Houston Law Center and the University of Texas Medical Branch at Galveston, *The Control of Air Toxics: Toxicology, Motivation and Houston Implications* (Sept. 2006), at p. 181.
  - 23 MIT Laboratory for Energy and the Environment, Energy Environment (July 2005) *Benefits of Environmental Regulation: Calculating the Economic Gains from Better Health*, p. 6.
  - 24 See maps at <http://www.tceq.state.tx.us/implementation/tox/AirPollutantMain/APWL.html>.
  - 25 Joost de Gouw, Carsten Warneke, NOAA, Environmental System Research Laboratory and CIRES, University of Colorado, *Emissions and Chemistry of Atmospheric VOCs: New Insights from Airborne and Ship-Based Measurements*, slide 24.
  - 26 Id, at slide 25.
  - 27 TCEQ, *Final Rapid Science Synthesis Report: Findings from the Second Texas Air Quality Study* (Aug. 31, 2007), Findings A1 and A2 (The highest (i.e. > 125 ppbv) ozone concentrations in the Houston/Galveston/Brazoria area result from rapid and efficient

ozone formation in relatively narrow, concentrated plumes, which originate from HRVOC and NO<sub>x</sub> co-emitted from petrochemical facilities. The Houston Ship Channel (HSC) is the origin of the plumes with the highest ozone concentrations.

(Winds carry the emission plumes from the ship channel throughout the Houston area.)

- <sup>28</sup> EPA, <http://www.epa.gov/air/ozonepollution/health.html>.
- <sup>29</sup> See, for example, U.S. EPA, *VOC Fugitive Losses: New Monitors, Emission Losses, and Potential Policy Gaps 2006 International Workshop* (Oct 25-27, 2006) p. 20.
- <sup>30</sup> EPA, *VOC Fugitive Losses: New Monitors, Emission Losses, and Potential Policy Gaps* (2006 International Workshop, Oct 25–27, 2006), p. 19.
- <sup>31</sup> Steven Krietenstein, Dow Chemical Co., *Flare Minimization Strategy During Plant Upsets: Freeport* (April 12, 2005).
- <sup>32</sup> EPA has identified cokers as one of the largest sources of refinery benzene emissions, pursuant to LIDAR studies. Coker toxic emissions are not, however, reflected in the state data. U.S. EPA, *Technical Memorandum: Potential Low Bias of Reported VOC Emissions from Petroleum Refining Industry* (July 27, 2007), p. 4–5.
- <sup>33</sup> SCAQMD Rule 1118(c)(1)(D) and (e); BAAQMD Rule 12-12-406.
- <sup>34</sup> See, for example, U.S. v. ExxonMobil Corporation, Consent Decree p. 80. See also, U.S. EPA, *EPA Enforcement: National Petroleum Refinery Initiative* (EPA-HQ-OAR-2007-0011-0112).