



Refinery Air Emission Metrics

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I. Introduction

The air emissions emitted from refineries in the U.S. continues to be an important topic for industry, US Environmental Protection Agency (“EPA”), state agencies, NGOs, and other environmental groups. Providing accurate and complete emission data is important for numerous reasons, including demonstrating permit compliance, demonstrating acceptable risk, avoiding lawsuits, etc.

This paper investigates the historical air emissions refiners have provided to the EPA through the Toxic Release Inventory (“TRI”) and then compares this data with the emission data set used by EPA in the current proposed Petroleum Refinery Sector Risk and Technology Review (“RTR”) rule.¹ Very surprising results were discovered. In addition, a comparison of the historical increase in environmental regulations is provided and contrasted with the refinery industry.

II. U.S. Refineries

For this study, the emissions data was limited to the U.S. refineries in operation in 2012 and for which there was available data. The TRI data program began in 1988. The Department of Energy (“DOE”) indicates that in 1988 there were 215 total operable refineries in the US.² In 2012, the DOE reported that there were 144 operable refineries in the US. Therefore in this study, only the refineries that were operating in 2012 and that had submitted TRI data every year since 1988 were used in the analysis.

III. TRI Data

A. TRI Refineries

For each of the refineries, TRI data was obtained from the EPA TRI database.³ Each refinery’s TRI emission database was obtained and then was combined into one TRI database. Review

¹ 79 Federal Register, June 30, 2014, pg. 36,880.

² DOE – Energy Information Administration, Petroleum and Other Liquids, U.S. Number of Operating Refineries as of January 1, 2014.

³ EPA TRI Explorer, http://iaspub.epa.gov/triexplorer/tri_release.chemical.



of this data indicated that several of the refineries had reported separate TRI refineries, even though some refineries were contiguous or adjacent. To ensure each refinery was distinct, our staff plotted the coordinates of each refinery to determine if the refineries were separate. In some cases, we combined the TRI emissions data sets of refineries to conform to the DOE list of refineries. There were, in some cases refineries listed in the DOE list that we could not find or did not submit TRI data. Ultimately, we ended up with 140 distinct TRI refinery data sets. A list of 140 TRI Refineries used in this analysis is included as Table A-1 in the Appendix.

B. TRI Air Pollutants

For each refinery, the TRI data was obtained for every year from 1988 to 2012, or 25 years of data. Each record consisted of the TRI emissions (air, water, waste, recycle, etc., total of 24 categories) for each refinery, for each pollutant, and for each emission category (over 1.4 million emission records). For all of the refineries, for all 25 years, a total of 181 separate TRI pollutants were identified as being emitted by a refinery sometime between 1988 - 2012. A list of all TRI Refinery Pollutants is included as Table A-2 in the Appendix.

C. TRI Air Emissions

We assembled the individual refinery data sets into one large database. The air emissions of each pollutant from every refinery were summed for each year and compiled into a spreadsheet. A sample of the spreadsheet showing the 20 largest air emissions pollutants for the years 2010 – 2012 is shown on Table 1. The entire spreadsheet is included at Table A-3 in the Appendix.

Table 1 shows that the highest air emissions come from ammonia and sulfuric acid. One small refinery in the south consistently accounts for over 20% of the ammonia emissions. The highest Volatile Organic Compound (“VOC”) emitted is n-Hexane.

In general, the TRI emissions had trended downward each year. Some spike in emissions occur, however, occasionally as in 2012 a new pollutant is added to the TRI pollutant list. In 2012, hydrogen sulfide (“H₂S”) was added and became the 9th highest emitting TRI air pollutant that year.

Another dramatic change has occurred with the air emissions of hydrogen cyanide (“HCN”). EPA has indicated, that based upon a few stack tests of the Fluid Catalytic Cracking Unit (“FCCU”), the emissions of HCN are dramatically higher than previously reported. The TRI air emissions of HCN have gone up by a factor of 10 since 2008.



Table 1
Highest 20 TRI Air Emissions, 2008 – 2012
(pounds per year)

#	Pollutant	2008	2009	2010	2011	2012	2008 - 2012
1	Ammonia	6,034,156	5,107,768	5,571,721	5,506,313	5,201,647	27,421,605
2	Sulfuric Acid	6,063,101	4,834,199	4,991,899	5,318,020	4,934,749	26,141,968
3	n-Hexane	3,208,544	2,736,911	2,953,131	3,073,976	3,021,475	14,994,037
4	Toluene	2,837,234	2,530,059	2,439,882	2,321,161	2,340,640	12,468,975
5	Propylene	3,062,746	2,217,611	1,922,824	1,988,014	1,868,551	11,059,746
6	Xylene	2,304,116	2,150,418	1,954,175	1,774,063	1,724,788	9,907,560
7	Hydrogen Cyanide	425,604	522,013	497,466	2,370,572	4,571,718	8,387,372
8	Benzene	1,745,957	1,461,587	1,472,636	1,380,688	1,310,264	7,371,133
9	Hydrochloric Acid	954,102	931,277	882,751	1,057,322	791,839	4,617,292
10	Ethylene	1,030,137	842,123	704,859	644,610	685,221	3,906,951
11	Methanol	598,292	570,991	720,457	763,278	790,821	3,443,839
12	Cyclohexane	644,829	716,626	647,985	544,871	619,019	3,173,329
13	Ethyl Benzene	584,748	545,074	520,443	463,843	445,264	2,559,372
14	1,2,4-Trimethylbenzene	557,684	531,272	485,132	404,984	399,946	2,379,017
15	Carbonyl Sulfide	468,182	343,388	318,112	325,063	283,822	1,738,566
16	Hydrogen Sulfide	0	0	0	0	1,553,583	1,553,583
17	Methyl Isobutyl Ketone	325,178	250,765	218,207	298,421	254,650	1,347,220
18	Hydrogen Fluoride	384,679	377,030	340,807	70,677	52,978	1,226,171
19	Naphthalene	227,933	188,410	190,243	185,466	272,509	1,064,561
20	1,3-Butadiene	95,351	90,005	92,273	213,475	225,674	716,778
	TOTAL – Top 20	31,552,572	26,947,526	26,925,001	28,704,817	31,349,158	
	TOTAL – All 181 Pollutants	32,989,365	28,113,014	28,079,051	29,895,369	32,571,386	



Additional analyses can be made with the database depending upon the analysis desired. The additional categories for TRI emissions are included on Table 2.

Table 2
TRI Source Categories

Categories
Fugitive Air
Stack Air
Total Air
Surface Water Discharge
Underground Injection
Land Disposal
Total on-site release
Off-site release
Total on- and off-site releases
Transfer to recycling
Transfer to energy recovery
Transfer to treatment
Transfer to POTWs
Other off-site transfer
Total transfers off-site for waste management
Recycled on-site
Recycled off-site
Energy recovery on-site
Energy recovery off-site
Treated on-site
Treated off-site
Quantity released on- and off-site
Total production related waste managed
Non production related waste managed

Analyses can be made to help a refinery understand how its refinery emissions compares with the industry norm. For example, we normalized the 2012 TRI air emissions based upon the 2012 crude capacity of each refinery. To do this we divided the total air emissions (fugitive and stack) by the crude capacity.⁴

⁴ Crude Capacity obtained from DOE-EIA, Refinery Capacity Report, 2012, June 2012.



The range of TRI air emissions divided by crude capacity ranged from 58.3 to 0.00 pounds-air/barrel-crude capacity. (Note, two Alaskan refineries reported no emissions for 2012. The 58.3 factor was from a small refinery with large ammonia emissions. Two (2) refineries were above 10.0 and an additional 3 refineries were between 5.0 and 10.0. Eighty-one (81) refineries were between 5.0 and 1.0 pounds or air emissions per barrel of crude capacity.

Analysis could be made for individual pollutants, different years, ranges of crude capacity, etc.

D. Number of Pollutants Reported by Refinery

We next determined the number of refineries that reported specific pollutants, by year. Shown on Table 3 is a sample of the analysis that was performed. This table shows for the 20 highest emitted pollutants, the number of refineries that reported each pollutant for the years 2008 – 2012.

Not surprisingly, benzene is the most reported pollutant by refineries. However, what is surprising, is that of the 140 TRI refineries, only ~120 refineries report benzene. A complete list of the number of reported chemicals, by year is shown in the Appendix, as Table A-4. Each refiner should review this table to see how many which pollutants are reported by their peer refineries to determine if additional research should be done by the refiner to confirm the potential emissions of TRI pollutants.

IV. EPA RTR Residual Risk Assessment

On June 30, 2014 EPA proposed the Petroleum Refinery Sector Risk and Technology Review rules. Accompanying this proposed was the Residual Risk Assessment.⁵ The RTR is a combined effort to evaluate both risk and technology as required by the Clean Air Act (“CAA”) after the application of maximum achievable control technology (“MACT”) standards. Section 112(f)(2) of the CAA directs EPA to conduct risk assessments on each source category subject to MACT standards, and to determine if additional standards are needed to reduce residual risks.

As part of this risk assessment, EPA reviews the actual Hazardous Air Pollutants, (“HAPs”) emissions from refineries and models these HAP emissions to determine if unacceptable risks

⁵ EPA Office of Air Quality Planning and Standards, Office of Air and Radiation, Draft – *Residual Risk Assessment for the Petroleum Refining Source Sector*, May 2014.



Table 3
Number of Refineries Reporting Each Pollutant

	Pollutant	2008	2009	2010	2011	2012
1	Ammonia	98	99	98	102	100
2	Sulfuric Acid	70	66	64	63	60
3	N-Hexane	118	121	120	119	119
4	Toluene	118	120	120	119	119
5	Propylene	99	101	98	100	100
6	Xylene	118	119	119	119	119
7	Hydrogen Cyanide	32	32	31	44	46
8	Benzene	120	122	122	122	121
9	Hydrochloric Acid	55	56	51	53	53
10	Ethylene	98	97	93	96	95
11	Methanol	67	67	66	64	64
12	Cyclohexane	112	114	112	113	114
13	Ethyl Benzene	118	121	122	122	120
14	1,2,4-Trimethylbenzene	111	114	115	114	115
15	Carbonyl Sulfide	60	56	54	61	63
16	Hydrogen Sulfide	0	0	0	0	113
17	Methyl Isobutyl Ketone	4	3	3	4	4
18	Hydrogen Fluoride	45	43	39	45	48
19	Naphthalene	114	115	112	114	115
20	1,3-Butadiene	84	83	77	81	80

remain after the implementation of the MACT standards. The applicable MACT standards for refineries are the MACT CC and MACT UUU regulations.⁶

A. ICR Emission Inventory “Actual” Data

On April 1, 2011 EPA sent an information collection request (“ICR”) to all petroleum refineries. The ICR was designed to collect among other things, information on emission inventories, and

⁶ 40 C.F.R. 63, Subpart CC were promulgated August 18, 1995, 60 Federal Register 43244, and 40 C.F.R. 63, Subpart UUU was promulgated February 9, 2005, 70 FR 6929.



limited source testing to fill known data gaps. The ICR consisted of four components: 1) a questionnaire to be completed by refineries by May 31, 2011; 2) an emissions inventory by June 30, 2011; 3) distillation feed analysis by August 31, 2011; and 4) emissions testing, for 88 selected emission sources located at specific refineries by August 31, 2011.

The EPA received this ICR data and compiled these data into databases and spreadsheets. We requested and received the emissions inventory and the air dispersion modeling files used to determine the actual emissions risk assessment. In addition, we also requested and received the “crosswalk” information, which allowed us to identify individual refineries. Data in the ICR emission inventory and the air dispersion modeling files were coded such that identification of specific refineries was difficult without the “crosswalk” information.

The ICR air dispersion files were used to determine the total amount of air emissions modelled by EPA. The “Actual” air dispersion modeling file consisted of 246,649 individual emissions sources. Each emission source represented the actual emissions from one pollutant, from one source.

B. ICR Refineries

The ICR database was reviewed and was found to have 142 distinct refineries. This list was compared with the list of refineries from the TRI data set. There were numerous discrepancies and differences. Many refineries had different names or owners. Some refineries on the ICR database list were not on the TRI database list. After careful review and comparison, we determined that there were 125 refineries that were on both the ICR and TRI databases. These 125 refineries were carried forward for further comparison.

C. ICR Pollutants

The ICR database pollutants contained only toxic that were HAPs emitted by refineries. The ICR database contained 138 pollutants. These pollutants were then compared to the TRI pollutants. This comparison revealed that there were a total of 69 pollutants that were on both the ICR and TRI databases. We combined some pollutants to make a similar comparison. For example, in the ICR database, there were three (3) different types of mercury emissions, (Elemental Gaseous Mercury, Gaseous Divalent Mercury, and Particulate Divalent Mercury). These three types of mercury were combined into one pollutant, “Mercury.” Likewise for the TRI database there were two (2) types of mercury, (Mercury, and Mercury Compounds). These were also combined into one pollutant, “Mercury.” Several other types of compounds were similarly combined.



