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Sources and Pathways to the Environment and Environmental Presence

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Executive Summary

In an attempt to successfully address and reduce contamination from toxic chemicals and other pollutants in the Oregon environment, the Oregon Department of Environmental Quality is in the early stages of developing a comprehensive agency-wide toxics reduction plan. The plan seeks to find a more efficient, sustainable approach to addressing contaminants of concern to human and ecological health. Team Toxics, a work group compromised of members from various DEQ departments, has been created to collaborate and create the framework for developing these strategies. In summer 2009, Team Toxics was in the very early stages of development, and found the need to gather as much information as possible about each chemical on the focus list. This project began as an internship for DEQ, to help compile research on each of the focus list chemicals, and present it in a consolidated, efficient format, that would facilitate general discussions early in the process and direct DEQ to areas that may need additional research.

Goal of Project

The goal of this project was to compile as much research as possible on each of the focus list chemicals. The information targeted in the research was data or literature describing sources that generate, use or release each chemical, the relative magnitude of those releases, and the presence of each chemical in the local environment. The data were compiled into two tables for each category: *Sources and Pathways to the Environment* and *Environmental Presence.* This standardized format provides an accessible, efficient way to assess the relative abundance of data in preparation for the development of the toxics reduction strategies for each chemical.

Methods Used

The tables of data for each Focus List category were populated using a variety of sources from research and agency publications to public databases containing environmental monitoring data. By using a standardized template, and searching the same sources for each of the chemicals, it is possible to compare the available data between chemicals, and between categories, and make qualitative assessments of the availability of data.

Storage, release and environmental monitoring data were primarily pulled from publicly available government databases maintained by both state and federal agencies. Knowing that the data contained in these resources would likely be incomplete, and not necessarily representative of actual conditions, quantitative values were not sued. The values were categorized and assigned a qualitative description such as present/absent or high/medium/low levels.

Narrative information describing the uses, sources and pathways to the environment of each chemical was taken primarily from the Agency for Toxic Substances and Disease Registry. Due to the limited time and resources, and large number of chemicals on the Focus List, it was impossible to do a thorough literature review and consider weight and quality of evidence to produce an original narrative description. It is assumed that the information published in ATSDR has been vetted and can be relied on to inform the development of the toxics reduction strategies.

Summary of Results Found

The compilation of research for this product provided a good starting point to inform the development of the Toxics Reduction Strategy. More monitoring and research will be necessary as the strategies for individual chemicals are formed. These documents will help DEQ to decide where the priorities lie for program development, continued research, new monitoring programs. By compiling all available data into a consolidated, accessible format, DEQ will be able to more easily assess and prioritize the steps needed to complete the Toxics Reduction Strategies for each of the listed categories.

Overall, several of the categories are well supported by data and literature. The Metals, Volatile Organic Compounds, and both Current Use and Legacy Pesticides are fairly well researched and reported on. In the case of the latter three categories, heavy regulation and oversight in other state programs contribute to the existing bank of knowledge. *Combustion and Petroleum By-Products*, *Flame Retardants* and *Industrial Chemicals* are relatively well researched, and have been found in the environment, when considered as a group. The behavior of the individual chemicals in these categories is an area where more research is needed. The final category, *Consumer Product Constituents*, is unique category in that most of the chemicals listed are considered emerging contaminants. In these cases the monitoring data are limited to just a few studies, and scientific research of the effects of the chemicals is relatively new, and still disputed in some cases. This is a category that would benefit from further research.

Implications of Results

The completed *Table of Data Sources* will help direct future research and planning for the Toxic Reduction Strategy. The narrative descriptions of *Uses, Sources, and Pathways* provides a foundation for general discussions and interaction with outside parties, such as the stakeholder groups developed to participate in the development of the Toxics Reduction Strategy. The *Environmental Presence* data provides a starting point for the more detailed planning, as it helps to illustrate potential health concerns, the relative magnitude of environmental releases, the affected environmental compartments, and the relative abundance of available research addressing each Focus List chemical.

The successful implementation of an agency-wide Toxics Reduction Strategy will have lasting impacts on environmental integrity and human health, as well as improve the coordination and efficiency of DEQ resources. A coordinated approach to the management of toxics, throughout all environmental compartments, should produce a more efficient, successful strategy to improving the quality of the Oregon environment.

Recommendations for Future Work

The work completed for this project was simply the first step in an ongoing process of gathering research necessary to inform the development and continuing management of DEQs toxic reduction strategies. Even following implementation of the strategies, emerging research will need to be reviewed for relevancy to DEQ programs.

There were several limitations that were encountered in this project. The primary limitation was time; there were simply too many chemicals to develop a comprehensive catalog of available research for each one, within the limited span of time. This could be addressed by increasing the staff assigned to the project. Another alternative is to determine the order in which the Toxics Reduction Strategies will be developed, and prioritize the research accordingly.

