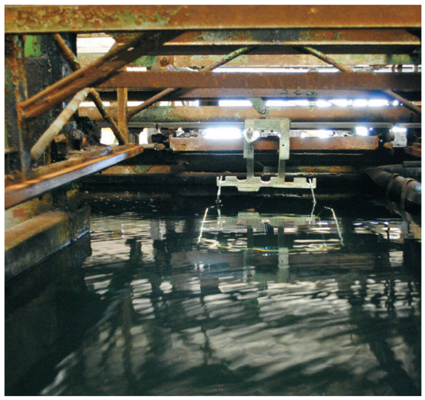
OPPORTUNITIES FOR CANCER PREVENTION:

Trends in the Use and Release of Carcinogens in Massachusetts



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Opportunities for Cancer Prevention: Trends in the Use and Release of Carcinogens in Massachusetts

Methods and Policy Report #29

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The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs and provides technical support to help Massachusetts companies and communities to reduce the use of toxic chemicals. For more information, visit our website, www.turi.org, write to the Toxics Use Reduction Institute, University of Massachusetts Lowell, 600 Suffolk St., Suite 501, Wannalancit Mills, Lowell, Massachusetts 01854, or call 978-934-3275.

This report is part of the Institute's series on Toxics Use Reduction and Disease Prevention. Other publications in this series include *Asthma-Related Chemicals in Massachusetts: An Analysis of Toxics Use Reduction Data* (2009) and *TUR and Disease Prevention Fact Sheet: Asthma* (2012).

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GLOSSARY OF TERMS USED

Cancer Incidence: The number of new cases of cancer of a specific site/type that develop in a specified population (e.g. Massachusetts) during a specified time period. Most commonly a year is the period of time examined.

Cancer Incidence Rate: The number of new cases of cancer of a specific site/type occurring in a specified population during a year, usually expressed as the number of cancers per 100,000 population at risk. The population used depends on the rate to be calculated. For cancer sites that occur in only one sex (e.g., prostate cancer), the sex-specific population (e.g., males at risk for prostate cancer) is used. Only new, rather than reoccurring, rates of cancer are included in an incidence rate. Thus, the time experienced by people/population in the denominator of an incidence rate is often referred to as the “time at risk.”

Age-Adjusted Cancer Incidence Rate: A weighted average of the age-specific cancer rates, where the weights are the proportions of persons in the corresponding age groups of a standard population. The potential confounding effect of age is reduced when comparing age-adjusted rates computed using the same standard population. Age-adjusted incidence rates are often reported as 5-year averages, calculated by totaling the number of cases (age- and sex-specific) over the five years, then using the person-years (age and sex-specific) to derive the five-year rate. This rate is then multiplied by a standard population age breakdown to calculate the age-adjusted rate.

Higher Hazard Substance: A chemical classification under TURA. Chemicals designated as Higher Hazard Substances are prioritized for attention under TURA, and have a reporting threshold of 1,000 lb/year of use.

Environmental Releases: Emissions to air, water or soil as well as fugitive emissions such as leaks through pipe fittings, tanks and loading/unloading operations, evaporative losses, etc. Includes the following TRI reported amounts: fugitive or non-point and point or stack air releases, discharge to water bodies or receiving streams, underground injection, disposal to land and surface impoundments or other disposal. Does not include amounts transferred off-site for treatment and/or eventual disposal or discharged to wastewater treatment facilities.

EPA Persistent, Bioaccumulative and Toxic (PBT) chemicals: Chemicals defined by the U.S. Environmental Protection Agency as persistent, bioaccumulative, and toxic (PBT) are automatically designated as Higher Hazard Substances under TURA (see above). PBTs have lower reporting thresholds (ranging from 0.1 gram to 100 pounds depending on the substance).

More and Less Hazardous Chemical Lists: Priority-setting lists established and maintained by the TURA Science Advisory Board. These lists are strictly informational to provide guidance to Massachusetts companies and the TURA program.

Toxics Use Reduction (TUR): An approach to pollution prevention that identifies cost-effective strategies to reduce the use of toxic materials. Strategies include process redesign, substitution with safer alternatives, and others.

Toxics Use Reduction Act (TURA): TURA was enacted into Massachusetts law in 1989 to encourage companies and communities to reduce their use of toxic chemicals. The law requires that Massachusetts companies that use or manufacture large quantities of any one of approximately 1,500 listed chemicals: (1) report their use and release byproduct generation of these chemicals every year, (2) prepare a Toxics Use Reduction Plan every two years describing how they can reduce their use of toxics, and (3) pay an annual fee based on the number of full-time employees and the number of chemicals reported. The 1989 statute defines large quantity as 25,000 pounds per year if a firm manufactures or processes a substance, or 10,000 pounds per year if a firm “otherwise uses” a substance. Applicable thresholds are lower for substances designated as Higher Hazard Substances under TURA and for substances designated as Persistent, Bioaccumulative and Toxic (PBT) by the U.S. EPA.

Use: Total chemical use including amounts reported by facilities under TURA as manufactured, processed or otherwise used.

EXECUTIVE SUMMARY

Toxics use reduction (TUR) is one part of a comprehensive cancer prevention strategy. TUR emphasizes reducing the use of cancer-causing chemicals by improving manufacturing processes and adopting safer alternatives. This report draws on 20 years of data collected from industries reporting to the Massachusetts Toxics Use Reduction Act program to assess trends in the use and release of chemicals associated with cancer. The analysis shows that reported use and releases of carcinogens among Massachusetts companies have decreased dramatically over time. Reported use declined 32% from 1990 to 2010, and reported releases declined 93% from 1991 to 2010. The report also identifies opportunities for the program to achieve further successes in preventing exposure to cancer-causing chemicals.

Introduction

In Massachusetts, the Toxics Use Reduction Act (TURA) program is an important facet of the state's capacity to prevent cancer. TURA is designed to protect public health and the environment, while promoting the competitiveness of Massachusetts businesses, by helping companies and communities to reduce their use of chemicals that are associated with cancer and other diseases. The TURA program works with both large and small businesses. These businesses' efforts to reduce toxics have benefits for workers as well as the general public.

Under TURA, facilities in certain industry sectors that use more than a specified amount of toxic chemicals and have 10 or more full-time employee equivalents are required to submit annual data on their use of toxic chemicals. This report uses data submitted under TURA to analyze use and release patterns for chemicals associated with cancer. The report is intended as a resource both for professionals working in the area of toxics use reduction and for those working in the area of cancer prevention.

Background

Cancer in Massachusetts: Cancer incidence rates have increased since the 1980s. Every day nearly 100 Massachusetts residents are diagnosed with cancer. According to data collected by the Massachusetts Department of Public Health, cancer incidence rates in Massachusetts have increased 14% among men and 19% among women since the mid-1980s, when surveillance efforts in the state first began. Incidence rates of many types of cancer have increased dramatically since the mid-1980s, including breast cancer, kidney cancer, leukemia, and non-Hodgkin's lymphoma, as well as childhood cancers, such as leukemia and brain and central nervous system cancer. The good news is that some cancers, such as bladder cancer and lung cancer among men and non-Hodgkin's lymphoma among women, show declines in recent years. However, others continue to rise; these include kidney cancer and liver cancer.

Cancer prevention requires a comprehensive approach, including efforts to reduce chemical carcinogens in workplaces and the environment. Risk factors for cancer act within complex causal webs reflecting the cumulative and combined effect of multiple factors across an individual's life. Factors affecting cancer risk include genetic inheritance, lifestyle factors such as diet and tobacco use, infectious disease agents, and industrial chemicals in workplaces and communities, among others. Science has yet to fully reveal all the mechanisms by which these factors interact to affect the development of cancer. However, there are many straightforward opportunities for prevention, including reducing or eliminating exposure to industrial carcinogens.

Primary prevention focuses on preventing healthy people from developing cancer in the first place. This is in contrast to secondary prevention activities, such as screening to detect early-stage cancers. The World Health Organization has noted that primary prevention strategies that eliminate or reduce exposure to recognized risk factors of cancer are the most cost-effective way to reduce the global burden of cancer.

In 2012, Massachusetts released its Comprehensive Cancer Prevention and Control Plan for 2012-2016. The plan outlines a broad array of prevention activities to reduce cancer risk associated with risk factors including tobacco, alcohol, poor nutrition, physical inactivity, and infectious disease agents as well as environmental and occupational exposures. Specific objectives and strategies are outlined for each. Regarding environmental and occupational risk factors, the plan includes objectives focused on educating both consumers and health care providers about industrial and environmental carcinogens.

Toxics Use Reduction: A core primary prevention strategy. Toxics Use Reduction (TUR) is a form of primary prevention. TUR focuses on minimizing the use of industrial carcinogens through process redesign and substitution with safer alternatives, rather than just controlling "end of pipe" emissions. By reducing or eliminating carcinogens at their source, TUR reduces the opportunity for exposure to industrial carcinogens in the workplace, in the environment, and in consumer products and is among the array of cancer prevention strategies outlined in the 2012-2016 Comprehensive Cancer Prevention and Control Plan for Massachusetts.

Methodology

To assess trends in the use and release of industrial carcinogens, this study used several authoritative sources to create a Master Carcinogen List of chemicals considered to be known or suspected carcinogens, and matched this list with the list of chemicals that are reportable under TURA.

Based on the carcinogens that have been reported by TURA filers at some point in the program during the period 1990 to 2010, a list of carcinogens with known or suspected links to specific types of cancer was generated. Eleven cancer sites were chosen as a focus for this report: bladder, brain and other central nervous system (CNS), breast, kidney, blood/bone marrow (leukemia), liver, lung, immune system (non-Hodgkin's lymphoma), pancreas, prostate, and testis.

The trend analysis examined annual quantities of industrial carcinogens that were used and released to the environment over the period 1990 to 2010. Trends were also examined for the use and environmental releases of chemicals grouped by their association with specific cancer types.

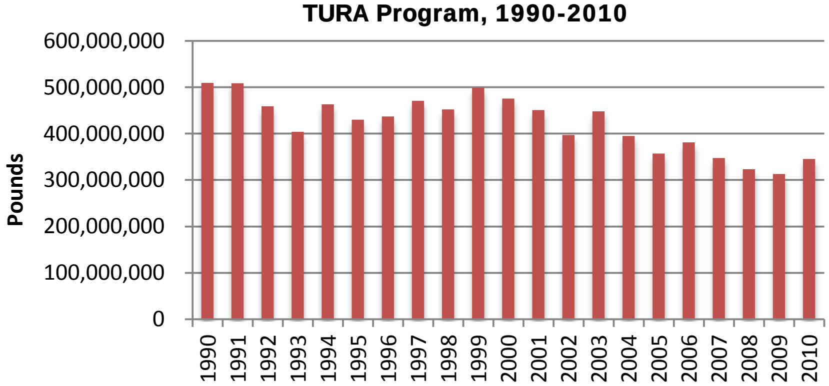
As background, the report also reviews trends in cancer incidence rates for these specific cancer types and provides information about the range of important risk factors for each, including lifestyle and dietary factors as well as specific chemicals. Where relevant, the report provides a brief description of other factors influencing trends in cancer incidence rates, such as screening or diagnostic changes.

Results

The Master Carcinogen List shows that 200 known or suspected industrial carcinogens are reportable under the TURA program. Seventy-four of these chemicals have been reported at some point over the period 1990 to 2010. The trend analysis examined use and environmental release patterns for these 74 chemicals.

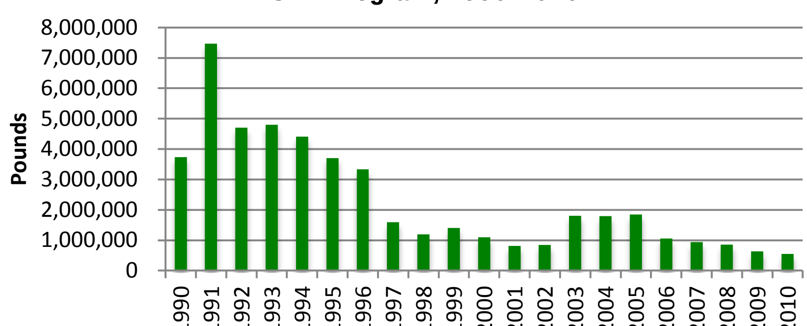
Overall trends: Use and releases of carcinogens have declined. From 1990 to 2010, facilities reporting to the TURA program documented significant reductions in their use and releases of known and suspected carcinogens. Overall, reported use of carcinogens declined 32% (Figure A). The chemical used in the largest amount was styrene monomer, which accounted for 76% of the total known and suspected carcinogen use from 1990 to 2010. Excluding styrene from the analysis, reported use of the remaining group of known and suspected carcinogens declined 53%. Reported releases have declined 93% since 1991, when reporting by electric utilities was phased into the TURA program (Figure B).

Figure A. Total Use of Known and Suspected Carcinogens TURA Program, 1990-2010



Based on publicly available data. Data claimed trade secret are not included in these figures.

Figure B. Total Environmental Releases of Known and Suspected Carcinogens TURA Program, 1990-2010



Based on publicly available data. Data claimed trade secret are not included in these figures.

Looking individually at the 74 known or suspected carcinogens that have been reported to the TURA program over the last twenty years, all show significant declines in reported environmental releases. As shown in Table A, some of the declines have been quite significant—over 90% for nearly a dozen chemicals. Moreover, the total amounts reduced are quite striking for some of these chemicals. For example, reported releases of trichloroethylene declined from 1.3 million pounds in 1990 to 51,000 pounds in 2010.

Table A. Known and Suspected Carcinogens with over 90% Declines in Reported Environmental Releases	
Chemical	**Percent Decline 1990-2010**
Cadmium and cadmium compounds	94%
Chromium and chromium compounds	91%
Di(2-ethylhexyl) phthalate	99%
Ethylene oxide	96%
Formaldehyde	91%
Methylene chloride	98%
Toluene diisocyanate	96%
Trichloroethylene	96%
Tetrachloroethylene	96%

For most of the 74 chemicals, reported use also declined. Notable declines from 1990-2010 included a 92% reduction in trichloroethylene use, an 85% reduction in tetrachloroethylene use, and a 69% reduction in the use of cadmium and cadmium compounds. However, some known and suspected carcinogens continued to be used in large amounts, despite overall declines. For example, in 2010 the chemicals with the highest reported use included styrene (291.9 million pounds), sulfuric acid (28.0 million pounds), toluene diisocyanate (6.7 million pounds), epichlorohydrin (4.2 million pounds), and lead and lead compounds (3.9 million pounds). In addition, some known and suspected carcinogens showed notable increases in reported use, including dioxin and dioxin-like compounds (unintentionally manufactured), ethylene oxide and hydrazine. With regard to dioxins, some of this increase may be the result of imprecise estimation techniques used by Waste to Energy (WtE) facilities (incinerators) to estimate their annual dioxin generation.

Trends in carcinogens associated with specific cancer sites: Use and releases have declined for most of the groups examined, but amounts are still large. As shown in Table B, reported use of the group of chemicals associated with each type of cancer decreased over the period 1990 to 2010. The group of chemicals associated with testicular cancer showed the largest decline in reported use, a decline of 88%.

All but one of the groups declined in releases. Reported releases of the group of chemicals associated with bladder cancer rose 18%. However, this is an understatement of actual progress; it reflects the addition of combustion-related emissions from Waste-to-Energy facilities (incinerators) to TURA reporting in 2003. Reductions in releases for the group of chemicals associated with cancers of the breast/mammary gland, liver, pancreas, prostate and testis all exceeded 90%. If these reported releases are excluded, there was a 94% reduction in the releases of the group of bladder carcinogens.

While the declines in reported use and release of known and suspected carcinogens by facilities reporting to TURA are promising, large amounts of carcinogens continue to be used and released. In 2010, over 300 million pounds of known and suspected carcinogens were used and over 500,000 pounds were released to the environment.

Table B. Use and Environmental Releases of Carcinogens associated with Specific Cancer Types Percent Change, 1990-2010		
Type of Carcinogen	Use % Change, 1990-2010	Environmental Releases % Change, 1990-2010
Bladder	-49%[¥]	+18%^
Brain/CNS	-51%	-78%^
Breast/Mammary Gland	-26% (-21% excluding styrene monomer^)	-97%
Kidney	-62%	-86%^
Leukemia	-28% (-59% excluding styrene monomer)	-86%^
Liver	-58%	-97%
Lung	-31%[¥] (-51% excluding styrene monomer)	-77%^
Non-Hodgkin's Lymphoma	-28%[¥] (-58% excluding styrene monomer)	-86%^
Pancreas	-28% (-53% excluding styrene monomer)	-97%
Prostate	-65%[¥]	-97%
Testis	-88%	-96%

^Overall trend is influenced by changes in TURA reporting requirements that eliminated the exemption for reporting combustion-related emissions by Waste to Energy (WtE) incinerators resulting in an increase in reported releases of lead and lead compounds beginning in 2003. Overall program progress is underestimated.
[¥] Overall program progress is underestimated due to changes in reporting for polycyclic aromatic compounds.

Table C shows the top three chemicals used or released in the largest quantities for each specific cancer type. As shown in the table, certain chemicals appear repeatedly, as they are associated with multiple types of cancer and are used or released in large quantities. These chemicals include persistent bioaccumulative toxic (PBT) chemicals such as lead and lead compounds and polycyclic aromatic compounds; solvents such as trichloroethylene and methylene chloride; feedstock chemicals such as formaldehyde and styrene monomer; and others. Most of these chemicals show significant declines in reported use and environmental releases since 1990. Yet many continue to be used in large amounts, as of 2010.

Table C. Top Three Chemicals by Amount Used/Released: Trends by Specific Cancer Type TURA Program, 1990-2010§

Specific Cancer Type	USE: Top 3 Carcinogens (1990-2010)	USE: % Change (1990-2010)	USE: Total Use (2010)	ENVIRONMENTAL RELEASES: Top 3 Carcinogens (1990-2010)	ENVIRONMENTAL RELEASES: % Change (1990-2010)	ENVIRONMENTAL RELEASES: Total Releases (2010)
Bladder	1. Lead and lead compounds	-81%*	3,910,928	1. Methylene chloride	-98%	24,087
	2. Methylene chloride	-55%	3,530,716	2. Lead and lead compounds*	-60%	347,103
	3. Polycyclic aromatic compounds^ψ	-97%*	382,534	2. Tetrachloroethylene	-96%	13,194
Brain/CNS	1. Lead and lead compounds	-81%*	3,910,928	1. Methylene chloride	-98%	24,087
	2. Formaldehyde#	-73%	2,517,014	2. Lead and lead compounds*	-60%	347,103
	3. Methylene chloride	-55%	3,530,716	3. Formaldehyde	-91%	16,100
Breast	1. Styrene monomer	-26%	291,850,681	1. Methylene chloride	-98%	24,087
	2. Toluene diisocyanate	+29%	6,741,872	2. Styrene monomer	-80%	20,976
	3. Methylene chloride	-55%	3,530,716	3. Acetaldehyde^	-100%	8,071 (2005)
Kidney	1. Lead and lead compounds	-81%*	3,910,928	1. Trichloroethylene	-96%	50,555
	2. Methylene chloride	-55%	3,530,716	2. Methylene chloride	-98%	24,087
	3. Nickel compounds	-66%	661,211	3. Lead and lead compounds*	-60%	347,103
Leukemia	1. Styrene monomer	-26%	291,850,681	1. Trichloroethylene	-96%	50,555
	2. Lead and lead compounds	-81%*	3,910,928	2. Methylene chloride	-98%	24,087
	3. Formaldehyde#	-73%	2,517,014	3. Lead and lead compounds*	-60%	347,103
Liver	1. Toluene diisocyanate	+29%	6,741,872	1. Trichloroethylene	-96%	50,555
	2. Methylene chloride	-55%	3,530,716	2. Methylene chloride	-98%	24,087
	3. Di(2-ethylhexyl) phthalate	-88%	1,166,842	3. Tetrachloroethylene	-96%	13,194
Lung	1. Styrene monomer	-26%	291,850,681	1. Sulfuric acid	-63%	67,293
	2. Sulfuric acid	-36%	27,938,964	2. Methylene chloride	-98%	24,087
	3. Lead and lead compounds	-81%*	3,910,928	3. Lead and lead compounds*	-60%	347,103
Non-Hodgkin's Lymphoma	1. Styrene monomer	-26%	291,850,681	1. Trichloroethylene	-96%	50,555
	2. Formaldehyde#	-73%	2,517,014	2. Formaldehyde	-91%	16,100
	3. Methylene chloride	-55%	3,530,716	3. Tetrachloroethylene	-96%	13,194
Pancreas	1. Styrene monomer	-26%	291,850,681	1. Methylene chloride	-98%	24,087
	2. Toluene diisocyanate	+29%	6,741,872	2. Styrene monomer	-80%	20,976
	3. Methylene chloride	-55%	3,530,716	3. Nickel compounds	-4%	1,318
Prostate	1. Methylene chloride	-55%	3,530,716	1. Trichloroethylene	-96%	50,555
	2. Polycyclic aromatic compounds^ψ	-97%*	382,534	2. Methylene chloride	-98%	24,087
	3. Trichloroethylene	-92%	294,836	3. Polycyclic aromatic compounds^ψ	-82%	13,194
Testis	1. Di(2-ethylhexyl) phthalate	-88%	1,166,842	1. Trichloroethylene	-96%	50,555
	2. Trichloroethylene	-92%	294,836	2. Di(2-ethylhexyl) phthalate	-99%	112
	3. Cadmium and cadmium compounds	-69%	266,672	3. Cadmium and cadmium compounds	-94%	70

§Based on publicly available data. Data claimed trade secret are not included in these figures.
*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.
#An understanding of the temporal trends for formaldehyde is incomplete due to a facility claiming trade secret status for all years except 2008.
^2005 was the last year facilities reported use of acetaldehyde.
ψBased on data for polycyclic aromatic compounds beginning in 2000 (not 1990).

Limitations of the analysis. This analysis has several limitations. First, the TURA program does not capture chemical use and environmental release data from all facilities in the Commonwealth that use, manufacture or release chemicals. In particular, facilities that do not meet the reporting thresholds, sectors such as health care and higher education that are not subject to TURA, and small facilities with fewer than 10 full-time employee equivalents are not included in the TURA data. The TURA data also do not reflect emissions from consumer products imported into the Commonwealth, which can also contain known or suspected carcinogens.

Second, data used in this report are not adjusted to reflect changes in production. Given the focus on cancer prevention opportunities, this analysis focuses on total use and releases, and does not analyze whether declines in use and releases were due to TUR activity or changes in production activity.

Third, some facilities subject to TURA requirements have made trade-secret claims, rendering their data inaccessible for this analysis.

Fourth, environmental release quantities are only those released on-site at the facility. Waste transferred off-site for treatment or disposal is not included, even though in some cases that will result in an eventual release to the environment.

Finally, this report does not investigate the relationship between the use and release of chemical carcinogens by TURA filers and cancer incidence rates in Massachusetts. Such an assessment would require information about exposure and would need to account for chemical carcinogens beyond those sources tracked by the TURA program, as well as such complex factors as susceptibility, other risk factors (such as diet and lifestyle factors), and long, variable latency periods.

Opportunities

The material presented in this report suggests a number of avenues for continued work to protect workers and the public from exposure to industrial carcinogens. These include policy activities within the TURA program, opportunities to encourage toxics use reduction by facilities in TURA-covered sectors, and opportunities that are not directly covered by TURA. These avenues are briefly described here.

TURA Program Policy Activities. The analysis in this report suggests a number of information and policy activities that can be undertaken by the TURA program. These include:

1. **Evaluate additional carcinogens for possible addition to the TURA list.** Approximately 30 known and suspected carcinogens are not currently reportable under TURA. These substances can be evaluated for possible addition to the TURA list of Toxic or Hazardous Substances in order to facilitate toxics use reduction activities by Massachusetts companies.
2. **Update and maintain the Carcinogen Master List.** The Carcinogen Master List was created as part of the background work for this report. Massachusetts companies, policymakers and the public are encouraged to use this Master List as an informational resource. Resources permitting, it would be useful to update this list routinely over time to incorporate new findings by the authoritative bodies on which it relies.
3. **Evaluate additional carcinogens for designation as Higher Hazard Substances.** Designating a chemical as a Higher Hazard Substance under TURA lowers the reporting threshold for that chemical, and highlights the chemical for particular attention by TURA filers and the TURA implementing agencies. Several

carcinogens have already been designated as Higher Hazard Substances and it may be appropriate for the TURA program to designate additional carcinogens for this list. For example, the TURA program could reexamine the group of known and suspected carcinogens that emerged as primary contributors to the use and release totals.

4. **Focus on high-priority groups of carcinogen users by designating Priority User Segments and/or lowering quantity thresholds under TURA, when appropriate.** The TURA Administrative Council, the governing body for the program, has the authority to designate a Priority User Segment under some circumstances. This designation extends TURA requirements to facilities with fewer than 10 full-time employee equivalents for a specified industry category. The Administrative Council also has the authority to lower reporting thresholds in some cases. Both of these authorities can be used to extend TURA reporting and planning requirements to additional facilities.
5. **Under the leadership of the TURA Administrative Council, partner with the Massachusetts Department of Public Health to incorporate TUR strategies into cancer education.** Educating consumers and medical providers about environmental causes of cancer is a specific focus of the 2012-2016 Massachusetts Comprehensive Cancer Control Plan.

Facilitating Toxics Use Reduction. This report also suggests a number of program-related activities that can be undertaken by the TURA program to enhance cancer prevention, including:

6. **Work to address key carcinogens discussed in this report.** This report can be used to identify key carcinogens that warrant additional attention, based on high volumes used or released, links to multiple types of cancer, or other factors. The TURA program may be able to prioritize TUR activities for the group of known and suspected carcinogens that are primary contributors to the use and environmental-release totals. For example, past successes with other halogenated solvents could be leveraged to help facilities reduce their use of methylene chloride.
7. **Work to help small businesses reduce carcinogen use.** The TURA program has achieved significant results in its work with large and medium-sized chemical users. In addition, the TURA program works with a number of small-business sectors to help them protect workers, customers and others from exposure to carcinogens. Examples include ongoing work with small metal finishers, dry cleaners, auto shops and nail salons. Going forward, there may be opportunities to expand the program’s work to reduce carcinogen use in these sectors, where total quantity of use may be relatively small but potential exposures may be significant.
8. **Work to reverse rising use of certain carcinogens.** This report notes that while reported use of most carcinogens under TURA has declined over time, reported use of a few carcinogens has risen. The TURA program may be able to work with users of these chemicals to identify options for reducing use going forward.

Beyond TURA Reporting and Planning: Other Opportunities. There are many other opportunities to prevent cancer through TUR that go beyond the sectors and firms covered by TURA reporting and planning. These opportunities include:

9. **Work to address exposure to carcinogens in consumer products**. A variety of consumer products contain known or suspected carcinogens. There are significant opportunities to protect human health and the environment by redesigning consumer products, and Massachusetts companies and

communities may be in a good position to lead some of these efforts. Lessons learned from the TURA program over the last 20 years may be informative for a range of activities including those of companies, nongovernmental organizations, state government, and the public.

10. **Work to address carcinogens in sectors not covered under TURA.** These sectors include health care and higher education. For example, ethylene oxide and formaldehyde are two known carcinogens that are relevant to the health care sector and for which TUR strategies are available.

Directions for Future Research: A number of additional research questions were generated as a result of this report. Examples include the following.

11. **Examine the flow of known and suspected carcinogens in consumer and industrial products.** Facilities reporting to the TURA program are required to report the amount of toxics that are "shipped in product." These data could be examined further to document TURA program results and to identify TUR opportunities relevant to reducing exposure to carcinogens further down the supply chain.
12. **Compile and review case studies of companies that have reduced carcinogen use.** The TURA program has developed case studies of a wide variety of companies that have successfully reduced their use of carcinogens while maintaining or enhancing their economic competitiveness. It would be useful to compile and categorize these existing case studies, and to gather additional data to reveal the variety of ways in which Massachusetts companies have reduced the use of carcinogens.
13. **Analyze opportunities for an epidemiological study.** This study does not examine associations between chemical use and release and cancer incidence. Future studies could potentially undertake this question. It could be helpful to assess the usefulness of the TURA data for an epidemiological study of chemical use and cancer incidence in Massachusetts. Such an analysis could determine what research design would be most appropriate and what resources would be needed in order to complete the study successfully. It could examine the relative merits of considering statewide data versus data at the municipal or regional level, and identify factors that would need to be accounted for, such as exposure measurements, latency and a variety of potential confounding factors, as well as inherent limitations in the data. An appropriate first step could be to convene an expert panel to examine the possible ways in which the TURA data could be analyzed in relation to cancer data.