The list of the 69 pollutants found on both the ICR and TRI database is shown on Table 4. For these pollutants a comparison was made between the 2010 TRI emissions and the ICR actual emissions. Since the ICR emission inventory was required by June 30, 2011, the data should be identical, as the 2010 TRI data was required to be submitted July 1, 2011, one day later.

Surprisingly, the comparison of the TRI emissions and the ICR emissions showed very different results. Shown on Table 5 is a comparison of the ICR actual emissions and the TRI emissions for the 69 pollutants on each list. The TRI data also shows how many refineries, each year reported a specific pollutant.



Table 4
Pollutants on the ICR and TRI Database

1	1,1,2-Trichloroethane	36	Hydrochloric Acid
2	1,3-Butadiene	37	Hydrogen Cyanide
3	1,3-Dichloropropene	38	Hydrogen Fluoride
4	Acetaldehyde	39	Hydrogen Sulfide
5	Acetonitrile	40	Lead
6	Acrolein	41	m-Cresol
7	Acrylonitrile	42	Manganese
8	Aniline	43	Mercury
9	Anthracene	44	Methanol
10	Antimony	45	Methyl Isobutyl Ketone
11	Arsenic	46	Methyl Tert-Butyl Ether
12	Benzene	47	m-Xylene
13	Benzidine	48	n-Hexane
14	Benzo[g,h,i,]Perylene	49	n,n-Dimethylformamide
15	Beryllium	50	Naphthalene
16	Biphenyl	51	Nickel
17	Cadmium	52	Nitrobenzene
18	Carbon Disulfide	53	o-Cresol
19	Carbon Tetrachloride	54	o-Xylene
20	Carbonyl Sulfide	55	p-Cresol
21	Chlorine	56	Phenanthrene
22	Chlorobenzene	57	Phenol
23	Chloroform	58	Phosphorus
24	Chromium (VI)	59	Polychlorinated Biphenyls
25	Cobalt	60	p-Phenylenediamine
26	Cresol	61	Propionaldehyde
27	Cumene	62	p-Xylene
28	Dibenzofuran	63	Quinoline
29	Diethanolamine	64	Selenium
30	Dioxins	65	Styrene
31	Ethyl Benzene	66	Tetrachloroethylene
32	Ethylene Glycol	67	Toluene
33	Ethylene Oxide	68	Trichloroethylene
34	Ethylidene Dichloride	69	Xylenes
35	Formaldehyde		



**Table 5
Comparison of ICR Actual Emissions to TRI Emissions**

#	Pollutant	ICR Data	TRI Data						ICR/Actual (%)
			2010		2011		2012		
			Tons	ton/yr	# Ref	ton/yr	# Ref	ton/yr	
1	Hexane	3,836.6	1,476.6	120	1,537.0	119	1,510.7	119	260%
2	Toluene	2,453.9	1,219.9	120	1,160.6	119	1,170.3	119	201%
3	Xylenes	1,924.6	977.1	119	887.0	119	862.4	119	197%
4	Benzene	1,241.9	736.3	122	690.3	122	655.1	121	169%
5	Hydrochloric Acid	931.5	441.4	51	528.7	53	395.9	53	211%
6	Methanol	469.4	360.2	66	381.6	64	395.4	64	130%
7	Ethyl Benzene	517.6	260.2	122	231.9	122	222.6	120	199%
8	Hydrogen Cyanide	3,682.1	248.7	31	1,185.3	44	2,285.9	46	1,480%
9	Hydrogen Fluoride	220.1	170.4	39	35.3	45	26.5	48	129%
10	Carbonyl Sulfide	372.8	159.1	54	162.5	61	141.9	63	234%
11	Methyl Isobutyl Ketone	129.0	109.1	3	149.2	4	127.3	4	118%
12	Naphthalene	270.3	95.1	112	92.7	114	136.3	115	284%
13	Cumene	168.6	68.4	75	69.9	78	54.9	80	247%
14	Phenol	63.6	66.9	59	54.9	60	48.9	58	95%
15	p-Xylene	121.8	57.0	5	64.5	6	63.5	7	214%
16	1,3-Butadiene	130.6	46.1	77	106.7	81	112.8	80	283%
17	Diethanolamine	52.0	39.9	28	40.4	26	44.8	29	130%
18	Formaldehyde	424.1	33.7	4	40.4	5	41.6	5	1,257%
19	Carbon Disulfide	125.6	33.6	58	34.0	64	38.1	64	374%
20	m-Xylene	108.5	26.9	6	22.5	7	50.3	8	403%
	All	17,244.5	6,626.7		7,475.5		8,385.3		260%

This table shows that for every pollutant but one (Phenol), the ICR air emissions used by EPA for the RTR Risk Assessment were much higher than the TRI air emissions reported by the refining industry. For the top 20 TRI air emission pollutants shown on Table 5, the average increase was 260%.

A complete list of the entire 69 pollutants is included as Table A-5, in the Appendix. This table shows that there were 16 of the 69 pollutants that EPA had an “actual” air emission rate for which the refining industry had no emissions. The average increase in emissions for all 69 pollutants was 278%.



In EPA's Residual Risk Assessment⁷ and in companion supporting documents⁸, EPA and their contractor (RTI International) explain the many changes to the actual air emissions data. Some of the changes were necessary, such as incorrect coordinates, data files reversed (i.e. temperature in the diameter column, etc.).

D. EPA Changes to Actual Emissions

However some of the changes were much more substantial to the actual emissions. EPA performed "augmentation of the VOC data with HAP emissions." In this exercise EPA changed data that was listed as VOC emissions to specific HAP emissions. EPA used specific weighting factors to augment the emission data. Table 6 shows the weighting factors EPA used for this augmentation.

**Table 6
Composition Used for VOC Augmentation**

Pollutant	Wt. Fraction
1,3-Butadiene	0.000077
n-Hexane	0.020000
2,2,4-Trimethyl Pentane	0.006630
Benzene	0.008320
Toluene	0.026200
Xylenes	0.028300
Ethyl Benzene	0.006560
Cumene	0.001120
1,2,4-Trimethyl Benzene	0.010000
Naphthalene	0.002820
Biphenyl	0.001050
Styrene	0.000271

⁷ EPA Office of Air Quality Planning and Standards, Office of Air and Radiation, Draft – *Residual Risk Assessment for the Petroleum Refining Source Sector*, May 2014.

⁸ Sroka, Kristin, RTI International, Memo to Brenda Shine, EPA OAQPS, *Emissions Data Quality Memorandum and Development of the Risk Model Input File*, March 3, 2014.

Johnson, Shelly, et.al., RTI International, Memo to Brenda Shine, EPA OAQPS, *Revision of the Risk Model Input File Based Upon Revisions to Petroleum Refinery Information Collection Request Responses and Additional Quality Assurance Review*, March 3, 2014.

Fry, Carrie Richardson, et.al., RTI International, Memo to Brenda Shine, EPA/OAQPS, *Development of the Risk Model Input File Based Upon the Responses to Component 2 of the Petroleum Refinery Information Collection Request*, April 12, 2012.



EPA also used default parameter (stack height, diameter, velocity, temperature) when this data was not provided or the provided parameters were not within EPA guidelines.

E. FCCU HCN Emissions

EPA also made other significant changes based upon their “judgment.” For example, EPA made changes to the large portions of the emissions based upon recent stack test data. One significant change was that based upon recent stack testing of 10 FCCU units, EPA now believes that hydrogen cyanide (“HCN”) emissions are 10 times higher than previously reported. Therefore, for the FCCU units that were not stack tested, EPA multiplied the HCN emission provided by the individual refiners by 10. When one looks at the data EPA used to make this important adjustment the data shows tremendous variability. Shown on Table 7 is the FCCU stack test data for HCN emissions that EPA used to conclude that the HCN emissions were low.

**Table 7
FCCU HCN Emissions**

Test	FCCU Fresh Feed*	HCN	Factor
	BBD	lb/hr	lb-HCN/MMBBL
FCCU #1	87,800	11.96	3,269.2
FCCU #2	165,000	0.46	66.9
FCCU #3	118,800	0.70	141.4
FCCU #4	54,500	2.07	911.6
FCCU #5	149,000	105.09	16,927.2
FCCU #6	75,000	41.96	13,425.6
FCCU #7	138,500	0.00	0.0
FCCU #8	145,000	32.21	5,331.9
FCCU #9	87,000	3.33	918.6
FCCU #10	22,000	5.63	6,141.8
	Average	20.34	4,713.4

*FCCU Fresh Feed Data taken from 2010 DOE-EIA - Refinery Capacity

Based upon this FCCU stack test data, EPA concluded that the new emission factor for HCN from FCCUs should be raised from 770 pounds of HCN per million barrels of FCCU feed (“lb-HCN/MMBBL”)⁹ to 8,000 lb-HCN/MMBBL¹⁰. It is unclear how EPA concluded that the HCN

⁹ Emission Estimation Protocol for Petroleum Refineries, Version 2.1.1, May 2011, Table 5-4, page 5-11.

¹⁰ Emissions Estimation Protocol for Petroleum Refineries, Draft Version 3, August 2014, Table 5-4, page 5-11.



factor should be 70% higher than the average of the stack tests they reference. When one notes that the source with the highest HCN emissions has permanently shutdown, the average drops to 3,356 lb-HCN/MMBBL.

This example points up the need for each refiner to be diligent in its review of EPA's changes to its own refinery.

F. EPA Changes to Short-term Emission Rate – “Escalation Factor”

EPA made adjustment to the short-term emission rates of certain emission processes. Shown on Table 8 are the “Escalation Factors” EPA used to increase the short-term emission rate of certain processes. EPA justified these changes based upon what EPA perceived was the variability of certain non-continuous processes.

**Table 8
Escalation Factors for Selected Refinery Processes¹¹**

Refinery Process	Escalation Factor
FCCU	2
SRU	2
CCR	2
Storage Vessels	4
Wastewater Systems	4
Delayed Coker	20
Cyclic Catalytic Reformer	10
Semi-Regenerative Catalytic Reformer	60
Transfer and Loading Operations	10

Based upon these escalation factors, EPA made changes to individual refinery emissions for the above listed processes.

G. Conclusion – EPA Residual Risk Review

EPA concludes in its Residual Risk Review that the results of the chronic inhalation cancer risk assessment are that the maximum lifetime individual cancer risk posed by the refining industry

¹¹ Fry, Carrie Richardson, et.al., RTI International, Memo to Brenda Shine, EPA/OAQPS, *Development of the Risk Model Input File Based Upon the Responses to Component 2 of the Petroleum Refinery Information Collection Request*, April 12, 2012, page 6.



is 60 in a million and that the emissions of naphthalene and benzene are the major contributors.

EPA also concludes that the major chronic non-cancer risk is driven by the emissions of hydrogen cyanide from FCCUs. The major acute non-cancer risks are driven by: acetaldehyde; acrolein; arsenic; benzene and nickel.

The writer finds it ironic that EPA increased the “actual” emissions of each of the compounds of the major cancer, chronic non-cancer, and acute non-cancer compounds from 169% to over 10,000% and then determines that these compounds are the “Risk Drivers.” To summarize, listed in Table 9 are the TRI emissions reported by refiners in 2010 and the “actual” emissions used by EPA (for the same year) for the Residual Risk Assessment.

Table 9
Comparison of EPA “Actual” Emissions to TRI Data

Pollutant	Risk Assessment Emissions (tons/yr)	2010 TRI Data (tons/yr)	Ratio of EPA Data/ TRI Data (%)
Benzene	1,241.9	736.3	169%
Naphthalene	270.3	95.1	284%
Hydrogen Cyanide	3,682.1	248.7*	1,480%
Acetaldehyde	71.86	1.06	6,783%
Acrolein	23.53	0.22	10,693%
Arsenic	0.48	0.0032	14,929%
Nickel	34.90	12.97	269%

This review should emphasize to each refiner, the need to carefully review the emission data EPA uses in the Residual Risk Assessment as well as in any further potential rule making.