Due to time limitations and concerns from stakeholders about the use of published peer-reviewed scientific research, the scope of this project only included citing sources that included direct monitoring data, or were published by a vetted source- usually federal government publications. In order for the catalog of research to be improved in a meaningful way, significantly more time needs to be invested into a literature review. The researcher also needs the ability to analyze and interpret the data that they encounter. When given more time to gather and carefully review research for a chemical, DEQ will be able to use the weight of evidence to accept to establish reasonable and defensible actions to achieve reduction of Focus List chemicals in the Oregon environment.

Finally, as the number of data sources increase, it will be necessary to create a new framework for cataloging the data. The current table of data are efficient and accessible for the relatively few sources citations used, but it will be necessary to find a new reporting format as the library of citations grows.

Management of Toxic Chemicals and Pollutants

As scientific understanding of the impacts of toxic pollutants to human health and the environment improves, strategies to reduce their release, presence, persistence, and effects must be developed. Over the last two decades, state and national governments around the world have developed programs and enacted regulations to limit the impacts of toxic pollutants (Davies 2006). Initially driven primarily by human health concerns, toxic reduction strategies now generally encompass effects to environmental receptors, as well.

The behavior of toxics in the environment varies widely, but many move between environmental compartments, and some are transformed or degraded by the environment. The impacts of metabolites can be significant; therefore, a successful reduction strategy for these types of pollutants must include their behaviors for the entirety of their life cycles. This task can be difficult for governments to implement for a variety of reasons, including scientific uncertainty (Hursthouse 2009), political pressure, and even the established bureaucratic structure that agencies utilize for the management of environmental problems (Graham 1992; Ryan 2005).

There have been a number of successful toxic reduction strategies enacted in other states and countries. The strategies have included source reduction (Deyoung 1993), technological improvements, remediation, mitigation, regulation and outreach. The state of Oregon seeks to improve their management of priority toxic pollutants. Before comprehensive reduction strategies can be implemented, there must first be an established process, collection of all available research, and some level of consensus regarding the presence, weight and validity of the data. In some cases, more research may be necessary before developing a targeted reduction approach.

Agency-wide Toxics Reduction Strategy

One of the primary missions of the Oregon Department of Environmental Quality [DEQ] is to protect the citizens of Oregon from the direct and indirect negative impacts of toxic pollutants. In the past, this mission has been addressed separately through DEQ's air, land and water quality programs.

It has become evident however, that many toxic compounds exist and persist in all three types of environmental media. With the goal of reducing environmental presence, and mitigating toxic effects, DEQ is developing a comprehensive, agency-wide approach to addressing priority environmental contaminants within Oregon.

The toxic compounds included in the agency-wide reduction strategy have been selected from individual program priority lists, and include those most hazardous to human health and ecological life. Collectively, these 161 pollutants are now known as the *Focus List*, and will serve as the pilot group for this program. As the program develops, more toxic compounds may be evaluated and added to this list.

The objectives of the agency-wide toxics reductions strategy are as follows:

- Optimize agency resources by focusing on the highest priority pollutants in a coordinated way.
- Implement actions that reduce toxic pollutants at the source, to the extent possible.
- Establish partnerships with other agencies and organizations in implementing the Strategy to increase the effective use of public and private resources.
- Use environmental outcome metrics to measure the effectiveness of Strategy implementation where feasible (DEQ 2009).

Reduction strategies for individual pollutants are being formed using a collaborative process that includes input from DEQ team members and selected external stakeholder groups. These groups include scientists, industry representatives and community members. To support a productive and scientifically sound decision-making process, credible data that speaks to the sources, pathways and environmental receptors of each pollutant must be compiled and distributed to all individuals contributing to management decisions. The work completed for this project provides a starting point for each category on the Focus List by providing data and citations that speak to the environmental presence of each chemical in Oregon, as well as the availability of relevant research in peer reviewed literature and agency publications.

Elements of a Toxics Reduction Strategy

Generally, toxic reduction strategies can be categorized three ways. Pollution prevention programs attempt to change the methods or materials of the process that generates the pollution. Pollution control programs generally use technology or other controls to trap or treat pollution before it enters the environment. Exposure reduction programs are used where the other two methods fail, and pollution has or will enter the environment. These programs usually focus on education and alternatives to allow people to avoid exposure to the potentially unsafe contamination.

Pollution control, prevention and exposure reduction can be achieved through a variety of regulatory and incentive based programs. DEQ plans to use a combination of direct and supporting strategies in building the agency-wide toxic reduction plan.

Direct strategies that may be utilized by DEQ include direct regulatory strategies and intergovernmental coordination strategies, which would be based on governmental regulation and action. Chemical replacement strategies may also be used in an attempt to find less toxic substitutes for chemicals currently in use. This strategy would likely be accomplished through regulation, as well as voluntary compliance. Other strategies that involve personal choice and responsibility include: incentive strategies, market-based strategies and financial strategies, where positive and negative financial reinforcement would be used to influence personal consumer choices. Educational strategies will be used in conjunction with other strategies to help inform the general public of the sources and effects of the toxic pollutants in the environment and the role of individual behavior in reducing the levels of contamination.