Conclusion: The Importance of Toxics Use Reduction for Cancer Prevention

Cancer prevention remains the most cost-effective and humane policy response available in the "war on cancer." Toxics use reduction, which prevents carcinogenic exposures at their source, is a powerful tool for cancer prevention. The large reductions in use and releases of known and suspected carcinogens by facilities reporting to the TURA program shows that when companies are required to examine their use of a chemical, many find ways to use it more efficiently, others find options for replacing the chemical with a safer substitute, and others change their manufacturing process altogether to eliminate the need for the chemical. Important lessons can be drawn from the success of these tools in reducing the use and release of carcinogens. Continued work to minimize the use of carcinogens in manufacturing and services can help to reduce the burden of cancer in Massachusetts.

Opportunities for Cancer Prevention: Trends in the Use and Release of Carcinogens in Massachusetts

INTRODUCTION

Today, one in every three women and one in every two men will be diagnosed with cancer at some point in their lives.[1] Every day, roughly 100 Massachusetts residents are diagnosed with cancer, corresponding to over 38,000 expected new cases of cancer in 2013.[1] Fortunately, cancer deaths in Massachusetts have declined, 1.4% annually among men and 2.2% annually among women in the period 2004-2008.[2] This decline translates into real lives that were extended, thanks to advances in early detection and treatment. Nevertheless, cancer remains the leading cause of death in Massachusetts.[3] In over two decades (from 1985 to 2008), the overall incidence of cancer in the state increased 19%.[4] Despite small declines in overall cancer incidence in recent years, the data compel us to increase policy on and programmatic attention to cancer prevention and the human suffering and economic costs it imparts.

Industrial carcinogens are just one of several important categories of risk factors for which prevention efforts can reduce cancer risk. Diet and lifestyle factors such as smoking are significant risk factors for a number of cancers; these too can be addressed with changes in public policy as well as individual behavior. Yet cancer is not caused by a single factor. Rather, it results from a complex, multi-factorial, multi-stage process.[7] Thus, cancer prevention requires a comprehensive approach to minimize preventable risks wherever and whenever possible. A comprehensive approach to preventing cancer must include strong public policies that reduce multiple risk factors, with a particular focus on Massachusetts residents who are living and working in conditions that make them disproportionately vulnerable.[8]

Industrial chemicals used and released during the production of materials and products are some of the most well-studied and well-recognized risk factors for cancer in humans. Of the 953 agents and exposure circumstances evaluated by the International Agency for Research on Cancer (IARC), over 400 are listed as "carcinogenic to humans," "probably carcinogenic to humans," or "possibly carcinogenic to humans," and the majority of these are considered industrial/occupational carcinogens.[5,6] These same agents that cause cancers in the workplace are also risk factors for cancer in the general public when they contaminate air, water, food, and consumer products.

In Massachusetts, the Toxics Use Reduction Act (TURA) program is an important facet of the state's capacity to prevent cancer. TURA was enacted in 1989 to encourage companies and communities to reduce their use of toxic chemicals. Under TURA, Massachusetts companies that use or manufacture large quantities[a] of any one of nearly 1,500 listed chemicals[b] are required to: (1) report their use and release of these chemicals every year; (2) prepare a Toxics Use Reduction Plan every two years describing how they can reduce their use of toxics; and (3) pay an annual fee. TURA is implemented by the Massachusetts Department of Environmental Protection (MassDEP), the

[a] The 1989 statute defines large quantity as 25,000 pounds per year if a firm manufactures or processes a substance, or 10,000 pounds per year if a firm "otherwise uses" a substance. Amendments to TURA adopted in 2006 provide for the designation of Higher and Lower Hazard Substances. For Higher Hazard Substances, the reporting and planning threshold is lowered to 1,000 pounds per year. Chemicals defined by the U.S. EPA as persistent, bioaccumulative, and toxic (EPA PBTs) have lower reporting thresholds (ranging from 0.1 gram to 100 pounds depending on the substance), and are automatically designated as Higher Hazard Substances.

[b] For a complete list of chemicals reportable under TURA see http://www.mass.gov/eea/docs/dep/toxics/approvals/chemlist.pdf (accessed May 2013).

Office of Technical Assistance and Technology (OTA), and the Toxics Use Reduction Institute (TURI). MassDEP is responsible for activities including data collection and enforcement. OTA provides confidential, on-site technical assistance to companies to support their efforts to reduce and/or eliminate toxic chemical use. The Toxics Use Reduction Institute (TURI) provides a range of other services including research on safer chemicals and materials, laboratory testing services, industry and community grants for TUR projects, policy analysis, and training for Toxics Use Reduction Planners.

In 2012, Massachusetts released its Comprehensive Cancer Prevention and Control Plan for 2012-2016. The Plan includes two overarching goals specific to prevention:

1. Create and sustain environments that support the prevention of cancer.
2. Promote behaviors, activities and policies that reduce the risk of cancer.

The plan outlines prevention strategies to reduce cancer risk associated with a number of risk factors, including tobacco, alcohol, poor nutrition and physical inactivity, infectious disease agents, and environmental and occupational substances. Specific objectives and strategies are outlined for each. Regarding environmental and occupational risk factors, the plan includes objectives focused on educating health care providers and consumers about industrial and environmental carcinogens. Under the objective relating to consumer education, TUR is included as one of the primary cancer prevention strategies: "Working collaboratively with academic groups and other organizations and their tracking systems, promote awareness of safe alternatives to reduce occupational/community exposure."[3]

The TURA data, which encompass 20 years of information from TURA industry filers, offer a useful source from which to conduct hazard surveillance in support of the Massachusetts Comprehensive Cancer Prevention and Control Plan. This report draws on the TURA data to assess the extent to which industrial carcinogens are being used and released by Massachusetts industries, and to identify how the TURA program can better serve cancer prevention goals. The report is also designed to serve as a resource for organizations and businesses working in the area of TUR to enhance understanding about the relationship between TUR and cancer prevention. Lastly, this report is intended to support the work of public health professionals working in the area of cancer prevention to identify opportunities for broader cancer prevention efforts in Massachusetts.

There are some limitations to the TURA data. Because the law excludes some industry sectors, not all industries in Massachusetts report under TURA. Furthermore, TURA reporting requirements do not apply to facilities that use listed chemicals in quantities lower than the applicable thresholds, or to facilities with fewer than ten full-time employee equivalents (FTEs). Finally, facilities can file "trade secret" information under certain conditions; whereas most of the TURA data are publicly available, this information is available only to the Department of Environmental Protection (MassDEP). Fewer than 10 companies per year choose to make trade secret claims, but in some cases their chemical use is high. Despite these limitations, the publicly available data reveal patterns in the use and release of carcinogens that can inform cancer prevention strategies.

Section I of this report provides background information on the importance of industrial carcinogens as significant risk factors for cancer, including relevant findings from the recent President's Cancer Panel's report on environmental cancer. Section II describes the methods used, including compiling a Master Carcinogen List of industrial chemicals which draws on three existing authoritative lists maintained by IARC, the National Toxicology

Program (NTP), and the Environmental Protection Agency (EPA). Section III provides results of this analysis, including identification of carcinogens not currently reportable under the TURA program, and trends in the use and release of carcinogens among TURA industry filers from 1990 to 2010. In addition to reviewing the overall use and release of carcinogens, the trend analysis examines the use and release of carcinogens associated with 11 specific cancer types of concern. Section III also reviews trends in cancer incidence for these 11 cancer types. Section IV concludes the report with a synthesis of the results and recommendations to help guide future policies and programs, and to make the connection between cancer prevention and sustainable production policies and practices.

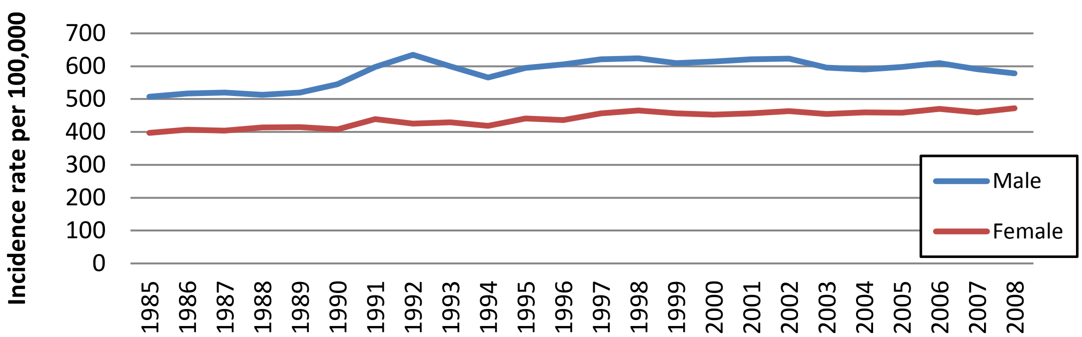
SECTION I: BACKGROUND

Cancer in Massachusetts

Cancer is a general term for more than 100 similar diseases. The diseases are collectively characterized by a process in which abnormal cells divide without control and are able to invade other tissues.[9]

In Massachusetts, the overall cancer incidence rates for both males and females have risen steadily since the Massachusetts Department of Public Health's Cancer Registry first began tracking the disease in 1982. Between 1985[c] and 2008, the age-adjusted incidence rate for all cancers combined among males increased from 508 cases per 100,000 per year to 578 cases per 100,000 per year, an increase of 14%.[4] While the cancer incidence rate among females is lower than in males, the overall increase is slightly higher—19% beginning with 397 cases per 100,000 in 1985 to 472 cases per 100,000 in 2008.[4] The most current 5-year data interval (2004-2008) demonstrates that age-adjusted cancer incidence rates for both males and females are higher in Massachusetts than in the rest of the country.[2,d] Of the 24 most common types of cancer, incidence rates for 14 cancer types are elevated among males, notably bladder, esophageal, kidney, liver, melanoma, prostate, and thyroid; and incidence rates for 17 cancer types are elevated among females, among them bladder, breast (including *in situ*), lung, melanoma, thyroid and uterine. Cancer incidence rates *not* elevated in Massachusetts when compared to incidence rates in the U.S. population as a whole include leukemia, breast, lung/bronchus, and laryngeal cancers among males, and leukemia, multiple myeloma and stomach and cervical cancers among females.[2]

Figure 1: Massachusetts Age-Adjusted Cancer Incidence Rate, All Sites, 1985-2008



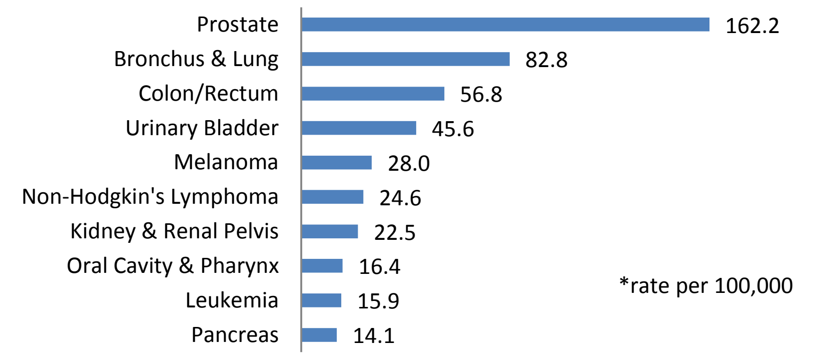
Source: MA Cancer Registry. Massachusetts Community Health Information Profile (MassCHIPVersion 3.00 r327). Massachusetts Department of Public Health.

Figures 2 and 3 show the age-adjusted cancer incidence rates for the 10 most common cancers among Massachusetts men and women, respectively. Among men in Massachusetts, prostate cancer was the most commonly diagnosed cancer from 2004-2008, followed by cancers of the bronchus/lung, colon/rectum, and urinary bladder (Figure 2).[2] These four cancer types accounted for approximately 58% of newly diagnosed cases.[2] Both

[c] 1985 is the first year of data available through the Massachusetts Community Health Information Profile database.
[d] U.S. comparison rates are based on data from the North American Association of Central Cancer Registries (NAACCR) and represent data from 80% of the U.S. population.

prostate and bronchus/lung cancers disproportionately impact Black, non-Hispanic men, whereas higher cancer incidence rates of colon/rectum and urinary bladder cancers are seen among White, non-Hispanic men.[2]

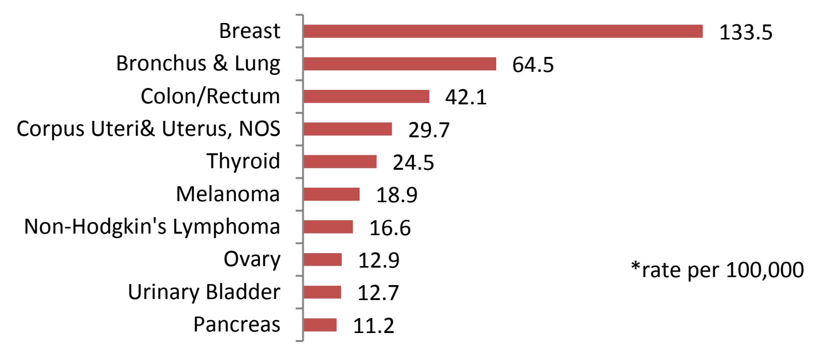
Figure 2: Cancer Incidence Rate* for the Leading Cancers among Men, Massachusetts 2004-2008



Note: Incidence rates are age-adjusted to the 2000 U.S. Standard Population
Source: Bureau of Health Information, Statistics & Evaluation. Cancer Incidence & Mortality in Massachusetts: 2004-2008. Massachusetts Department of Public Health. August 2011.

Among Massachusetts women, from 2004 to 2008, breast cancer was the most commonly diagnosed cancer, followed by cancers of the bronchus/lung, colon/rectum, and uterus (Figure 3).[2] These four cancers comprised 59% of newly diagnosed cases during these years.[2] Rates for all four leading cancer types among women are higher among White, non-Hispanic women than any other racial/ethnic group.[2]

Figure 3: Cancer Incidence Rate* for the Leading Cancers among Women, Massachusetts 2004-2008



Note: Incidence rates are age-adjusted to the 2000 U.S. Standard Population
Source: Bureau of Health Information, Statistics & Evaluation. Cancer Incidence & Mortality in Massachusetts: 2004-2008. Massachusetts Department of Public Health. August 2011.

Industrial carcinogens: Overview

For this report, the term "industrial carcinogens" is used to describe known or suspected carcinogenic chemicals that are found in the workplace. These chemicals are typically released in some quantity into the environment, and/or contained in trace levels in consumer products.

People can be exposed to industrial carcinogens at multiple points in the life cycle of a chemical or product. Industrial carcinogens are manufactured and/or used in workplaces and also released as emissions that pollute air, water, or soil. Many carcinogens used in production processes can also remain in or on consumer products as contaminants or as integral parts of the products themselves; consumers can then be exposed to these carcinogens, either intentionally (e.g., applying a skin cream) or incidentally (e.g., using a paint stripper). These same carcinogens can be released again to the environment in municipal waste streams (e.g., landfills, incinerators, hazardous waste sites, and illegal dumping) when consumers dispose of products containing carcinogens.

IARC has identified over 400 known, probable, and possible carcinogens (IARC Group 1, Group 2A and Group 2B, respectively).[5] Similarly, the U.S. NTP's 12th Report on Carcinogens has identified over 250 substances that are either known or reasonably anticipated to be human carcinogens.[10] Not all of these substances are industrial carcinogens. Agents such as environmental tobacco smoke, hormones, microbiologic organisms, viruses and dietary constituents are among the carcinogens on these lists that are not industrial in origin. However, based on a recent review of the IARC monographs, the majority of group 1 and group 2B carcinogens are considered industrial/occupational carcinogens.[e,6] The IARC review identified:

- 28 definite (group 1) human occupational/industrial carcinogens
- 27 probable (group 2A) human occupational/industrial carcinogens
- 113 possible (group 2B) human occupational/industrial carcinogens
- 18 occupations and industries that definitely, probably, or possibly increase risk of cancer (IARC groups 1, 2A, and 2B, respectively)

Despite the extensive analyses performed by IARC and NTP on certain chemicals, knowledge about the carcinogenicity of the full universe of chemicals in commerce is extremely limited. NTP has published long-term carcinogenicity studies on fewer than 1% of the over 83,000 chemicals registered for commercial use in the U.S. today, and approximately 20% of the high production chemicals (chemicals whose production volumes are equal to or greater than 1 million pounds per year).[11-13]

The burden of cancer associated with industrial carcinogens

The National Institute for Occupational Safety and Health (NIOSH) estimates that millions of workers may be exposed to known or suspected industrial carcinogens.[14] Yet no recent comprehensive national assessment of occupational exposures to carcinogens is available; the last assessment conducted by NIOSH was over thirty years ago.[8] Because these agents are ubiquitous in the environment, exposure among the general public is likely to be extensive, albeit generally at levels lower than those experienced in occupational settings. For example, EPA's recent National Air Toxic Assessment (2010) estimates that the average increased cancer risk from inhaling carcinogens found in outdoor air during 2005 was 50 people per million—equivalent to approximately 320 cancer cases per year among Massachusetts residents from air pollution alone.[15] Given that people are exposed to carcinogens through a myriad of other exposure routes as well, and given the vast number of chemicals that have

[e] In their review, Siemiatycki and colleagues (2004) used the term "occupational carcinogens," because the studies they evaluated focused primarily on findings from occupational epidemiology.[6] The literature linking environmental exposures to cancer is also based primarily on these same occupational studies. Thus it is appropriate to extend these researchers' findings to an examination of industrial carcinogens as defined for this report.

not been evaluated for carcinogenicity, the number of cancers caused by industrial carcinogens in Massachusetts is likely to be much higher.

Exposure to a carcinogen does not always result in cancer. Cancer is a complex, multi-stage, multi-factorial process. Research has identified at least six essential cellular alterations that unfold over time to overwhelm the body's natural defense systems and ultimately produce a cancerous tumor.[7]

For any particular person, risk factors act within multidimensional causal webs.[16] Factors affecting cancer risk include diet, genetic inheritance, lifestyle factors, and industrial chemicals in workplaces and communities, among others. Science has yet to fully reveal all the mechanisms[f] by which these factors interact to affect the initiation, promotion, and progression of an individual's cancer. Other factors, such as the timing of exposure—such as exposure *in utero* —also affect cancer risk later in life.

Despite this complexity, there are many straightforward opportunities for prevention. A cancer strategy that removes any known risk from the equation will help prevent some cancers. Some researchers have used the metaphor of a pie to describe the factors involved in the causal mechanism of an individual's cancer.[17] Each slice of the pie is a component cause contributing to the development of cancer. A given causal mechanism of cancer therefore requires the joint action of many component causes. One slice could represent an inherited genetic trait; another slice could represent a lifestyle risk factor, such as smoking; another slice could represent an occupational exposure to one or more carcinogens; and so on. By removing any one of those slices of the pie, the causal mechanism cannot be completed and cancer is prevented.

In 1981, Sir Richard Doll and Sir Richard Peto estimated that the majority of cancer deaths could be avoided through tobacco smoking cessation (30%), reduced intake of alcoholic beverage (3%), and diet (35%), while only a small percentage of cancer deaths could be prevented by reducing exposure to risks in workplaces (4%), the environment (2%) and industrial products (less than 1%).[18] Since they suggest that environmental and occupational risk factors contribute minimally to the overall burden of cancer, these widely quoted "attributable fractions" have been used repeatedly to exclude environmental and occupational risk factors from prevention priorities of government and advocacy groups.[19] However, in 2010, the President's Cancer Panel found that the true burden of environmentally (including occupational) induced cancer has been grossly underestimated.[8]

The President's Cancer Panel has provided guidance on the direction of the National Cancer Program since its creation in 1971. In 2008-2009, with input from over 45 experts from academia, government, industry, cancer advocacy and environmental organizations, the Panel produced a landmark report entitled "Reducing Environmental Cancer Risk: What We Can Do Now."[8] The report concluded that the precise contribution of environmental and occupational exposures to cancer risk is unknown, but that past attributable fractions are likely substantial underestimations. The Panel did not offer more current estimations, but noted several methodological limitations that impact the validity of existing calculations such as those by Doll and Peto. The Panel's critiques mirror those in the peer-reviewed literature.[20-22] Limitations identified by the Panel include the following:

[f] Mechanisms can include inflammation, DNA damage, gene suppression or over-expression, epigenetic changes, and others.

- When estimating attributable fractions, researchers make an assumption that an individual is only exposed to one chemical at a time. This ignores the reality that individuals are exposed to a combination of multiple industrial carcinogens.
- Attributable fractions do not account for specific combinations of exposures that can produce synergistic effects, thus intensifying their impact as compared to the effect of single exposures.
- Industrial carcinogens are more diverse and numerous than previously recognized.
- Low dose exposures matter. The adage "the dose makes the poison" does not reflect current understanding of mechanisms responsible for the development of some cancers, including epigenetics—in which chemicals cause heritable changes in gene expression—and endocrine disruption. Damage by so-called "endocrine disrupting chemicals" is often associated with the timing of the exposure (e.g., during particular windows of vulnerability in embryonic development) rather than with high doses, for example.

Toxics use reduction: A core primary prevention strategy

The World Health Organization has noted that primary prevention efforts to eliminate or reduce exposure to recognized risk factors of cancer are "by far the most cost-effective and sustainable intervention for reducing the burden of cancer globally."[23] Primary prevention interventions focus on preventing healthy people from developing the cancer in the first place. This is in contrast to secondary prevention activities, such as screening to detect early-stage cancers.

In the 1990s, TUR became an important approach to pollution prevention that focused on minimizing the use of toxic substances through process redesign and substitution with safer alternatives, rather than controlling emissions at the "end of the pipe." TUR strategies are now considered central to environmental management programs; the U.S. EPA and a number of state-level environmental agencies/departments have dedicated TUR programs.

TUR mirrors the most effective disease prevention strategy: preventing carcinogenic exposures at their source. However, it has not been routinely promoted by or integrated into cancer prevention and control programs and policies sponsored by health agencies, health care institutions and cancer advocacy organizations. The most recent Massachusetts Comprehensive Cancer Control Plan takes a new approach, which could serve as a model for other states.

In 2012, the Massachusetts Department of Public Health issued its 2012-2016 Massachusetts Comprehensive Cancer Prevention and Control Plan. The plan outlines a broad array of prevention activities to reduce cancer risk associated with risk factors including tobacco, alcohol, poor nutrition, physical inactivity, and infectious disease agents as well as environmental and occupational exposures. Specific objectives and strategies are outlined for each. Regarding environmental and occupational risk factors, the plan includes objectives focused on educating both consumers and health care providers about industrial and environmental carcinogens.

Massachusetts' plan is the first such state plan that elevates "promoting awareness of safer alternatives to occupational/community exposure to carcinogens" as a primary cancer prevention strategy.[3] Notably, the prestigious President's Cancer Panel recommended such an approach in its 2010 report, urging that "Green Chemistry" initiatives and research, including process redesign, should be pursued and supported more aggressively, but new products must be well studied prior to and following their introduction into the environment and stringently regulated to ensure their short- and long-term safety."[8]

SECTION II: METHODOLOGY

TURA data

Under TURA, Massachusetts facilities in TURA-covered sectors that manufacture, process or otherwise use certain amounts of reportable chemicals and have ten or more full-time employee equivalents are required to report on their use of these chemicals every year (including information on byproducts generated and amount of chemicals incorporated into products, as well as emissions data required under the federal Toxics Release Inventory [TRI]). TURA also requires these facilities to prepare a Toxics Use Reduction Plan every two years, and to pay an annual fee.

Sectors covered under TURA include manufacturing; electric, gas and sanitary services; chemical distribution; personal services (such as dry cleaning); and automotive repair, among others. Key sectors that are not subject to TURA but do use significant amounts of toxic chemicals include the health care sector, higher education (e.g. universities), and construction. Laboratory activities, pilot plants and pilot production units are also exempt from TURA requirements.

TURA reporting requirements do not apply to facilities that use listed chemicals in quantities lower than the applicable thresholds, or to facilities with fewer than ten full-time employee equivalents.[g]

Industrial carcinogen list

For the purposes of the present study, TURI created a Master Carcinogen List[h] of chemicals considered "known or suspected carcinogens" by using the following authoritative sources:

- International Agency for Research on Cancer (IARC)
  - Group 1 (known human carcinogen), 2A (probable human carcinogen)
- EPA's Integrated Risk Information System (IRIS)
  - 1986 guidelines: human carcinogen, probable human carcinogen with limited human evidence, probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans
  - 1996 guidelines: known/likely human carcinogen
  - 1999 & 2005 guidelines: carcinogenic to humans, likely to be carcinogenic to humans
- National Toxicology Program's 12th Report on Carcinogens (latest edition)
  - "known" and "reasonably anticipated" to be a human carcinogen

EPA's Toxic Release Inventory (TRI) uses the above criteria, and also includes IARC 2B substances, for determining what qualifies as a carcinogen in their *de minimis* rules.[24] This selection of criteria is also supported by the conclusion of the President's Cancer Panel, which noted that laboratory and animal studies do not always predict human responses, and urged the adoption of an environmental health paradigm for long-latency diseases such as

[g] The TURA Administrative Council has the authority to extend TURA requirements to facilities with fewer than ten FTEs under certain circumstances by designating a Priority User Segment; however, this authority has not been implemented to date.

[h] The Master Carcinogen List can be found at: www.turi.org/mastercarcinogenlist. Chemicals from the Master Carcinogen list that are relevant to this analysis can be found in Appendices A and B.

cancer to enable regulatory and non-regulatory responses based on compelling animal studies before cause and effect in humans has been proven.

To generate a list of industrial carcinogens reported under TURA, chemicals on the Master Carcinogen List were matched with: (a) the chemicals on the TURA list of Toxic or Hazardous Substances, and (b) the list of chemicals that have actually been reported under TURA at any point between 1990 and 2010. Chemicals were matched using the unique Chemical Abstracts Service (CAS) number and broad classes of chemicals were matched by using chemical name. In a few cases, specific CAS numbers did not match and chemical names were used.

There are two cases in which it is difficult to extract data specific to the individual carcinogen from the TURA data: sulfuric acid mists and hexavalent chromium. These carcinogens are often reported by facilities along with other non-carcinogen compounds. For example, the form of sulfuric acid that is linked to lung cancer is sulfuric acid mists. The majority of uses of sulfuric acid do not generate sulfuric acid mists. Data specific to sulfuric acid mists are unavailable in the TURA data. Likewise, for chromium compounds, only the hexavalent form is associated with lung cancer, but all valence states are reported together in the same category. The TURA program has issued regulations that separate the reporting of hexavalent chromium compounds from other valence states; these regulations are effective starting in reporting year 2012.

Carcinogen list of specific cancer sites

Based on the carcinogens reported by TURA filers at some point in the program during the period 1990-2010, a list of carcinogens with known or suspected links to specific cancer sites was created. Eleven cancer sites were chosen as a focus for this report: (1) bladder, (2) brain and other central nervous system (CNS), (3) breast, (4) kidney, (5) leukemia, (6) liver, (7) lung, (8) non-Hodgkin's lymphoma, (9) pancreatic, (10) prostate, and (11) testicular. Several sources were used to create the group of carcinogens associated with specific cancer types:

- Siemiatycki and colleagues' (2004) cancer site list of occupational carcinogens indicating strong or suggestive evidence based on reviews of the IARC monographs.[6]
- Appendix F of the President's Cancer Panel 2010 report, which provides an overview of the evidence linking specific cancer sites with dozens of occupational and environmental carcinogens.[8] The appendix is an update to a review paper by Clapp and colleagues.[19]
- Cogliano and colleagues' (2011) site-specific list of agents with sufficient or limited evidence of an association in humans as linked to specific cancer sites based on reviews of the IARC monographs.[25]
- The NTP's 12th Report on Carcinogens.[10] Site-specific evidence based on effects observed in both toxicological and epidemiological studies were used.
- Rudel and colleagues' (2007) list of chemicals that increased mammary gland tumors in animal studies.[26]

Trend analysis

Our analysis of trends in the TURA data focused on chemicals that have been reported to the program at some point during the period 1990 to 2010. The analysis examined total annual quantities of industrial carcinogens that were used and released to the environment (emissions to air, water or soil as well as fugitive emissions such as leaks through pipe fittings, tanks and loading/unloading operations, evaporative losses, etc.). In addition, trends in the use and release of chemicals grouped by their association with the 11 specific cancer types were examined, including specific chemicals driving each of the trends. As this analysis is not attempting to discern where toxics use reduction has been occurring, but just to report the change in total uses and releases, the trends are not adjusted for changes in production. Therefore, some of the increases and decreases may be due to corresponding changes in levels of production.