V. Increase in Environmental Regulations

The review of how EPA “adjusted” the emissions from refiners to make the “facts” coincide with the conclusions caused the writers to wonder how the perceived increase in environmental regulations compared to regulations of other US government agencies. TO do this we researched the Code of Federal Regulations (“C.F.R.”) website and identified a site that allowed the review of historical C.F.R.s.¹²

¹² <http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR>

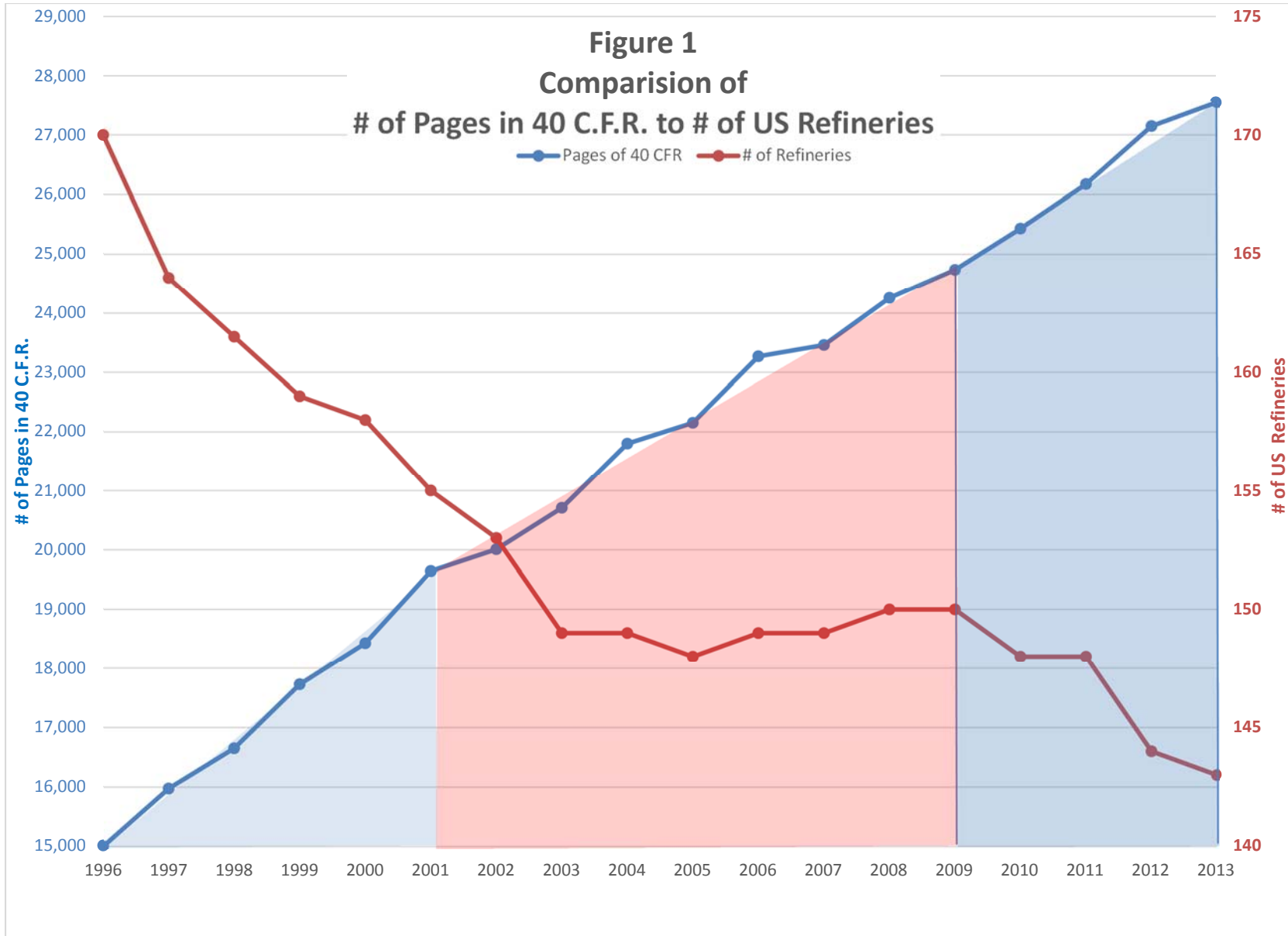


For this analysis we determined the current number of volumes of regulations for each U.S. agency and then also determined the number of volumes and number of pages of EPA regulations. The EPA regulations are found in Title 40 – Protection of the Environment. Currently there are 49 Titles in the entire C.F.R.s. (One Title has been withdrawn, Title 35 – Panama Canal).

In 2013 there were a total of 237 volumes in all of the 49 Titles, (average of 4.4 Volumes per Title). For the EPA Title 40 there were 34 volumes or 14.3% of all of the US regulations. As you might expect this number has been increasing much faster than any other US agency. The agency with the second highest number of volumes was the Internal Revenue, Title 26, with 20 Volumes. For curiosity, the writers determined the number of pages in all of the EPA Title 40 Volumes for the years 1996 – 2013. In 1996, there were 18 Volumes with a total of 15,004 pages of regulations. By 2013 these numbers had grown to 34 Volumes with 27,550 pages of regulations.

In 1996, there were 170 operable refineries in the US. In 2013 there were 143 operating refineries. Shown on Figure 1 is a comparison of the number of pages of environmental regulations compared the number of operating refineries in the US.

The writer will let the reader make his own conclusions regarding the relationship of these two items.





If you would like a copy of the TRI database with data from all refineries since 1988, please contact the writer and we will either send you the file electronically (~21MB) or send a disk with the data. If you have any questions about this paper or about release reporting, please feel free to contact the writer directly.

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Disclaimer: The information provided in this presentation is intended solely as an educational resource, and should not be used as a substitute for careful review of the rulemaking and enforcement actions themselves and consultation with competent legal and technical professionals as to site-specific circumstances.

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Appendix

1. Table A-1, List of TRI Refineries (140)
2. Table A-2, List of TRI Refinery Pollutants (181)
3. Table A-3, List of TRI Refinery Air Emissions, 1988 – 2012
4. Table A-4, Number of TRI Pollutants Reported by Refineries
5. Table A-5, Comparison of EPA ICR “Actual” Emissions to 2010 TRI Data



**Table A-1
TRI Refineries**

1	ALON REFINING KROTZ SPRINGS INC	HWY 105 S	KROTZ SPRINGS	ST LANDRY	LA
2	ALON USA - BIG SPRING REFINERY	IH 20 AT REFINERY RD	BIG SPRING	HOWARD	TX
3	AMERICAN REFINING GROUP INC	77 N KENDALL AVE	BRADFORD	MCKEAN	PA
4	ANTELOPE REFINING	2070 HWY 59	DOUGLAS	CONVERSE	WY
5	BIG WEST OIL LLC	333 W CENTER ST	NORTH SALT LAKE	DAVIS	UT
6	BP CHEMICAL PLANT TEXAS CITY	2800 FM 519 E	TEXAS CITY	GALVESTON	TX
7	BP CHERRY POINT REFINERY	4519 GRANDVIEW RD	BLAINE	WHATCOM	WA
8	BP PRODUCTS NORTH AMERICA WHITING	2815 INDIANAPOLIS BLVD	WHITING	LAKE	IN
9	BP-HUSKY REFINING LLC	4001 CEDAR POINT RD	OREGON	LUCAS	OH
10	BTB REFINING LLC	6600 UP RIVER RD	CORPUS CHRISTI	NUECES	TX
11	CALCASIEU REFINING CO	4359 W TANK FARM RD	LAKE CHARLES	CALCASIEU	LA
12	CALUMET LUBRICANTS & WAXES LLC	3333 MIDWAY ST	SHREVEPORT	CADDO	LA
13	CALUMET LUBRICANTS CO LP	10234 HWY 157	PRINCETON	BOSSIER	LA
14	CALUMET LUBRICANTS CO LP CALUMET COTTON VALLEY	1756 OLD HWY 7	COTTON VALLEY	WEBSTER	LA
15	CALUMET MONTANA REFINING LLC	1900 10TH ST NE	GREAT FALLS	CASCADE	MT
16	CALUMET SUPERIOR LLC	2407 STINSON AVE	SUPERIOR	DOUGLAS	WI
17	CATLETTSBURG REFINING LLC	11631 US RT 23	CATLETTSBURG	BOYD	KY
18	CHALMETTE REFINING LLC	500 W ST BERNARD HWY	CHALMETTE	ST BERNARD	LA
19	CHEVRON PRODUCTS CO - HAWAII REFINERY	91-480 MALAKOLE ST	KAPOLEI	HONOLULU	HI
20	CHEVRON PRODUCTS CO - SALT LAKE REFINERY	2351 N 1100 W	SALT LAKE CITY	SALT LAKE	UT
21	CHEVRON PRODUCTS CO DIV OF CHEVRON USA INC	324 W EL SEGUNDO BLVD	EL SEGUNDO	LOS ANGELES	CA
22	CHEVRON PRODUCTS CO PASCAGOULA REFINERY	250 INDUSTRIAL RD	PASCAGOULA	JACKSON	MS
23	CHEVRON PRODUCTS CO RICHMOND REFINERY	841 CHEVRON WAY	RICHMOND	CONTRA COSTA	CA
24	CHS INC LAUREL REFINERY	803 HWY 212 S	LAUREL	YELLOWSTONE	MT
25	CITGO PETROLEUM CORP	1601 HWY 108 E	SULPHUR	CALCASIEU	LA
26	CITGO PETROLEUM CORP LEMONT REFINERY	135TH ST & NEW AVE	LEMONT	WILL	IL
27	CITGO REFINING & CHEMICALS CO LP - WEST PLANT	7350 INTERSTATE HWY 37	CORPUS CHRISTI	NUECES	TX
28	CITGO REFINING & CHEMICALS CO LP EAST PLANT	1801 NUECES BAY BLVD	CORPUS CHRISTI	NUECES	TX
29	COFFEYVILLE RESOURCES REFINING & MARKETING	400 N LINDEN	COFFEYVILLE	MONTGOMERY	KS
30	CONTINENTAL REFINING CO LLC	501 REFINERY RD	SOMERSET	PULASKI	KY
31	CONVENT REFINERY	FOOT OF SUNSHINE BRIDGE- LA HW Y 44	CONVENT	ST JAMES	LA
32	COUNTRYMARK REFINING & LOGISTICS LLC	1200 REFINERY RD	MOUNT VERNON	POSEY	IN
33	DEER PARK REFINING LP	5900 HWY 225 E	DEER PARK	HARRIS	TX
34	DELAWARE CITY REFINERY	4550 WRANGLE HILL RD	DELAWARE CITY	NEW CASTLE	DE
35	DELEK REFINING LTD	1702 E COMMERCE ST	TYLER	SMITH	TX
36	DIAMOND SHAMROCK REFINING CO LP	6701 FM 119	SUNRAY	MOORE	TX
37	ERGON REFINING INC	2611 HAINING RD	VICKSBURG	WARREN	MS
38	ERGON WEST VIRGINIA INC	9995 OHIO RIVER BLVD	NEWELL	HANCOCK	WV
39	EXXONMOBIL BILLINGS REFINERY	700 EXXONMOBIL RD	BILLINGS	YELLOWSTONE	MT
40	EXXONMOBIL OIL BEAUMONT REFINERY (PART)	E END OF BURT ST	BEAUMONT	JEFFERSON	TX
41	EXXONMOBIL OIL CORP - TORRANCE REFINERY	3700 W 190TH ST	TORRANCE	LOS ANGELES	CA