Supporting strategies that will be used in the Toxics Reduction planning include monitoring and assessment, by DEQ and other public and private organizations. A successful toxics reduction plan will be an ongoing process that may need to adapt over time. It will be essential to continue monitoring and assess the results of actions taken to determine if the strategy is effective. The supporting strategies will not directly reduce the levels of toxic chemicals in the environment, but they can help direct the actions that will. (DEQ 2010) The DEQ agency-wide toxics reduction strategy attempts to evaluate the best combination of methods and strategies to reduce toxic pollutants in the environment.

The Focus List

To successfully launch this program with the limited resources available to DEQ, it was necessary to refine the number of pollutants to be addressed by this program. To begin the selection process of which chemicals should be prioritized in the development of a toxics reduction strategy, the Base List was created. Any pollutant that was listed as a priority in any existing DEQ or inter-agency program was placed on the Base List. From the Base List, three lists were created (See Appendix A1).

The top priority pollutants for the program are placed on the Focus List. The Focus List is comprised of pollutants that are listed as a priority in three or more programs that come from at least two different divisions. (See Appendix A2) Once a pollutant is on the Focus List, the task becomes to identify uses, sources and pathways to the environment. Once the available data are synthesized, it becomes possible to address the effectiveness of current pollution abatement programs.

Pollutants that are listed in fewer than three programs, or only in a single division, may be placed on one of two lower-priority lists. Where data exist on uses, sources, and monitoring, a pollutant may be placed on the evaluation list. When time and resources allow, Team Toxics will develop an evaluation process to determine if pollutants should be moved to the Focus List. Pollutants that have little to no available data are placed on the data needs list until more data becomes available.

DEQ Development of Toxic Reduction Strategies

Approach

In a July 2010, the Oregon Environmental Quality Commission (OEQC) issued a draft resolution mandating the adoption of a toxic chemical and pollutant reduction strategy by DEQ. The OEQC acknowledged deficiencies in research and available data on the tens of thousands of toxic chemicals and pollutants discharged into the environment. The commission found that the deficiencies prevented public and government agencies from properly characterizing risk and developing reduction strategies (OEQC 2010).

In the resolution, the OEQC directs DEQ to consider all readily available, credible information, and exercise best professional judgment in the face of scientific uncertainty. The resolution also recommends a process and a timeline to create and implement a toxic reduction strategy.

The OEQC has suggested the following step-wise approach to meeting their ambitious deadline of implementing the Toxics Reduction Strategy by the end of 2011:

- Identify Toxic Chemicals and Pollutants
- **Identify Sources and Pathways and Characterize Listed Toxic Chemicals and Pollutants**
- Evaluate Existing Programs
- Identify, Evaluate and Select Recommended Actions
- Implementation Plan

Scope of Project

For the purposes of developing and implementing a plan, OEQC expects DEQ to assess the quality and quantity of available data, as well as identify where additional research or data are needed. Once the toxic chemicals and pollutants were selected for the Focus List, it was necessary for DEQ to identify the following:

- Sources that generate, use or release each listed chemical
- Relative magnitudes of release of each chemical to the Oregon environment
- Pathways to the environment and environmental fate
- Potential human or ecological exposure to each chemical and associated risk of exposure

Beginning in August 2009, the scope of this project was to compile as many sources of data as possible that cite each Focus List chemical. The intention of this research project was to help generate the information listed above to assist in the formation of the Toxic Reduction Strategy.

Initially the plan was to produce full narrative reports for each of the chemicals. These full reports were time consuming, and after concerns about assessing the weight and reliability of peer-reviewed scientific research, it was decided that a new, more efficient approach was necessary.

Table of Data Sources

In January 2010, a more streamlined approach to data collection was created. It was recognized that there was not time to both collect and analyze the research and data for each of the Focus List Chemicals. The scope of the project was narrowed to simply collecting and citing credible sources of data.

The data collected for each Focus List chemical covers the broad categories of Use, Sources and Pathways to the Environment, and Environmental Presence. The *Table of Data Sources* provides summary information that allows for easy comparison and generalized discussion in the early stages of planning the Toxics Reduction Strategy. The standardized format helps to highlight chemicals for which research is particularly abundant or deficient, which could help direct program prioritization.

Interaction with DEQ

The intention of the agency-wide toxics reduction strategy is to build on existing programs and improve coordination between departments for a more successful, comprehensive approach to toxics reduction. An internal DEQ work group, Team Toxics, was formed to create the process for developing the strategies. I became involved with the project in July 2009, when I was selected to be a research intern to assist in the compilation of data for Team Toxics. Work for this project was completed under the direction and supervision of Kevin Masterson and Cheryl Grabham, of Team Toxics.