Reporting by facilities to the TURA program varies from year to year for a number of reasons. These include the following:

- Not all industry sectors were required to report in the first year. When the program began in 1990, only manufacturing companies were required to report use of toxic materials. Starting in 1991, both manufacturing and certain non-manufacturing companies, such as electric utilities, were required to report.
- Different chemicals were added to the reporting requirement in different years. Some chemicals have been required since reporting began in 1990. Additional chemicals have been added to the list and some have been delisted in subsequent years.
- The reporting quantity threshold for certain chemicals have been lowered in recent years. The reporting thresholds can be lowered when a chemical is designated as a Higher Hazard Substance (threshold lowered to 1,000 lbs). In addition, EPA PBT substances have thresholds ranging from 0.1 gram to 100 pounds.
- Facilities subject to TURA requirements are allowed to make trade secret claims under some circumstances.[i] If this trade secret claim is approved, the facility must still provide the chemical use information to MassDEP, but this information is not shared with other government agencies or with the public. In some cases, trade secret claims make a significant difference in the data. In reporting year 2009, for example, facilities reported a total of 881 million pounds of chemicals to MassDEP. Of this total, 165 million pounds were filed with a trade secret claim, so that data on only 716 million pounds (81% of the total) were made available to other government agencies and the public. These trade secret claims can also make a difference in which chemicals rise to the top as being reported in the largest quantities. MassDEP noted that if trade secret information had been taken into account, four chemicals—butyraldehyde, formaldehyde, sodium bisulfite, and vinyl acetate—would have been included in the list of the top 20 chemicals used in highest volumes under TURA in 2009.

Where relevant, we describe the influence of specific reporting changes on the observed trends.

[i] In order to gain approval of a trade secret claim, a facility must show that it has "not disclosed the information to anyone else" and has taken "reasonable measures to protect the confidentiality" of the information; the information is not required to be disclosed under other laws; and disclosure "is likely to cause substantial harm to the competitive position" of the facility. Massachusetts General Laws c. 21I, Section 20.

SECTION III: RESULTS

Industrial carcinogens reportable and not reportable under TURA

The Master Carcinogen List (compiled from authoritative sources as described in the methods above) includes approximately 300 substances or exposure circumstances known or suspected to cause cancer in humans. Of these, 200 are reportable under TURA (see Appendix A). The vast majority of the remaining carcinogens not reportable under TURA are either not industrial (e.g., therapeutic agents, dietary factors, lifestyle factors, viruses, etc.); non-specific (e.g., diesel exhaust, gasoline); or associated with exposure circumstances (e.g., welding fumes, work in textile manufacturing). However, there are approximately 30 known and suspected carcinogens that are industrial in nature (including some obsolete pesticides, coal tars and soots) and not currently reportable under TURA. These agents are listed in Appendix B.

Table 1: Industrial Carcinogens and TURA's Higher Hazard Substance Designations & More Hazardous Chemicals List
Known* Industrial Carcinogens designated by TURA as a Higher Hazard Substance (subject to lower reporting thresholds) as of 2012 • Cadmium and compounds • Hexavalent chromium and compounds • Formaldehyde • Trichloroethylene
Known* Industrial Carcinogens on the TURA More Hazardous List • Arsenic and compounds • Benzene • Crystalline silica • Dioxin and dioxin-like compounds^ • Ethylene oxide • Nickel and compounds • Polycyclic aromatic hydrocarbons^ • Sulfuric acid [mists]
Known* Industrial Carcinogens *Not* on the TURA More Hazardous List at the time of this study (SAB voted in November 2012 to add them to their more hazardous list) • 1,3-Butadiene • 4,4'-Methylene bis(2-chloroaniline) (MOCA)
**Known based on classifications by IARC, EPA (IRIS), or NTP* *^Subject to lower reporting thresholds based on a persistent bioaccumulative toxic (PBT) designation*

Of the 200 industrial carcinogens that are reportable under the TURA program, 74 have been reported at some point in the program's history, from 1990-2010. Our trend analysis examined these 74 industrial carcinogens.

The 2006 amendments to TURA created the authority for the TURA program to designate Higher and Lower Hazard Substances. These lists have regulatory consequences. A Higher Hazard Substance designation lowers the threshold for application of TURA requirements to 1,000 pounds per year. In addition, in order to provide additional guidance to Massachusetts companies, the TURA Science Advisory Board (SAB) maintains lists of More and Less Hazardous Chemicals that are subsets of the larger TURA list. These lists are strictly informational.

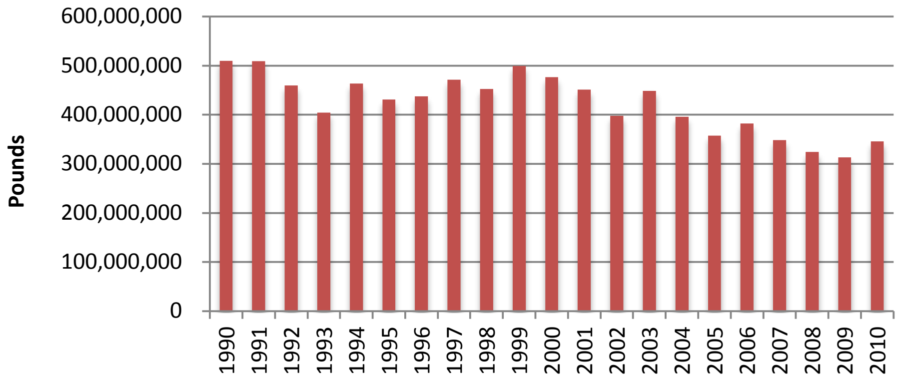
Table 1 shows the known carcinogens that have been designated as Higher Hazard Substances under TURA to date, as well as the known carcinogens that are included on the SAB's More Hazardous Chemicals list. Two chemicals that are reportable under TURA and are classified as IARC Group 1 carcinogens, 1,3-Butadiene and 4,4'-Methylene bis(2-chloroaniline), were not included on the SAB's More Hazardous Chemicals list at the time of this study. The SAB has since reviewed them and in November 2012 voted to add them to the More Hazardous list.

Overall use and release trends

From 1990 to 2010, facilities reporting to the TURA program documented significant reductions in their use and releases of known and suspected carcinogens. While total use fluctuated over the years, overall there was a 32% decline, from 509.4 million pounds in 1990 to 345.7 million pounds in 2010 (see Figure 4). The largest amount used was styrene monomer, which comprised 76% of the known and suspected carcinogen total cumulative use from 1990 to 2010. Excluding styrene, even greater declines occurred: a 53% reduction, from 113.9 million pounds in 1990, to 53.5 million pounds in 2010.

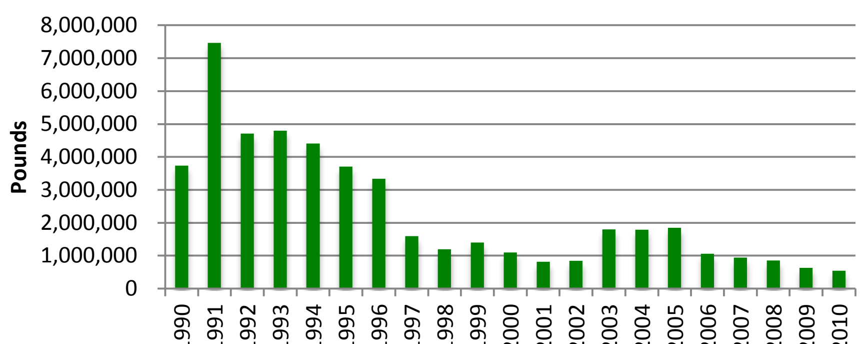
Total environmental releases have declined substantially since 1991, when reporting by electric utilities was phased into the TURA program. From 1991 to 2010, total environmental releases declined by 93%, from 7.5 million pounds to 548,800 pounds, respectively (see Figure 5).

Figure 4. Total Use of Known and Suspected Carcinogens TURA Program, 1990-2010



Based on publicly available data. Data claimed trade secret are not included in these figures.

Figure 5. Total Environmental Releases of Known and Suspected Carcinogens TURA Program, 1990-2010



Based on publicly available data. Data claimed trade secret are not included in these figures.

Of the 74 known or suspected carcinogens that have been reported to the TURA program over the last twenty years, all show significant declines in environmental releases. As shown in Table 2, some of the declines have been quite significant—over 90%. Moreover, the total amounts reduced for some of these chemicals are quite striking. For example, releases of trichloroethylene declined from 1.3 million pounds in 1990 to 51,000 pounds in 2010.

Use of a majority of the 74 chemicals also declined. Notable declines included a 92% reduction in trichloroethylene use, an 85% reduction in tetrachloroethylene use, and a 69% reduction in the use of cadmium and cadmium compounds. However, there were increases in use of some chemicals from 1990 to 2010, most notably dioxin and compounds, ethylene oxide, and hydrazine.

Table 2: Known and Suspected Carcinogens with over 90% Declines in Reported Environmental Releases

Chemical	Percent Decline 1990-2010
Cadmium and cadmium compounds	94%
Chromium and chromium compounds	91%
Di(2-ethylhexyl) phthalate	99%
Ethylene oxide	96%
Formaldehyde	91%
Methylene chloride	98%
Toluene Diisocyanate	96%
Trichloroethylene	96%
Tetrachloroethylene	96%

Over the last 10 years, the reported generation of dioxin and compounds has increased over two orders of magnitude, from 12 grams in 2000 to 1,980 grams in 2010 (Appendix D). In addition, the data show that in 2003, there was a large spike in the reported generation of dioxin and compounds, 11,827 grams—3 orders of magnitude higher than the previous year. Corresponding releases in 2005 were also high, over 2,200 grams, and remained at that level for another year before falling. Facilities reporting dioxin releases include municipal solid waste incinerators (Waste to Energy (WtE) incinerators) and electric utilities, with the former reporting the highest releases. WtE incinerators were first required to report under TURA in 2003. Some of this increase is likely the result of imprecise estimation techniques utilized by WtE incinerators to estimate their annual dioxin generation.

Use of ethylene oxide has increased 20-fold, from 13,900 pounds in 1990 to 287,000 pounds in 2010. The increase in ethylene oxide is based on use by a single medical supply company that began reporting in 1993. Use of hydrazine increased 132%, from 75,317 pounds in 1990 to 174,404 pounds in 2010. The increase in recent use of hydrazine is driven primarily by a single resin manufacturer.

The 2008 data on the use of formaldehyde included reports from one resin manufacturer that had filed its information as trade secret in prior and subsequent years. This manufacturer used 10 times more formaldehyde than the other users combined. From 1990 to 2010, the TURA data show that total formaldehyde use and environmental releases decreased by 73% and 85% respectively. However, the reported use rose dramatically in 2008 due to the inclusion of the resin manufacturer: Between 2007 and 2008, reported use rose 12-fold.

Trends in carcinogens associated with specific cancer types/sites

The following sections summarize trends in carcinogens associated with specific types of cancer. Each section begins by describing trends in cancer incidence and the state of knowledge regarding known risk factors for the specific cancer site in question. Results from the site-specific carcinogen TURA data analysis are then provided, including a list of the site-specific carcinogens that have been reported to TURA, as well as trends in total use and environmental releases of these from 1990 to 2010.

For types of cancer where styrene is among the group of carcinogens contributing to the trends in use and release (breast/mammary gland, leukemia, liver, lung, non-Hodgkin's lymphoma, pancreatic), data are described with and without styrene monomer. Styrene monomer use in Massachusetts far exceeds the use of other chemicals. Therefore, in order to examine differences in trends over time for the multiple carcinogens associated with specific cancer types, trends are charted without styrene monomer use.

Bladder

Table 3: Known or Suspected Bladder Carcinogens Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
97-56-3	*o*-Aminoazotoluene
1001^ 7440-38-2	Arsenic and arsenic compounds
75-27-4	Bromodichloromethane
1004^ 7440-43-9	Cadmium and cadmium compounds
67-66-3	Chloroform
8001-58-9	Creosotes
612-83-9	3,3'-Dichlorobenzidine dihydrochloride
1026^ 7439-92-1	Lead and lead compounds
101-14-4	4,4'-Methylene bis(2-chloroaniline)
1040^	Polycyclic aromatic compounds
127-18-4	Tetrachloroethylene (perc)
*For evidence sources see Appendix C ^MA DEP compound category	

Bladder Cancer Overview. During 2004-2008, bladder cancer was the 4th most commonly diagnosed cancer among males and the 9th most commonly diagnosed cancer among females in Massachusetts.[2] During this 5-year time period, bladder cancer in Massachusetts was nearly four times higher among males compared to females, corresponding to average annual age-adjusted incidence rates of 45.6 men per 100,000 (6,724 total cases) and 12.7 women per 100,000 (2,624 total cases). The bladder cancer incidence rate among White, non-Hispanic males was nearly twice as high as among Black, non-Hispanic males.[2] These gender and racial differences in bladder cancer risk in Massachusetts are consistent with national trends.[1] The incidence rate of bladder cancer in Massachusetts is declining. From 2004 to 2008, the rate among males declined 0.8% annually while the rate among females declined 2.8% annually.[2]

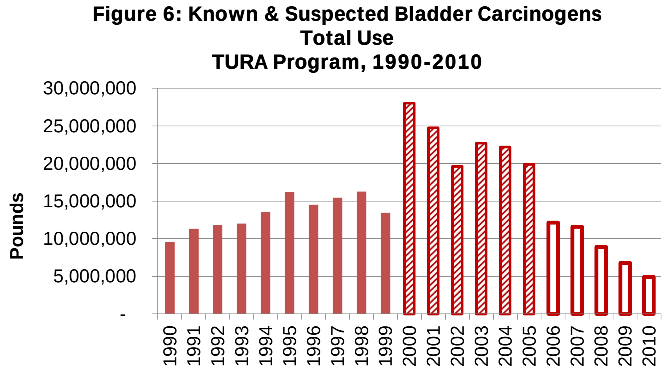
Tobacco smoking is a significant risk factor for bladder cancer.[1] The disease has also been linked to a range of chemicals including aromatic amines, such as aniline among dye workers, and arsenic in drinking water.[30] Growing evidence suggests links to halogenated solvents, such as tetrachloroethylene (perchloroethylene, or perc), which is still widely used as a dry cleaning solvent in the state.[27]

Trends in Use and Environmental Release of Bladder Carcinogens. Table 3 lists 11 chemicals or categories of chemicals that have been reported to the TURA program (1990 to 2010) and that research has linked with bladder cancer. Two of the chemicals (arsenic and cadmium) are considered known human carcinogens by authoritative bodies, while the remaining are considered suspected human carcinogens. With the exception of *o*-aminoazotoluene—where evidence linking exposure to bladder cancer is based on experimental animal studies—various levels of evidence from epidemiologic studies link the chemicals in Table 3 with human bladder cancer (See Appendix C).

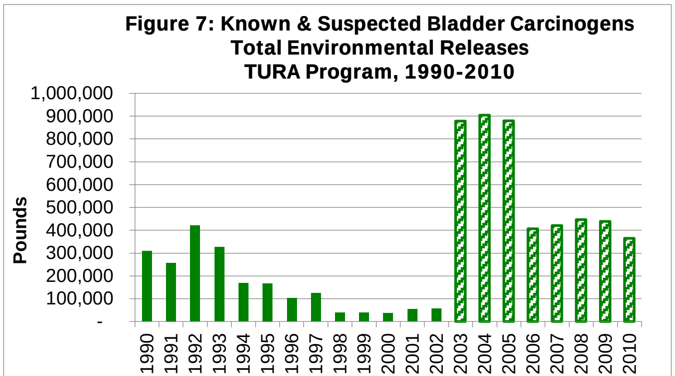
From 1990 to 2010, use of the group of 11 chemicals/categories with known or suspected links to bladder cancer declined 49%, from 9.6 million pounds to 4.9 million pounds (Figure 6). Lead and lead compounds, methylene chloride and polycyclic aromatic compounds (PACs) were the three chemicals used in the largest amounts over this time period (see Appendix D and Table 4). The large increase in reported use in 2000 reflects changes in reporting requirements. In 2000, PACs were designated as PBTs under TRI, which lowered the reporting threshold to 100 pounds.[j] As a result, most electric utilities and manufacturing facilities reported large quantities of PACs for the first time in 2000. In 2006, the TURA program exempted all manufacturers except for electric utilities from reporting PACs in fuel oil, and there was a corresponding decrease in use. In 2001, reporting thresholds for lead and lead compounds were also reduced to 100 pounds.

[j] In addition, EPA clarified the guidance for calculating the estimated quantities of PACs in fuel and generated as emissions, as the de minimis exemption no longer applied to this and other PBT chemicals.

Due to changes in reporting requirements, environmental releases of the bladder carcinogens in Table 3 increased, from 309,000 pounds in 1990 to 364,000 pounds in 2010 (Figure 7). In 2003, reported releases of lead and lead compounds rose dramatically due to changes in reporting requirements that eliminated the exemption for reporting by WtE incinerators. If releases of lead and lead compounds by WtE incinerators are excluded, there was a 94% reduction in environmental releases from 1990-2010. As shown in Figure 7, between 2004 and 2010, environmental releases declined by 60%, in part due to one of the WtE incinerators switching from on-site land disposal to transferring waste off-site for disposal.[k] The top three chemicals released in the largest amounts during 1990-2010 were methylene chloride, lead, and tetrachloroethylene (See Table 4 and Appendix D).



Note: In 2000, the TRI PBT rule lowered the reporting threshold for PACs to 100 pounds. In 2006, TURA amendments eliminated reporting of PACs by non-utilities.



Note: 2003-2010 data reflect an increase in releases of lead and lead compounds due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) incinerators.

Table 4. Use and Environmental Releases of Known or Suspected Bladder Carcinogens: Primary Industries
TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Lead and lead compounds	3,910,928	-81%*	Electricity generation, Municipal waste incineration, Fabricated metal products; plastics and resins, Ready-mix concrete	143
2.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives); Chemical distribution	11
3.	Polycyclic aromatic compounds	382,534	-97%	Electricity generation, Asphalt paving mixtures	26
ENVIRONMENTAL RELEASES					
1.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
2.	Lead and lead compounds	347,103	-60%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
3.	Tetrachloroethylene	13,194	-96%	Metal finishing, Chemical distribution, Dry cleaning	17
*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.					

[k] See Glossary for definition of environmental releases; it does not include amounts transferred off-site for disposal.

Brain and Central Nervous System

Table 5: Known or Suspected Carcinogens Associated with Brain & CNS Cancers Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
75-55-8	2-Methylaziridine
107-13-1	Acrylonitrile
1001^ 7440-38-2	Arsenic and arsenic compounds
71-43-2	Benzene
75-09-2	Methylene chloride
106-89-8	Epichlorohydrin
75-21-8	Ethylene oxide
50-00-0	Formaldehyde
1026^ 7439-92-1	Lead and lead compounds
98-95-3	Nitrobenzene
1336-36-3	Polychlorinated biphenyls
*For evidence sources see Appendix C ^MA DEP compound category	

Brain (and Central Nervous System) Cancer Overview. Cancers of the brain and central nervous system (CNS) are not a common diagnosis. During 2004-2008 in Massachusetts, the average annual age-adjusted incidence rate of brain and CNS cancer among males was 8.7 per 100,000 (1,355 total cases) and 6.2 per 100,000 (1,132 total cases) among females.[2] However, brain and CNS cancers are the second most common cancer among children (ages 0-19). While it is a very rare childhood disease, the average annual incidence rate (unadjusted) during 2004-2008 of brain and CNS cancer among Massachusetts children (ages 0-19) was 2.8 children per 100,000 (282 total cases).[4] Despite declines over the last three years, the average 5-year rate in this age group has risen 26% from 1985-1989 to 2004-2008.[4] Nationally, the incidence rate of brain and CNS cancer among children has also risen dramatically. Since 1975, the national incidence rate of brain cancer among children between the ages of 0 and 19 increased 55.2%.[28] Improved diagnostics are thought to explain some of the reported increase during the mid-1980s,[29] but the rate of incidence continue to rise. From 1993 to 2009, the rate of brain and CNS cancer incidence in children 0-19 nationally increased 3.2%.[28]

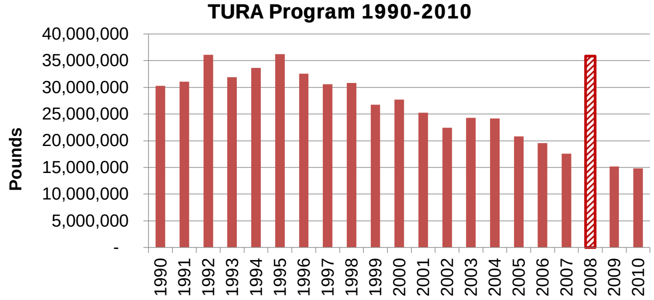
The only established environmental risk factor for brain tumors is ionizing radiation exposure.[30] Other known risk factors include rare hereditary syndromes and immune suppression.[1] However, research suggests that a variety of chemicals may increase the risk of brain and CNS cancers. In addition to chemicals identified in Table 5, epidemiological evidence also suggests that brain and CNS cancers may be linked to vinyl chloride, chemicals in mineral or lubricating oil, pesticides, chemicals involved in synthetic rubber manufacturing, nitrosamines (used for meat curing) and hair dyes.[19,31] With regard to pesticides, studies suggest risk of brain and CNS cancers among children may be elevated among those with parental exposure to pesticides prior to conception and during pregnancy.[32,33]

Trends in Use and Release of Brain/CNS Carcinogens. Table 5 lists 11 chemicals or categories of chemicals that have been reported to the TURA program (1990 to 2010) that research suggests may be linked with brain and CNS cancers. Four of the chemicals (arsenic, benzene, ethylene oxide and formaldehyde) are considered known human carcinogens based primarily on evidence related to other cancer sites. However, epidemiological studies and/or studies in experimental animals have linked brain/CNS cancers to these 11 chemicals or chemical categories (Appendix C).

Use of these 11 chemicals/categories of chemicals has declined among facilities reporting to the TURA program. There was a 51% reduction in the use of chemicals known or suspected to be associated with brain and CNS cancer, from 30.3 million pounds in 1990 to 14.8 million pounds in 2010 (Figure 8). Lead and lead compounds, formaldehyde and methylene chloride were used in the greatest amounts during 1990 to 2010 (see Appendix D and Table 6). As mentioned earlier, trend information for formaldehyde is incomplete as one facility claimed trade secret status in all but one year. The spike in 2008 reflects formaldehyde reporting by this facility.

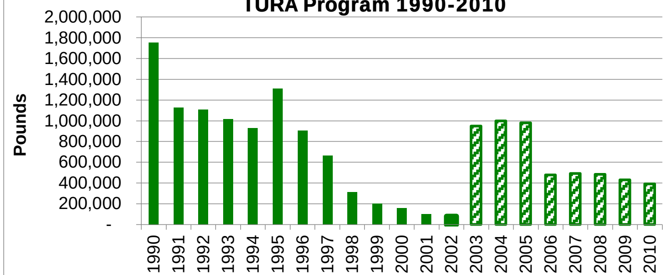
There was a 78% decline in total environmental releases reported by TURA filers for the 11 brain and CNS carcinogens, from 1.8 million pounds in 1990 to 391,000 pounds 2010 (Figure 9). This is an understatement of progress, as releases of lead and lead compounds by WtE incinerators were first required to be reported in 2003, and resulted in a large increase. If these facilities are excluded from the analysis, there was a 97% overall decline in releases from 1990-2010. The top three chemicals driving these release totals include methylene chloride, lead, and formaldehyde (See Appendix D and Table 6).

Figure 8: Known & Suspected Brain/CNS Carcinogens, Total Use TURA Program 1990-2010



Note: In 2008, reported formaldehyde use increased due to reporting by a facility that claimed trade secret status in prior and subsequent years.

Figure 9: Known & Suspected Brain/CNS Carcinogens Total Environmental Releases TURA Program 1990-2010



Note: 2003-2010 data reflect an increase in releases of lead and lead compounds due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) incinerators.

Table 6. Use and Environmental Releases of Known or Suspected Brain/CNS Carcinogens: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Lead and lead compounds	3,910,928	-81%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
2.	Formaldehyde	2,517,014	-73%	Chemicals and allied products (primarily resins and industrial organic chemicals), paper mills and coated paper	7
3.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
ENVIRONMENTAL RELEASES					
1.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
2.	Lead and lead compounds	347,103	-60%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
3.	Formaldehyde	16,100	-91%	Chemicals and allied products (primarily resins and industrial organic chemicals), paper mills and coated paper	7
*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.					

Breast

Breast Cancer Overview. In Massachusetts, breast cancer is the most commonly diagnosed cancer in females. During 2004-2008, the average annual age-adjusted incidence rate for invasive breast cancer (not including in situ cases) was 133.5 females per 100,000 (25,807 total cases) and 1.3 males per 100,000 (190 total cases)—among the highest female incidence rate in the country.[2,34] While the rate of breast cancer among females has decreased nationally, there has been a slight increase among those in Massachusetts in recent years—an 1% annual increase in the age-adjusted rate of invasive breast cancer incidence from 2004-2008.[2] However, the rate has decreased in Massachusetts since the peaks observed during the mid to late 1990s.[4] The incidence rate of breast cancer varies by race and ethnicity, occurring more often among White non-Hispanic females than any other racial/ethnic group.[2]

Table 7: Known or Suspected Breast/Mammary Gland Carcinogens Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
96-12-8	1,2-Dibromo-3-chloropropane
106-99-0	1,3-Butadiene
123-91-1	1,4-Dioxane
75-55-8	2-Methylaziridine
612-83-9	3,3'-Dichlorobenzidine dihydrochloride
101-14-4	4,4'-Methylene bis(2-chloroaniline)
75-07-0	Acetaldehyde
107-13-1	Acrylonitrile
71-43-2	Benzene
56-23-5	Carbon tetrachloride
75-09-2	Methylene chloride
1060^	Dioxin and compounds
107-06-2	Ethylene dichloride
75-21-8	Ethylene oxide
118-74-1	Hexachlorobenzene
302-01-2	Hydrazine
98-95-3	Nitrobenzene
97-56-3	*o*-Aminoazotoluene
1336-36-3	Polychlorinated biphenyls
100-42-5	Styrene monomer
91-08-7, 584-84-9, 26471-62-5	Toluene Diisocyanate

*For evidence sources see Appendix C
^MA DEP compound category

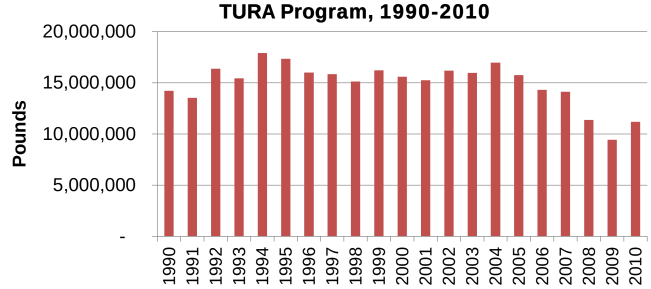
Factors that are known to increase breast cancer risk include those that influence reproductive hormones (e.g. age at menarche, parity, age at first birth, use of hormone replacement therapy), physical inactivity, alcohol consumption, clinical factors (e.g. breast density, bone density, certain types of benign breast conditions), family history of the disease, and radiation (e.g. therapeutic, diagnostic, environmental radiation).[1] In addition, growing evidence suggests that exposure to chemicals may be associated with the risk of developing breast cancer.[35] The vast majority of the evidence suggesting a role of chemicals in breast cancer causation is from studies in experimental animals. For example, one recent review found that for each of 216 chemicals, at least one animal has confirmed an association between that chemical and the development of mammary gland tumors.[26] However, studies of breast cancer in humans are increasing. For example, current studies by the Agency for Toxic Substances and Disease Registry (ATSDR) may reveal a better understanding of the potential link between male breast cancer and exposure to chlorinated solvents in drinking water, including previously identified associations among female breast cancer risk and exposure to tetrachloroethylene.[36]

Trends in Use and Environmental Releases of Breast/Mammary Gland Carcinogens. Table 7 lists the 21 chemicals reported to the TURA program (1990 to 2010) that research suggests may be linked with breast or mammary gland carcinogenesis. Five of the chemicals are considered known human carcinogens by authoritative bodies (1,3-butadiene, 4,4'-Methylene bis(2-chloroaniline), benzene, dioxin and compounds [specifically TCDD] and ethylene oxide), while the remaining are considered suspected human carcinogens. Evidence linking the majority of these chemicals specifically to breast cancer or mammary gland tumors is primarily from experimental animal studies (Appendix C).

While use has fluctuated over time, there was a 26% reduction in the use of chemicals known or suspected to be associated with breast/mammary gland carcinogenesis, from 409.5 million pounds in 1990 to 303.0 million pounds in 2010. Styrene monomer, toluene diisocyanate and methylene chloride were the top three breast/mammary gland carcinogens used during the 1990 to 2010 period (see Appendix D and Table 8). Because the volume of styrene used far exceeds all other chemicals, styrene trends can mask those of other chemicals. Excluding styrene (see Appendix D for styrene monomer trends), the use of chemicals known or suspected to be associated with breast/mammary gland carcinogenesis declined 21%, from 14.2 million pounds in 1990 to 11.2 million pounds in 2010 (Figure 10 excludes styrene monomer).

Environmental releases have decreased dramatically since the inception of the TURA program in 1990. Facilities reporting to the TURA program documented a 97% decline in total environmental releases of breast/mammary gland carcinogens, from 1.7 million pounds in 1990 to 47,000 pounds in 2010 (Figure 11). The top three chemicals driving this trend were methylene chloride, styrene and acetaldehyde (See Appendix D and Table 8). The increased regulatory focus on methylene chloride contributed significantly to the drop in releases in the late 1990s.