**Table A-1
TRI Refineries**

42	EXXONMOBIL OIL CORP JOLIET REFINERY	INTERSTATE 55 & ARSENAL RD E	CHANNAHON	WILL	IL
43	EXXONMOBIL REFINING & SUPPLY BATON ROUGE REFINERY	4045 SCENIC HWY	BATON ROUGE	EAST BATON ROUGE	LA
44	EXXONMOBIL REFINING & SUPPLY BAYTOWN REFINERY (PART)	2800 DECKER DR	BAYTOWN	HARRIS	TX
45	FLINT HILLS RESOURCES ALASKA LLC	1100 H&H LN	NORTH POLE	FAIRBANKS NORTH STAR	AK
46	FLINT HILLS RESOURCES CORPUS CHRISTI LLC - EAST PLANT	1700 NUECES BAY BLVD	CORPUS CHRISTI	NUECES	TX
47	FLINT HILLS RESOURCES CORPUS CHRISTI LLC - WEST PLANT	2825 SUNTIDE RD	CORPUS CHRISTI	NUECES	TX
48	FLINT HILLS RESOURCES PINE BEND LLC ST PAUL	2209 CHILDS RD	SAINT PAUL	RAMSEY	MN
49	FORELAND REFINING CORP EAGLE SPRINGS REFINERY	HC 34 BOX 34830 65 MI SW OF ELY ON HWY 6	ELY	NYE	NV
50	FRONTIER EL DORADO REFINING LLC	1401 S DOUGLAS RD	EL DORADO	BUTLER	KS
51	FRONTIER REFINING INC	2700 E 5TH ST	CHEYENNE	LARAMIE	WY
52	HOLLY REFINING & MARKETING - TULSA LLC	1700 S UNION	TULSA	TULSA	OK
53	HOLLY REFINING & MARKETING - TULSA LLC	902 W 25TH ST	TULSA	TULSA	OK
54	HOLLY REFINING & MARKETING CO WOODS CROSS REFINERY	393 S 800 W	WOODS CROSS	DAVIS	UT
55	HOUSTON REFINING LP	12000 LAWNDALDE ST	HOUSTON	HARRIS	TX
56	HUNT REFINING CO A CORP	1855 FAIRLAWN RD	TUSCALOOSA	TUSCALOOSA	AL
57	HUNT SOUTHLAND REFINING CO - SANDERSVILLE	177 HANEY RD HWY 11 N (2MI N OF SVILLE)	HEIDELBERG	JONES	MS
58	KERN OIL & REFINING CO	7724 E PANAMA LN	BAKERSFIELD	KERN	CA
59	LAZARUS REFINERY LLC	11372 US HWY 87 E	NIXON	WILSON	TX
60	LIMA REFINING CO	1150 S METCALF ST	LIMA	ALLEN	OH
61	LION OIL CO	1000 MCHENRY AVE	EL DORADO	UNION	AR
62	LUNDAY-THAGARD CO	9301 GARFIELD AVE	SOUTH GATE	LOS ANGELES	CA
63	MARATHON PETROLEUM CO LP	4663 W AIRLINE HWY	GARYVILLE	ST JOHN THE BAPTIST	LA
64	MARATHON PETROLEUM CO LP	502 10TH ST S	TEXAS CITY	GALVESTON	TX
65	MARATHON PETROLEUM CO LP - MICHIGAN REFINING DIV	1300 S FORT ST HES DEPT	DETROIT	WAYNE	MI
66	MARATHON PETROLEUM CO LP ILLINOIS REFINING DIV	100 MARATHON AVE	ROBINSON	CRAWFORD	IL
67	MARATHON PETROLEUM CO LP OHIO REFINING DIV	2408 GAMBRINUS AVE SW	CANTON	STARK	OH
68	MARTIN OPERATING PTNR LP	484 E 6TH ST	SMACKOVER	UNION	AR
69	MONROE ENERGY LLC - TRAINER REFINERY	4101 POST RD	TRAINER	DELAWARE	PA
70	MOTIVA ENTERPRISES LLC	2555 SAVANNAH AVE	PORT ARTHUR	JEFFERSON	TX
71	MOTIVA ENTERPRISES LLC NORCO REFINERY	15536 RIVER RD	NORCO	ST CHARLES	LA
72	NATIONAL COOPERATIVE REFINERY ASSOC - SRU	1360 IRON HORSE RD	MCPHERSON	MCPHERSON	KS
73	NAVAJO REFINING CO	501 E MAIN ST	ARTESIA	EDDY	NM
74	NUSTAR ASPHALT REFINING LLC	7 FOUNDATION DR	SAVANNAH	CHATHAM	GA
75	NUSTAR ASPHALT REFINING LLC	4 PARADISE RD	PAULSBORO	GLOUCESTER	NJ
76	PARAMOUNT PETROLEUM BAKERSFIELD REFINERY AREA 3	3663 GIBSON ST	BAKERSFIELD	KERN	CA
77	PARAMOUNT PETROLEUM BAKERSFIELD REFINERY AREAS 1 & 2	6451 ROSEDALE HWY	BAKERSFIELD	KERN	CA
78	PARAMOUNT PETROLEUM CORP	14700 DOWNEY AVE	PARAMOUNT	LOS ANGELES	CA
79	PASADENA REFINING SYSTEM INC	111 RED BLUFF RD	PASADENA	HARRIS	TX
80	PAULSBORO REFINING CO LLC	800 BILLINGSPOUR RD	PAULSBORO	GLOUCESTER	NJ
81	PELICAN REFINING CO LLC	4646 LA. HWY 3059	LAKE CHARLES	CALCASIEU	LA
82	PETRO STAR INC NORTH POLE REFINERY	1200 H & H LN	NORTH POLE	FAIRBANKS NORTH STAR	AK



**Table A-1
TRI Refineries**

83	PETRO STAR VALDEZ REFINERY	2.5 MILE DAYVILLE RD	VALDEZ	VALDEZ-CORDOVA	AK
84	PHILADELPHIA ENERGY SOLUTIONS REFINING PHILADELPHIA REFINERY	3144 PASSYUNK AVE	PHILADELPHIA	PHILADELPHIA	PA
85	PHILLIPS 66 - ALLIANCE REFINERY	15551 HWY 23	BELLE CHASSE	PLAQUEMINES	LA
86	PHILLIPS 66 CO - BAYWAY REFINERY	1400 PARK AVE	LINDEN	UNION	NJ
87	PHILLIPS 66 CO BILLINGS REFINERY	401 S 23RD ST	BILLINGS	YELLOWSTONE	MT
88	PHILLIPS 66 CO GULF COAST LUBES PLANT	1697 PAKTANK RD	SULPHUR	CALCASIEU	LA
89	PHILLIPS 66 CO SWEENEY REFINERY COMPLEX	8189 OLD FM 524	OLD OCEAN	BRAZORIA	TX
90	PHILLIPS 66 FERNDALE REFINERY	3901 UNICK RD	FERNDALE	WHATCOM	WA
91	PHILLIPS 66 LAKE CHARLES REFINERY	2200 OLD SPANISH TRAIL	WESTLAKE	CALCASIEU	LA
92	PHILLIPS 66 LOS ANGELES REFINERY MARINE TERMINAL	150 PIER A ST	WILMINGTON	LOS ANGELES	CA
93	PHILLIPS 66 PONCA CITY	1000 S PINE ST	PONCA CITY	KAY	OK
94	PHILLIPS 66 SAN FRANCISCO REFINERY	1380 SAN PABLO AVE	RODEO	CONTRA COSTA	CA
95	PHILLIPS 66 CO BORGER REFINERY	STATE HWY SPUR 119 N	BORGER	HUTCHINSON	TX
96	PLACID REFINING CO LLC	1940 LOUISIANA HWY 1, N	PORT ALLEN	WEST BATON ROUGE	LA
97	PREMCO REFINING GROUP INC PORT ARTHUR	1801 S GULFWAY DR	PORT ARTHUR	JEFFERSON	TX
98	SAN ANTONIO REFINERY	7811 S PRESA ST	SAN ANTONIO	BEXAR	TX
99	SAN JOAQUIN REFINING CO INC	3542 SHELL ST	BAKERSFIELD	KERN	CA
100	SHELL CHEMICAL LP (MOBILE SITE)	400 INDUSTRIAL PKWY EXT	SARALAND	MOBILE	AL
101	SHELL NORCO CHEMICAL PLANT WEST SITE	16122 RIVER RD	NORCO	ST CHARLES	LA
102	SHELL OIL PRODUCTS US - MARTINEZ REFINERY	3485 PACHECO BLVD	MARTINEZ	CONTRA COSTA	CA
103	SHELL OIL PRODUCTS US - PUGET SOUND REFINERY	8505 S TEXAS RD	ANACORTES	SKAGIT	WA
104	SILVER EAGLE REFINING WOODS CROSS	2355 S 1100 W	WOODS CROSS	DAVIS	UT
105	SILVER EAGLE REFINING-EVANSTON	2990 COUNTY RD 180	EVANSTON	UINTA	WY
106	SINCLAIR CASPER REFINING CO	5700 E HWY 20/26	CASPER	NATRONA	WY
107	SINCLAIR WYOMING REFINING CO	100 E LINCOLN AVE	SINCLAIR	CARBON	WY
108	SOUTH HAMPTON RESOURCES INC	7752 FM 418	SILSBEE	HARDIN	TX
109	ST PAUL PARK REFINING CO LLC	301 ST PAUL PARK RD	SAINT PAUL PARK	WASHINGTON	MN
110	SUNCOR ENERGY COMMERCE CITY REFINERY	5801 BRIGHTON BLVD	COMMERCE CITY	ADAMS	CO
111	TESORO ALASKA - KENAI REFINERY	MILE 22.5 KENAI SPUR HWY	KENAI	KENAI PENINSULA	AK
112	TESORO HAWAII REFINERY	91-325 KOMOHANA ST	KAPOLEI	HONOLULU	HI
113	TESORO LOGISTICS - SALT LAKE CITY TERMINAL	475 W 900 N	SALT LAKE CITY	SALT LAKE	UT
114	TESORO LOS ANGELES REFINERY	2101 E PACIFIC COAST HWY	WILMINGTON	LOS ANGELES	CA
115	TESORO REFINING & MARKETING CO LLC	150 SOLANO WAY	MARTINEZ	CONTRA COSTA	CA
116	TESORO REFINING & MARKETING CO LLC- MANDAN REFINERY	900 OLD RED TRAIL NE	MANDAN	MORTON	ND
117	TESORO REFINING & MARKETING LLC	W MARCH POINT RD	ANACORTES	SKAGIT	WA
118	TESORO SULFUR RECOVERY PLANT	23208 S ALAMEDA STEET	CARSON	LOS ANGELES	CA
119	TOLEDO REFINING CO LLC	1819 WOODVILLE RD	OREGON	LUCAS	OH
120	TOTAL PETROCHEMICALS USA INC - PORT ARTHUR REFINERY	HWY 366 & 32ND ST	PORT ARTHUR	JEFFERSON	TX
121	ULTRAMAR INC WILMINGTON REFINERY	2402 E ANAHEIM ST	WILMINGTON	LOS ANGELES	CA
122	UNITED REFINING CO	15 BRADLEY ST	WARREN	WARREN	PA
123	US OIL & REFINING CO	3001 MARSHALL AVE	TACOMA	PIERCE	WA



**Table A-1
TRI Refineries**

124	VALERO REFINING - MERAUX LLC MERAUX REFINERY	2500 E ST BERNARD HWY	MERAUX	ST BERNARD	LA
125	VALERO REFINING - NEW ORLEANS LLC	14902 RIVER RD	NORCO	ST CHARLES	LA
126	VALERO REFINING - TEXAS LP	1301 LOOP 197 S	TEXAS CITY	GALVESTON	TX
127	VALERO REFINING - TEXAS LP CORPUS CHRISTI WEST PLANT	5900 UP RIVER RD	CORPUS CHRISTI	NUECES	TX
128	VALERO REFINING - TEXAS LP HOUSTON REFINERY	9701 MANCHESTER	HOUSTON	HARRIS	TX
129	VALERO REFINING CO - CALI FORNIA BENICIA REFINERY	3400 E SECOND ST	BENICIA	SOLANO	CA
130	VALERO REFINING CO - TENNESSEE LLC	2385 RIVERPORT RD	MEMPHIS	SHELBY	TN
131	VALERO REFINING CO -OKLAHOMA VALERO ARDMORE REFINERY	ONE VALERO WAY	ARDMORE	CARTER	OK
132	VALERO REFINING TEXAS LP CORPUS CHRISTI EAST PLANT	1300 CANTWELL LN	CORPUS CHRISTI	NUECES	TX
133	VALERO THREE RIVERS REFINERY	301 LEROY ST	THREE RIVERS	LIVE OAK	TX
134	VALERO WILMINGTON ASPHALT PLANT	1651 ALAMEDA ST	WILMINGTON	LOS ANGELES	CA
135	VENTURA REFINING & TRANSMISSION	24322 E 910 RD	THOMAS	CUSTER	OK
136	WESTERN EL PASO REFINERY	6501 TROWBRIDGE DR	EL PASO	EL PASO	TX
137	WESTERN REFINING SOUTHWEST INC - GALLUP REFINERY	I-40 EXIT 39	JAMESTOWN	MCKINLEY	NM
138	WOOD RIVER REFINERY	900 S CENTRAL AVE	ROXANA	MADISON	IL
139	WYNNEWOOD REFINING CO	906 S POWELL	WYNNEWOOD	GARVIN	OK
140	WYOMING REFINING CO LLC	740 W MAIN ST	NEWCASTLE	WESTON	WY