Contributions to the *Table of Data Sources* were made by other members of Team Toxics. For example, Toxicity and Carcinogen Data were provided by Bruce Hope, narrative pesticide information was provided by the Oregon Department of Agriculture, and data, research and formatting guidelines were provided by Kevin Masterson and Cheryl Grabham.

I am also using the work completed in my internship with DEQ to satisfy the community project requirement for the Masters in Environmental Management Program at Portland State University, with the guidance of Dr. Alan Yeakley and Dr. Joe Maser.

Compilation of Research

Table of Data Sources

The scope of this project was to compile as much data as possible on each of the focus list chemicals. In order to inform the development of Toxics Reduction Strategies for each of the many pollutants on the list, Team Toxics needs to be able to efficiently access available data and assess where more research may be necessary.

A standardized data table was the easiest way to catalog all of the research collected for each of the Focus List Chemicals. The research is divided into two categories. The *Uses, Sources, Pathways to the Environment* data table provides basic narrative information for a credible government source. This table is important to provide context for the data found on the other data table, *Environmental Presence.* This data table consolidates a variety of data sources and uses letter codes to denote where a Focus List chemical has been reported by a specific source.

While some of the sources provided quantitative data on environmental release or concentration in a monitoring detection, it is recognized that the data collected are likely to be outdated or incomplete. Rather than attempt to quantify environmental releases with unreliable data, the available data were ranked and recorded in a way that allowed for relative comparisons. For example, reported levels of storage or environmental release were ranked using low/medium/high designations. Monitoring data were reported as simple presence or absence, rather than attempt to analyze the significance of the detections.

Sources of Data

In order to be able to assess the relative availability of data for the Focus list compounds and categories, it was necessary to create a standardized process and format for locating and reporting available, credible data sources. The sources listed below represent the primary resources used to locate and catalog data for each chemical.

The data compiled for each of the Focus List chemicals were divided into two categories. The first category, *Uses, Sources and Pathways to the Environment,* is intended to be a narrative description that contains as much data as possible regarding why and how the chemical enters the environment, how it moves through the environmental compartments, and what its environmental fate might be. Due to time limitations, this category was populated using primarily a single source, since it is a credible, government-published resource, and should have already considered available research.

Agency for Toxic Substances and Disease Registry (ATSDR)

The ATSDR is a federal public health agency that is part of United States Department of Health and Human Services. The mission of ATSDR includes "advancing the science of environmental public health and educating communities, partners and policy makers about environmental health risks and protective measures." In support of this mission, ATSDR produces toxicological profiles for hazardous substances found at sites listed on the National Priorities List (NPL). There are currently 310 toxicological profiles that have been published by ATSDR, all of which are available on the ATSDR website (atsdr.cdc.gov).

The toxicological profiles include a description of each substance and its relevance to human health concerns. Each contains detailed descriptions of the ways a person might be exposed, and what the health risks of that exposure could be. The profiles also included information on production, import, use and disposal. This information was used to populate the *Uses* column in the spreadsheet. The *Sources and Pathways* column was also populated with descriptions from the toxicological profiles. The profiles addressed the potential for human exposure, which included a discussion of the sources of the substance released into the environment, as well as its environmental fate. The data and descriptions found in the toxicological profiles, when available, were the exclusive source of narrative descriptions in the spreadsheet.

There are potential limitations in using ATSDR to inform the Toxics Reduction Strategy. There does not appear to be a mechanism for updating the profiles quickly or easily to include emerging research. This means that some of the toxicological profiles were not available for the many of the emerging contaminants, and many of the existing profiles were out of date.

The second category of data compiled for this project was categorized as *Environmental Presence* data. This data came from a variety of sources and covers estimated toxicity to address environmental health concerns, relative levels of storage and release to the environment, and presence or absence in environmental monitoring data, where available.

Toxicity

Ecological Structure Activity Relationships (ECOSAR)

ECOSAR is a computer model created by the EPA to predict aquatic toxicity of industrial chemicals (USEPA 2009). Since part of the goal of the Toxic Reduction Strategy is to address contaminants as they move across environmental compartments, each of the Focus List Chemicals was run through the ECOSAR model to estimate toxicity, regardless of how it was generally released to the environment. Some of the compounds on the Focus List were not soluble enough to predict a toxicity value, denoted with a dash (-). Toxicity values are reported in mg/L.

Report on Carcinogens

The carcinogenicity of each Focus List chemical was determined using the U.S. Department of Health and Social Services *Report on Carcinogens* (DEQ P3 2010).