Figure 10: Known & Suspected Breast & Mammary Gland Carcinogens Total Use* TURA Program, 1990-2010



*Excludes styrene monomer.

Figure 11: Known & Suspected Breast & Mammary Gland Carcinogens Total Environmental Releases TURA Program, 1990-2010

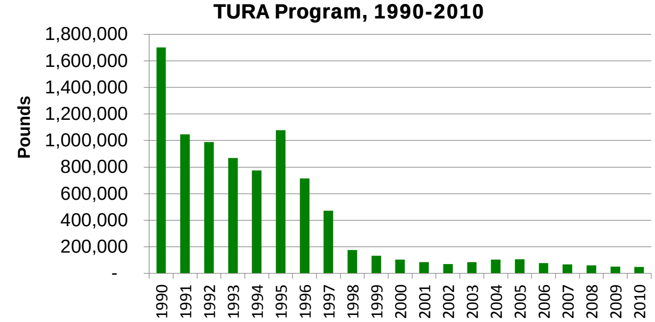


Table 8. Use of Known/Suspected Breast/Mammary Carcinogens: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Styrene Monomer	291,850,681	-26%	Plastic materials and resins, Chemical distribution	11
2.	Toluene Diisocyanate	6,741,872	+29%	Plastic resin manufacturing, Paints, Polyurethane foam products	4
3.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily paints, pharmaceuticals and adhesives), Chemical distribution	11
ENVIRONMENTAL RELEASES					
1.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily paints, pharmaceuticals and adhesives), Chemical distribution	11
2.	Styrene Monomer	20,976	-80%	Plastic materials and resins, Chemical distribution	11
3.	Acetaldehyde	8,071*	-100%*	Plastics materials and resins	0
*2005 was the last year facilities reported use of acetaldehyde					

Kidney

Kidney Cancer Overview. During 2004-2008, kidney cancer was the 7th most commonly diagnosed cancer among males and the 11th most commonly diagnosed cancer among females in Massachusetts.[2] During this time period, males experienced the disease nearly twice as often as females, as reflected in the average annual age-adjusted incidence rates of 22.5 males per 100,000 (3,547 total cases) and 11.0 females per 100,000 (2,131 total cases).[2]

Table 9: Known or Suspected Kidney Carcinogens Reported to the TURA Program, 1990-2010

CAS	Chemical*
106-99-0	1,3-Butadiene
123-91-1	1,4-Dioxane
79-06-1	Acrylamide
1001^ 7440-38-2	Arsenic and arsenic compounds
75-27-4	Bromodichloromethane
1012^ 7440-43-9	Cadmium and cadmium compounds
67-66-3	Chloroform
75-09-2	Methylene Chloride
1060^	Dioxin and dioxin compounds
118-74-1	Hexachlorobenzene
1026^ 7439-92-1	Lead and lead compounds
1029^	Nickel compounds
98-95-3	Nitrobenzene
106-46-7	*p*-Dichlorobenzene
1045^	Polychlorinated alkanes
127-18-4	Tetrachloroethylene
79-01-6	Trichloroethylene

*For evidence sources see Appendix C
^ MA DEP compound category

Age-adjusted incidence rates for kidney cancer among both males and females in Massachusetts have doubled since 1985. Among males, the incidence rate increased from 11.9 per 100,000 in 1985 to 24.1 per 100,000 in 2008, while the rate among females increased from 5.8 per 100,000 in 1985 to 11.3 per 100,000 in 2008.[2,4] The incidence rate of kidney cancer continues to show increases in the most recent years as well. During 2004-2008, the kidney cancer incidence rate increased by 2.3% per year in females and 3.1% per year in males.[2] The rate of incidence is also increasing nationally.[1] While a partial explanation of recent increase may be that abdominal imaging performed for other reasons is detecting more cases of early stage disease,[1] the reasons for the overall and long-term rise in the incidence rate of kidney cancer remain unclear.

Exposure to some chemicals is a known risk factor for kidney cancer. For example, the U.S. EPA has recently classified trichloroethylene as a known human carcinogen and sufficient evidence links the chemical specifically to kidney cancer.[37] Trichloroethylene is widely used as a solvent in vapor degreasing and parts cleaning; in adhesives; and as a chemical intermediate. In addition to chemical exposure, other known risk factors for kidney cancer include tobacco smoking, obesity, high blood pressure and some hereditary conditions.

Trends in Use and Environmental Releases of Kidney Carcinogens. Table 9 lists 17 chemicals or categories of chemicals reported to the TURA program (1990 to 2010) that research suggests may be linked with kidney cancer. Six of the chemicals are considered known human carcinogens by authoritative bodies (1,3-butadiene, arsenic and arsenic compounds, cadmium and cadmium compounds, dioxin and dioxin compounds, nickel compounds and trichloroethylene). Strong evidence links trichloroethylene with kidney cancer. Suggestive evidence from epidemiological studies as well as experimental animal studies links increased risk of kidney cancer with exposure to cadmium and cadmium compounds and arsenic and arsenic compounds (Appendix C). Links with kidney cancer for the remaining chemicals listed in Table 9 are supported by toxicological evidence (Appendix C).

Use of these 17 chemicals/categories of chemicals has declined among facilities reporting to the TURA program. Between 1990 and 2010, there was a 62% reduction in the use of chemicals known or suspected to be associated with kidney cancer, from 23.3 million pounds to 8.9 million pounds (Figure 12). Lead and lead compounds, methylene chloride, and nickel compounds were the top three chemicals used during 1990 to 2010 (see Appendix D and Table 10).

Environmental releases of the 17 known or suspected kidney carcinogens by facilities reporting to the TURA program decreased by 86%, from 3.2 million pounds in 1990 to 438,000 pounds in 2010 (Figure 13). This is an understatement of progress, as lead and lead compound releases by WtE incinerators were first required to be reported in 2003, resulting in increases (excluding these facilities there was a 97% reduction in releases from 1990-2010). The top three chemicals driving this trend were trichloroethylene, methylene chloride and lead and lead compounds (see Appendix D and Table 10).

Figure 12: Known & Suspected Kidney Carcinogens Total Use TURA Program, 1990-2010

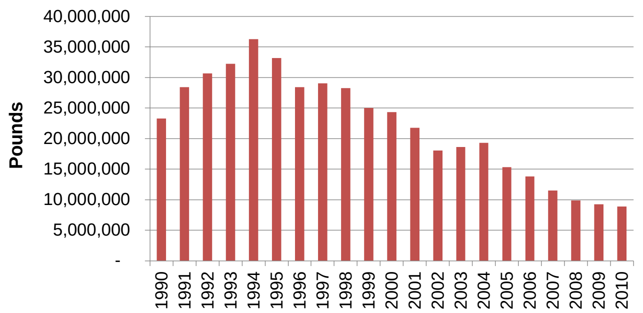
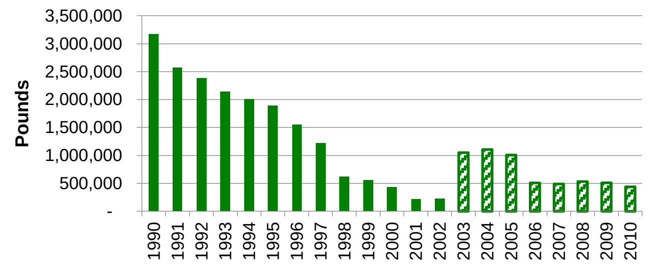


Figure 13: Known & Suspected Kidney Carcinogens Total Environmental Releases TURA Program, 1990-2010



Note: 2003-2010 data reflect an increase in releases due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) incinerators.

Table 10. Use of Known/Suspected Kidney Carcinogens: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Lead and lead compounds	3,910,928	-81%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
2.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Nickel compounds	661,211	-66%	Metal Plating, wire and cable, Electricity generation	7
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Metal Finishing, Chemical distribution, Chemicals and allied products	16
2.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Lead and lead compounds	347,103	-60%	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.					

Leukemia

CAS	CHEMICAL*
Table 11: Known or Suspected Leukemogens Reported to the TURA Program, 1990-2010	
106-99-0	1,3-Butadiene
75-55-8	2-Methylaziridine
612-83-9	3,3'-Dichlorobenzidine dihydrochloride
75-07-0	Acetaldehyde
1001^ 7440-38-2	Arsenic and arsenic compounds
71-43-2	Benzene
1004^ 7440-43-9	Cadmium and cadmium compounds
56-23-5	Carbon tetrachloride
106-46-7	*p*-Dichlorobenzene
75-09-2	Methylene chloride
107-06-2	Ethylene dichloride
75-21-8	Ethylene oxide
96-45-7	Ethylene thiourea
50-00-0	Formaldehyde
302-01-2	Hydrazine
1026^ 7439-92-1	Lead and lead compounds
1045	Polychlorinated alkanes
1336-36-3	Polychlorinated biphenyls
100-42-5	Styrene monomer
79-01-6	Trichloroethylene
*For evidence sources see Appendix C ^MA DEP compound category	

Leukemia Overview. Leukemia was the 9th most commonly diagnosed cancer among males and the 12th most commonly diagnosed cancer among females in Massachusetts during 2004-2008.[2] During this 5-year period, the average annual age-adjusted incidence rate was 15.9 males per 100,000 (2,392 total cases), and 9.7 females per 100,000 (1,877 total cases).[2] The leukemia incidence rate among females has risen in recent years—an increase of 1.2% per year between 2004-2008.[2] Over the last 24 years, the age-adjusted leukemia rate among females has increased 57%, from 6.7 per 100,000 in 1985 to 10.5 per 100,000 in 2008.[4] While the corresponding rate among males has decreased in recent years (1.3% per year from 2004 to 2008), there was a 51% increase from 1985 to 2008 (10.6 per 100,000 in 1985 to 16.0 per 100,000 in 2008).[4] Nationally, the leukemia incidence rate among males and females combined has increased by approximately 0.5% per year since 1992.[1]

Leukemia among children, while rare, is the most common childhood cancer. The incidence rate (unadjusted) among Massachusetts children ages 0-19 in 2008 was 4.9 per 100,000 (79 cases), an increase of 44% since 1985 when 3.4 children were diagnosed per 100,000.[4] The corresponding rate nationally increased 30% between 1975 and 2009.[28]

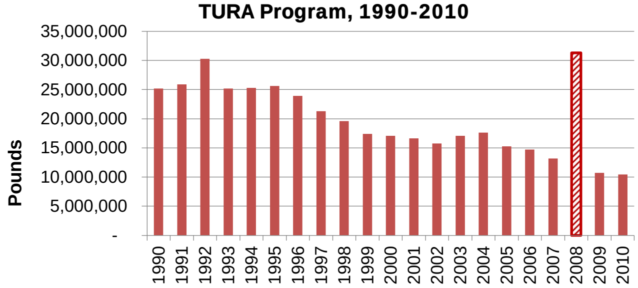
A number of chemicals are known risk factors for leukemia. For example, benzene can cause some types of leukemia and recent studies suggest that even extremely low levels of exposures over long periods of time can increase risk.[38,39] Additional known chemical risk factors for leukemia include 1,3-butadiene, and formaldehyde.[25] Risk factors for leukemia not shown in Table 11 include pesticides. Studies have documented increased risk among workers exposed to a number of different pesticides as well as an increased risk among children who grow up on farms, whose parents were occupationally exposed to pesticides or where pesticides were used in the child's home.[33] Ionizing radiation, some viruses, genetic disorders and tobacco smoking are also known risk factors for leukemia.

Trends in Use and Environmental Releases of Leukemogens. Table 11 lists 20 chemicals/chemical categories reported to the TURA program that have been linked to leukemia. 1,3-butadiene, arsenic and arsenic compounds, cadmium and cadmium compounds, ethylene oxide, formaldehyde and trichloroethylene are considered known human carcinogens by at least one authoritative body. Strong or suggestive evidence from epidemiological studies link leukemia with 1,3-butadiene, benzene, ethylene oxide, formaldehyde, styrene monomer and trichloroethylene. Evidence linking risk of leukemia with other chemicals listed in Table 11 is based on experimental animal studies (Appendix C).

There was a 28% reduction in the use of the group of 20 chemicals known or suspected of being associated with leukemia, from 420.4 million pounds in 1990 to 302.3 million pounds in 2010. Styrene, lead and lead compounds and formaldehyde account for the largest amounts of leukemogens used during 1990 to 2010 (see Appendix D and Table 12). The volume of styrene used far exceeds all other chemicals and can mask other trends. Excluding styrene, there was a 59% decline, from 25.2 million pounds in 1990 to 10.4 million pounds in 2010 (Figure 14). The spike in 2008 reflects reporting of formaldehyde use by one facility that claimed trade secret status in all years except 2008.

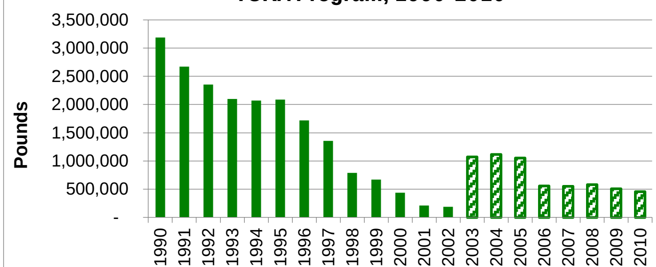
There was an 86% decreased in environmental releases of the 20 known or suspected leukemogens by facilities reporting to the TURA program, from 3.2 million pounds in 1990 to 457,000 pounds in 2010 (Figure 15). This is an understatement of progress, as releases of lead and lead compounds by WtE incinerators were first required to be reported in 2003 (a decline of 96% from 1990-2010 if these releases are excluded from the analysis). The top three chemicals driving these release totals were trichloroethylene, methylene chloride and lead and lead compounds (See Appendix D and Table 12).

Figure 14: Known & Suspected Leukemogens Total Use* TURA Program, 1990-2010



*Excludes styrene monomer.
Note: In 2008, formaldehyde use substantially increased due to reporting by a facility that claimed trade secret status in prior and subsequent years.

Figure 15: Known & Suspected Leukemogens Total Environmental Releases TURA Program, 1990-2010



Note: 2003-2010 data reflect an increase in releases of lead and lead compounds due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) incinerators.

Table 12. Use of Known/Suspected Leukemogens: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Styrene Monomer	292,654,148	-26%	Plastic materials and resins, Chemical distribution	11
2.	Lead and lead compounds	3,910,928	-81%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
3.	Formaldehyde	1,390,994	-73%^	Chemicals and allied products (primarily resins and industrial organic chemicals), paper mills and coated paper	7
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Plating, Chemical distribution, Chemicals and allied products	16
2.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Lead and lead compounds	347,103	-60%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143

*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.
^Understanding of formaldehyde use is incomplete; one facility claimed trade secret status in all years except 2008.

Liver

Liver & Biliary Cancer Overview. Liver and biliary cancer (cancer of the liver bile ducts) was the 12th most common cancer diagnosed in males and the 18th most common cancer diagnosed in females in Massachusetts during the period 2004-2008.[2] During this 5-year time period, the average age-adjusted incidence rate among males was nearly four times that of females, corresponding to 11.4 males per 100,000 (1,825 total cases) versus 3.2 females per 100,000 (644 total cases).[2] The age-adjusted incidence rate of liver and biliary cancer has increased dramatically in the Commonwealth. Among males, the age-adjusted incidence rate increased 276% from 1985 to 2008, from 3.3 per 100,000 to 12.4 per 100,000, respectively.[2,4] Among females, the corresponding rate rose 208% (1.2 per 100,000 in 1985 to 3.7 per 100,000 in 2008).[2,4] Considering just the most recent years of age-adjusted incidence data (from 2004 to 2008), there was an annual percent increase of 8.3% among females and 4.9% among males.[2] While the incidence rate of liver cancer is also increasing nationally (3.6% a year in males and 3.0% a year among females from 2004 to 2008), the magnitude of change is greater in Massachusetts.[1]

The increase in liver cancer incidence is in part due to increases in rates of chronic hepatitis B and hepatitis C infection, primary risk factors for the disease.[1] Other risk factors include alcohol-related cirrhosis and non-alcoholic fatty liver disease associated with obesity.[1] In addition, evidence suggests that exposure to a range of chemicals may increase liver cancer risk. While the evidence is not definitive, epidemiologic studies suggest that exposure to arsenic, polychlorinated biphenyls (PCBs), nickel compounds, trichloroethylene and methylene chloride may increase liver cancer risk. While not reported by TURA filers, vinyl chloride is considered a known liver carcinogen (both angiosarcoma and hepatocellular carcinoma). In addition, exposure to ionizing radiation is also a known liver carcinogen.

Table 13: Known or Suspected Liver Carcinogens Reported to the TURA Program, 1990-2010

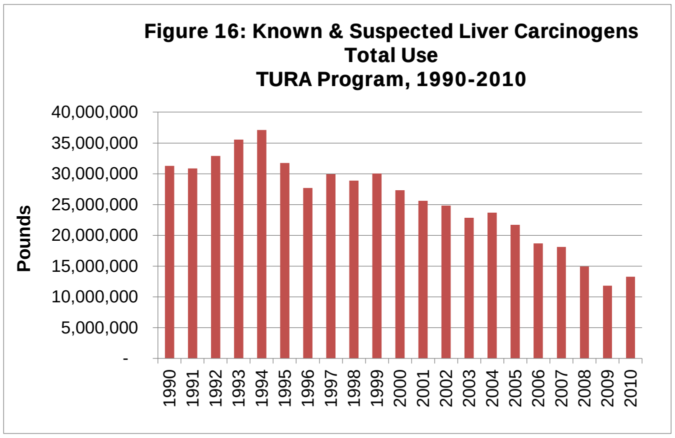
CAS	Chemical*
117-81-7	Di(2-ethylhexyl) phthalate (DEHP)
96-12-8	1,2-Dibromo-3-chloropropane
123-91-1	1,4-Dioxane
107-13-1	Acrylonitrile
1001^ 7440-38-2	Arsenic and arsenic compounds
75-27-4	Bromodichloromethane
106-99-0	1,3-Butadiene
7440-43-9 1004	Cadmium and cadmium compounds
56-23-5	Carbon tetrachloride
67-66-3	Chloroform
612-83-9	3,3'-Dichlorobenzidine dihydrochloride
75-09-2	Methylene chloride
107-06-2	Ethylene dichloride
118-74-1	Hexachlorobenzene
302-01-2	Hydrazine
90-94-8	Michler's ketone
1029	Nickel compounds
98-95-3	Nitrobenzene
97-56-3	*o*-Aminoazotoluene
106-46-7	*p*-Dichlorobenzene
1040	Polycyclic aromatic compounds
1045	Polychlorinated alkanes
1336-36-3	Polychlorinated biphenyls
91-08-7 584-84-9 26471-62-5	Toluene diisocyanates
127-18-4	Tetrachloroethylene (perc)
79-01-6	Trichloroethylene
101-14-4	4,4'-Methylene bis(2-chloroaniline)
62-56-6	Thiourea

*For evidence sources see Appendix C
^MA DEP compound category

Trends in Use and Environmental Releases of Liver Carcinogens. Table 13 lists 28 chemicals or categories of chemicals reported to the TURA program (1990 to 2010) that research evidence suggests may be linked with liver or biliary cancer. Three of the chemicals—arsenic and arsenic compounds, nickel compounds, and 4,4'-Methylene bis(2-chloroaniline)—are considered known human carcinogens by at least one authoritative body. As mentioned above, strong or suggestive evidence from epidemiological studies link liver or biliary cancer with a number of chemicals, in particular the following: arsenic and arsenic compounds, methylene chloride, nickel compounds, PCBs and trichloroethylene. Evidence supporting associations between increased risk of liver cancer and additional chemicals listed in Table 13 is primarily from experimental animal studies (Appendix C).

Use of these 25 chemicals/categories of known or suspected liver/biliary carcinogens has declined among facilities reporting to the TURA program. There was a 58% reduction in the use of these chemicals, from 31.3 million pounds in 1990 to 13.3 million pounds in 2010 (Figure 16). Toluene diisocyanate, methylene chloride and di(2-ethylhexyl) phthalate (DEHP) were used in the greatest amounts during 1990 to 2010 (See Appendix D and Table 14).

Environmental releases of the 25 known or suspected liver carcinogens by facilities reporting to the TURA program declined by 97%, from 3.2 million pounds in 1990 to 93,000 pounds in 2010 (Figure 17). The top three chemicals driving these reductions were trichloroethylene, methylene chloride and tetrachloroethylene (See Appendix D and Table 14).



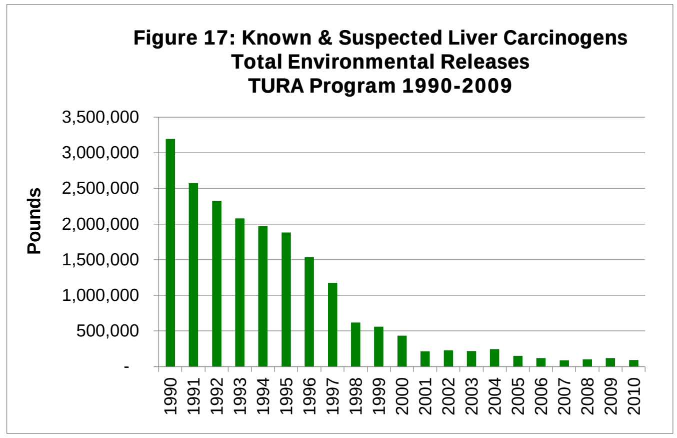


Table 14. Use of Known/Suspected Liver Carcinogens: Primary Industries
TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Toluene Diisocyanate	6,741,872	+29%	Plastics resins manufacturing, Paints, Plastic foam products	4
2.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Di(2-ethylhexyl) phthalate (DEHP)	1,166,842	-88%	Plastic materials and resins, Chemical distribution	6
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Plating, Chemical distribution, Chemicals and allied products	16
2.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Tetrachloroethylene	13,194	-96%	Metal finishing, Chemical distribution, Dry cleaning	17

Lung

Lung Cancer Overview. Cancers of the lung and bronchus are the 2nd leading cancer among both males and females in Massachusetts. From 2004 to 2008, the average annual age-adjusted incidence rate for lung and bronchus cancer among males was 82.8 per 100,000 (12,417 total cases) and 64.5 per 100,000 (12,834 total cases) among females.[2] The incidence rate is notably lower among females than males, and Black, non-Hispanic males experience a higher rate than do White, non-Hispanic males.[2] The age-adjusted lung and bronchus cancer incidence rate in Massachusetts among males has decreased 19% since the high of 98.2 per 100,000 in 1991.[4] Only very recently has the corresponding rate among females decreased—from 2004-2008 there was a 1% decline.[2] Nationally, the incidence rate for lung and bronchus cancer decreased 1.9% per year among males and 0.3% per year among women during this period.[1]

Trends in lung cancer incidence reflect corresponding trends in tobacco smoking—a known lung carcinogen and a leading cause of lung cancer.[40] Ionizing radiation, including radon gas, is also a significant known risk factor of lung cancer and is naturally present at high levels in the soil and rock of several Massachusetts counties. Other chemicals/materials that are known lung cancer risk factors include asbestos, crystalline silica, bis (chloromethyl) ether (BCME) and chloromethyl methyl ether (CMME), mustard gas, and several metals such as arsenic, beryllium, cadmium and chromium.[19]

Table 15: Known or Suspected Lung Carcinogens Reported to the TURA Program, 1990-2010

CAS	CHEMICAL*
96-12-8	1,2-Dibromo-3-chloropropane
106-99-0	1,3-Butadiene
101-14-4	4,4'-Methylene bis(2-chloroaniline)
75-07-0	Acetaldehyde
79-06-1	Acrylamide
107-13-1	Acrylonitrile
1001^ 7440-38-2	Arsenic and arsenic compounds
71-43-2	Benzene
98-07-7	Benzotrichloride
1004^ 7440-43-9	Cadmium and cadmium compounds
1012^ 18540-29-9	Hexavalent chromium and compounds
8001-58-9	Creosotes
75-09-2	Methylene chloride
1060^	Dioxin and dioxin compounds
106-89-8	Epichlorohydrin
107-06-2	Ethylene dichloride
75-21-8	Ethylene oxide
50-00-0	Formaldehyde
302-01-2	Hydrazine
1026^ 7439-92-1	Lead and lead compounds
1029^ 7786-81-4	Nickel and nickel compounds
7440-02-0	Nickel (metallic)
98-95-3	Nitrobenzene
97-56-3	*o*-Aminoazotoluene
1040^	Polycyclic aromatic compounds
1336-36-3	Polychlorinated biphenyls
1095^	Silica, crystalline
7664-93-9 8014-95-7	Sulfuric acid mists/fumes
100-42-5	Styrene monomer

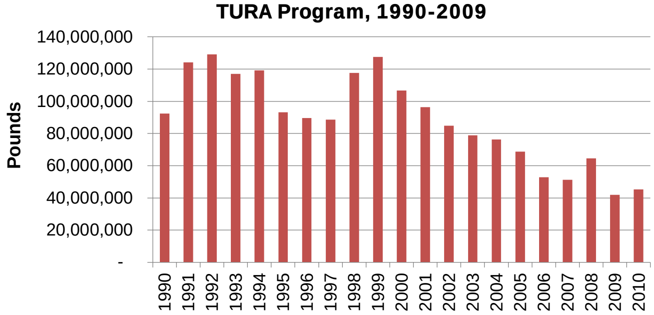
*For evidence sources see Appendix C
^MA DEP compound category

Trends in Use and Environmental Releases of Lung Carcinogens. Table 15 lists 28 chemicals or categories of chemicals reported to the TURA program (1990 to 2010) that are known or suspected of being associated with lung cancer. Thirteen of the chemicals are considered known human carcinogens (several based on sites other than lung cancer [Appendix C]). For approximately half of the chemicals listed, links with lung cancer are based on strong/definitive or suggestive evidence from epidemiological studies, while links between lung cancer and the remaining chemicals are based on evidence primarily from experimental animal studies (Appendix C).

Despite use fluctuations in the early years of the TURA program, there was a 31% reduction in the use of chemicals known or suspected to be associated with lung cancer, from 487.6 million pounds in 1990 to 337.1 million pounds in 2010. Styrene monomer, sulfuric acid and lead and lead compounds were the top three chemicals used during 1990 to 2010 (see Appendix D and Table 16). For sulfuric acid, the majority of TURA facility uses are not those that create sulfuric mists, the form of sulfuric acid linked with lung cancer. The volume of styrene used far exceeds that of all other chemicals and masks trends. Excluding styrene, there was a 51% decline over the period 1990 to 2010 in chemicals associated with lung cancer (Figure 18 excludes styrene). As discussed earlier, trend information for formaldehyde is incomplete because of the trade secret status of one facility's reports.

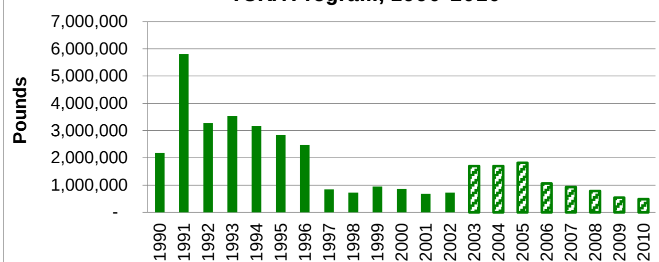
Among facilities reporting to the TURA program, there was a 77% decline in environmental releases of lung carcinogens, from 2.1 million in 1990 to 483,000 in 2010. The spike in releases in 1991 was due to sulfuric acid emissions from newly reporting electric utilities. When measured from 1991, there was a 92% decline in total environmental releases from 1991 to 2010 (Figure 19). This is an understatement of progress, as releases of lead and lead compounds by WtE incinerators were first required to be reported in 2003, and resulted in a large increase (a 98% decrease from 1991-2010 excluding these facilities). The three chemicals released in the greatest amounts were sulfuric acid, methylene chloride and lead and lead compounds (see Appendix D and Table 16). For sulfuric acid, the majority of releases are not likely to produce sulfuric acid mists, the form of sulfuric acid associated with lung cancer.

Figure 18: Known & Suspected Lung Carcinogens Total Use* TURA Program, 1990-2009



*excludes styrene monomer.

Figure 19: Known & Suspected Lung Carcinogens Total Environmental Releases TURA Program, 1990-2010



Note: 2003-2010 data reflect an increase in releases of lead and lead compounds due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) incinerators.

Table 16. Use of Known/Suspected Lung Carcinogens: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Styrene Monomer	291,850,681	-26%	Plastic materials and resins, Chemical distribution	11
2.	Sulfuric Acid	27,938,964	-36%	in Food manufacturing sanitation, Chemicals and allied products, Metal Finishing, Semiconductors	97
3.	Lead and compounds	3,910,928	-81%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143
ENVIRONMENTAL RELEASES					
1.	Sulfuric acid	67,293	-63%	Sanitation in food manufacturing, Chemicals and allied products, Plating, Semiconductors	97
2.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Lead and compounds	347,103	-60%*	Electricity generation, Municipal waste incineration, Fabricated metal products, Ready-mix concrete	143

*Percent change excludes reporting by Waste to Energy (WtE) incinerators; reporting of combustion-related emissions were phased into the program in 2003.