Table A-2
TRI Refinery Pollutants

1	1,1,1-TRICHLOROETHANE	62	CHLORINE	123	METHYL TERT-BUTYL ETHER
2	1,1,2-TRICHLOROETHANE	63	CHLORINE DIOXIDE	124	METHYLENE BROMIDE
3	1,2,3-TRICHLOROPROPANE	64	CHLOROBENZENE	125	METHYLENEBIS(PHENYLISOCYANATE)
4	1,2,4-TRICHLOROBENZENE	65	CHLORODIFLUOROMETHANE	126	MIXTURE
5	1,2,4-TRIMETHYLBENZENE	66	CHLOROETHANE	127	MOLYBDENUM TRIOXIDE
6	1,2-DIBROMOETHANE	67	CHLOROFORM	128	M-XYLENE
7	1,2-DICHLOROETHANE	68	CHLOROMETHANE	129	N,N-DIMETHYLFORMAMIDE
8	1,2-DICHLOROETHYLENE	69	CHLOROTRIFLUOROMETHANE	130	NAPHTHALENE
9	1,2-DICHLOROPROPANE	70	CHROMIUM	131	N-BUTYL ALCOHOL
10	1,3-BUTADIENE	71	CHROMIUM COMPOUNDS	132	N-HEXANE
11	1,3-DICHLOROPROPYLENE	72	COBALT	133	NICKEL
12	1,3-PHENYLENEDIAMINE	73	COBALT COMPOUNDS	134	NICKEL COMPOUNDS
13	2,3-DICHLOROPROPENE	74	COPPER	135	NITRATE COMPOUNDS
14	2,4,5-TRICHLOROPHENOL	75	COPPER COMPOUNDS	136	NITRIC ACID
15	2,4-DICHLOROPHENOL	76	CRESOL	137	NITROBENZENE
16	2,4-DIMETHYLPHENOL	77	CUMENE	138	N-METHYL-2-PYRROLIDONE
17	2,4-DINITROTOLUENE	78	CUMENE HYDROPEROXIDE	139	O-CRESOL
18	2,6-XYLIDINE	79	CYANIDE COMPOUNDS	140	O-XYLENE
19	2-METHOXYETHANOL	80	CYCLOHEXANE	141	OZONE
20	4,4'-ISOPROPYLIDENEDIPHENOL	81	DIBENZOFURAN	142	P-CRESOL
21	ACETALDEHYDE	82	DICHLORODIFLUOROMETHANE	143	PHENANTHRENE
22	ACETONE	83	DICHLOROMETHANE	144	PHENOL
23	ACETONITRILE	84	DICYCLOPENTADIENE	145	PHOSPHORIC ACID
24	ACETOPHENONE	85	DIETHANOLAMINE	146	PHOSPHORUS (YELLOW OR WHITE)
25	ACROLEIN	86	DIISOCYANATES	147	PHTHALIC ANHYDRIDE
26	ACRYLIC ACID	87	DIMETHYL PHTHALATE	148	POLYCHLORINATED BIPHENYLS
27	ACRYLONITRILE	88	DIMETHYL SULFATE	149	POLYCYCLIC AROMATIC COMPOUNDS
28	ALLYL ALCOHOL	89	DIMETHYLAMINE	150	P-PHENYLENEDIAMINE
29	ALLYL CHLORIDE	90	DIOXIN AND DIOXIN-LIKE COMPOUNDS	151	PROPIONALDEHYDE
30	ALUMINUM	91	DIPHENYLAMINE	152	PROPYLENE
31	ALUMINUM OXIDE	92	EPICHLOROHYDRIN	153	PROPYLENE OXIDE
32	AMMONIA	93	ETHYLBENZENE	154	P-XYLENE
33	AMMONIUM NITRATE	94	ETHYLENE	155	PYRIDINE
34	AMMONIUM SULFATE	95	ETHYLENE GLYCOL	156	QUINOLINE
35	ANILINE	96	ETHYLENE OXIDE	157	SEC-BUTYL ALCOHOL
36	ANTHRACENE	97	ETHYLIDENE DICHLORIDE	158	SELENIUM



Table A-2
TRI Refinery Pollutants

37	ANTIMONY	98	FORMALDEHYDE	159	SELENIUM COMPOUNDS
38	ANTIMONY COMPOUNDS	99	FORMIC ACID	160	SILVER
39	ARSENIC	100	FREON 113	161	SILVER COMPOUNDS
40	ARSENIC COMPOUNDS	101	GLYCIDOL	162	SODIUM DIMETHYLDITHIOCARBAMATE
41	ASBESTOS	102	HEXACHLOROBENZENE	163	SODIUM HYDROXIDE
42	BARIUM	103	HYDRAZINE	164	SODIUM NITRITE
43	BARIUM COMPOUNDS	104	HYDROCHLORIC ACID	165	STYRENE
44	BENZENE	105	HYDROGEN CYANIDE	166	SULFURIC ACID
45	BENZIDINE	106	HYDROGEN FLUORIDE	167	TERT-BUTYL ALCOHOL
46	BENZO(G,H,I)PERYLENE	107	HYDROGEN SULFIDE	168	TETRACHLOROETHYLENE
47	BENZOYL CHLORIDE	108	HYDROQUINONE	169	THALLIUM
48	BERYLLIUM	109	ISOBUTYRALDEHYDE	170	TITANIUM TETRACHLORIDE
49	BERYLLIUM COMPOUNDS	110	ISOPRENE	171	TOLUENE
50	BIPHENYL	111	ISOPROPYL ALCOHOL	172	TOLUENE-2,4-DIISOCYANATE
51	BROMOCHLORODIFLUOROMETHANE	112	LEAD	173	TRANS-1,3-DICHLOROPROPENE
52	BROMOMETHANE	113	LEAD COMPOUNDS	174	TRICHLOROETHYLENE
53	BROMOTRIFLUOROMETHANE	114	MANGANESE	175	TRICHLOROFLUOROMETHANE
54	BUTYL BENZYL PHTHALATE	115	MANGANESE COMPOUNDS	176	VANADIUM
55	BUTYRALDEHYDE	116	M-CRESOL	177	VANADIUM COMPOUNDS
56	CADMIUM	117	MERCURY	178	VINYL ACETATE
57	CADMIUM COMPOUNDS	118	MERCURY COMPOUNDS	179	XYLENE
58	CARBON DISULFIDE	119	METHANOL	180	ZINC
59	CARBON TETRACHLORIDE	120	METHYL ETHYL KETONE	181	ZINC COMPOUNDS
60	CARBONYL SULFIDE	121	METHYL ISOBUTYL KETONE		
61	CERTAIN GLYCOL ETHERS	122	METHYL METHACRYLATE		



**Table A-3
TRI Refinery Air Emissions, pounds per year**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	1,1,1-Trichloroethane	174,227	175,212	117,340	100,583	145,595	180,525	126,541	79,891	28,061	21,503	2,591	10,180	890	1,980	487	76	0	500	490	250	206	341	182	193	195
2	1,1,2-Trichloroethane	70	75	82	59	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,666	1,820	2,837	1,363	1,401	1,413
3	1,2,3-Trichloropropane	0	0	0	0	0	0	0	0	0	0	5,038	4,505	5,302	5,302	84,859	2,840	1,800	161	441	2	10	0	0	0	0
4	1,2,4-Trichlorobenzene	0	0	0	0	0	0	0	0	0	0	0	0	1,460	5,050	0	0	0	0	0	0	0	0	0	0	0
5	1,2,4-Trimethylbenzene	1,063,412	1,426,069	1,232,256	1,095,376	1,108,150	965,712	850,602	738,658	629,014	600,170	661,494	543,780	696,856	516,164	496,658	502,702	484,014	501,027	650,601	466,072	557,684	531,272	485,132	404,984	399,946
6	1,2-Dibromoethane	4,390	3,514	2,028	2,029	790	1,041	4,050	4,196	6,510	9,308	8,374	7,508	8,804	7,756	4,968	4,860	4,510	4,347	2,581	2,936	1,755	1,984	1,843	2,102	1,666
7	1,2-Dichloroethane	9,268	10,336	9,052	14,617	20,525	16,404	18,885	26,005	27,858	19,403	16,596	18,782	15,157	16,213	7,372	2,175	1,353	2,328	1,985	2,268	2,445	2,189	2,923	2,635	2,878
8	1,2-Dichloroethylene	0	500	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1,2-Dichloropropane	1,589	549	1,330	940	800	610	800	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1,3-Butadiene	135,119	81,004	146,997	160,884	132,546	145,934	105,659	69,503	93,807	49,833	149,716	155,541	81,863	79,747	84,997	53,402	55,931	47,641	56,747	87,289	95,351	90,005	92,273	213,475	225,674
11	1,3-Dichloropropylene	1,190	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1,3-Phenylenediamine	0	0	0	0	0	0	0	1,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	2,3-Dichloropropene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	2,4,5-Trichlorophenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	2,4-Dichlorophenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	2,4-Dimethylphenol	0	0	5	4,734	6,287	0	0	0	0	0	0	0	910	908	550	1,471	534	76	2	2	1	6	5	7	9
17	2,4-Dinitrotoluene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	2,6-Xylidine	0	0	0	0	0	0	0	0	0	0	360	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	2-Methoxyethanol	9,171	10,272	12,142	18,605	16,778	8,905	10,524	3,203	3,863	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	4,4'-Isopropylidenediphenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0
21	Acetaldehyde	0	0	0	1,345	1,295	0	0	0	0	0	0	0	580	0	0	0	0	150	239	330	322	248	2,119	2,196	6,245
22	Acetone	292,800	355,800	363,380	337,850	380,460	357,765	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Acetonitrile	0	0	0	0	0	0	0	0	0	0	2,500	2,000	970	970	696	933	861	2,601	1,900	3,697	7,009	11,107	16,489	15,357	14,677
24	Acetophenone	0	0	0	0	0	0	0	710	562	2,244	1,541	1,280	1,474	1,451	593	0	2,300	170	420	171	1,906	1,846	0	0	0
25	Acrolein	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	25	357	298	361	440	306	295
26	Acrylic Acid	0	280	280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Acrylonitrile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,100	740	1,136	514	570	575
28	Allyl Alcohol	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Allyl Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	Aluminum	0	0	0	0	0	0	0	0	0	0	0	0	0	2,905	0	0	0	0	0	3	3	0	0	0	0
31	Aluminum Oxide	14,121,633	326,157	69,000	0	0	0	0	0	15,232	0	0	0	0	99	0	0	0	0	0	0	0	0	0	0	0
32	Ammonia	7,305,255	7,108,201	7,514,530	6,784,654	6,341,122	7,419,907	7,993,592	7,206,901	6,590,005	7,808,330	7,510,215	5,698,232	4,747,887	4,983,801	5,773,838	6,970,543	7,773,476	7,433,286	8,033,938	8,092,962	6,034,156	5,107,768	5,571,721	5,506,313	5,201,647
33	Ammonium Nitrate	250	250	66	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Ammonium Sulfate	42,411	0	260	10	1,548	8,149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Aniline	0	0	0	0	0	0	0	0	0	0	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Anthracene	1,131	1,811	1,040	37	223	402	4,524	2,631	4,120	3,961	3,058	3,239	3,001	2,574	3,250	2,707	2,523	2,379	2,192	2,311	2,343	2,309	1,901	2,332	1,466
37	Antimony	1,833	1,364	279	0	11	11	0	0	0	580	666	863	716	686	421	691	700	1,810	1,117	1,062	705	434	569	458	338
38	Antimony Compounds	4,074	2,580	1,130	5,069	3,274	6,486	3,972	3,528	5,019	5,524	3,712	3,404	2,682	4,098	2,282	3,176	3,903	6,348	5,042	3,585	1,901	1,305	1,075	965	1,122
39	Arsenic	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	9	9	6	6	15	14
40	Arsenic Compounds	0	0	0	13	13	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	2	0
41	Asbestos	250	1,000	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