Storage and Use

State Fire Marshall Hazardous Substance Information System (HSIS)

The Oregon Community Right to Know and Protection Act requires the Office of the State Fire Marshal to maintain public records of hazardous substances stored in Oregon above a certain threshold (DEQ P3). The data collected in HSIS was used to populate the *Stored in* Oregon column. As many of the stores of these chemicals are in use, the amount stored will vary throughout the year, so the data are reported in ranges that facilities are permitted to store. For the purposes of the project, the relative levels of use were reported by categorizing pesticide use as follows:

Oregon State Fire Marshall, total:

- *High*: stored at greater than 15 facilities or max range exceeds 250,000 kg
- *Medium*: stored at 6-14 facilities; max range not to exceed 100,000-249,000 kg
- *Low*: stored at 5 facilities or less; max range not to exceed 1,000- 4,00 kg

Oregon Pesticide Use Reporting System (PURS)

For two years, the Oregon Department of Agriculture recorded pesticide use in Oregon, providing a valuable baseline for estimating pesticide use in Oregon. The data obtained from PURS was used to populate the *Use in Oregon* column of the data table, which is only included in the *Current Use* and *Legacy Pesticide* Categories. Nearly every pesticide on the Focus List is reported in PURS. For the purposes of the project, the relative levels of use were reported by categorizing pesticide use as follows: (DEQ P3)

Oregon Pesticide Use Reporting System, total:

- *High*: greater 20,000 kg/yr
- *Medium*: between 4,500 and 20,000 kg/yr
- *Low*: less than 4,500 kg/yr

Release

EPA Toxics Release Inventory (TRI)

TRI is a database that catalogs toxic chemicals disposed or released to the environment by certain industrial and federal generators (USEPA 2009). The database was of limited use in estimating annual release in Oregon for those of the Focus List chemicals that are listed. Less than 300 facilities in Oregon report to the TRI (DEQ P3). Only relatively large generators of waste are required to report to TRI, and in some cases a potentially significant portion of environmental releases are not catalogued. The data reported in TRI was used to populate the *Released to the Environment* column. Since quantitative data were unreliable, DEQ used TRI to categorize the relative magnitude of the reported releases as follows: (DEQ P3)

Oregon Toxics Release Inventory (TRI), total:

- *High*: greater than or equal to 1,000 kg/yr
- *Medium*: between 100 and 1,000 kg/yr
- *Low*: less than 100 kg/yr

EPA National Air Toxics Assessments (NATA)

NATA is a database managed by EPA to record and report air emission data from across the country (USEPA 2002). Most of the data in NATA is reported to the TRI, so this source was somewhat redundant. However, if any of the Focus List chemicals found in NATA were underreported or left out of TRI, the NATA value was ranked using the same categorization as TRI data, and used to complete the *Released to Environment* category.

DEQ Hazardous Waste Generation Reports (HW)

Hazardous waste generation and disposal in the Oregon is tracked and reported by the DEQ. (DEQ P3) This information is available to the general public and was checked against each of the Focus List chemicals to search for detections. This resource was of only limited use, as many of the Focus List chemicals are not also listed as HW. For the purposes of this project, a simple presence or absence in HW Generation reports was denoted with a yes (Y) or no (N) in the *Hazardous Waste Generation* column of the *Data Sources* table.

Presence in the Environment

National Water Information System (NWIS)

USGS monitors surface and groundwater resources within the United States, collecting data and recording both physical and chemical characteristics of water resources. The current and historic monitoring data are compiled and made available for public use through the NWIS: Web Interface (USGS 2007). The full CASRN of each of the Focus List Chemicals was entered in to the NWIS system to look for detections within Oregon. The presence of Focus List chemicals in statewide monitoring data were recorded in the *Monitoring Data* column, denoted as (**G**).

There are benefits and limitations to the way this data were accessed and recorded. The NWIS records detailed information about site location, sample matrix and results for each detection. However, the spreadsheet records simple presence or absence of a chemical, but does not provide context for the significance of the detection. Most of the Focus List compounds have been detected in Oregon waters; however, nearly all of the detections in NWIS appear to come for two particular sampling events and locations. The data do not clearly reflect the distribution of the substance over geography or time.

Oregon DEQ Laboratory Analytical Storage and Retrieval (LASAR)

LASAR is a publicly available, web-based application that provides access to a consolidated source of air and water monitoring data collected within Oregon (DEQ LASAR 2010). The database can be searched using a number of parameters, including CASRN numbers. LASAR allowed for a quick assessment of whether or not each compound had been detected in the air or water monitoring data. For the scope of this project, LASAR was used to make a simple presence or absence determination, denoted in the *Monitoring Data* column with (**L**), where the compound had been detected. Higher-level assessment of quantity, frequency and significance of detections is recommended when developing specific toxic reduction strategies.

Oregon DEQ Environmental Cleanup Site Information (ECSI)

ECSI is a publicly available, web-based application that provides access to land quality monitoring data collected within Oregon (DEQ ECSI). ECSI was created to help DEQ track and monitor sites with known or suspected contamination, even following corrective actions. The database can be searched using a number of parameters, including CASRN numbers. ECSI allowed for a quick assessment of whether or not each compound has been released to or detected in land quality data. For the scope of this project, ECSI was used to make a simple presence or absence determination, denoted in the *Monitoring Data* column with (**E**), where the compound had been detected. ECSI contains information that may be outdated, unconfirmed or incomplete. ECSI also does not include monitoring data reported under the Underground Storage Tank Program (UST), possibly ignoring significant or widespread petroleum contamination. In order for ECSI to be a useful source for informing toxic reduction strategies, it may be necessary to improve the system of reporting and cataloging data.