Non-Hodgkin's Lymphoma

Non-Hodgkin's Lymphoma overview. Non-Hodgkin's lymphoma (NHL) is the 6th most common cancer among males and 7th leading cancer in females in Massachusetts. From 2004 to 2008, the average annual age-adjusted incidence rate for NHL was 24.6 males per 100,000 (3,776 total cases) and 16.6 females per 100,000 (3,337 total cases).[2] The incidence rate is highest among non-Hispanic, White males and females compared to other races/ ethnicities.[2] From 1985 to 2008, age-adjusted incidence rates in Massachusetts rose significantly: 57% among males and 44% among females.[2,4] While NHL among children is a very rare disease, the rise in incidence rates among children ages 0-19 is particularly striking. Despite yearly fluctuations, the rate (unadjusted) among children ages 0-19 climbed nearly 71%, from 0.97 individuals per 100,000 (16 cases) in 1985 to 1.66 individuals per 100,000 (27 cases) in 2007.[4] The national rate of childhood NHL also increased, rising 39% from 1975 to 2009.[28]

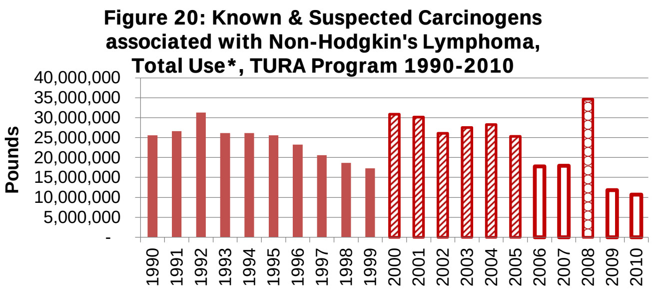
Table 17: Known or Suspected Carcinogens associated with Non-Hodgkin's Lymphoma Reported to the TURA Program, 1990-2010	
CAS	**Chemical Name***
106-99-0	1,3-Butadiene
75-07-0	Acetaldehyde
1001^ 7440-38-2 1327-52-2	Arsenic and arsenic compounds
71-43-2	Benzene
98-07-7	Benzotrichloride
1004^ 7440-43-9	Cadmium and cadmium compounds
56-23-5	Carbon tetrachloride
75-09-2	Methylene chloride
1060^	Dioxin and dioxin compounds
107-06-2	Ethylene dichloride
75-21-8	Ethylene oxide
50-00-0	Formaldehyde
118-74-1	Hexachlorobenzene
1026^ 7439-92-1	Lead and lead compounds
1336-36-3	Polychlorinated biphenyls
1040^	Polycyclic aromatic compounds
100-42-5	Styrene monomer
127-18-4	Tetrachloroethylene
79-01-6	Trichloroethylene
*For evidence sources see Appendix C ^MA DEP compound category	

The best-described risk factor for NHL is immune deficiency; individuals taking immune suppressant medications after organ transplantation and for a range of diseases are at increased risk of NHL.[1] NHL risk is also elevated among individuals with specific viral infections, such as HIV, and in people with severe autoimmune conditions.[1] A range of environmental and occupational exposures may also increase risk. For example, substantial evidence links NHL with dioxin exposure. Other studies document elevated risk of NHL among people exposed to a range of solvents, such as tetrachloroethylene and trichloroethylene, as well as among people exposed to pesticides, including phenoxy herbicides such as 2,4-D.[19,31] Evidence of increased risk of NHL among children exposed to pesticides is strongest for those whose parents were exposed prior to conception or during pregnancy.[19]

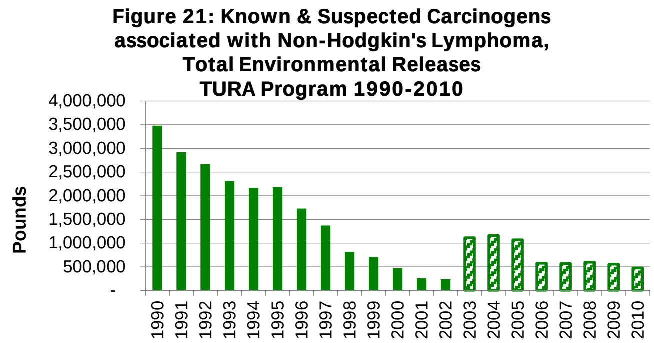
Trends in Use and Environmental Releases of Carcinogens associated with Non-Hodgkin's Lymphoma. Table 17 lists 19 chemicals/categories of chemicals reported to the TURA program (1990 to 2010) linked to NHL. 1,3-butadiene, arsenic and arsenic compounds, benzene, cadmium and cadmium compounds, ethylene oxide, formaldehyde and trichloroethylene are considered known human carcinogens by authoritative bodies, based on evidence for cancer types other than NHL (Appendix C). Epidemiological evidence supports suggestive links with NHL, including 1,3-butadiene, benzene, dioxin and dioxin compounds, formaldehyde, PCBs, tetrachloroethylene, and trichloroethylene; evidence for the remaining is based on experimental animal studies (Appendix C).

Use and environmental releases of chemicals known or suspected to be associated with NHL have declined. There was a 28% reduction in use, from 420.8 million pounds in 1990 to 302.6 million pounds in 2010. Styrene, formaldehyde and methylene chloride were used in the greatest amounts by TURA filers during 1990 to 2010 (see Appendix D and Table 18). The sharp increase in 2000 reflects reporting changes associated with PACs, which reduced the use reporting threshold to 100 pounds and eliminated the *de minimis* exemption (see explanation in Appendix D). As mentioned earlier, trend information for formaldehyde is incomplete as one facility claimed trade secret status in all years except 2008 (corresponding to the 2008 spike). Excluding styrene (the volume of styrene used far exceeds all other chemicals), there was a 58% decline over the period 1990 to 2010 (Figure 20).

Declines in environmental releases were greater: From 1990 to 2010, the volume of chemicals associated with NHL decreased 86%, from 3.5 million pounds to 471,000 pounds (Figure 21). This is an understatement of progress. Releases of lead and lead compounds by WtE facilities (incinerators) were first required to be reported in 2003, resulting in a large increase. Excluding reporting of these releases, there was a 96% decline from 1990-2010. The top three chemicals released during this period were trichloroethylene, formaldehyde and tetrachloroethylene (see Appendix D and Table 18).



*Excludes styrene monomer. Note: In 2000, the TRI PBT rule lowered the reporting threshold for PACs to 100 pounds. In 2006, TURA amendments eliminated reporting of PACs by non-utilities. In 2008, formaldehyde use increased substantially due to reporting by a facility that claimed trade secret status in prior and subsequent years.



Note: 2003-2010 data reflect an increase in releases of lead and lead compounds due to a change in reporting requirements that eliminated the exemption for reporting by Waste to Energy (WtE) facilities (incinerators).

Table 18. Use of Known/Suspected Carcinogens associated with Non-Hodgkin's Lymphoma: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Styrene Monomer	291,850,681	-26%	Plastic materials and resins, Chemical distribution	11
2.	Formaldehyde*	2,517,014	-73%	Chemicals and allied products (primarily resins and industrial organic chemicals), paper mills and coated paper	7
3.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Plating, Chemical distribution, Chemicals and allied products	16
2.	Formaldehyde	16,100	-91%*	Chemicals and allied products (primarily resins and industrial organic chemicals), paper mills and coated paper	7
3.	Tetrachloroethylene	13,194	-96%	Metal finishing, Chemical distribution, Dry cleaning	17

* An understanding of formaldehyde trends is incomplete given that one facility claimed trade secret status in all years except for 2008.

Pancreas

Pancreatic Cancer overview. Pancreatic cancer is the 10th most common cancer among both males and females in Massachusetts. From 2004 to 2008, the average annual age-adjusted incidence rate for pancreatic cancer was 14.1 males per 100,000 (2,128 total cases) and 11.2 females per 100,000 (2,335 total cases).[2] The incidence rate is highest among Black, non-Hispanic males and females compared to other races/ethnicities.[2] From 1985 to 2008, age-adjusted incidence rates in Massachusetts rose 38% among males and 39% among females.[2,4] Nationally, rates are also rising. Since 2004, the rate of pancreatic cancer incidence across the U.S. has risen 1.5% per year.[1]

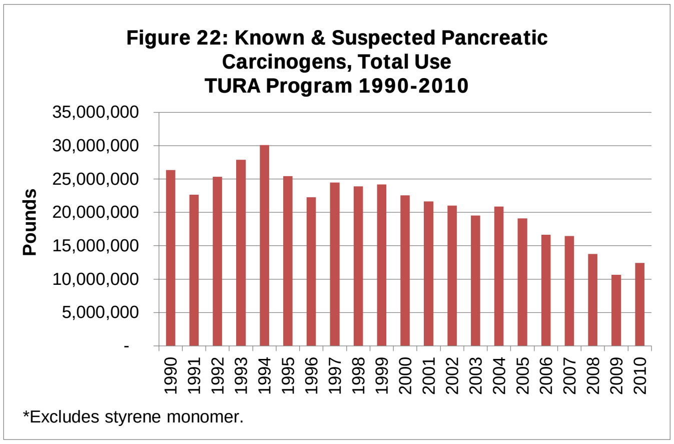
Table 19. Known or Suspected Pancreatic Carcinogens Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
106-99-0	1,3-Butadiene
75-07-0	Acetaldehyde
79-06-1	Acrylamide
1004^ 7440-43-9	Cadmium and cadmium compounds
117-81-7	di(2-ethylhexyl) phthalate (DEHP)
75-09-2	Methylene chloride
107-06-2	Ethylene dichloride
1029^	Nickel compounds
100-42-5	Styrene monomer
91-08-7 584-84-9 26471-62-5	Toluene diisocyanates
1336-36-3	Polychlorinated biphenyls
*For evidence sources see Appendix C ^MA DEP compound category	

Studies investigating pancreatic cancer risk factors have primarily explored the role of lifestyle factors. Smoking is considered a known risk factor for pancreatic cancer.[1] Smoking appears to double the risk of pancreatic cancer compared to the risk among non-smokers.[1] Additional risk factors include obesity as well as alcohol consumption.[1] While chemicals are not among the risk factors commonly cited for pancreatic cancer, recent research suggests increased risk from cadmium exposure.[41] In addition, a recent review of occupational studies suggest a strong and consistent link between pancreatic cancer and exposure to polycyclic aromatic hydrocarbons (PAHs) as well as chlorinated hydrocarbons.[42] Beyond those chemicals identified in Table 19, epidemiological evidence also suggests that pancreatic cancer may be linked to chemicals not reported under TURA, including metal working fluids, some pesticides and non-specified chemicals in the semiconducting and food industries.[19,31]

Trends in Use and Environmental Releases of Pancreatic Carcinogens. Table 19 lists 11 chemicals or categories of chemicals reported to the TURA program (1990 to 2010) for which research evidence substantiates suggestive links with pancreatic cancer. 1,3-butadiene, cadmium and cadmium compounds and nickel compounds are considered known human carcinogens by authoritative bodies, based on links with cancer types other than pancreatic cancer (Appendix C). Epidemiological evidence suggests links between pancreatic cancer and approximately half of the chemicals listed in Table 19, including acrylamide, cadmium and cadmium compounds, methylene chloride, ethylene dichloride, nickel compounds and styrene monomer. Evidence for the remaining chemicals is from experimental animal studies (Appendix C).

There was a 28% reduction in the use of chemicals known or suspected to be associated with pancreatic cancer, from 421.6 million pounds in 1990 to 304.3 million pounds in 2010. Styrene monomer, toluene diisocyanate and methylene chloride were the top three chemicals used during the 1990 to 2010 period (see Appendix D and Table 20). Excluding styrene monomer (the amount of styrene used far exceeds all other chemicals), there was a 53% decline over the period 1990 to 2010 (Figure 22 excludes styrene monomer).

Among facilities reporting to the TURA program, there was a 97% decline in environmental releases of chemicals associated with pancreatic cancer, from 1.7 million pounds in 1990 to 47,000 pounds in 2010 (Figure 23). The top three chemicals driving these release totals were methylene chloride, styrene monomer and nickel compounds (See Appendix D and Table 20).



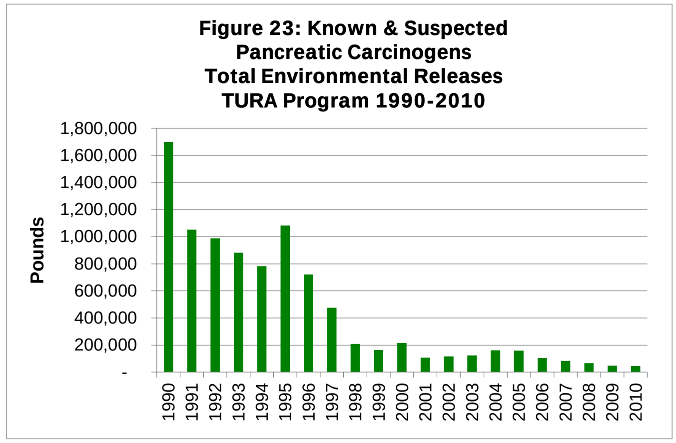


Table 20. Use of Known/Suspected Carcinogens associated with Pancreatic Cancer: Primary Industries TURA Program, 1990-2010

Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Styrene Monomer	291,850,681	-26%	Plastic materials and resins, Chemical distribution	11
2.	Toluene Diisocyanate	6,741,872	+29%	Plastics resins manufacturing, Paints, Plastic foam products	4
3.	Methylene Chloride	3,530,716	55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
ENVIRONMENTAL RELEASES					
1.	Methylene Chloride	24,087	-98%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
2.	Styrene monomer	20,976	-80%	Plastic materials and resins, Chemical distribution	11
3.	Nickel compounds	1,318	-4%	Plating, Wire and cable, Electricity generation	7

Prostate

Table 21. Known or Suspected Prostate Carcinogens Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
10016 7440-38-2	Arsenic and arsenic compounds
1004^ 7440-43-9	Cadmium and cadmium compounds
1060^	Dioxin and dioxin compounds
75-09-2	Methylene chloride
1040^	Polycyclic aromatic compounds
79-01-6	Trichloroethylene
*For evidence sources see Appendix C ^MA DEP chemical compound category	

Prostate Cancer overview. Prostate cancer is the leading type of cancer among Massachusetts males. From 2004 to 2008, the average annual age-adjusted incidence rate for prostate cancer was 162.2 males per 100,000 (25,547 total cases).[2] The incidence rate is significantly higher among Black, non-Hispanic males than other racial/ethnic categories. During the period 2004-2008, the prostate cancer incidence rate among Black, non-Hispanic men was 51% higher than among Hispanic men, 60% higher than among White, non-Hispanic men, and 240% higher than rates among Asian, non-Hispanic men (247.6 individuals per 100,000 compared to 163.9 individuals per 100,000, 155.2 individuals per 100,000 and 72.8 individuals per 100,000, respectively).[2] From 1985 to 2008, the age-adjusted incidence rate for prostate cancer in Massachusetts rose 59%.[2,4] Much of this increase occurred in the late 1980s and early 1990s as a result of screening efforts using the prostate-specific antigen (PSA) blood test. Since 2000, the rate of prostate cancer incidence has decreased.[4]

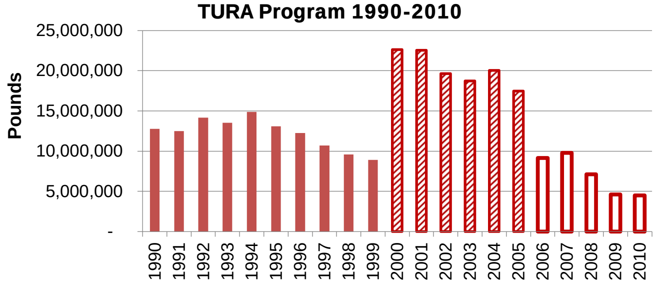
Although prostate cancer is the leading cause of cancer among men, little is known regarding modifiable risk factors for the disease. Studies suggest that dietary factors such as high intake of processed meat or dairy foods as well as obesity increase prostate cancer risk.[1] There is also strong emerging evidence suggesting that sun exposure is protective against prostate cancer via its effect on vitamin D.[43] Evidence from occupational studies suggest that prostate cancer risk may increase as a result of exposure to certain chemicals. In addition to those listed in Table 21, other chemicals not reported to the TURA program have been shown in studies to elevate cancer risk among exposed people. Pesticides associated with prostate cancer include dioxin-contaminated phenoxyherbicides, phorate, fosofos, coumaphos, butylate, cyanazine, and several chlorinated pesticides, such as hexachlorobenzene, chlordane and DDT/DDE.[19,43] In addition, several studies have documented associations between prostate cancer and exposure to metal working fluids. In one study, risk of prostate cancer among men exposed to straight fluids (a type of metal working fluid) before the age of 23 years was dramatically high, suggesting that exposures in early adulthood are critical to the risk of prostate cancer later in life.[44]

Trends in Use and Environmental Releases of Prostate Carcinogens. Table 21 lists six chemicals or categories of chemicals reported to the TURA program (1990 to 2010) for which research evidence demonstrates suggestive links with prostate cancer. With the exception of methylene chloride, all chemicals are considered known human carcinogens by at least one authoritative institution. Evidence supporting the classification of these chemicals as known carcinogens comes from studies examining links between exposure and cancer types other than prostate cancer. However, epidemiologic studies provide suggestive evidence for links between prostate cancer and all chemicals listed in Table 21. Particularly strong evidence links prostate cancer and exposure to arsenic and arsenic compounds, cadmium and cadmium compounds and dioxin (Appendix C).

From 1990 to 2010, the reported use of chemicals known or suspected of being associated with prostate cancer declined 65%, from 12.8 million pounds to 4.5 million pounds (Figure 24). The large increase that occurred in 2000 reflects reporting changes for polycyclic aromatic compounds, which reduced the use reporting threshold to 100 pounds and eliminated the *de minimis* exemption. If excluded, slightly more progress is demonstrated—a 68% decrease from 1990-2010. The primary chemicals associated with prostate cancer used during this time were methylene chloride, polycyclic aromatic compounds and trichloroethylene (See Appendix D and Table 22).

From 1990 to 2010, reported environmental releases of known or suspected prostate carcinogens decreased by 97%, from 2.9 million pounds to 75,000 pounds (Figure 25). The top three chemicals driving these environmental release totals were trichloroethylene, methylene chloride and polycyclic aromatic compounds (See Appendix D and Table 22).

Figure 24: Known & Suspected Prostate Carcinogens, Total Use TURA Program 1990-2010



Note: In 2000, the TRI PBT rule lowered the reporting threshold for PACs to 100 pounds. In 2006, TURA amendments eliminated reporting of PACs by non-utilities.

Figure 25: Known & Suspected Prostate Carcinogens Total Environmental Releases TURA Program 1990-2010

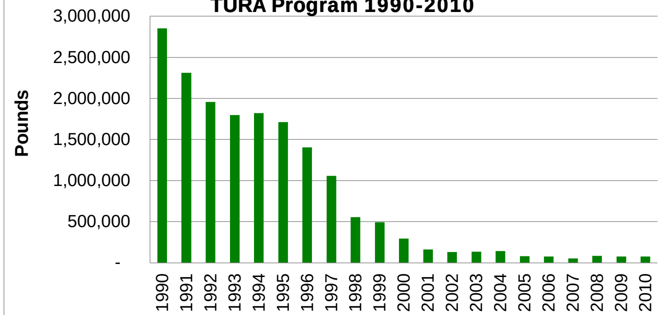


Table 22. Use of Known/Suspected Prostate Carcinogens: Primary Industries TURA Program, 1990-2010					
Rank (1990-2010)	**Chemical Name**	**Total in 2010 (latest year of TURA data)**	**% Change (1990-2010)**	**Primary Industry Sectors**	**# of Facilities Reporting (2010)**
USE					
1.	Methylene Chloride	3,530,716	-55%	Chemicals and allied products (primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Polycyclic aromatic compounds	382,534	-97%*	Electricity generation, Asphalt paving mixtures	26
3.	Trichloroethylene	294,836	-92%	Plating, Chemical distribution, Chemicals and allied products	16
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Plating, Chemical distribution, Chemicals and allied products	16
1.	Methylene Chloride	24,087	-98%	Chemicals and allied products primarily pharmaceuticals, paints and adhesives), Chemical distribution	11
3.	Polycyclic aromatic compounds	649	-82%*	Electricity generation, Asphalt paving mixtures	26
*Based on data beginning 2000					

Testis

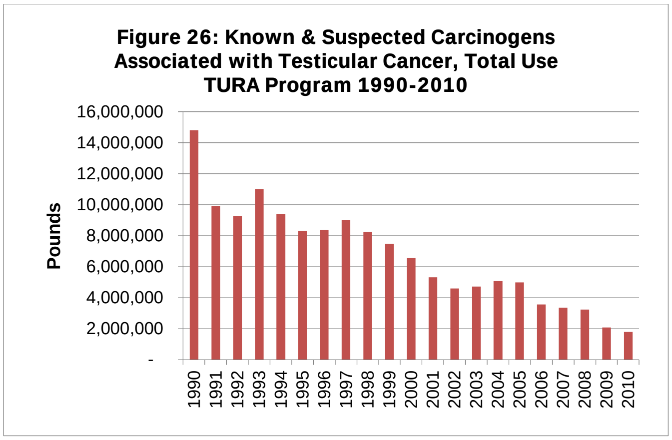
Table 23. Known or Suspected Testicular Carcinogens Reported to the TURA Program, 1990-2010	
CAS	**Chemical***
106-99-0	1,3-Butadiene
1004^ 7440-43-9	Cadmium and cadmium compounds
117-81-7	Di(2-ethylhexyl) phthalate
1336-36-3	Polychlorinated biphenyls
79-01-6	Trichloroethylene
*For evidence sources see Appendix C ^MA DEP chemical compound category	

Testicular Cancer Overview. Testicular cancer among males is not a common cancer—it is ranked 18th among cancers in Massachusetts males.[2] However, the disease is the leading cancer among males 15 to 35 years of age. During the period 2004-2008, the average annual age-adjusted incidence rate for testicular cancer was 6.2 per 100,000 males (990 total cases).[2] The disease is most common among White, non-Hispanic men compared to other races/ethnicities.[2] From 1985 to 2008, the age-adjusted incidence rate in Massachusetts rose 29%.[2,4]

Factors known to increase the risk of testicular cancer include cryptorchidism (undescended testicles) and disorders that cause the testicles to develop abnormally, such as Klinefelter syndrome.[45] Because of the steep rise in testicular cancer over the last few decades, research is investigating whether lifestyle or environmental factors are influencing the increase in incidence. Evidence suggests that exposures *in utero* may be a key risk factor of concern. For example, several studies suggest that maternal exposure to pesticides increases the risk of sons born with cryptorchidism.[46-48] In addition, one study observed that mothers of men with testicular cancer had significantly elevated blood serum concentrations of organochlorine chemicals, including PCBs, hexachlorobenzene and chlordane.[49]

Trends in Use and Environmental Releases of Testicular Carcinogens. Table 23 lists five chemicals or categories of chemicals reported to the TURA program (1990 to 2010) for which research evidence suggests links with testicular cancer. 1,3-butadiene, cadmium and cadmium compounds and trichloroethylene are considered known human carcinogens by at least one authoritative body based primarily on evidence of links between exposure and cancer sites other than the testis. With the exception of studies on PCBs, evidence for chemical links with testicular cancer in Table 23 is based on experimental animal studies. For PCBs, there is some epidemiologic evidence linking exposure to testicular cancer (Appendix C).

Among facilities reporting to the TURA program, the use of chemicals associated with testicular cancer has declined steadily and dramatically. From 1990 to 2010, there was an 88% reduction in the use of chemicals known or suspected of being associated with testicular cancer, from 14.8 million pounds to 1.8 million pounds (Figure 26). The primary testicular carcinogens used during this time period were DEHP, trichloroethylene, and cadmium and cadmium compounds (see Appendix D and Table 24). Facilities reporting to the TURA program documented a 96% reduction in environmental releases of known or suspected testicular carcinogens from 1990 to 2010, from 1.3 million pounds to 51,000 pounds (Figure 27). The top three chemicals driving these release totals were trichloroethylene, DEHP, and cadmium and cadmium compounds (see Appendix D and Table 24).



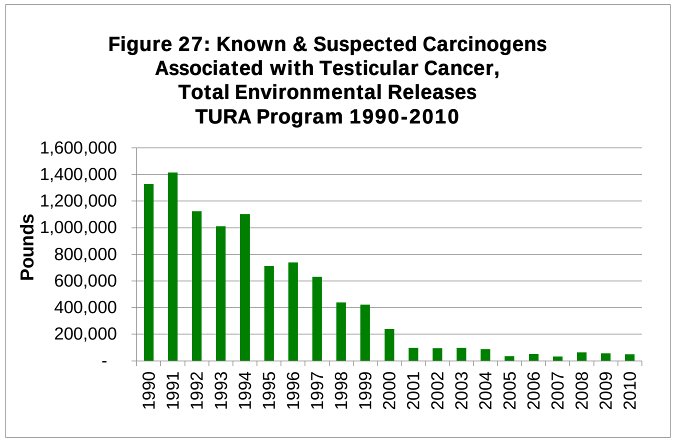


Table 24. Use of Known/Suspected Carcinogens associated with Testicular Cancer: Primary Industries TURA Program, 1990-2010					
Rank (1990-2010)	Chemical Name	Total in 2010 (latest year of TURA data)	% Change (1990-2010)	Primary Industry Sectors	# of Facilities Reporting (2010)
USE					
1.	Di(2-ethylhexyl) phthalate	1,166,842	-88%	Plastic materials and resins, Chemical distribution	6
2.	Trichloroethylene	294,836	-92%	Plating, Chemical distribution, Chemicals and allied products	16
3.	Cadmium and cadmium compounds	266,672	-69%	Fabricated metal (primarily plating), Wire and cable	11
ENVIRONMENTAL RELEASES					
1.	Trichloroethylene	50,555	-96%	Plating, Chemical distribution, Chemicals and allied products	16
2.	Di(2-ethylhexyl) phthalate	112	-99%	Plastic materials and resins, Chemical distribution	6
3.	Cadmium and cadmium compounds	70	-94%	Fabricated metal (primarily plating), Wire and cable	11

DISCUSSION & OPPORTUNITIES

This analysis of trends in use and environmental releases of known and suspected carcinogens suggests several important TUR opportunities that can help advance cancer prevention activities in Massachusetts. This section summarizes the findings and what these results suggest for future programmatic and policy opportunities for the TURA program.

Known and suspected carcinogens reportable under TURA

A review of the TURA list of reportable chemicals compared to the Master Carcinogen List reveals that approximately 30 known and suspected industrial carcinogens are not currently reportable under TURA (see Appendix B). While some of these substances are obsolete pesticides or unspecified chemicals/ materials such as soot, several are potentially used by Massachusetts industries. It may be appropriate to consider these chemicals for possible listing under TURA.

Both known and suspected carcinogens deserve attention. The Master Carcinogen List is based on authoritative sources, which consider evidence from animal studies as well as evidence from epidemiological studies. It would be useful to update this Master Carcinogen List periodically.

Chemicals on the SAB's "More Hazardous Chemicals" list

This analysis revealed that 1,3-butadiene and 4,4'-methylene bis(2-chloroaniline) (MBOCA), both considered known carcinogens by authoritative bodies and both reportable under TURA, were not on the TURA program's Science Advisory Board's list of "More Hazardous Chemicals." The More Hazardous Chemicals list is an informational list maintained by the Science Advisory Board to provide guidance to Massachusetts companies and the TURA program. Both of these chemicals have been reported by Massachusetts industries at some point in the 20 years of the TURA program. 1,3-butadiene is used to make synthetic rubber and plastics, including acrylics. MBOCA is used primarily in the manufacture of polyurethane products. Responding to this analysis, in November 2012, the SAB added these two substances to the More Hazardous Chemicals list.

Overall carcinogen trends

The trend analysis reveals that total use and environmental releases of known and suspected carcinogens by Massachusetts industries reporting to the TURA program have declined significantly over the last 20 years: Total use of known and suspected carcinogens declined 32%, while total environmental releases declined 93%. Moreover, for the vast majority of the 74 known or suspected industrial carcinogens reported under TURA, use and environmental releases of each have declined. Examples of notably declines in use include trichloroethylene (92%), tetrachloroethylene (85%) and cadmium and cadmium compounds (69%). Moreover, nearly a dozen chemicals demonstrated over a 90% decline in environmental releases, including cadmium and cadmium compounds (94%), methylene chloride (98%), trichloroethylene (96%), and tetrachloroethylene (96%), among others. These declines are a significant public and environmental health achievement, and affirm the commitment of industry and the effectiveness of the TURA program.