**Table A-3
TRI Refinery Air Emissions, pounds per year**

Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
42 Barium	0	0	33	247	0	0	0	50	50	45	14	41	40	36	5	5	3,382	225	137	36	36	26	26	113	109
43 Barium Compounds	142,450	46,900	53,029	31,741	5,001	0	0	0	0	7	28	270	0	251	3,753	3,150	3,400	0	451	340	760	0	255	228	240
44 Benzene	5,326,282	4,259,466	4,406,170	4,414,102	4,139,806	3,567,629	3,117,339	2,984,847	2,615,640	2,549,511	2,339,547	2,039,620	2,233,171	1,946,834	1,921,074	1,893,991	1,682,210	1,780,484	1,691,620	1,658,449	1,745,957	1,461,587	1,472,636	1,380,688	1,310,264
45 Benzidine	0	0	0	0	0	16	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46 Benzo(g,h,i)Perylene	0	0	0	0	0	0	0	0	0	0	0	0	2,235	2,410	1,136	1,217	1,391	1,649	1,013	935	873	407	798	548	622
47 Benzoyl Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48 Beryllium	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	7	5	1	1	1	1	3	3
49 Beryllium Compounds	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 Biphenyl	22,940	14,330	9,000	8,504	7,296	7,084	3,421	8,468	5,656	7,687	10,166	13,439	15,247	15,393	17,950	19,575	12,474	13,753	8,735	9,746	19,714	15,019	14,210	14,018	13,639
51 Bromochlorodifluoromethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52 Bromomethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	30	40	40	29	29	26	25
53 Bromotrifluoromethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54 Butyl Benzyl Phthalate	0	0	0	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 Butyraldehyde	0	0	0	0	0	0	0	0	0	0	2,800	2,601	33,100	22,900	4	2,982	0	0	0	0	0	0	0	0	0
56 Cadmium	0	0	0	0	28	31	0	0	0	0	0	0	0	0	0	0	0	0	35	9	9	6	7	29	28
57 Cadmium Compounds	0	0	0	27	0	4	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
58 Carbon Disulfide	1,579	64,250	44,000	49,017	2,500	2,700	3,200	1,666	15,133	8,285	9,315	24,865	35,230	49,356	58,643	66,163	71,489	54,991	132,622	68,611	94,798	66,276	67,132	67,975	76,284
59 Carbon Tetrachloride	28,440	21,966	41,591	37,692	39,405	19,259	11,114	20,877	18,591	19,055	10,790	7,679	6,915	6,808	3,253	2,006	2,055	2,333	1,925	4,005	3,679	2,789	128	120	123
60 Carbonyl Sulfide	0	180,000	206,000	136,000	113,000	135,000	123,000	146,493	219,540	183,461	246,925	345,745	565,504	688,032	472,905	562,054	522,928	551,960	580,370	558,580	468,182	343,388	318,112	325,063	283,822
61 Certain Glycol Ethers	131	4,213	759	23,623	22,760	2,455	5,254	5,245	4,646	5,767	11,042	7,753	10,504	8,667	13,621	10,275	12,195	18,262	6,418	5,891	4,395	4,545	4,864	4,552	5,842
62 Chlorine	544,603	435,230	504,506	479,407	456,723	155,160	183,640	237,892	274,751	218,157	213,390	239,132	204,105	253,120	183,258	168,442	155,314	146,096	127,139	75,345	39,792	33,408	21,857	55,149	53,941
63 Chlorine Dioxide	0	0	0	0	0	0	0	0	20	3	0	2	228	780	750	750	750	750	750	553	561	561	8	6	0
64 Chlorobenzene	0	0	0	0	0	238	63	8	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65 Chlorodifluoromethane	0	0	0	0	0	0	164,146	381,678	71,616	51,180	63,520	50,430	29,290	40,880	79,480	70,906	69,871	86,875	23,748	5,400	6,048	7,576	4,412	91	5,506
66 Chloroethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67 Chloroform	0	70	0	0	0	0	25	0	0	0	0	0	17,020	0	0	0	0	0	0	0	0	0	0	0	0
68 Chloromethane	3,100	2,943	2,943	2,943	0	0	0	0	0	1,382	1,385	1,382	1,385	1,382	0	0	0	0	0	0	0	0	0	0	0
69 Chlorotrifluoromethane	0	0	0	0	0	0	0	250	0	0	0	0	0	35,000	35,000	35,000	35,000	0	0	0	0	0	0	0	0
70 Chromium	20,787	10,149	9,808	10,875	15,179	6,372	2,848	1,515	214	15	16	35	20	518	495	0	1,171	149	54	25	628	728	764	253	46
71 Chromium Compounds	98,555	92,394	65,007	37,633	18,488	27,497	21,542	14,128	1,657	473	327	595	400	647	3,321	4,938	3,730	1,904	2,648	3,647	2,902	2,959	3,559	3,883	4,726
72 Cobalt	800	819	750	11	0	7	5	5	5	5	5	52	47	64	44	102	190	25	40	13	14	24	10	30	29
73 Cobalt Compounds	285	326	616	533	69	403	43	84	257	952	92	461	267	164	1,013	271	1,338	470	2,399	1,168	1,883	1,123	1,007	749	2,662
74 Copper	16	319	268	315	337	1,329	1,416	1,638	1,346	47	37	14	250	134	83	106	707	142	113	346	93	91	106	96	95
75 Copper Compounds	1,520	1,049	538	826	688	875	758	1,045	654	3,137	2,580	1,806	952	1,060	4,634	4,134	3,685	3,078	2,649	1,307	1,368	1,902	1,952	1,588	2,440
76 Cresol	55,386	44,072	45,263	119,943	30,616	33,448	39,530	53,706	44,101	51,151	34,729	21,914	20,004	28,265	30,057	30,385	29,211	28,454	31,170	34,623	39,161	22,399	20,111	18,644	16,136
77 Cumene	691,156	652,098	685,292	644,200	586,563	565,147	527,171	440,237	243,801	206,441	220,847	261,903	244,710	222,751	151,969	148,081	159,627	151,099	289,717	159,507	138,498	137,591	136,785	139,738	109,721
78 Cumene Hydroperoxide	37,000	32,000	32,000	32,000	31,000	31,000	34,000	12,300	4,501	5,301	5,001	5,101	5,201	5,101	440	0	0	0	0	0	0	0	0	0	0
79 Cyanide Compounds	0	0	0	0	0	0	0	0	0	0	0	0	50,000	28,000	121,753	97,756	169,743	121,194	77,329	12,065	17,420	18,236	15,553	15,118	17,337
80 Cyclohexane	2,034,554	1,921,211	1,981,226	2,217,622	1,929,802	1,703,943	1,620,040	1,681,775	1,746,090	1,749,628	1,429,449	1,288,095	1,205,780	1,153,449	1,082,342	1,100,029	754,950	838,445	748,278	668,206	644,829	716,626	647,985	544,871	619,019
81 Dibenzofuran	0	0	0	0	0	0	0	0	0	0	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82 Dichlorodifluoromethane	0	0	0	805,000	561,000	467,000	330,000	71,950	0	10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Table A-3
TRI Refinery Air Emissions, pounds per year

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
124	Methylene Bromide	0	0	0	53	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125	Methylenebis(Phenylisocyanate)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	Mixture	0	0	0	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	456	0	201	0	0	0	0
127	Molybdenum Trioxide	1,487	15,160	2,213	2,280	2,021	3,424	2,501	926	1,525	1,275	991	2,758	1,649	2,953	2,573	1,968	10,466	2,436	10,056	1,746	5,654	3,310	1,883	3,437	3,545
128	m-Xylene	932,022	598,502	788,436	608,254	620,224	919,929	448,365	272,720	425,153	446,769	263,863	292,456	128,871	180,579	133,441	127,844	112,048	75,181	79,906	60,174	58,501	50,588	53,762	44,996	100,659
129	n,n-Dimethylformamide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	18	0	0	1	2	3	1	1	6
130	Naphthalene	379,823	397,101	423,583	286,236	309,149	307,494	256,447	262,061	264,974	223,410	251,733	211,346	203,507	225,798	190,878	229,720	233,024	243,304	248,714	221,503	227,933	188,410	190,243	185,466	272,509
131	n-Butyl Alcohol	0	500	81	5	5	0	150	130	73	69	17,300	11,141	123	995	1,325	520	802	1,173	607	920	3,595	1,516	1,120	1,208	591
132	n-Hexane	0	0	0	0	0	0	0	5,257,404	5,076,069	4,470,443	4,127,305	3,646,188	3,697,065	3,633,148	3,774,703	3,806,529	3,355,049	3,827,200	3,324,116	3,212,019	3,208,544	2,736,911	2,953,131	3,073,976	3,021,475
133	Nickel	8,201	3,554	10,234	6,825	1,608	2,536	1,905	3,102	18,909	778	3,857	1,159	3,312	4,564	2,812	2,656	6,003	6,034	3,579	2,020	2,390	1,856	2,117	2,143	897
134	Nickel Compounds	18,095	21,833	15,845	17,050	19,051	36,724	37,209	38,839	39,579	34,473	37,230	30,516	19,974	32,875	34,975	36,576	33,564	33,821	30,662	28,192	21,231	20,435	23,823	20,457	19,537
135	Nitrate Compounds	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10
136	Nitric Acid	250	250	47	47	370	370	500	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137	Nitrobenzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138	n-Methyl-2-Pyrrolidone	0	0	0	0	0	0	0	297,460	432,608	393,739	273,925	229,648	428,490	217,489	193,375	392,769	248,816	124,337	91,912	83,000	105,500	8,400	9,098	1,480	7,790
139	o-Cresol	0	0	0	4,800	0	0	0	1	0	0	0	0	0	1	1	64	18	0	0	0	0	0	0	0	0
140	o-Xylene	588,390	378,762	493,409	373,745	419,279	427,428	278,445	246,470	330,760	432,567	236,694	174,307	105,129	184,540	87,864	84,184	76,955	56,901	59,940	47,370	40,663	34,677	36,407	29,200	44,426
141	Ozone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31,557	31,748	96,717	63,426
142	p-Cresol	0	0	0	2,100	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
143	Phenanthrene	0	0	0	0	0	0	0	1,974	2,692	4,959	1,498	13,825	18,121	6,753	5,122	3,438	3,082	5,268	3,172	3,380	5,163	5,697	4,905	6,892	27,409
144	Phenol	430,342	409,558	421,754	422,580	459,175	466,985	463,643	455,553	159,705	120,381	86,919	76,585	82,873	140,548	113,610	181,122	187,129	156,626	101,120	119,993	115,039	82,555	133,825	109,788	97,704
145	Phosphoric Acid	1,538	1,000	1,025	290	525	288	37	662	996	570	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	Phosphorus	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	0	0	0	0
147	Phthalic Anhydride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148	Polychlorinated Biphenyls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
149	PAC	0	0	0	0	0	0	0	26,352	27,466	42,602	84,851	45,040	129,168	126,526	80,700	50,781	36,729	50,403	31,994	26,884	33,010	17,617	11,463	12,021	11,674
150	p-Phenylenediamine	0	0	0	0	0	0	0	0	0	0	355	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	Propionaldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152	Propylene	4,866,956	6,341,841	5,724,455	6,658,593	5,743,924	4,963,067	6,180,851	5,408,192	4,486,364	4,653,486	4,407,569	3,656,256	3,291,949	3,036,362	2,976,482	2,594,802	2,657,017	2,840,384	3,583,300	2,643,236	3,062,746	2,217,611	1,922,824	1,988,014	1,868,551
153	Propylene Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,300	4,100	4,400	0	0	0	0	0	0
154	p-Xylene	681,263	490,677	667,626	530,654	507,250	906,219	414,232	935,252	738,896	886,623	352,290	481,179	347,744	425,660	274,260	290,220	230,872	176,138	166,642	129,685	120,468	127,707	114,006	128,931	127,047
155	Pyridine	0	0	0	0	130	0	5,700	11,000	1,000	0	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0
156	Quinoline	0	0	0	0	0	0	0	0	0	0	190	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157	Sec-Butyl Alcohol	500	500	500	500	500	0	0	0	0	0	2,909	0	0	0	0	5,801	36	32	154	67	32	123	103	110	130
158	Selenium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	44	44	31	32	49	47
159	Selenium Compounds	0	0	3,300	3,327	3,300	3,300	3,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	Silver	2,084	1,581	1,336	1,605	1,600	1,800	2,849	3,849	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
161	Silver Compounds	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	9,205	11,005	12,005	11,011	5,712	6,411	4,411	5,610	7,211	9,110
162	Sodium Dimethyldithiocarbamate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163	Sodium Hydroxide	5,315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
164	Sodium Nitrite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	360	0	0	0	0	0