Other Sources

A variety of other sources were cited in the *Monitoring Data* column, where evidence of a Focus List chemical was found. Time limitations prevented a thorough literature review for each chemical. Priority was placed on Oregon-specific monitoring detections, which were often listed in DEQ and EPA reports and presentations. Peer-reviewed journal articles were cited in some cases where significant numbers of research articles were found. Not all of the sources were reviewed, but by citing them in the Data Sources Table, the sources are available to be accessed easily for future review as the Toxic Reductions Strategies are developed. Each source was assigned a letter code for the data table; the full citation can be found on the Reference Sheet. Oregon-specific references are highlighted in bold.

Summary of Research

The results of the research for each category of chemicals on the Focus List are summarized below. Please see Appendix B for the full version of the *Table of Data Sources*.

Combustion and Petroleum By-Products

Focus List Selection

The Combustion and Petroleum By-Product category is comprised of dioxins and furans, naphthalenes, and polycyclic aromatic hydrocarbons (PAH). Each of these groups is listed as priority pollutants in all three DEQ divisions, Air Quality, Land Quality and Water Quality. Dioxins and furans are listed in five programs, while naphthalenes are listed in four. Total PAHs are listed in nine individual DEQ programs over the three divisions.

Dioxins and Furans

Production and Use

Chlorinated dibenzodioxins (CDDs) are not manufactured commercially in the United States except on a small scale for use in chemical and toxicological research. CDDs are unique among the large number of organochlorine compounds of environmental Interest in that they were never intentionally produced as desired commercial end products (ATSDR 1998). No data specifically addressing production and use of furan or chlorinated dibenzofuran (CDF) compounds was encountered during this project.

Sources, pathways, and affected media

CDDs and CDFs are released to the environment during combustion processes (e.g., municipal solid waste, medical waste, and industrial hazardous waste incineration, and fossil fuel and wood combustion); during the production, use, and disposal of certain chemicals (e.g., PCBs, chlorinated benzenes, chlorinated pesticides); during the production of bleached pulp by pulp and paper mills; and during the production and recycling of several metals (ATSDR 1998).

Environmental presence

The uses, sources, pathways and environmental presence of dioxins appear to be relatively well documented. The toxicity and health impacts have been well researched and documented by EPA and ATSDR. Oregon-specific environmental presence is well documented through a variety of programs. The compounds have been reported in various sources of environmental monitoring data within Oregon. These compounds have been reported in ECSI, LASAR and USGS, as well as by the DEQ and EPA monitoring programs. Dioxins and furans are not stored in Oregon, nor have they been reported in Hazardous Waste. There were several sources of data from outside Oregon. The ATSDR database provided thorough background information regarding production, use, sources and pathways of the dioxins and furans. Additionally, the compounds have been reportedly detected in human tissue.

Recommendations for Improving Catalog of Available Data

There was no data encountered that addressed furan compounds. Future Toxic Reduction Strategies could benefit from further research and monitoring in this area.

Naphthalenes

Production and Use

Naphthalene is produced from coal tar or petroleum. It is used as an intermediate in production of phthalic anhydride, which is used for plasticizers, resins, dyes, insect repellants, pharmaceuticals and more. The estimated U.S. production capacity of naphthalene was 215 million pounds. 21 facilities in Oregon store naphthalene on site (ATSDR 2005).

Sources, pathways, and affected media

Most naphthalene is released to the environment through the combustion of wood and fossil fuels. Significant contributions of naphthalene to air also include off-gassing from moth repellant and cigarette smoke. Releases to soil and water generally occur as a result of coal-tar production and manufactured gas plants (ATSDR 2005).

Environmental presence

Naphthalene is released in relatively high quantities to the environment and has widespread reported detections in Oregon. It has been reported in the ECSI, HW, LASAR, and USGS databases. It has also been reported in several sources outside of Oregon, including in human tissue and wastewater. The ATSDR database provided thorough background information regarding production, use, sources and pathways of naphthalenes.

Recommendations for Improving Catalog of Available Data

Naphthalenes were listed as a group on the Focus List, and therefore were not searchable by CAS numbers. Identifying individual naphthalene compounds of concerns might yield more environmental presence data. Additionally, personal use products, such as moth balls and cigarettes, seem to be a significant source of naphthalene releases to the environment. It may be helpful to attempt to estimate the significance of these contributions when developing the Toxics Reduction Strategy.

Polycyclic Aromatic Hydrocarbons (PAH)

Production and Use

PAHs are by-products of combustion and petroleum, so they are not used, produced or stored in Oregon.

Sources, pathways, and affected media

There are two types of PAH compounds: petrogenic and pyrogenic. Petrogenic PAHs are naturally occurring in petroleum products and are released along with petroleum products to the environment. Pyrogenic PAH inputs are generally more significant, and created as a by-product of combustion. Pyrogenic PAHs are released to the atmosphere, but can be deposited on water and land resources.