However, some known and suspected carcinogens continued to be used in large amounts, despite overall declines. For example, in 2010, the top five chemicals used include styrene (291.9 million pounds), sulfuric acid (including fuming) (28.0 million pounds), toluene diisocyanate (6.7 million pounds), epichlorohydrin (4.2 million pounds), and lead and lead compounds (3.9 million pounds). In addition, some known and suspected carcinogens—dioxin and dioxin-like compounds (unintentionally manufactured), ethylene oxide and hydrazine—show notable increases in use.

While total quantity of use is an important factor to consider when targeting resources of TUR programs, known and suspected carcinogens used in low volumes are also of concern. Because of their low volumes, these compounds do not stand out in the aggregate trends, yet they may pose significant risks to health. The generation of dioxins and dioxin-like compounds as unintended byproducts of a variety of industrial processes, including solid waste incineration, is an important example. Exposure to very small doses of dioxins—specifically 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD)—is strongly linked to specific types of cancer such as sarcomas, lung and non-Hodgkin's lymphoma. Thus, though dioxins do not affect overall trends in use and environmental releases, the reported increases seen over the last decade—two orders of magnitude, from 12 grams in 2000 to 1,980 grams in 2010—are of concern. However, some of this increase may be the result of imprecise estimation techniques utilized by WtE incinerators to estimate their annual dioxin generation.

Cancer Type Carcinogen Trends

The use of carcinogens associated with the 11 specific cancer types discussed in this report has declined over the past 20 years. Declines in total use from the period 1990 to 2010 ranged from a 26% decline in the group of chemicals known or suspected of causing breast/mammary gland cancer to an 88% decline in the group of chemicals associated with testicular cancer (Table 25). Styrene monomer is used as a feedstock chemical in the manufacture of plastic resins, and has had only modest reductions in use. Styrene is associated with many cancer types, and highly influences the use trends for those cancer types. Therefore, results were also calculated excluding styrene.

With the exception of the group of bladder carcinogens, reported environmental releases of chemicals associated with all the cancer types showed declines from 1990 to 2010 (Table 25). Declines in total environmental releases over this period ranged from 77% for lung carcinogens, to 97% for breast/mammary gland, liver, pancreatic and prostate. Reported environmental releases of the group of bladder carcinogens increased 18% because of changes in reporting requirements for lead and lead compounds by WtE incinerators; if these reported releases are excluded there was a 94% reduction in releases of the group of bladder carcinogens.

As the analysis of the group of carcinogens associated with specific cancer types reveals, certain chemicals appear repeatedly as key drivers of the use and environmental release trends, including styrene monomer, lead and lead compounds, methylene chloride, formaldehyde, and trichloroethylene (see Table 26). As described earlier, despite promising declines in use of all these chemicals except toluene diisocyanate, the magnitudes still being used are quite high, often in the millions of pounds for many chemicals and in the hundreds of millions in the case of styrene monomer. The quantity of use and releases raises concern for public health and demonstrates a continued need and opportunity regarding future TUR activities.

Table 25. Use and Environmental Releases of Carcinogens Associated with Specific Cancer Types Percent Change, 1990-2010 TURA Program		
Type of Carcinogen	Use % Change, 1990-2010	Environmental Releases % Change, 1990-2010
Bladder	-49%[¥]	+18%*
Brain/CNS	-51%	-78%*
Breast/Mammary Gland	-26% (-21% excluding styrene monomer)	-97%
Kidney	-62%	-86%*
Leukemia	-28% (-59% excluding styrene monomer)	-86%*
Liver	-58%	-97%
Lung	-31%[¥] (-51% excluding styrene monomer)	-77%*
NHL	-28%[¥] (-58% excluding styrene monomer)	-86%*
Pancreas	-28% (-53% excluding styrene monomer)	-97%
Prostate	-65%[¥]	-97%
Testis	-88%	-96%

*Trend is influenced by changes in TURA reporting requirements that eliminated the exemption for reporting by Waste to Energy incinerators resulting in an increase in reported releases of lead and lead compounds beginning in 2003. Overall progress is therefore underestimated.
[¥]Overall progress underestimated due to changes in reporting for polycyclic aromatic compounds.

In addition to trends in uses and environmental releases of known and suspected carcinogens, this report also provides information on trends in the incidence of cancer in Massachusetts. Of the 11 types of cancer most strongly linked to exposure to industrial chemicals, age-adjusted incidence rates for some have increased since 1985, including kidney, non-Hodgkin's lymphoma and liver cancers in both men and women. Of particular concern is the rise in incidence of childhood cancers since 1985. While the declines in use and releases of known and suspected carcinogens by facilities reporting to TURA are promising, the rates of cancer highlight considerable opportunity for improvement. Current quantities of known and suspected carcinogens being used and released into the environment are still sizable. In 2010, over 300 million pounds of known and suspected carcinogens were used and over 500,000 pounds were released into the environment. Importantly, the dramatic reductions in carcinogen use and releases over the past twenty years document the feasibility of TUR as a public health strategy and demonstrate the effectiveness of the industry/TURA partnership as a model for improved environmental health.

The list of chemicals in Table 26 can also be used to help target priorities for the TURA program going forward. Many of these known and suspected carcinogens are already high priorities. The program has taken action to designate cadmium and cadmium compounds, formaldehyde, tetrachloroethylene, and trichloroethylene as Higher Hazard Substances. In addition, lead and lead compounds as well as polycyclic aromatic compounds (PACs) are automatically designated as Higher Hazard Substances because they are EPA PBTs. It is expected that more chemicals from this list will be designated as Higher Hazard Substances in coming years. For example, methylene chloride emerges as an important area for additional work. There is also an opportunity to work with the Department of Public Health to incorporate toxics information and priorities into initiatives to educate medical providers about cancer prevention.

Data Limitations

This analysis has several limitations. First, the TURA program does not capture chemical use and environmental release data from all facilities in the Commonwealth that use, manufacture or release chemicals. The program also does not address chemicals in consumer products or personal care products, which can contain trace levels of known or suspected carcinogens. The trends discussed here pertain only to companies that use chemicals in relatively high volumes above certain thresholds. They do not include chemical use or releases from small firms with fewer than 10 employees, which are not required to report to the TURA program. In addition, the data do not encompass the use of chemicals by the health care sector, higher education (e.g., universities), government, laboratory activities, pilot plants and pilot production units—all of which are exempt from TURA requirements. Many of the sectors not covered by TURA are important users of the priority known and suspected carcinogens identified in Table 26. For example, hospitals and other health care institutions may be significant users of chemicals such as ethylene oxide and formaldehyde.

Table 26. Chemicals Driving Site-Specific Carcinogen Use and Environmental Release Trends

Chemicals Driving Site-Specific Carcinogen Use Trends	Chemicals Driving Site-Specific Carcinogen Environmental Release Trends
Cadmium and cadmium compounds	Acetaldehyde
Diethylhexylphthalate	Cadmium and cadmium compounds
Formaldehyde	Formaldehyde
Lead and lead compounds	Lead and lead compounds
Methylene chloride	Methylene chloride
Nickel and nickel compounds	Nickel and nickel compounds
Polycyclic aromatic compounds	Polycyclic aromatic compounds
Styrene monomer	Styrene monomer
Sulfuric acid	Sulfuric acid
Toluene diisocyanate	Tetrachloroethylene
Trichloroethylene	Trichloroethylene

Data used in this report are not adjusted to reflect changes in production. Given the focus on cancer prevention opportunities, this analysis assesses total use and releases, and does not analyze whether declines in use and releases were due to TUR activity or changes in production activity.

Some facilities subject to TURA requirements have made trade secret claims, rendering their data inaccessible for this analysis. In some cases, these trade secret claims affect which chemicals rise to the top as being reported in the largest quantities. Trends in the use and releases of formaldehyde are subject to this limitation. One resin manufacturer claimed trade secret status for all years except 2008 (see Appendix D).

Environmental release quantities are only those released on-site at the facility. Waste transferred off-site for treatment or disposal is not included, even though in some cases that will result in an eventual release to the environment.

Finally, it is important to note that the cancer incidence trend information is presented for context only. This report does not investigate a causal relationship between carcinogen use and releases and trends in cancer incidence in Massachusetts. Exploring such a link is outside the scope of this analysis for a number of reasons, including lack of individual exposure information, exposure to industrial and environmental carcinogens beyond those reported to the TURA program and long, variable latency periods.

Opportunities

The material presented in this report suggests a number of avenues for continued work to protect workers and the public from exposure to industrial carcinogens. These include policy activities within the TURA program, opportunities to encourage toxics use reduction by facilities in TURA-covered sectors, and opportunities that are not directly covered by TURA. These avenues are briefly described here.

TURA Program Policy Activities. The analysis in this report suggests a number of information and policy activities that can be undertaken by the TURA program. These include:

1. **Evaluate additional carcinogens for possible addition to the TURA list.** Approximately 30 known and suspected carcinogens are not currently reportable under TURA. These substances can be evaluated for possible addition to the TURA list of Toxic or Hazardous Substances in order to facilitate toxics use reduction activities by Massachusetts companies.
2. **Update and maintain the Carcinogen Master List.** The Carcinogen Master List was created as part of the background work for this report. Massachusetts companies, policymakers and the public should be encouraged to use this Master List as an informational resource. Resources permitting, it would be useful to update this list routinely over time to incorporate new findings by the authoritative bodies on which it relies.
3. **Evaluate additional carcinogens for designation as Higher Hazard Substances.** Designating a chemical as a Higher Hazard Substance under TURA lowers the reporting threshold for that chemical, as well as highlighting the chemical for particular attention by TURA filers and the TURA implementing agencies. Several carcinogens have already been designated as Higher Hazard Substances and it may be appropriate for the TURA program to designate additional carcinogens to this list. For example, the TURA program could reexamine the group of known and suspected carcinogens that emerge as primary contributors to the use and environmental release totals.
4. **Focus on high-priority groups of carcinogen users by designating Priority User Segments and/or lowering quantity thresholds under TURA, when appropriate.** Under TURA, designation of a Priority User Segment for a Higher Hazard Substance focuses programmatic attention on a specific use of the chemical, and includes smaller users. In some cases, it may also be appropriate to lower reporting thresholds below the 1,000 pounds/year that applies to Higher Hazard Substances. These actions can extend the reach of TURA to facilities using smaller quantities of the chemical of concern.
5. **Under the leadership of the TURA Administrative Council, partner with the Massachusetts Department of Public Health to incorporate TUR strategies into education related to cancer.** Education of consumers and medical providers about environmental causes of cancer is a specific focus of the 2012-2016 Massachusetts Comprehensive Cancer Control Plan.

Facilitating Toxics Use Reduction. This report also suggests a number of program-related activities that can be undertaken by the TURA program to enhance cancer prevention, including:

6. **Work to address key carcinogens discussed in this report.** This report can be used to identify key carcinogens that warrant additional attention, based on high volumes used or released, links to multiple types of cancer, or other factors. The TURA program may be able to prioritize TUR activities for the group of known and suspected carcinogens that are primary contributors to the use and environmental release

totals. For example, past successes with other halogenated solvents could be leveraged to help facilities reduce their use of methylene chloride.

7. **Work to help small businesses reduce carcinogen use.** The TURA program has achieved significant results in its work with large and medium-sized chemical users. In addition, the TURA program works with a number of small business sectors to help them protect workers, customers and others from exposure to carcinogens. Examples include ongoing work with small metal finishers, dry cleaners, auto shops and nail salons. Going forward, there may be opportunities to expand the program's work to reduce carcinogen use in these sectors, where total quantity of use may be relatively small but potential exposures may be significant.
8. **Work to reverse rising use of certain carcinogens.** This report notes that while reported use of most carcinogens under TURA has declined over time, reported use of a few carcinogens has risen. The TURA program may be able to work with users of these chemicals to identify options for reducing use going forward.

Beyond TURA Reporting and Planning: Other Opportunities. There are many other opportunities to prevent cancer through TUR that go beyond the sectors and firms covered by TURA reporting and planning, including:

9. **Work to address exposure to carcinogens in consumer products**. A variety of consumer products contain known or suspected carcinogens. There are significant opportunities to protect human health and the environment by redesigning consumer products, and Massachusetts companies and communities may be in a good position to lead some of these efforts. Lessons learned from the TURA program over the last 20 years may be informative for a range of activities including those of companies, nongovernmental organizations, state government, and the public.
10. **Work to address carcinogens in sectors not covered under TURA.** These sectors include health care and higher education. For example, ethylene oxide and formaldehyde are two known carcinogens that are relevant to the health care sector and for which TUR strategies are available.

Directions for Future Research: A number of additional research questions were generated as a result of this report. Examples include the following.

11. **Examine the flow of known and suspected carcinogens in consumer and industrial products.** Facilities reporting to the TURA program are required to report the amount of toxics that are "shipped in product." These data could be examined further to document TURA program results and to identify TUR opportunities relevant to reducing exposure to carcinogens further down the supply chain.
12. **Compile and review case studies of companies that have reduced carcinogen use.** The TURA program has developed case studies of a wide variety of companies that have successfully reduced their use of carcinogens while maintaining or enhancing their economic competitiveness. It would be useful to compile and categorize these existing case studies, and to gather additional data to reveal the variety of ways in which Massachusetts companies have reduced the use of carcinogens.
13. **Analyze opportunities for an epidemiological study.** This study does not examine associations between chemical use and release and cancer incidence. Future studies could potentially undertake this question. It could be helpful to assess the usefulness of the TURA data for an epidemiological study of chemical use and cancer incidence in Massachusetts. Such an analysis could determine what research design would be

most appropriate and what resources would be needed in order to complete the study successfully. It could examine the relative merits of considering statewide data versus data at the municipal or regional level, and identify factors that would need to be accounted for, such as exposure measurements, latency and a variety of potential confounding factors, as well as inherent limitations in the data. An appropriate first step could be to convene an expert panel to examine the possible ways in which the TURA data could be analyzed in relation to cancer data.

Conclusion: The Importance of Toxics Use Reduction for Cancer Prevention

Cancer prevention remains the most cost-effective and humane policy response available in the "war on cancer." Toxics use reduction, which prevents carcinogenic exposures at their source, is a powerful tool for cancer prevention. The large reductions in use and releases of known and suspected carcinogens by facilities reporting to the TURA program shows that when companies are required to examine their use of a chemical, many find ways to use it more efficiently, others find options for replacing the chemical with a safer substitute, and others change their manufacturing process altogether to eliminate the need for the chemical. The success of these tools in bringing about substantial reductions in the use and release of carcinogens holds important lessons. Continued work to minimize the use of carcinogens in manufacturing and services can help to reduce the burden of cancer in Massachusetts.

Appendix A: KNOWN OR SUSPECTED CARCINOGENS REPORTABLE UNDER TURA

Classifications used:

- International Agency for Research on Cancer (IARC) (latest list of classifications as of June 1, 2011)
  - Group 1 (known human carcinogen), 2A (probable human carcinogen)
- EPA's Integrated Risk Information System (IRIS)
  - 1986 guidelines: human carcinogen, probable human carcinogen with limited human evidence, probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans
  - 1996 guidelines: known/likely human carcinogen
  - 1999 & 2005 guidelines: carcinogenic to humans, likely to be carcinogenic to humans
- National Toxicology Program's 12th Report on Carcinogens (latest edition)
  - "known" and "reasonably anticipated" to be a human carcinogen

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
* PBT (Persistent Bioaccumulative Toxic); HHS (Higher Hazard Substance) [Special Reporting Threshold noted (e.g., 100 lbs)] + Classification based on most recent guideline if reviewed under multiple guidelines ^Not included in this carcinogen analysis; chemicals to be first reported under TURA in 2012 ¥ Four-digit number are not official CAS numbers, but chemical compound category numbers assigned by MA DEP.					
75-07-0	Acetaldehyde		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
53-96-3	2-Acetylaminofluorene				Reasonably anticipated
79-06-1	Acrylamide		Group 2A	Likely to be carcinogenic to humans (2005 guidelines)	Reasonably anticipated
107-13-1	Acrylonitrile		Group 2B	Probable human carcinogen – based on limited evidence of carcinogenicity in humans (1986 guidelines)	Reasonably anticipated
309-00-2	Aldrin			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
319-84-6	alpha-Hexachlorocyclohexane (alpha-HCH)			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
92-67-1	4-Aminobiphenyl (4-amino-diphenyl)		Group 1		Known
82-28-0	1-Amino-2-methylanthraquinone				Reasonably anticipated
81-49-2	1-Amino-2,4-dibromoanthraquinone^		Group 2B		Reasonably anticipated
117-79-3	2-Aminoanthraquinone				Reasonably anticipated
97-56-3	*o*-Aminoazotoluene (C.I. Solvent Yellow 3)		Group 2B		Reasonably anticipated
61-82-5	Amitrole				Reasonably anticipated
62-53-3	Aniline			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
134-29-2	*o*-Anisidine hydrochloride				Reasonably anticipated
7440-38-2	Arsenic and arsenic compounds	Arsenic acid (1327-52-2) reported as Arsenic compounds (DEP #[¥] 1001)	Group 1	Human carcinogen (1986 guidelines)	Known
1332-21-4; 13768-00-8; 12172-73-5; 17068-78-9; 12001-29-5; 12001-28-4; 14567-38-8	Asbestos (all forms)		Group 1	Human carcinogen (1986 guidelines)	Known
71-43-2	Benzene		Group 1	Known/likely human carcinogen (1996 guidelines)	Known
92-87-5	Benzidine [and its salts]		Group 1	Human carcinogen (1986 guidelines)	Known
56-55-3	Benzo(a)anthracene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
50-32-8	Benzo(a)pyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 1	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
205-99-2	Benzo(b)fluoranthene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
205-82-3	Benzo(j)fluoranthene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2B		Reasonably anticipated
207-08-9	Benzo(k)fluoranthene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
98-07-7	Benzotrichloride		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
100-44-7	Benzyl chloride		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
7440-41-7	Beryllium and beryllium compounds		Group 1	Known/likely human carcinogen (1996 guidelines)	Known
57-57-8	beta-Propiolactone		Group 2B		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
3296-90-0	2,2-Bis(bromomethyl)-1,3-propanediol^		Group 2B		Reasonably anticipated
111-44-4	Bis(2-chloroethyl)ether			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
542-88-1	Bis(chloromethyl)ether		Group 1	Human carcinogen (1986 guidelines)	Known
75-27-4	Bromodichloromethane		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
75-25-2	Bromoform			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
106-99-0	1,3-Butadiene		Group 1	Carcinogenic to humans (1999 Guidelines)	Known
7440-43-9	Cadmium and cadmium compounds		Group 1	Probable carcinogen – based on limited evidence of carcinogenicity in humans (1986 guidelines)	Known
56-23-5	Carbon tetrachloride		Group 2B	Likely to be carcinogenic to humans (2005 guidelines)	Reasonably anticipated
305-03-3	Chlorambucil		Group 1		Known
12789-03-6	Chlordane(also CAS# 57-74-9)	PPT/HHS (10lbs)	Group 2B	Known/likely human carcinogen (1996 guidelines)	
143-50-0	Chlordecone (Kepone)		Group 2B		Reasonably anticipated
115-28-6	Chlorendic acid		Group 2B		Reasonably anticipated
108171-26-2	Chlorinated paraffins (Average chain length, C12;approximately 60 percent chlorine by weight)	Reported as Polychlorinated Alkanes (DEP #¥ 1045)	Group 2B		Reasonably anticipated
98-87-	α-Chlorinated toluenes (benzal chloride, benzo-trichloride, benzyl chloride) and benzoyl chloride (combined exposures)		Group 2A		
98-88-4	α-Chlorinated toluenes (benzal chloride, benzo-trichloride, benzyl chloride) and benzoyl chloride (combined exposures)		Group 2A		
67-66-3	Chloroform		Group 2B	Likely to be carcinogenic to humans (1999 guidelines)	Reasonably anticipated
107-30-2	Chloromethyl methyl ether (technical grade)		Group 1	Human carcinogen (1986 guidelines)	Known
563-47-3	3-Chloro-2-methylpropene				Reasonably anticipated
95-69-2	*p*-Chloro-*o*-toluidine		Group 2A		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
3165-93-3	p-chloro-o-toluidine hydrochloride (4-Chloro-o-toluidine, hydrochloride)				Reasonably anticipated
126-99-8	Chloroprene		Group 2B		Reasonably anticipated
18540-29-9	Chromium(VI)	Lithium Chromate (CAS 14307-35-8); Chromic Sulfate (CAS 10101-53-8); Chromic Acid (CAS 7738-94-5) Reported as Chromium VI compounds (DEP #[¥] 1012)	Group 1	Known/likely human carcinogen (1996 guidelines)	Known
218-01-9	Chyrsene, Benzo(a)phenanthrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
7440-48-4, 12070-12-1	Cobalt metal with tungsten carbide	Reported as Cobalt Compounds (CAS[¥] 1013)	Group 2A		
10026-24-1	Cobalt sulfate and other soluble cobalt (II) salts	Reported as Cobalt Compounds (DEP #[¥] 1013)	Group 2B		Reasonably anticipated
N/A	Coke oven emissions			Human carcinogen (1986 guidelines)	Known
8001-58-9	Creosotes		Group 2A	Probable human carcinogen – based on limited evidence of carcinogenicity in humans (1986 guidelines)	
120-71-8	*p*-Cresidine, 1,3-Propane sultone		Group 2B		Reasonably anticipated
135-20-6	Cupferron				Reasonably anticipated
608-73-1	Cyclohexane, 1,2,3,4,5,6-hexachloro-			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
50-18-0	Cyclophosphamide (anhydrous)		Group 1		Known
6055-19-2, 50-18-0	Cyclophosphamide (hydrated)		Group 1		
39156-41-7	2,4-Diaminoanisole sulfate				Reasonably anticipated
101-80-4	4,4'-Diaminodiphenyl ether (4,4'-Oxydianiline)		Group 2B		Reasonably anticipated
95-80-7	2,4-Diaminotoluene		Group 2B		Reasonably anticipated
62-73-7	Dichlorvos (DDVP)		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
117-81-7	di(2-ethylhexyl) phthalate (DEHP)		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
226-36-8	Dibenz(a,h)acridine	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated
224-42-0	Dibenz(a,j)acridine	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated
192-65-4	Dibenzo(a,e)pyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)			Reasonably anticipated
53-70-3	Dibenzo(a,h)anthracene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
189-64-0	Dibenzo(a,h)pyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated
191-30-0	Dibenzo(a,l)pyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2A		Reasonably anticipated
189-55-9	Dibenzo[a,i]pyrene, Benzo(r,s,t)pentaphene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated
194-59-2	7H-Dibenzo(c,g)carbazole	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)		Group 2B		Reasonably anticipated
106-46-7	*p*-Dichlorobenzene		Group 2B		Reasonably anticipated
91-94-1	3,3'-Dichlorobenzidine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
612-83-9	3,3'-Dichlorobenzidine dihydrochloride				Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
72-54-8	p,p'-Dichlorodiphenyldichloro-ethane(p,p' DDD)			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
72-55-9	p,p'-Dichlorodiphenyldichloro-ethylene (p,p' DDE)			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
50-29-3	Dichlorodiphenyltrichloro-ethane (DDT)		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
75-09-2	Dichloromethane (Methylene chloride)		Group 2B	Likely to be carcinogenic in humans (2005 guidelines)	Reasonably anticipated
542-75-6	1,3-Dichloropropene		Group 2B	Known/likely human carcinogen (1996 guidelines)	Reasonably anticipated
60-57-1	Dieldrin			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
1464-53-5	Diepoxybutane				Reasonably anticipated
64-67-5	Diethyl sulfate		Group 2A		Reasonably anticipated
56-53-1	Diethylstilbestrol		Group 1		Known
101-90-6	Diglycidyl resorcinol ether (DGRE)		Group 2B		Reasonably anticipated
60-11-7	4-Dimethylaminoazo-benzene		Group 2B		Reasonably anticipated
57-14-7	1,1-Dimethylhydrazine (UDMH)		Group 2B		Reasonably anticipated
540-73-8	1,2-Dimethylhydrazine		Group 2A		
119-90-4	3,3'-Dimethoxybenzidine (*o*-Dianisidine)		Group 2B		Reasonably anticipated
119-93-7	3,3'-Dimethylbenzidine (ortho-Tolidine)		Group 2B		Reasonably anticipated
77-78-1	Dimethyl sulfate		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
79-44-7	Dimethylcarbamoyl chloride		Group 2A		Reasonably anticipated
42397-64-8	1,6-Dinitropyrene^		Group 2B		Reasonably anticipated
42397-65-9	1,8-Dinitropyrene^		Group 2B		Reasonably anticipated
25321-14-6	Dinitrotoluene mixture, 2,4-/2,6-			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
123-91-1	1,4-Dioxane		Group 2B	Likely to be carcinogenic to humans (2005 guidelines)	Reasonably anticipated
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	PBT/HHS (0.1 g) Reported as Dioxin & Dioxin Compounds (DEP #¥ 1060)		Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	PBT/HHS (0.1 g) Reported as Dioxin & Dioxin Compounds (DEP #[¥] 1060)	Group 1		Known
57-41-0	Diphenylhydantoin (Phenytoin)		Group 2B		Reasonably anticipated
106-89-8	Epichlorohydrin		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
62-50-0	Ethyl methanesulfonate		Group 2B		Reasonably anticipated
106-93-4	Ethylene dibromide		Group 2A	Likely to be carcinogenic to humans (1999 guidelines)	Reasonably anticipated
107-06-2	Ethylene dichloride (1,2-Dichloroethane)		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
75-21-8	Ethylene oxide		Group 1		Known
96-45-7	Ethylene thiourea				Reasonably anticipated
133-07-3	Folpet			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
50-00-0	Formaldehyde (gas)		Group 1	Probable human carcinogen – based on limited evidence of carcinogenicity in humans (1986 guidelines)	Reasonably anticipated
110-00-9	Furan^		Group 2B		Reasonably anticipated
1303-00-0	Gallium arsenide	Reported as Arsenic Compounds (DEP #[¥] 1001)			
765-34-4	Glycidaldehyde		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
556-52-5	Glycidol^		Group 2A		Reasonably anticipated
76-44-8	Heptachlor	PBT/HHS (10 lbs)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
1024-57-3	Heptachlor epoxide			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
118-74-1	Hexachlorobenzene	PBT/HHS (10 lbs)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
N/A	Hexachlorocyclohexane (technical grade) hexachlorocyclohexane (alpha isomer), hexachlorocyclohexane (beta isomer), hexachlorocyclohexane (gamma isomer)		Group 2B		Reasonably anticipated
58-89-9	Hexachlorocyclohexanes (Cyclohexane, 1,2,3,4,5,6-hexachloro- ,(1.alpha.,2.alpha.,3.beta.,4.alpha.,5.alpha.,6.beta.); Lindane)				Reasonably anticipated
67-72-1	Hexachloroethane		Group 2B		Reasonably anticipated
680-31-9	Hexamethylphosphor-amide		Group 2B		Reasonably anticipated
302-01-2	Hydrazine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
10034-93-2	Hydrazine sulfate			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
122-66-7	Hydrazobenzene (1,2-Diphenylhydrazine)			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
193-39-5	Indeno(1,2,3-cd)pyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
78-79-5	Isoprene		Group 2B		Reasonably anticipated
7439-92-1	Lead	PBT/HHS (100 lbs)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
N/A	Lead compounds	Lead Nitrate (CAS 10099-74-8) and Lead Chromate (CAS 10101-53-8) Reported as Lead Compounds (DEP #¥ 1026)	Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
148-82-3	Melphalan		Group 1		Known
75-55-8	2-Methylaziridine (Propyleneimine, aziridine)		Group 2B		Reasonably anticipated
93-15-2	Methyleugenol^		Group 2B		Reasonably anticipated
3697-24-3	5-Methylchrysene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #¥ 1040)	Group 2B		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS+	NTP
101-14-4	4,4'-Methylene bis(2-chloroaniline)		Group 1		Reasonably anticipated
101-61-1	4,4'-Methylene bis(N,N-dimethyl)benzenamine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
101-77-9	4,4'-Methylenedianiline		Group 2B		Reasonably anticipated
70-25-7	N-Methyl-N'-nitro-N-nitrosoguanidine		Group 2A		Reasonably anticipated
90-94-8	Michler's ketone		Group 2B		Reasonably anticipated
505-60-2	Mustard Gas		Group 1		Known
91-20-3	Naphthalene		Group 2B		Reasonably anticipated
91-59-8	2-Naphthylamine (beta-Naphthylamine)		Group 1		Known
7440-02-0	Nickel (Metallic)		Group 2B		Reasonably anticipated
13463-39-3	Nickel carbonyl	Reported as Nickel Compounds (DEP #¥ 1029)		Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
N/A	Nickel compounds	Nickel sulfate (CAS 7786-81-4) Reported as Nickel Compounds (DEP #¥ 1029)	Group 1		Known
12035-72-2	Nickel subsulfide	Reported as Nickel Compounds (DEP #¥ 1029)		Human carcinogen (1986 guidelines)	
N/A	Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation		Group 2A		
139-13-9	Nitrilotriacetic acid		Group 2B		Reasonably anticipated
98-95-3	Nitrobenzene		Group 2B		Reasonably anticipated
91-23-6	o-Nitroanisole		Group 2B		Reasonably anticipated
1836-75-5	Nitrofen		Group 2B		Reasonably anticipated
51-75-2	Nitrogen mustard (Mechlorethamine)		Group 2A		
75-52-5	Nitromethane^		Group 2B		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
79-46-9	2-Nitropropane		Group 2B		Reasonably anticipated
5522-43-0	1-Nitropyrene	PBT/HHS (100 lbs) Reported as Polycyclic aromatic Compounds (DEP #[¥] 1040)	Group 2A		Reasonably anticipated
57835-92-4	4-Nitropyrene^		Group 2B		Reasonably anticipated
1116-54-7	N-Nitrosodiethanolamine			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
55-18-5	N-Nitrosodiethylamine		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
62-75-9	N-Nitrosodimethylamine		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
86-30-6	N-Nitrosodiphenylamine			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
4549-40-0	N-Nitrosomethylvinylamine		Group 2B		Reasonably anticipated
59-89-2	N-Nitrosomorpholine		Group 2B		Reasonably anticipated
924-16-3	N-Nitrosodi-*n*-butylamine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
759-73-9	N-Nitroso-N-ethylurea		Group 2A		Reasonably anticipated
684-93-5	N-Nitroso-N-methylurea		Group 2A		Reasonably anticipated
621-64-7	N-Nitrosodi-*n*-propylamine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
16543-55-8	N-Nitrosonornicotine		Group 1		Reasonably anticipated
100-75-4	N-Nitrosopiperidine		Group 2B		Reasonably anticipated
930-55-2	N-Nitrosopyrrolidine		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
88-72-2	o-Nitrotoluene				Reasonably anticipated
87-86-5	Pentachlorophenol			Likely to be carcinogenic to humans (2005 guidelines)	
62-44-2	Phenacetin		Group 2A		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
Multiple	Polybrominated biphenyls	Reported as Polybrominated biphenyls (DEP #[¥] 1034)			Reasonably anticipate
1336-36-3	Polychlorinated biphenyls (PCBs)		Group 2A	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
1120-71-4	1,3-Propane sultone				Reasonably anticipated
75-56-9	Propylene oxide		Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
91-22-5	Quinoline			Known/likely human carcinogen (1996 guidelines)	
50-55-5	Reserpine				Reasonably anticipated
94-59-7	Safrole		Group 2B		Reasonably anticipated
7446-34-6	Selenium sulfide^			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
14808-60-7	Silica, crystalline (inhaled in the form of quartz or cristobalite from occupational sources)		Group 1		Known
18883-66-4	Streptozocin (streptozotocin)		Group 2B		Reasonably anticipated
100-42-5	Styrene		Group 2B		Reasonably anticipated
96-09-3	Styrene oxide		Group 2A		Reasonably anticipated
95-06-7	Sulfallate, (Carbamodithioic acid, diethyl-, 2-chloro-2-propenyl ester)		Group 2B		Reasonably anticipated
7664-93-9	Sulfuric acid (Strong inorganic acid mists containing sulfuric acid)		Group 1		Known
127-18-4	Tetrachloroethylene (Perchloroethylene)	HHS	Group 2A		Reasonably anticipated
116-14-3	Tetrafluoroethylene^		Group 2B		Reasonably anticipated
509-14-8	Tetranitromethane		Group 2B		Reasonably anticipated
62-55-5	Thioacetamide		Group 2B		Reasonably anticipated
139-65-1	4,4'-Thiodianiline		Group 2B		Reasonably anticipated
62-56-6	Thiourea				Reasonably anticipated
1314-20-1	Thorium dioxide				Known
26471-62-5	Toluene diisocyanates		Group 2B		Reasonably anticipated