**Table A-3
TRI Refinery Air Emissions, pounds per year**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
165	Styrene	12,775	6,762	6,739	10,397	7,791	11,239	5,320	71,856	4,826	4,315	6,787	5,855	10,339	9,313	10,327	18,456	17,158	23,443	89,708	28,923	31,078	19,641	26,989	22,397	36,170
166	Sulfuric Acid	774,201	800,508	731,453	1,252,302	1,660,100	1,178,909	1,019,563	514,418	2,378,626	2,950,742	7,607,683	8,351,932	9,350,888	10,260,705	10,763,040	10,705,034	10,163,512	7,649,135	7,244,094	6,484,193	6,063,101	4,834,199	4,991,899	5,318,020	4,934,749
167	Tert-Butyl Alcohol	77,750	77,127	105,859	55,329	22,028	15,531	27,057	43,719	116,373	29,079	5,110	5,654	4,845	3,902	1,836	9,314	1,008	537	244	322	6,355	4,972	4,808	643	533
168	Tetrachloroethylene	688	695	683	1,751	4,015	23,448	27,827	36,588	42,711	56,383	53,917	56,464	70,497	66,699	61,774	55,003	61,431	41,051	42,870	45,580	44,802	54,885	38,432	45,820	39,979
169	Thallium	0	0	250	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	Titanium Tetrachloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
171	Toluene	13,490,725	10,395,067	11,099,922	10,239,638	9,648,059	8,584,194	7,357,169	7,213,069	6,186,325	5,629,528	5,626,057	4,723,484	4,027,657	4,156,925	4,028,835	3,646,743	3,744,838	3,443,894	3,402,008	3,084,267	2,837,234	2,530,059	2,439,882	2,321,161	2,340,640
172	Toluene-2,4-Diisocyanate	0	0	30	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173	Trans-1,3-Dichloropropene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174	Trichloroethylene	1,050	2,520	2,805	4,445	1,705	0	3,400	14,600	66,724	53,453	49,699	62,780	62,651	57,643	23,098	32,155	27,228	30,579	37,609	35,959	35,632	29,800	40,307	30,064	18,901
175	Trichlorofluoromethane	0	0	0	38,000	210	4,800	0	750	0	0	0	0	0	0	0	0	0	29	34	46	46	33	33	29	28
176	Vanadium	2,340	1,586	1,329	1,761	0	0	0	393	617	1,062	683	2,402	5,878	4,296	2,183	4,195	1,858	4,358	4,750	1,973	1,364	129	84	118	81
177	Vanadium Compounds	0	0	0	0	0	0	0	0	0	0	0	0	21,353	20,098	19,914	19,383	16,646	14,373	10,449	6,141	5,125	5,477	4,367	5,664	5,178
178	Vinyl Acetate	500	500	10	1,244	500	250	850	755	480	0	282	290	356	666	193	210	782	847	830	810	925	0	0	0	0
179	Xylene	5,796,542	5,480,109	5,271,202	4,688,253	4,997,273	4,259,275	4,412,105	4,180,291	3,196,990	3,435,335	3,367,056	2,776,438	2,663,668	2,675,159	2,655,396	2,312,509	2,312,953	2,388,655	2,665,294	2,396,913	2,304,116	2,150,418	1,954,175	1,774,063	1,724,788
180	Zinc	250	250	637	700	410	0	210	2,619	2,218	6,654	6,654	6,608	0	0	0	1	0	0	38	26	34	0	21	41	34
181	Zinc Compounds	18,477	22,505	18,322	24,264	22,114	33,881	36,048	36,212	38,283	43,669	46,614	45,143	52,135	51,528	62,064	83,369	49,098	43,803	78,628	54,105	46,220	45,226	47,802	55,043	37,805
	TOTAL By Year	74,278,214	57,086,721	55,846,907	54,131,533	51,667,717	48,010,678	44,846,070	48,630,309	50,533,722	50,901,126	54,133,141	48,417,050	44,834,773	45,218,600	44,932,595	44,475,516	41,118,080	37,982,872	38,597,962	35,438,650	32,989,365	28,113,014	28,079,051	29,895,369	32,571,386



**Table A-4
Number of TRI Pollutants Reported by Refineries**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min	Max	
#	Number of Operating Refineries →	195	193	194	184	183	175	171	165	162	159	157	155	155	150	144	145	146	144	142	145	146	141	137	137	134			
1	1,1,1-Trichloroethane	26	24	27	28	30	29	31	24	9	8	5	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	31	
2	1,1,2-Trichloroethane	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	
3	1,2,3-Trichloropropane	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	
4	1,2,4-Trichlorobenzene	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
5	1,2,4-Trimethylbenzene	85	85	88	92	92	94	96	100	98	102	109	109	110	108	108	109	105	106	109	107	111	114	115	114	115	85	115	
6	1,2-Dibromoethane	15	15	12	8	5	6	5	8	6	6	6	5	6	6	6	5	5	5	5	5	5	4	4	4	4	4	15	
7	1,2-Dichloroethane	21	18	15	15	11	9	7	8	8	6	6	4	4	4	4	4	3	3	3	4	4	4	4	4	4	3	21	
8	1,2-Dichloroethylene	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
9	1,2-Dichloropropane	4	3	2	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
10	1,3-Butadiene	51	57	60	66	66	61	57	66	67	67	69	69	70	74	78	79	80	79	81	81	84	83	77	81	80	51	84	
11	1,3-Dichloropropylene	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
12	1,3-Phenylenediamine	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
13	2,3-Dichloropropene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14	2,4,5-Trichlorophenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
15	2,4-Dichlorophenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16	2,4-Dimethylphenol	0	0	1	1	1	0	0	0	0	0	0	0	3	3	3	3	4	3	1	1	1	2	2	2	2	0	4	
17	2,4-Dinitrotoluene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
18	2,6-Xylidine	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
19	2-Methoxyethanol	11	13	15	16	10	9	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	
20	4,4'-Isopropylidenediphenol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	
21	Acetaldehyde	0	0	0	2	2	0	0	0	0	0	0	0	2	0	0	0	0	1	1	1	1	1	2	2	2	0	2	
22	Acetone	3	5	5	3	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
23	Acetonitrile	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	1	1	1	2	3	3	4	4	0	4	
24	Acetophenone	0	0	0	0	0	0	0	1	1	1	2	1	1	1	2	0	1	1	1	1	1	1	0	0	0	0	2	
25	Acrolein	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	
26	Acrylic Acid	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
27	Acrylonitrile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	
28	Allyl Alcohol	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
29	Allyl Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	Aluminum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	
31	Aluminum Oxide	82	7	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	82	
32	Ammonia	67	68	70	72	76	73	73	80	78	85	85	84	83	86	84	87	91	95	98	98	98	99	98	102	100	67	102	
33	Ammonium Nitrate	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
34	Ammonium Sulfate	2	0	2	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
35	Aniline	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
36	Anthracene	2	3	3	3	5	4	5	6	8	8	9	10	9	16	13	14	13	14	16	21	22	25	24	27	23	2	27	
37	Antimony	5	5	2	0	1	1	0	0	0	1	2	3	3	4	4	3	3	3	4	4	4	3	4	4	3	3	0	5
38	Antimony Compounds	2	3	2	6	7	8	7	8	9	12	11	9	8	10	10	9	13	13	14	12	13	12	14	15	13	2	15	
39	Arsenic	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	
40	Arsenic Compounds	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	0	2	



**Table A-4
Number of TRI Pollutants Reported by Refineries**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min	Max
#	Number of Operating Refineries →	195	193	194	184	183	175	171	165	162	159	157	155	155	150	144	145	146	144	142	145	146	141	137	137	134		
41	Asbestos	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
42	Barium	0	0	1	3	0	0	0	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	3
43	Barium Compounds	3	3	3	3	2	0	0	0	0	1	1	2	0	1	2	1	1	0	2	1	2	0	2	1	2	0	3
44	Benzene	114	110	113	116	115	116	115	117	115	120	124	125	125	124	123	124	122	121	121	118	120	122	122	122	121	110	125
45	Benzidine	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
46	Benzo(g,h,i)Perylene	0	0	0	0	0	0	0	0	0	0	0	0	70	75	77	77	76	73	78	71	75	82	80	84	87	0	87
47	Benzoyl Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	Beryllium	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1
49	Beryllium Compounds	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
50	Biphenyl	7	7	6	7	8	9	6	8	10	10	12	16	15	15	15	15	13	15	21	24	28	29	30	32	33	6	33
51	Bromochlorodifluoromethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	Bromomethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1
53	Bromotrifluoromethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	Butyl Benzyl Phthalate	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
55	Butyraldehyde	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1
56	Cadmium	0	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	2
57	Cadmium Compounds	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	2
58	Carbon Disulfide	1	2	1	3	1	1	1	5	8	8	11	23	23	26	33	34	36	46	51	57	59	57	58	64	64	1	64
59	Carbon Tetrachloride	19	20	23	24	24	16	12	9	6	6	6	4	3	3	2	2	2	2	2	3	3	3	2	2	2	2	24
60	Carbonyl Sulfide	0	1	2	2	3	3	2	6	10	13	16	28	27	31	41	41	42	53	60	61	60	56	54	61	63	0	63
61	Certain Glycol Ethers	3	5	5	6	8	5	8	6	8	9	11	12	12	13	15	16	17	19	14	16	14	13	16	14	15	3	19
62	Chlorine	68	69	68	62	53	50	51	48	46	44	42	36	36	35	35	32	36	37	33	32	30	24	22	23	19	19	69
63	Chlorine Dioxide	0	0	0	0	0	0	0	1	2	2	1	2	2	1	1	1	1	1	1	1	2	2	1	1	0	0	2
64	Chlorobenzene	0	0	0	0	0	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
65	Chlorodifluoromethane	0	0	0	0	0	0	5	5	5	3	4	4	5	4	4	4	4	4	2	2	2	2	2	1	2	0	5
66	Chloroethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	Chloroform	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
68	Chloromethane	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
69	Chlorotrifluoromethane	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1
70	Chromium	8	8	6	6	7	5	4	4	3	2	1	2	1	3	3	0	2	3	4	3	3	4	4	3	1	0	8
71	Chromium Compounds	26	30	28	21	14	14	11	9	5	5	4	9	10	7	8	10	9	15	14	13	13	11	11	15	14	4	30
72	Cobalt	4	5	3	1	0	1	1	1	1	2	1	3	2	2	2	3	3	2	1	2	2	3	2	2	2	0	5
73	Cobalt Compounds	4	4	6	7	6	8	5	5	5	6	7	10	11	13	21	20	20	25	38	28	39	34	32	41	42	4	42
74	Copper	1	2	3	3	2	3	2	3	3	2	2	1	1	2	1	1	2	3	2	3	2	4	3	3	3	1	4
75	Copper Compounds	5	4	3	10	7	9	5	10	7	6	11	13	12	17	17	15	14	14	16	14	16	15	15	14	15	3	17
76	Cresol (Mixed Isomers)	9	12	14	12	13	12	16	17	13	12	13	15	17	21	24	26	26	26	25	27	30	34	34	37	37	9	37
77	Cumene	33	38	40	38	38	38	40	44	47	47	50	52	53	59	60	61	59	66	70	70	74	78	75	78	80	33	80
78	Cumene Hydroperoxide	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
79	Cyanide Compounds	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5	6	8	12	12	13	14	14	13	13	12	0	14
80	Cyclohexane	97	101	102	107	101	101	103	107	105	110	114	115	116	115	115	114	110	112	112	112	112	114	112	113	114	97	116



**Table A-4
Number of TRI Pollutants Reported by Refineries**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min	Max	
#	Number of Operating Refineries →	195	193	194	184	183	175	171	165	162	159	157	155	155	150	144	145	146	144	142	145	146	141	137	137	134			
81	Dibenzofuran	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
82	Dichlorodifluoromethane	0	0	0	6	8	6	4	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
83	Dichloromethane	1	0	0	1	2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	
84	Dicyclopentadiene	0	0	0	0	0	0	0	2	0	0	1	2	3	2	2	0	2	2	2	2	2	1	2	1	1	0	3	
85	Diethanolamine	23	21	20	22	21	24	26	28	26	27	32	28	27	28	29	31	29	28	27	25	23	28	28	26	29	20	32	
86	Diisocyanates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
87	Dimethyl Phthalate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
88	Dimethyl Sulfate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
89	Dimethylamine	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	
90	Dioxin and Like Compounds	0	0	0	0	0	0	0	0	0	0	0	0	56	53	52	54	55	53	58	61	60	60	60	65	68	0	68	
91	Diphenylamine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
92	Epichlorohydrin	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
93	Ethylbenzene	102	103	107	111	110	111	110	112	110	116	120	120	121	120	119	120	117	115	116	116	118	121	122	122	120	102	122	
94	Ethylene	82	87	86	87	90	89	87	91	89	93	95	95	96	95	94	96	96	97	97	98	98	97	93	96	95	82	98	
95	Ethylene Glycol	11	12	11	15	13	13	13	13	14	14	11	8	12	15	16	15	17	13	14	10	15	15	13	13	11	8	17	
96	Ethylene Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	
97	Ethylidene Dichloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
98	Formaldehyde	2	2	3	6	4	2	2	3	3	3	3	4	5	2	5	5	5	7	5	5	5	5	4	5	5	2	7	
99	Formic Acid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
100	Freon 113	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	
101	Glycidol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
102	Hexachlorobenzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
103	Hydrazine	1	2	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
104	Hydrochloric Acid	12	17	18	19	20	19	18	19	18	18	22	25	28	31	35	38	41	48	51	52	55	56	51	53	53	12	56	
105	Hydrogen Cyanide	0	0	1	2	2	2	2	3	3	2	1	3	3	8	12	14	16	26	27	33	32	32	31	44	46	0	46	
106	Hydrogen Fluoride	46	46	44	47	48	47	44	46	44	47	43	43	44	44	44	43	44	43	45	42	45	43	39	45	48	39	48	
107	Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	0	113	
108	Hydroquinone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
109	Isobutyraldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
110	Isoprene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	14	0	14
111	Isopropyl Alcohol	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
112	Lead	14	10	6	5	5	4	3	1	1	1	0	1	1	17	14	18	16	15	15	17	16	14	15	14	15	0	18	
113	Lead Compounds	28	26	23	22	14	17	13	12	10	10	11	10	13	67	73	72	76	75	77	76	79	82	80	82	80	10	82	
114	Manganese	0	3	1	1	3	3	3	2	2	0	0	1	1	2	2	3	3	3	6	6	4	4	3	4	3	0	6	
115	Manganese Compounds	11	9	11	8	5	5	4	3	4	3	4	3	2	3	4	3	4	6	5	7	9	6	4	4	3	2	11	
116	m-Cresol	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	
117	Mercury	0	0	0	0	0	0	0	0	0	0	0	0	23	22	21	20	19	20	19	21	20	21	20	20	21	0	23	
118	Mercury Compounds	0	0	0	1	1	1	0	0	0	0	0	0	65	63	65	66	68	72	75	78	79	76	76	78	76	0	79	
119	Methanol	38	40	44	46	50	57	56	61	60	62	62	61	66	66	65	66	64	62	65	65	67	67	66	64	64	38	67	
120	Methyl Ethyl Ketone	16	15	15	14	14	12	12	14	14	13	15	14	14	13	15	14	0	0	0	0	0	0	0	0	0	0	16	