Environmental presence

Of the 29 PAHs listed, twelve of the individual compounds are listed in five or more sources of and eight were not detected in any environmental monitoring data reviewed for this project. PAHs were reported in ECSI, USGS, LASAR; none have been reported in Hazardous Waste. Most of the PAHs have been reported in TRI, NATA or both. There were several sources of data from outside Oregon. The ATSDR database provided thorough background information regarding sources and pathways of many of the combustion and petroleum by-products. PAHs are well researched and abundant data are available, though not all of it is specific to Oregon.

Recommendations for Improving Catalog of Available Data

In developing the Toxic Reduction Strategy for PAHs, it may be beneficial to compile more research about the individual PAHs. There is research that suggests the environmental behavior and fate or petrogenic and pyrogenic PAH compounds may be significantly different. It could be beneficial to invest more time into exploring those differences and how they might affect a Toxics Reduction Strategy for PAHs as a whole.

Consumer Product Constituents

Focus List Selection

Only a handful of pollutants categorized as Consumer Product Constituents are found on the focus list. None of the pollutants in this category are listed in the Air Quality division, but the majority are listed in multiple programs in both Land and Water Quality divisions. The exception to this pattern is found with the phthalates. Phthalates are listed as a group in several land quality programs, while the individual phthalates are listed in the Water Quality division.

Production and Use

Phthalates are widely used as a plasticizer, and are found in many household products, building materials, personal care products, medical products, packaging, toys and electronics (ATSDR 1995; Rudel 2009).

Triclosan is used as a broad-spectrum antibacterial agent on commercial, institutional, and industrial, residential, and public access premises. It is also used as a material preservative in a variety of household products and is a minor ingredient in some pesticides.

Bisphenol-A is used as an intermediate in a wide variety of plastics. It is also used as an intermediate product in the production of resins and flame retardants.

Diethyltoluamide, N, N- (DEET) is the active ingredient in many widely-used insect repellants.

Nonylphenol, 4- (& ethoxylates) is a degradation product of Nonylphenol Ethoxylates(NPE). NPE is used in a variety of consumer product applications as well as in industrial settings in products such as surfactants, detergents, wetting agents, dispersants, defoamers, de-inkers, and antistatic agents (Servos 2003).

Sources, pathways, and affected media

Generally, the listed consumer product constituents are released either during the intended use of the product, or its subsequent disposal. The affected media depends on the nature of the chemical, although water resources are the most consistently affected by consumer products, as many of these products are washed down the drain, or enter groundwater through landfill leachate.

Environmental presence

Many consumer product constituents are considered emerging contaminants. Environmental monitoring data are limited. All have been reported in at least two of the three major databases of Oregon detections: ECSI, LASAR and USGS NWIS. Only half are stored in Oregon and reported to the State Fire Marshall. Bis (2-ethylhexyl) phthalate is reported to be stored in high quantities, and has been detected in Hazardous Waste generation data, along with Diethylphthalate, although it is reportedly stored only in low quantities in Oregon. The bulk of the monitoring data available has been collected from national or international sources, where the environmental effects of consumer products has been under scrutiny for some time. The ATSDR database contains thorough background information regarding production, use, sources and pathways of about half of the compounds in this category.

Recommendations for Improving Catalog of Available Data

Developing a Toxic Reduction Strategy for the Consumer Product Constituents would benefit from significantly more research and environmental monitoring. One of the limitations of categorizing the available data is that the impacts to human and ecological health are still debated. Until the scientific community generally accepts the toxic effects of these compounds, it will be difficult to categorize and defend monitoring detections as significant. It would also be helpful to be able to estimate use of the consumer products, perhaps through product sales, as well as get more information about the quantity of each chemical in each product. In many cases the levels of use could be used to directly estimate the levels of release to the environment.

Current Use Pesticides

Focus List Selection

Most of the Current Use Pesticides on the focus list are listed under multiple water quality programs, as well as the Household Hazardous Waste Program (HHW) in the Land Quality Department. Pentachlorophenol, widely used as a wood preservative, is listed under six different programs in the Land and Water Quality divisions.

Production and Use

The pesticides listed here are all widely used as herbicides, insecticides, fungicides. Many are also found in household products. Pentachlorophenol is also used as a wood preservative.

Sources, pathways, and affected media

Current Use Pesticides are released to the environment primarily during their intended uses, as herbicides, pesticides or insecticides. The majority of the pesticides are discharged to land and surface water through urban and agricultural runoff. Household products containing the pesticides are often washed into the municipal sewage systems. A small quantity of two of the current use pesticides is released as emissions to the atmosphere from wastewater effluent.