CAS	Chemical Name	Special TURA Reporting Requirements*	IARC	IRIS[+]	NTP
95-53-4	*o*-Toluidine		Group 1		Reasonably anticipated
636-21-5	*o*-Toluidine hydrochloride				Reasonably anticipated
8001-35-2	Toxaphene	PBT/HHS (10 lbs)	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
79-01-6	Trichloroethylene	HHS	Group 1	Carcinogenic to humans (2005 guidelines)	Reasonably anticipated
88-06-2	2,4,6-Trichlorophenol			Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	Reasonably anticipated
126-72-7	Tris(2,3-dibromopropyl)phosphate		Group 2A		Reasonably anticipated
51-79-6	Urethane (Ethyl carbamate, carbamic acid)		Group 2A		Reasonably anticipated
75-01-4	Vinyl chloride		Group 1	Known/likely human carcinogen (1996 guidelines)	Known
75-02-5	Vinyl Fluoride		Group 2A		Reasonably anticipated

* PBT (Persistent Bioaccumulative Toxin); HHS (Higher Hazard Substance) [Special Reporting Threshold noted (e.g. 100 lbs)]

[+] Classification based on most recent guideline if reviewed under multiple guidelines

^Not included in this carcinogen analysis chemicals to be first reported under TURA in 2012

Appendix B: KNOWN OR SUSPECTED CARCINOGENS NOT REPORTABLE UNDER TURA

Classifications used:

- International Agency for Research on Cancer (IARC) (latest list of classifications as of June 1, 2011)
  - Group 1 (known human carcinogen), 2A (probable human carcinogen)
- EPA's Integrated Risk Information System (IRIS)
  - 1986 guidelines: human carcinogen, probable human carcinogen with limited human evidence, probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans
  - 1996 guidelines: known/likely human carcinogen
  - 1999 & 2005 guidelines: carcinogenic to humans, likely to be carcinogenic to humans
- National Toxicology Program's 12th Report on Carcinogens (latest edition)
  - "known" and "reasonably anticipated" to be a human carcinogen

CAS	Chemical Name	Type of Chemical	IARC	IRIS	NTP
140-57-8	Aramite	Pesticide	Group 2B	Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
103-33-3	Azobenzene	Industrial Chemical		Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
569-61-9	C.I. Basic Red 9 monohydrochloride	Industrial Chemical	Group 2B		Reasonably anticipated
15541-45-5	Bromate	Industrial Chemical		Known/likely human carcinogen (1996 guidelines)	
2425-06-1	Captafol	Fungicide	Group 2A		Reasonably anticipated
95-83-0	4-Chloro-*o*-phenylenediamine	Industrial Chemical	Group 2B		Reasonably anticipated
8007-45-2; 65996-89-6	Coal-tars	Broad category	Group 1		Known
27208-37-3	Cyclopenta[cd]pyrene	Combustion byproduct	Group 2A		
224-42-0	Dibenz[a.j]acridine	Combustion byproduct	Group 2A		
136-35-6	Diazoaminobenzene	Industrial Chemical			Reasonably anticipated
96-13-9	2,3-Dibromo-1-propanol	Industrial Chemical	Group 2B		Reasonably anticipated
79-43-6	Dichloroacetic acid	Industrial Chemical	Group 2B	Likely to be carcinogenic to humans (1999 guidelines)	
2475-45-8	Disperse Blue 1	Industrial Chemical	Group 2B		Reasonably anticipated
66733-21-9	Erionite	Mineral	Group 1		Known
60568-05-0	Furmecyclox	Pesticide		Probable human carcinogen – based on sufficient evidence in animals (1986 guidelines)	
NA	Glass wool	Material			Reasonably anticipated
22398-80-7	Indium phosphide	Material	Group 2A		
13552-44-8	4,4'-Methylenedianiline dihydrochloride	Industrial Chemical			Reasonably anticipated
66-27-3	Methyl methanesulfonate	Industrial Chemical	Group 2A		Reasonably anticipated

CAS	Chemical Name	Type of Chemical	IARC	IRIS	NTP
NA	Mineral oils (untreated and mildly treated)	Broad Category	Group 1		Known
2385-85-5	Mirex	Obsolete Pesticide	Group 2B		Reasonably anticipated
7496-02-8	6-Nitrochrysene	Combustion byproduct	Group 2A		Reasonably anticipated
55-86-7	Nitrogen mustard hydrochloride (Mechlorethamine hydrochloride)	Industrial Chemical			Reasonably anticipated
10595-95-6	N-Nitroso-N-methylethylamine	Industrial Chemical	Group 2B	Probable human carcinogen – based on sufficient evidence of carcinogenicity in animals (1986 guidelines)	
NA	Refractory ceramic fibers	Synthetic mineral	Group 2B	Probable human carcinogen – based on sufficient evidence of carcinogenicity in animals (1986 guidelines)	
68308-34-9	Shale-oils	Broad Category	Group 1		
N/A	Soots	Broad Category	Group 1		Known
96-18-4	1,2,3-Trichloropropane	Industrial Chemical	Group 2A		Reasonably anticipated
593-60-2	Vinyl bromide	Industrial Chemical	Group 2A		Reasonably anticipated
106-87-6	4-Vinyl-1-cyclohexene diepoxide (Vinyl cyclohexenedioxide)	Industrial Chemical	Group 2B		Reasonably anticipated

Appendix C: SOURCES OF EVIDENCE FOR CARCINOGENS ASSOCIATED WITH SPECIFIC CANCER TYPES

CAS Number	Chemical Name	Bladder	Brain/CNS	Breast	Kidney	Leukemia	Liver
75-07-0	Acetaldehyde			D tox [benign only]		D tox^	
79-06-1	Acrylamide			D tox, epi; E	D epi		
107-13-1	Acrylonitrile		D tox	D tox; E			D tox
97-56-3	*o*-Aminoazotoluene	D tox		D tox; E			D tox
7440-38-2 DEP #1001	Arsenic and arsenic compounds	A1; C1; D epi	A2; D tox		C2; D epi	D tox, epi^	A2; D epi
71-43-2	Benzene		A2	D tox; E		A1; B1; C1^; D tox, epi	
75-27-4	Bromodichloromethane	A1			D tox		D tox
106-99-0	1,3-Butadiene			D tox; E	D tox	A1; B2; C1^; D tox, epi	D tox
7440-43-9 DEP #1004	Cadmium and cadmium compounds	D epi			A2; C2; D epi	D tox	D tox
56-23-5	Carbon tetrachloride			D tox; E		A2; D epi	D tox, epi
67-66-3	Chloroform	D epi			D tox		D tox
8001-58-9	Creosotes	A1; B2; C2					
96-12-8	1,2-Dibromo-3-chloropropane			D tox; E			D tox
106-46-7	*p*-Dichlorobenzene				D tox	D tox, epi	D tox
612-83-9	3,3'-Dichlorobenzidine dihydrochloride	D tox, epi		D tox; E		D tox	D tox
117-81-7	di(2-ethylhexyl) phthalate (DEHP)						D tox
123-91-1	1,4-Dioxane			D tox; E	D tox		D tox
DEP #1060	Dioxin and dioxin compounds			A2	D tox		D tox
106-89-8	Epichlorohydrin		B2; D epi				
107-06-2	Ethylene dichloride			D tox; E		D epi^	D tox
75-21-8	Ethylene oxide		D tox [benign only]	A2; C2; D tox [benign only], epi; E		A1; B1; C2^; D tox^ [benign only], epi	
96-45-7	Ethylene thiourea					D tox	D tox
50-00-0	Formaldehyde		D epi			A2; B2; C1^; D epi	
118-74-1	Hexachlorobenzene			D epi	D tox [benign only]		D tox
302-01-2	Hydrazine			E		D tox	D tox
7439-92-1 DEP #1026	Lead and lead compounds	D epi	A2; D tox]		A2; D tox	D tox	
75-55-8	2-Methylaziridine		D tox	D tox; E		D tox	

CAS Number	Chemical Name	Bladder	Brain/CNS	Breast	Kidney	Leukemia	Liver
101-14-4	4,4'-Methylene bis(2-chloroaniline)	A1; B2 D tox, epi		D tox; E			D tox
75-09-2	Methylene Chloride		A2; D epi	A2; D tox [benign only], epi; E	D epi	D epi^	D tox, epi
90-94-8	Michler's ketone						D tox
DEP #1040	Polycyclic aromatic compounds	A2; B2; C2 [soots]; D tox		A2; D tox; E			D tox
DEP #1029	Nickel compounds				D tox		D tox [benign only]
98-95-3	Nitrobenzene		D epi	D tox [benign only]; E	D tox [benign only]		D tox [benign only]
DEP #1045	Polychlorinated alkanes				D tox	D tox	D tox
1336-36-3	Polychlorinated biphenyls		D epi	A2; D epi		D epi^	A1; B2; C2, D tox, epi
100-42-5	Styrene			D tox; E		C2^, D epi	
127-18-4	Tetrachloroethylene	A2; C2 [dry cleaning]			D tox		D tox
62-56-6	Thiourea						D tox [benign only]
91-08-7 584-84-9 26471-62-5	Toluene Diisocyanates			D tox [benign only]; E			D tox [benign only]
79-01-6	Trichloroethylene				A2; B2; D tox, epi	A2; D tox	A1; B2; C2; D tox, epi

A1: "Strong" evidence according to Clapp RW et al. Appendix F of President's Cancer Panel. *Reducing Environmental Cancer Risk: What We Can Do Now*. US Department of Health and Human Services, National Institutes of Health, National Cancer Institute. April 2010.

A2: "Suggestive" evidence according to Clapp RW et al. Appendix F of President's Cancer Panel. *Reducing Environmental Cancer Risk: What We Can Do Now*. US Department of Health and Human Services, National Institutes of Health, National Cancer Institute. April 2010.

B1: "Strong" evidence according to Siemiatycki J, et al. Listing occupational carcinogens. *Environ Health Perspect* 2004;112(15):1447-59.

B2: "Suggestive" evidence according to Siemiatycki J, et al. Listing occupational carcinogens. *Environ Health Perspect* 2004;112(15):1447-59.

C1: "Sufficient" evidence according to Cogliano VJ, et al. Preventable exposures associated with human cancers. *J Natl Cancer Inst*;103(24):1827-39.

C1^: "Sufficient" evidence for leukemia and/or lymphoma. Same source as C1.

C2: "Limited" evidence according to Cogliano VJ, et al. Preventable exposures associated with human cancers. *J Natl Cancer Inst*;103(24):1827-39.

C2^: "Limited" evidence for leukemia and/or lymphoma. Same source as C2.

D tox: Support from toxicological evidence according to evidence summarized in National Toxicology Program. *12th Report on Carcinogens (Roc).* Accessed: June 15, 2011. Available at: http://ntp-server.niehs.nih.gov/roc12/INDEXC5F2.HTM?objectid=035E57E7-BDD9-2D9B-AFB9D1CADC8D09C1. If "benign only" is noted, this corresponds to "some evidence of carcinogenicity" by the National Toxicology Program.

D tox^: Based on evidence for lymphatic, hemolymphoreticular, or lymphohematopoietic cancers. Evidence source same as D tox.

D epi: Support from epidemiologic evidence according to evidence summarized in National Toxicology Program. *12th Report on Carcinogens (Roc).* Accessed: June 15, 2011. Available at: http://ntp-server.niehs.nih.gov/roc12/INDEXC5F2.HTM?objectid=035E57E7-BDD9-2D9B-AFB9D1CADC8D09C1.

D epi^: Based on evidence for lymphatic, hemolymphoreticular, or lymphohematopoietic cancers. Evidence source same as D epi.

E: Evidence according to Rudel et al. Chemicals causing mammary gland tumors in animals signal new directions for epidemiology, chemicals testing, and risk assessment for breast cancer prevention. *Cancer* 2007;108:2635-66.

Appendix C (continued)

CAS Number	Chemical Name	Lung	NHL	Pancreatic	Prostate	Testicular
75-07-0	Acetaldehyde	D epi	D tox^	D tox [benign only]		
79-06-1	Acrylamide	D tox [benign only]		B2; D epi		
107-13-1	Acrylonitrile	D tox, epi				
97-56-3	*o*-Aminoazotoluene	D tox [benign only]				
7440-38-2 DEP #1001	Arsenic and arsenic compounds	A1; B1; C1; D tox, epi	D tox, epi^		A2; C2; D epi	
71-43-2	Benzene	A2; D tox	A2; C1^, D epi			
98-07-7	Benzotrichloride	D tox, epi	D tox^			
106-99-0	1,3-Butadiene	D tox	A2; B2; C1^, D epi^	D tox		D tox
56-23-5	Carbon tetrachloride		D epi			
7440-43-9 DEP #1004	Cadmium and cadmium compounds	A1; B1; C1; D tox, epi	D tox^	A2	A2; C2; D tox, epi	D tox
DEP #1012	Chromium VI and chromium VI compounds	A1; B1; C1; D tox, epi				
8001-58-9	Creosotes	A1, B2				
96-12-8	1,2-Dibromo-3-chloropropane	D tox				
612-83-9	3,3'-Dichlorobenzidine dihydrochloride					
117-81-7	di(2-ethylhexyl) phthalate (DEHP)			D tox [benign only]		D tox [benign only]
DEP #1060	Dioxin and dioxin compounds	A1; B2; C2; D tox, epi	A1; B2; C2^; D tox, epi		A2	
106-89-8	Epichlorohydrin	B2; D epi				
107-06-2	Ethylene dichloride	D tox [benign only]	D tox, epi^	D epi		
75-21-8	Ethylene oxide	D tox [benign only]	C2^, D epi			
50-00-0	Formaldehyde	D tox, epi	C1^, D epi, tox^			
118-74-1	Hexachlorobenzene		D epi			
302-01-2	Hydrazine	D tox, epi				
7439-92-1 DEP #1026	Lead and lead compounds	A2; D tox [benign only], epi	D tox			
101-14-4	4,4'-Methylene bis(2-chloroaniline)	D tox				
75-09-2	Methylene Chloride	D tox	D epi^	D epi	D epi	
DEP #1029	Nickel compounds	A1; B1; C1; D tox, epi		A2		
7440-02-0	Nickel (metallic)	D tox				
98-95-3	Nitrobenzene	D tox				
1336-36-3	Polychlorinated biphenyls	D tox	A2; D epi^	D tox [benign only]		D epi
DEP #1040	Polycyclic aromatic compounds	A1; B2; D tox	D tox^		A2	
DEP #1095	Silica, crystalline	A1; B1; C1; D tox				

CAS Number	Chemical Name	Lung	NHL	Pancreatic	Prostate	Testicular
7664-93-9 8014-95-7	Strong inorganic acid mists containing sulfuric acid	A2; B2; C2				
100-42-5	Styrene	D tox	A2; D epi	D epi		
127-18-4	Tetrachloroethylene		A2; B2; C2^; D epi			
91-08-7	Toluene Diisocyanate A			D tox [benign only]		
584-84-9	Toluene Diisocyanate B			D tox [benign only]		
26471-62-5	Toluene diisocyanates			D tox [benign only]		
79-01-6	Trichloroethylene		A2; B2; C2^; D tox, epi		D epi	D tox

A1: "Strong" evidence according to Clapp et al. Appendix F of President's Cancer Panel. *Reducing Environmental Cancer Risk: What We Can Do Now*. U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. April 2010.

A2: "Suggestive" evidence according to Clapp et al. Appendix F of President's Cancer Panel. *Reducing Environmental Cancer Risk: What We Can Do Now*. U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. April 2010.

B1: "Strong" evidence according to Siemiatycki J, et al. Listing occupational carcinogens. *Environ Health Perspect* 2004;112(15):1447-59.

B2: "Suggestive" evidence according to Siemiatycki J, et al. Listing occupational carcinogens. *Environ Health Perspect* 2004;112(15):1447-59.

C1: "Sufficient" evidence according to Cogliano VJ, et al. Preventable exposures associated with human cancers. *J Natl Cancer Inst*;103(24):1827-39.

C1^: "Sufficient" evidence for leukemia and/or lymphoma. Same source as C1.

C2: "Limited" evidence according to Cogliano VJ, et al. Preventable exposures associated with human cancers. *J Natl Cancer Inst*;103(24):1827-39.

C2^: "Limited" evidence for leukemia and/or lymphoma. Same source as C2.

D tox: Support from toxicological evidence according to evidence summarized in National Toxicology Program. *12th Report on Carcinogens (Roc).* Accessed: June 15, 2011. Available at: http://ntp-server.niehs.nih.gov/roc12/INDEXC5F2.HTM?objectid=035E57E7-BDD9-2D9B-AFB9D1CADC8D09C1. If "benign only" is noted, this corresponds to "some evidence of carcinogenicity" by the National Toxicology Program.

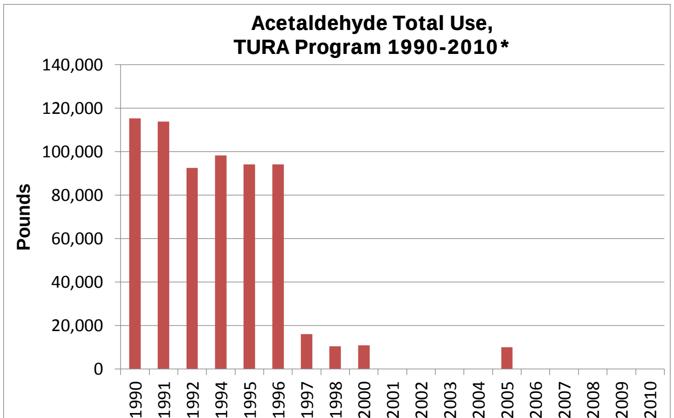
D tox^: Based on evidence for lymphatic, hemolymphoreticular, or lymphohematopoietic cancers. Evidence source same as D tox.

D epi: Support from epidemiologic evidence according to evidence summarized in National Toxicology Program. *12th Report on Carcinogens (Roc).* Accessed: June 15, 2011. Available at: http://ntp-server.niehs.nih.gov/roc12/INDEXC5F2.HTM?objectid=035E57E7-BDD9-2D9B-AFB9D1CADC8D09C1.

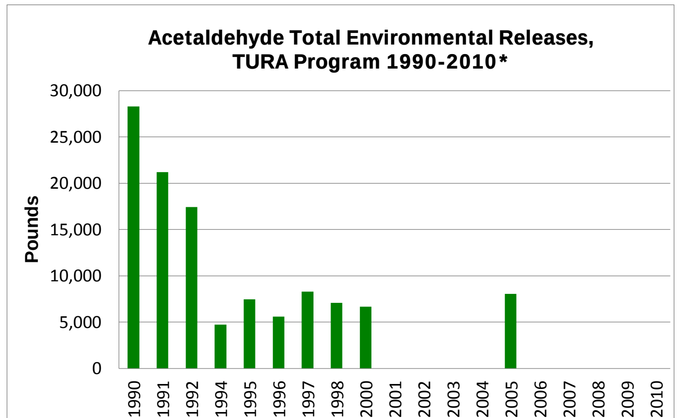
D epi^: Based on evidence for lymphatic, hemolymphoreticular, or lymphohematopoietic cancers. Evidence source same as D epi.

Appendix D: SELECTED KNOWN & SUSPECTED CARCINOGENS: USE & ENVIRONMENTAL RELEASE TRENDS

Use and environmental release trends are provided for a selected array of known and suspected carcinogens. Notes on each chemical are provided to help explain the observed trends. TURI fact sheets provide more information on some of these chemicals, including information on safer alternatives. These fact sheets can be found at: www.turi.org/chemicalfactsheets.

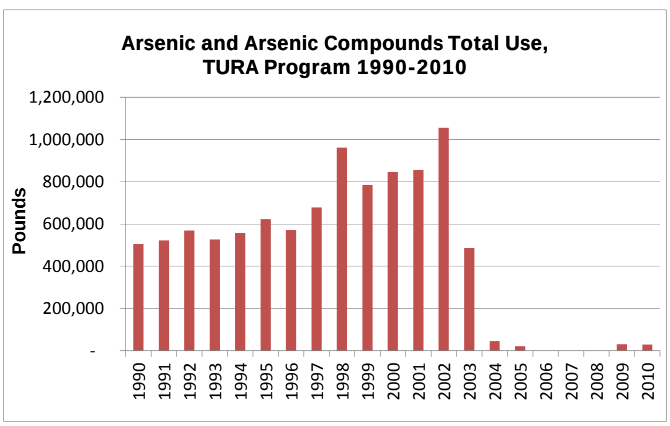


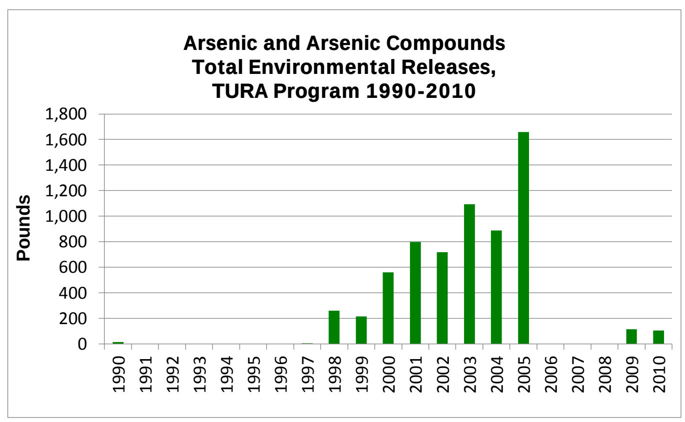
*Use of acetaldehyde did not meet the reporting threshold in 2001-2004 and 2006-2010.



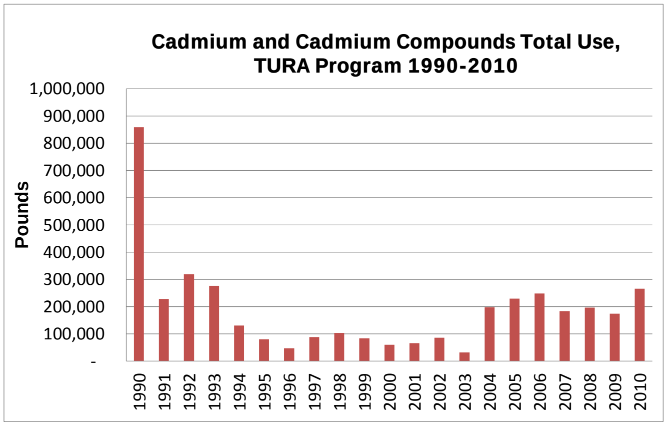
*Use of acetaldehyde did not meet the reporting threshold in 2001-2004 and 2006-2010.

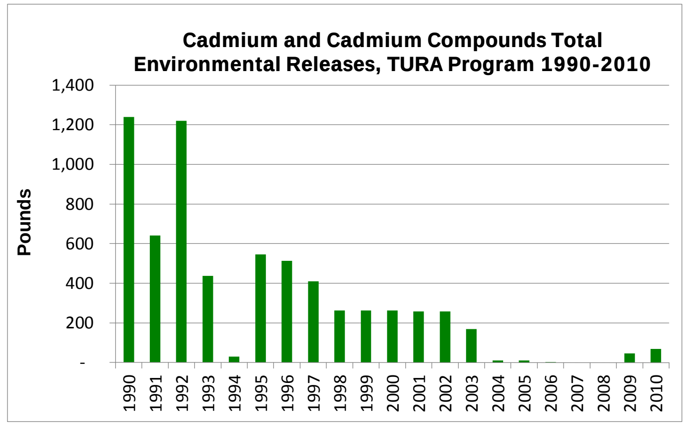
Acetaldehyde: Acetaldehyde was reported by one facility in 1990 and is no longer reported.