**Table A-4
Number of TRI Pollutants Reported by Refineries**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min	Max
#	Number of Operating Refineries →	195	193	194	184	183	175	171	165	162	159	157	155	155	150	144	145	146	144	142	145	146	141	137	137	134		
121	Methyl Isobutyl Ketone	2	3	2	2	3	4	4	4	3	3	3	4	3	4	5	5	5	5	5	6	4	3	3	4	4	2	6
122	Methyl Methacrylate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123	Methyl Tert-Butyl Ether	40	47	49	49	56	59	63	63	58	59	60	56	51	48	45	35	27	25	25	11	7	6	5	4	4	4	63
124	Methylene Bromide	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
125	Methylenebis(Phenylisocyanate)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	Mixture	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
127	Molybdenum Trioxide	10	11	10	14	15	14	9	14	17	18	21	20	20	23	28	23	20	23	25	23	30	24	30	26	23	9	30
128	M-Xylene	13	12	12	14	15	13	14	10	13	14	15	12	10	8	8	8	8	8	7	5	5	6	6	7	8	5	15
129	n,n-Dimethylformamide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	1	1	1	1	1	0	2
130	Naphthalene	57	59	63	69	72	69	69	83	85	86	88	92	94	95	94	96	100	105	106	111	114	115	112	114	115	57	115
131	n-Butyl Alcohol	0	1	1	1	1	0	1	1	1	1	1	3	2	4	3	2	6	8	4	5	9	7	8	5	3	0	9
132	n-Hexane	0	0	0	0	0	0	0	101	103	108	115	120	120	119	118	119	115	116	118	117	118	121	120	119	119	0	121
133	Nickel	10	9	12	8	7	7	8	7	6	4	6	7	8	6	8	7	7	9	5	4	3	3	4	4	3	3	12
134	Nickel Compounds	19	17	17	25	23	28	25	27	28	31	35	35	36	41	42	44	47	49	57	55	54	56	57	57	58	17	58
135	Nitrate Compounds	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	0	1
136	Nitric Acid	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
137	Nitrobenzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138	n-Methyl-2-Pyrrolidone	0	0	0	0	0	0	0	7	7	7	7	7	5	5	5	6	5	3	2	2	2	2	3	1	2	0	7
139	o-Cresol	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0	0	0	2
140	o-Xylene	15	14	13	14	15	14	14	11	12	15	16	13	11	9	7	7	7	8	7	6	5	6	6	7	8	5	16
141	Ozone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	3	0	4
142	p-Cresol	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
143	Phenanthrene	0	0	0	0	0	0	0	4	8	7	7	9	12	23	22	23	22	22	28	33	33	37	33	34	34	0	37
144	Phenol	23	24	27	26	25	21	22	29	29	30	29	32	32	39	44	51	47	55	54	57	57	62	59	60	58	21	62
145	Phosphoric Acid	5	3	5	6	5	6	4	9	10	11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
146	Phosphorus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1
147	Phthalic Anhydride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148	Polychlorinated Biphenyls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
149	PACs	0	0	0	0	0	0	0	34	37	37	43	43	104	104	107	106	106	105	108	104	105	108	109	111	113	0	113
150	p-Phenylenediamine	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
151	Propionaldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
152	Propylene	89	93	91	92	95	95	95	97	92	96	98	98	98	98	97	98	97	98	99	98	99	101	98	100	100	89	101
153	Propylene Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1
154	p-Xylene	13	12	12	14	15	14	14	11	12	13	14	11	9	7	7	7	6	6	6	4	5	4	5	6	7	4	15
155	Pyridine	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
156	Quinoline	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
157	Sec-Butyl Alcohol	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	2	2	1	2	2	2	2	2	2	1	0	2
158	Selenium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1
159	Selenium Compounds	0	0	1	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3
160	Silver	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1



**Table A-4
Number of TRI Pollutants Reported by Refineries**

	Pollutant	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min	Max	
#	Number of Operating Refineries →	195	193	194	184	183	175	171	165	162	159	157	155	155	150	144	145	146	144	142	145	146	141	137	137	134			
161	Silver Compounds	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	
162	Sodium Dimethyldithiocarbamate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163	Sodium Hydroxide	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	
164	Sodium Nitrite	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	
165	Styrene	14	11	10	8	9	8	11	13	12	12	16	15	13	13	16	17	18	19	27	30	32	33	37	38	38	8	38	
166	Sulfuric Acid	24	24	28	31	29	29	20	16	16	19	37	44	48	56	60	59	59	63	68	68	70	66	64	63	60	16	70	
167	Tert-Butyl Alcohol	5	5	6	5	6	7	8	11	11	11	12	12	12	9	12	8	6	7	8	7	7	5	5	4	3	3	12	
168	Tetrachloroethylene	2	1	1	1	6	18	22	34	36	41	47	46	50	49	50	51	53	52	52	55	57	56	57	54	52	1	57	
169	Thallium	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
170	Titanium Tetrachloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
171	Toluene	111	111	112	117	114	113	113	115	111	116	121	124	124	122	121	120	119	117	118	119	118	120	120	119	119	111	124	
172	Toluene-2,4-Diisocyanate	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
173	Trans-1,3-Dichloropropene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
174	Trichloroethylene	1	1	1	3	1	0	2	2	3	4	4	5	4	5	5	4	5	5	4	3	3	3	5	3	2	0	5	
175	Trichlorofluoromethane	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	
176	Vanadium	3	3	3	2	0	0	0	1	1	1	1	2	5	4	4	4	5	7	5	6	6	6	5	6	4	0	7	
177	Vanadium Compounds	0	0	0	0	0	0	0	0	0	0	0	0	16	18	18	16	15	14	17	19	21	23	22	24	25	0	25	
178	Vinyl Acetate	1	1	1	2	1	1	1	1	1	0	2	2	2	2	2	2	2	2	1	1	1	0	0	0	0	0	2	
179	Xylene	99	102	104	105	102	104	104	109	106	109	115	118	118	119	119	118	115	115	116	116	118	119	119	119	119	99	119	
180	Zinc (Fume Or Dust)	1	1	1	2	1	0	1	1	1	1	1	1	0	0	0	1	0	0	1	1	1	0	1	1	1	0	2	
181	Zinc Compounds	15	17	16	20	22	22	20	24	24	24	27	26	26	28	30	27	28	28	39	40	34	35	35	37	36	15	40	



**Table A-5
Comparison of EPA ICR “Actual” Emissions to 2010 TRI Data**

#	Pollutant	Model Data	TRI Data			Model/ 2010 TRI
			2010	2011	2012	
		Tons	ton/yr	ton/yr	ton/yr	%
1	1,1,2-Trichloroethane	1.3	0.7	0.7	0.7	193%
2	1,3-Butadiene	130.6	46.1	106.7	112.8	283%
3	1,3-Dichloropropene	1.8	0.0	0.0	0.0	
4	Acetaldehyde	71.9	1.1	1.1	3.1	6,783%
5	Acetonitrile	12.0	8.2	7.7	7.3	146%
6	Acrolein	23.5	0.2	0.2	0.1	10,693%
7	Acrylonitrile	8.6	0.3	0.3	0.3	3,339%
8	Aniline	6.9	0.0	0.0	0.0	
9	Anthracene	16.6	1.0	1.2	0.7	1,746%
10	Antimony	5.8	0.3	0.2	0.2	2,048%
11	Arsenic	0.5	3.2E-03	8.3E-03	7.1E-03	14,929%
12	Benzene	1,241.9	736.3	690.3	655.1	169%
13	Benzidine	1.96E-03	0.0	0.0	0.0	
14	Benzo[g,h,i,j]Perylene	0.8	0.4	0.3	0.3	205%
15	Beryllium	0.9	0.0	0.0	0.0	247,312%
16	Biphenyl	41.0	7.1	7.0	6.8	577%
17	Cadmium	1.2	3.3E-03	1.4E-02	1.4E-02	37,508%
18	Carbon Disulfide	125.6	33.6	34.0	38.1	374%
19	Carbon Tetrachloride	4.69E-03	0.1	0.1	0.1	7%
20	Carbonyl Sulfide	372.8	159.1	162.5	141.9	234%
21	Chlorine	21.7	10.9	27.6	27.0	198%
22	Chlorobenzene	5.4	0.0	0.0	0.0	
23	Chloroform	1.0	0.0	0.0	0.0	
24	Chromium (VI)	0.8	2.2	2.1	2.4	37%
25	Cobalt	1.8	0.5	0.4	1.3	361%
26	Cresol	57.8	10.1	9.3	8.1	575%
27	Cumene	168.6	68.4	69.9	54.9	247%
28	Dibenzofuran	0.2	0.0	0.0	0.0	
29	Diethanolamine	52.0	39.9	40.4	44.8	130%
30	Dioxins	6.18E-08	2.4E-05	2.6E-05	2.4E-05	0%
31	Ethyl Benzene	517.6	260.2	231.9	222.6	199%
32	Ethylene Glycol	1.32E-04	11.8	10.4	12.5	0%
33	Ethylene Oxide	0.1	0.1	0.2	0.2	94%
34	Ethylidene Dichloride	0.6	0.0	0.0	0.0	
35	Formaldehyde	424.1	33.7	40.4	41.6	1,257%
36	Hexane	3,836.6	1,476.6	1,537.0	1,510.7	260%
37	Hydrochloric Acid	931.5	441.4	528.7	395.9	211%
38	Hydrogen Cyanide	3,682.1	248.7	1,185.3	2,285.9	1,480%
39	Hydrogen Fluoride	220.1	170.4	35.3	26.5	129%



**Table A-5
Comparison of EPA ICR “Actual” Emissions to 2010 TRI Data**

#	Pollutant	Model Data	TRI Data			Model/ 2010 TRI
			2010	2011	2012	
		Tons	ton/yr	ton/yr	ton/yr	%
40	Hydrogen Sulfide	697.5	0.0	0.0	776.8	90%
41	Lead	3.6	2.9	3.0	2.6	121%
42	Manganese	5.4	2.9	2.9	2.5	187%
43	m-Cresol	1.0	0.0	0.0	0.0	
44	Mercury	1.9	0.9	1.0	0.8	213%
45	Methanol	469.4	360.2	381.6	395.4	130%
46	Methyl Isobutyl Ketone	129.0	109.1	149.2	127.3	118%
47	Methyl Tert-Butyl Ether	118.8	9.1	7.8	8.2	1,303%
48	m-Xylene	108.5	26.9	22.5	50.3	403%
49	N,N-Dimethylformamide	4.64E-03	0.0	0.0	0.0	927%
50	Naphthalene	270.3	95.1	92.7	136.3	284%
51	Nickel	34.9	13.0	11.3	10.2	269%
52	Nitrobenzene	0.2	0.0	0.0	0.0	
53	o-Cresol	2.6	0.0	0.0	0.0	
54	o-Xylene	70.6	18.2	14.6	22.2	388%
55	p-Cresol	0.2	0.0	0.0	0.0	
56	Phenanthrene	14.1	2.5	3.4	13.7	576%
57	Phenol	63.6	66.9	54.9	48.9	95%
58	Phosphorus	1.6	0.0	0.0	0.0	
59	Polychlorinated Biphenyls	1.00E-03	0.0	0.0	0.0	
60	p-Phenylenediamine	4.29E-04	0.0	0.0	0.0	
61	Propionaldehyde	3.97E-04	0.0	0.0	0.0	
62	p-Xylene	121.8	57.0	64.5	63.5	214%
63	Quinoline	2.32E-02	0.0	0.0	0.0	
64	Selenium	2.3	1.60E-02	2.43E-02	2.36E-02	14,339%
65	Styrene	345.9	13.5	11.2	18.1	2,563%
66	Tetrachloroethylene	22.3	19.2	22.9	20.0	116%
67	Toluene	2,453.9	1,219.9	1,160.6	1,170.3	201%
68	Trichloroethylene	5.4	20.2	15.0	9.5	27%
69	Xylenes	1,924.6	977.1	887.0	862.4	197%
	All	18,854.9	6,783.9	7,637.2	9,341.1	278%