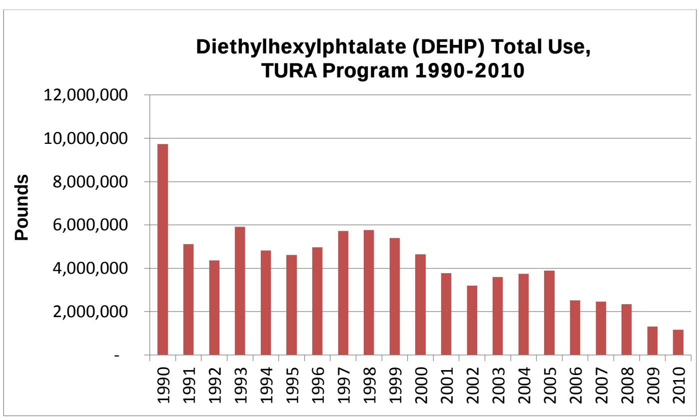


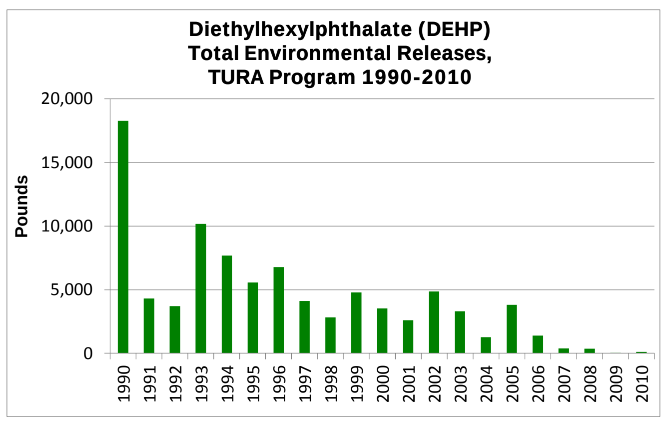
Arsenic and arsenic compounds: One facility reported using arsenic and arsenic compounds in 2010, a reduction from three facilities in 1990, with as many as seven facilities reporting in intermediate years. The significant reduction in use between 2003 and 2004 is due to the U.S. EPA phasing out the use of copper chromium arsenate in wood preservation for nearly all residential applications. The increase in arsenic releases, especially in 2005, is attributed to coal-burning electric utilities. Metal emissions at these facilities are variable and estimated based on the type of fuel used. In 2006, facilities no longer had to report amounts that were manufactured or processed (i.e., used) between 10,000 and 25,000 lbs, once they had tripped the regular threshold for another chemical. (The elimination of the "automatic" 10,000 lb threshold was in the 2006 amendments.) For most of these chemicals, those quantities are small and do not affect trends, but for arsenic and arsenic compounds, it eliminated the few utilities that had been reporting in prior years. In 2009, one electric utility began reporting again because their use exceeded the 25,000 lb threshold, potentially due to changes in fuel mixtures used.





Cadmium and cadmium compounds: Eleven facilities reported using cadmium and cadmium compounds in 2010, an increase from nine facilities in 1990. In 1990, cadmium and cadmium compounds were used as pigment and stabilizers in resins, a use that has declined significantly. In 2008, the TURA program designated cadmium and cadmium compounds as Higher Hazard Substances, lowering the reporting threshold to 1,000 lb/year. For more information about trends in the use and release of cadmium and cadmium compounds, see TURI's "Cadmium and Cadmium Compound Fact Sheet."[l]

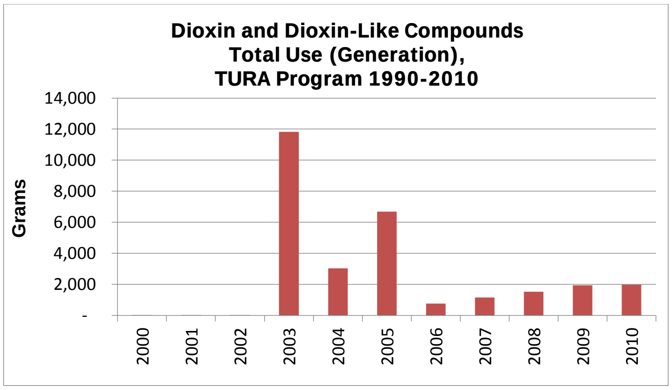


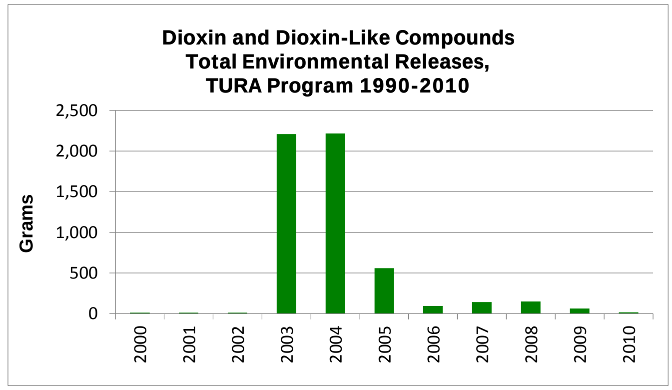


DEHP: Six facilities reported using DEHP in 2010, a reduction from 22 in 1990. The large reduction in use from 1990 to 1991 is attributed to reductions by one rubber and resin manufacturing facility, likely due to substitution of DEHP with other plasticizers. For more information about trends in the use and release of DEHP, see TURI's "DEHP Fact Sheet."[m]

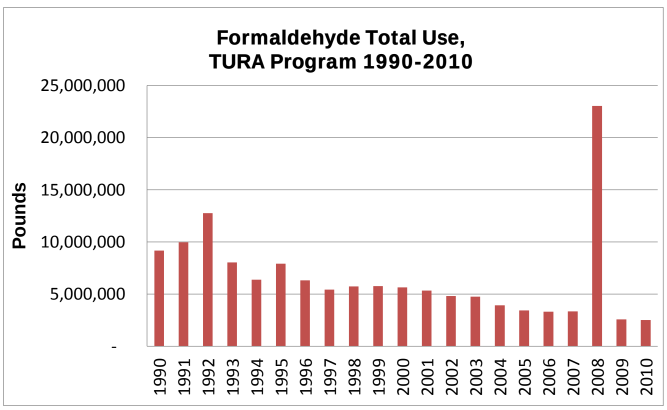
[l] Toxics Use Reduction Institute, "Cadmium and Cadmium Compound Fact Sheet" (June 2008). Available at www.turi.org/chemicalfactsheets. Information on uses of and alternatives to cadmium and cadmium compounds can also be found in Toxics Use Reduction Institute, "Higher Hazard Substance Recommendation: Cadmium (CAS #7440-43-9) and Cadmium Compounds" (2007), available at www.turi.org/policyanalyses.

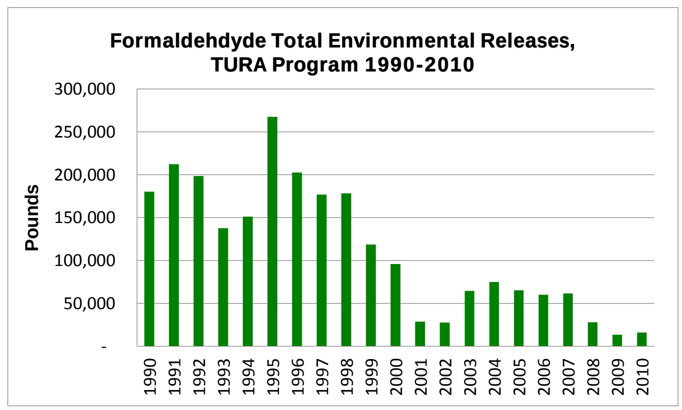
[m] Toxics Use Reduction Institute, "DEHP Fact Sheet" (June 2007). Available at www.turi.org/chemicalfactsheets.





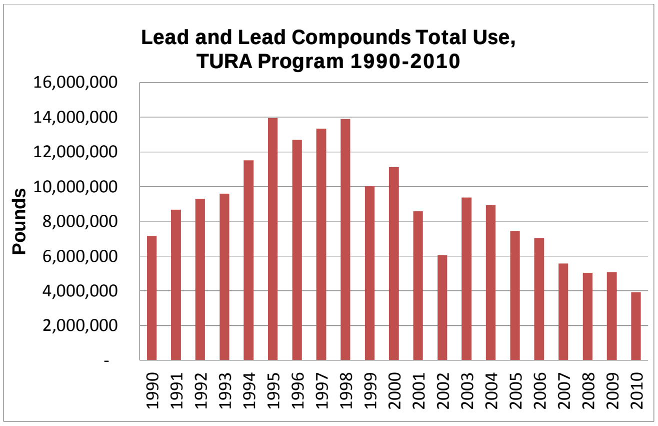
Dioxin and dioxin-like compounds: Nine facilities reported generating dioxins in 2010. Reporting thresholds for dioxin were reduced to 0.1 gram in 2000 due to the TRI PBT rule. Prior to 2000, the reporting threshold for dioxin was not reached by any facility. The primary generators of dioxins reporting to the TURA program are WtE incinerators. These facilities generally estimate their generation of dioxins from stack samples and these estimations may be extrapolated from as little as one sample per year.

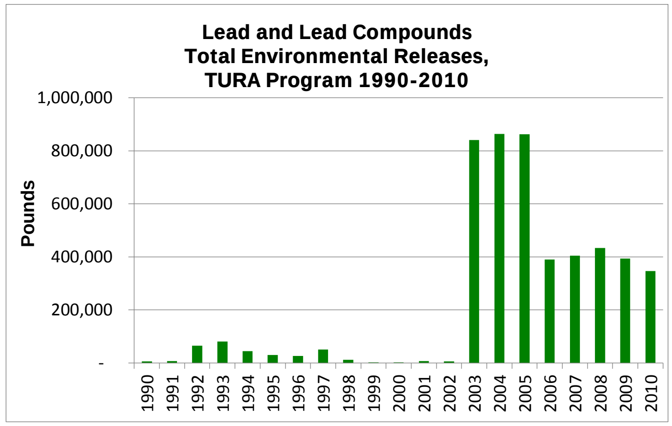




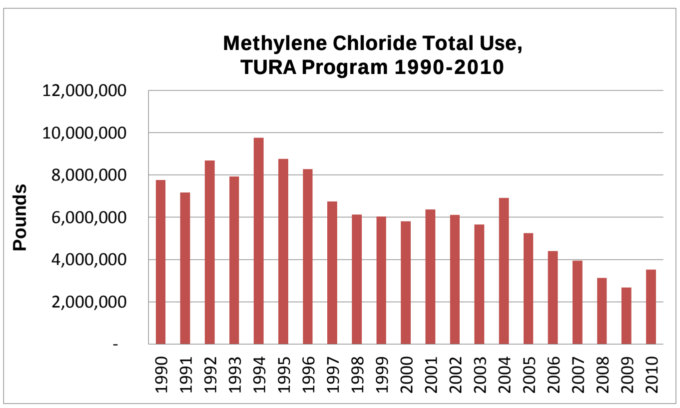
Formaldehyde: Seven facilities reported using formaldehyde in 2010, a decrease from 16 facilities in 1990. In 2008 reported use of formaldehyde increased significantly due to reporting by one facility that in both prior and subsequent years claimed trade secret status. For more information about trends in the use and release of formaldehyde, see TURI's "Formaldehyde Fact Sheet."[n]

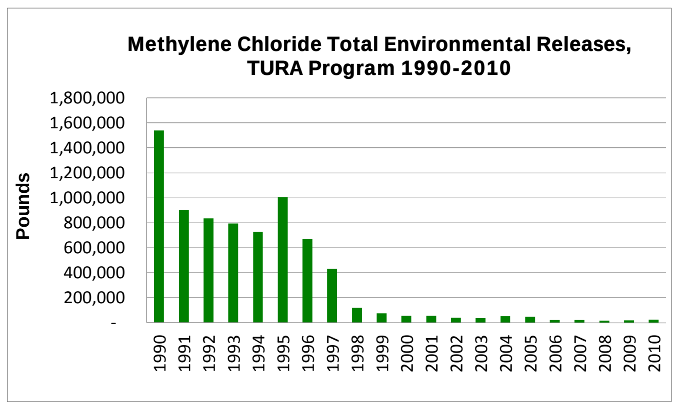
[n] Toxics Use Reduction Institute, "Formaldehyde Fact Sheet" (March 2013). Available at www.turi.org/chemicalfactsheets. Information on uses of and alternatives to formaldehyde can also be found in Toxics Use Reduction Institute, "Higher Hazard Substance Designation Recommendation: Formaldehyde (CAS # 50-00-0)" (2011), available at www.turi.org/policyanalyses.





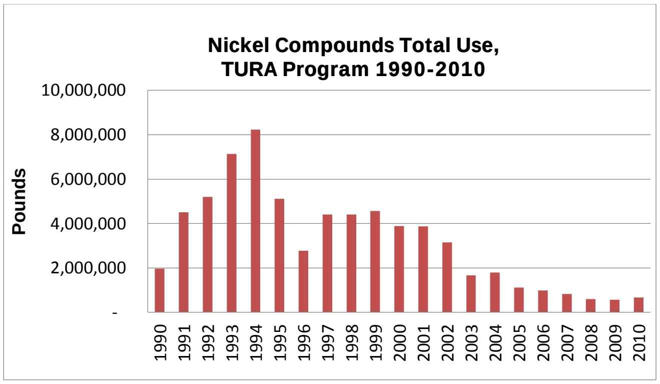
Lead and lead compounds: 143 facilities reported using lead and lead compounds in 2010, an increase from 51 facilities in 1990. Lead and lead compounds are categorized by the U.S. EPA as persistent, bioaccumulative and toxic (EPA PBTs). In 2001, the reporting threshold for lead was lowered to 100 pounds. A large number of facilities, using relatively small quantities of lead, were added due to this reporting change. The large increase in environmental releases between 2002 and 2003 is due to a change in reporting requirements, which eliminated the exemption for reporting by WtE incinerators. For more information about trends in the use and release of lead and lead compounds, see TURI's "Lead Fact Sheet."[o]

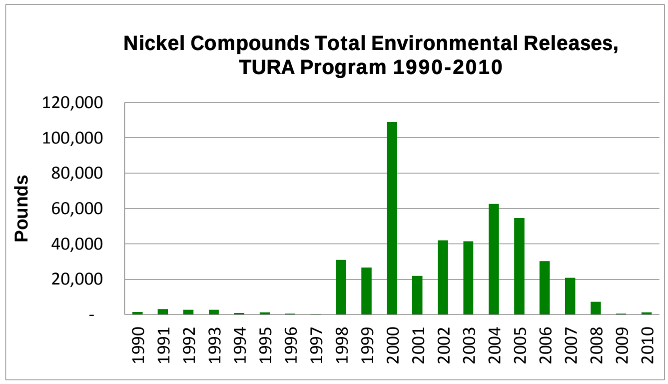




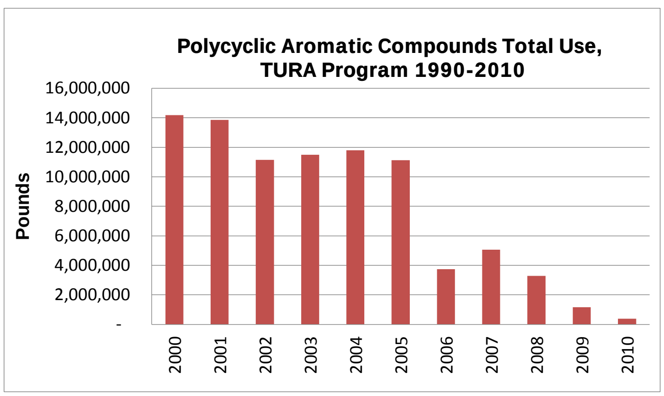
Methylene chloride: Eleven facilities reported using methylene chloride in 2010, a reduction from 41 in 1990. Increased regulatory focus helped to drive reductions in the late 1990s, particularly regarding environmental releases.

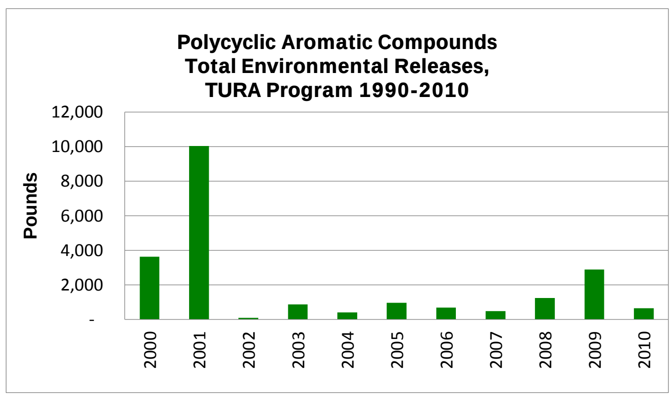
[o] Toxics Use Reduction Institute, "Lead Fact Sheet" (October 2007). Available at www.turi.org/chemicalfactsheets.



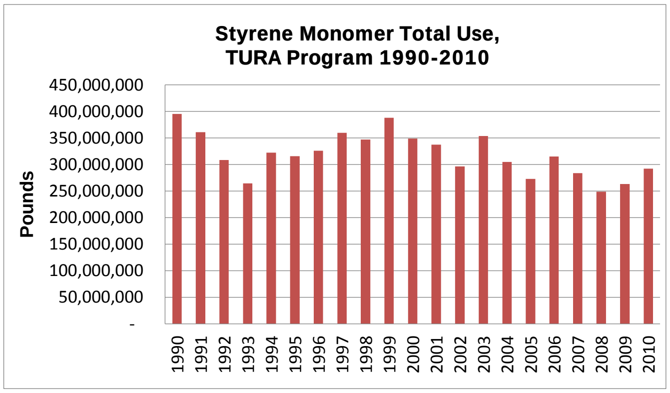


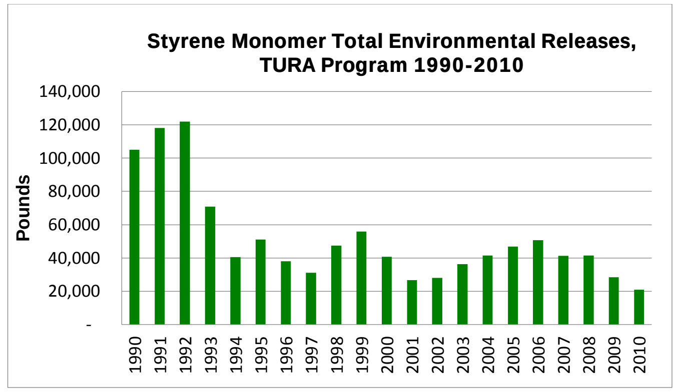
Nickel compounds: Seven facilities reported using nickel compounds in 2010, a decrease from 10 in 1990. The reduction in reported use of nickel compounds in 1995 corresponds to a change in reporting requirements in 1994 that delisted metal alloys (e.g., nickel used in stainless steel). The fluctuation in subsequent years is likely due to confusion by some companies about how to report alloys correctly. In 1998, electric utilities were first required to report under the federal TRI, and were provided with new guidance for reporting emissions from their combustion processes. While evidence linking cancer with nickel is primarily for nickel compounds, facilities reporting under TURA that use both a metal and its compounds are allowed to report all metals and metal compounds together in the compound category.



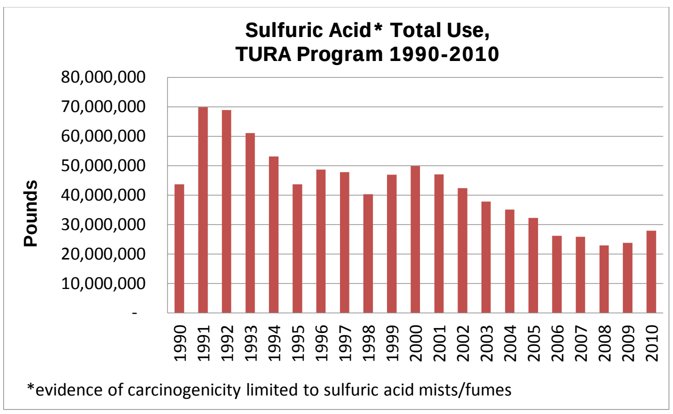


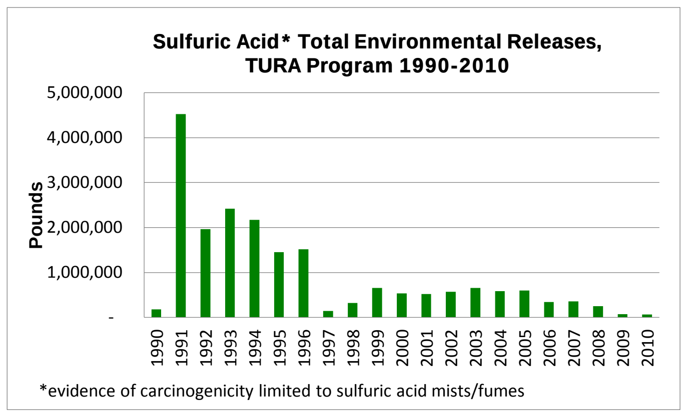
Polycyclic aromatic compounds: 26 facilities reported using polycyclic aromatic compounds (PACs) in 2010. There are several reporting changes that affect PACs. In 2000, the TRI PBT rule lowered the reporting threshold for PACs to 100 pounds and eliminated the *de minimis* exemption. EPA then clarified the guidance for calculating the estimated quantities of PACs in fuel and generated as emissions; as a result, most electric utilities and manufacturing facilities reported large quantities of PACs for the first time in 2000. Therefore, 2000 was selected as the "base year" for analysis of PACs. In 2006, the TURA amendments eliminated reporting of PACs in fuel oil by non-utilities, resulting in a decrease in use.



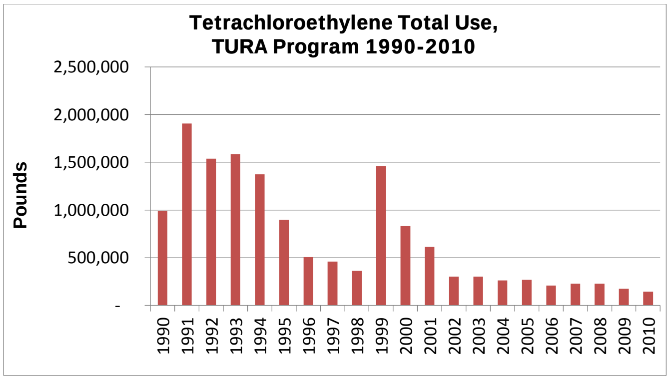


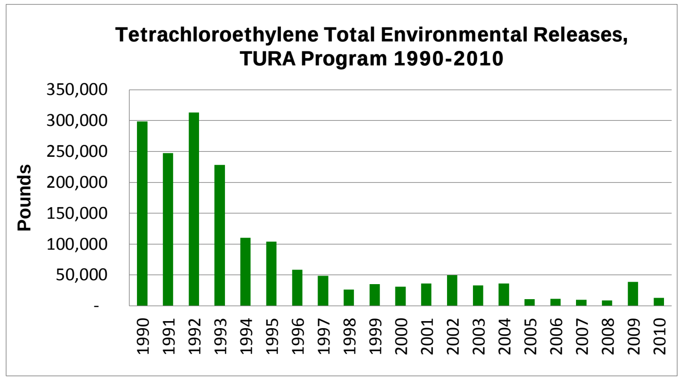
Styrene monomer: 11 facilities reported using styrene monomer in 2010, down from 13 in 1990. Overall use is down likely due to TUR and changes in levels of production. Releases are also down as a result of TUR. Styrene is a feedstock chemical for polystyrene resins, and production in that industry has remained strong, so use reductions are modest. The industry has worked successfully to reduce releases.



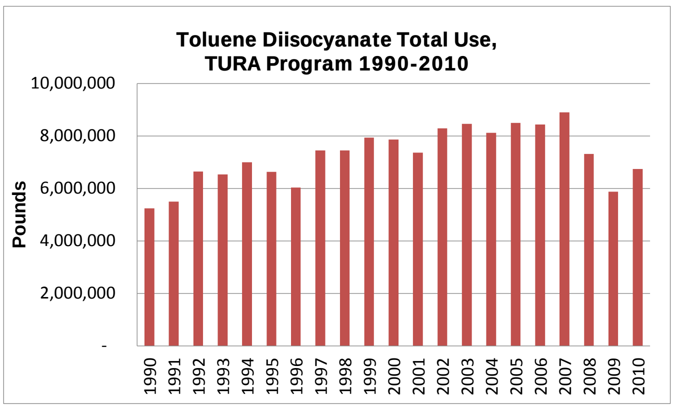


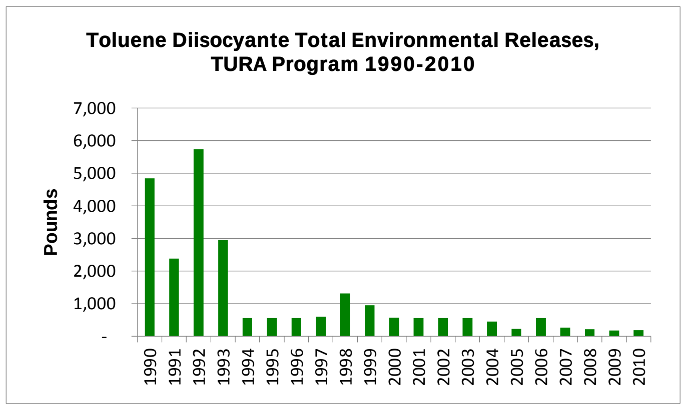
Sulfuric acid: 97 facilities reported using sulfuric acid in 2010, down from 165 in 1990. The increase in use and releases in 1991 resulted from the addition of the electric utility industry to TURA in 1991. It is important to note that only sulfuric acid mists are linked to lung cancer. However, the TURA data cannot differentiate between different forms of sulfuric acid.





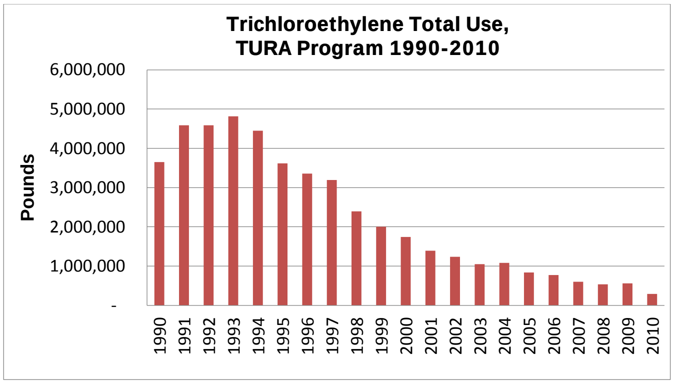
Tetrachloroethylene: 17 facilities reported using tetrachloroethylene (also known as perchloroethylene, or PCE) in 2010, up from 16 reporting in 1990. There is a spike in reported use in 1999 due to reporting by one facility that had not previously reported under TURA. That facility reported for just two years (approximately 1 million pounds in 1999, and 235,000 pounds in 2000). In 2009, the TURA program designated PCE as a Higher Hazard Substance, lowering the reporting threshold to 1,000 lbs/year. For more information about trends in the use and release of PCE, see TURI's "Perchloroethylene Fact Sheet."[p]

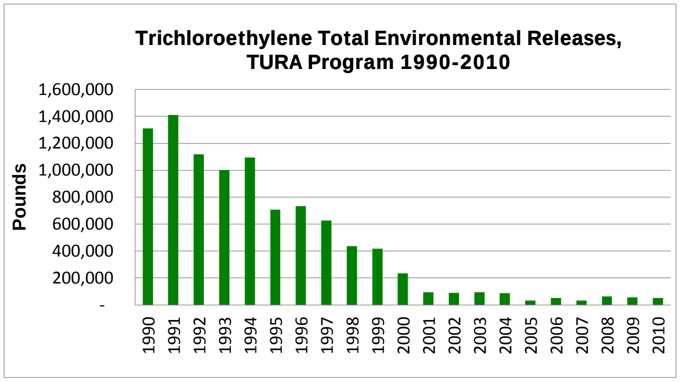




Toluene Diisocyanate: Four facilities reported using toluene diisocyanate (TDI) in 2010, down from 13 in 1990.

[p] Toxics Use Reduction Institute, "Perchloroethylene Fact Sheet" (2007). Available at www.turi.org/chemicalfactsheets. Information on uses of and alternatives to perchloroethylene can also be found in Toxics Use Reduction Institute, "Higher Hazard Substance Designation Recommendation: Perchloroethylene, Tetrachloroethylene, or PCE (CAS #127-18-4)" (March 2008), available at www.turi.org/policyanalyses. Information specific to the use of perchloroethylene in dry cleaning is available at www.turi.org/drycleaning.





Trichloroethylene: 16 facilities reported using trichloroethylene in 2010, down from 41 in 1990. In 2008 the TURA program designated trichloroethylene (TCE) as a Higher Hazard Substance, lowering the reporting threshold to 1,000 lbs/year. For more information about trends in the use and release of trichloroethylene, see TURI's "Trichloroethylene Fact Sheet."[q]

[q] Toxics Use Reduction Institute, "Trichloroethylene Fact Sheet" (August 2008). Available at www.turi.org/chemicalfactsheets. Information on uses of and alternatives to trichloroethylene can also be found in Toxics Use Reduction Institute, "Higher Hazard Substance Designation Recommendation: Trichloroethylene – TCE (Case # 79-01-6)" (October 2007), available at www.turi.org/policyanalyses.

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OPPORTUNITIES FOR CANCER PREVENTION:

Trends in the Use and Release of Carcinogens in Massachusetts

Toxics use reduction (TUR) is one part of a comprehensive cancer prevention strategy. TUR emphasizes reducing the use of cancer causing chemicals by improving manufacturing processes and adopting safer alternatives. This report draws on 20 years of data collected from industries reporting to the Massachusetts Toxics Use Reduction Act Program to assess trends in the use and release of chemicals associated with cancer.

The analysis shows that reported use and releases of carcinogens among Massachusetts companies have decreased dramatically over time. The report also identifies opportunities for the TURA program to achieve further successes in preventing exposure to cancer-causing substances. This report is designed to be a resource both for professionals working in the areas of toxics use reduction and for those working in the area of cancer prevention.

This report is available at www.turi.org/carcinogens2013report.

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