Environmental presence

In comparison with the other Focus List categories, the environmental monitoring data for the Current Use Pesticide category is the most abundant and evenly distributed. About half of the pesticides on the Focus List are reported by the State Fire Marshall to be used and stored in high levels in Oregon. Only two pesticides have been reported in Hazardous Waste Generation. All of the pesticides have been reported to be present in Oregon by the USGS NWIS. All but one of the compounds was reported in the LASAR database while only a few are included in ECSI. TRI data are very limited, however estimated release data can be obtained through PURS, as the majority of the pesticides are released to the environment during their intended use. PURS data are available for all but three of the Current use Pesticides. In addition to environmental monitoring databases, EPA reports and scientific journal articles were available that addressed pesticide contamination within Oregon. There were several sources of data from outside Oregon; however the abundance of local data overshadows the contribution of data to this category.

Recommendations for Improving Catalog of Available Data

Pesticide use and release to the environment was fairly well tracked and documented for the two years that PURS was funded. Restoring funding to PURS would benefit the development of a Toxic Reduction Strategy, as would gathering more quantitative information on use and disposal of household products, since that may be a significant source of the environmental contribution.

Flame Retardants

Focus List Selection

The Flame Retardant category is made up exclusively of Polybrominated Diphenyl Ether (PBDE) congeners. As a group, PBDEs are listed as a priority in the Cleanup Program of the Land Quality division, as well as two programs in the Water Quality Division.

Production and Use

PBDEs are used as additive flame retardants in thermoplastics. The commercial pentaBDE product is used predominantly (95–98%) for flame retardant purposes as an additive in consumer products manufactured by the furniture industry. Historical uses of commercial pentaBDE included coatings for specialty textiles, printed circuit board components, hydraulic and oilfield completion fluids, and rubber products. However, all of these uses have been discontinued in recent years. In the past, automotive and airplane seating cushions contained FPUF with commercial pentaBDE. However, this use was discontinued in the early 1990s (ATSDR 2004).

Sources, pathways, and affected media

Additive flame retardants are physically combined with the polymer material being treated rather than chemically combined (as in reactive flame retardants). This means that there is a possibility that they may diffuse out of the treated material to some extent.

Releases from to the environment include leaching from in-use or discarded products, combustion, or incineration of in-use or discarded products. PBDEs may be released into the environment from their manufacture and use in a wide range of consumer products. PBDEs are released to land (i.e., landfills) as waste from their manufacture (both raw material and polymer) and as municipal wastes with the disposal of consumer products. In the future, the disposal of plastic consumables containing PBDEs to landfills is likely to increase in the United States and elsewhere in the world. Since pentaBDE technical mixtures are additive flame retardants, they may be subject to volatilization or leaching from the polymer matrix during the lifetime of the use of the foam article. Industrial and urban effluents are significant sources of PBDEs to surface waters and sediments. PBDEs are also released to farmland with their disposal as biosolids (ATSDR 2004).

Environmental presence

The Flame Retardants category is populated entirely by PBDEs. The category lists PBDEs as a whole as well as ten individual congeners. This category has the least available monitoring data both within and outside of Oregon. Some local data exists and is cited primarily in LASAR and DEQ and EPA monitoring program reports. Monitoring data regarding individual PBDEs congeners is minimal. Only one congener was not reported in any data sets considered, while most were reported in only two or three. Only half of the PBDEs have been reported in local monitoring data. None of the PBDEs are stored in Oregon or reported in Hazardous Waste Generation data. There are a few sources of monitoring data from outside of Oregon including detections in particulate air quality studies and in human tissue. The ATSDR database provided thorough background information regarding production and use, as well as sources and pathways of PBDEs as a whole, but did not address the congeners individually.

Recommendations for Improving Catalog of Available Data

To better inform the development of a Toxic Reduction Strategy for flame retardants, further research is needed on the quantity of release to the environment. While some data exist that addresses PBDEs as a group, little data or research has been cited that addresses the PBDE compounds individually.

Industrial Chemicals and Intermediates

Focus List Selection

This group is mostly populated with Polychlorinated Biphenyls (PCBs). As a group, PCBs are listed under seven different programs in the Land and Water Quality divisions. Ammonia is listed in multiple Water Quality programs.

Production and Use

PCBs are no longer produced or used in the United States, except in very limited applications. Prior to 1974, PCBs were used both for nominally closed applications such as capacitor and transformers, and heat transfer and hydraulic fluids, as well as and in open- end applications such as flame retardants, inks and dyes, adhesives, paints, plasticizers, and insulators (ATSDR 2000).

Ammonia is both manufactured and naturally occurring. It is used primarily in agricultural fertilizers. A smaller proportion is used in a variety of applications, including water purification, refrigerants, household cleaners, corrosion inhibitors, and in the manufacture of pharmaceuticals and explosives. There are 2338 facilities that manufacture or process ammonia in the U.S. Maximum production reported in 1999 at16.6 million metric tons (ATSDR 2004).

Sources, pathways, and affected media

Both PCBs and ammonia have been reported to impact air, land and water quality. PCBs have been released to the environment solely by human activity. Aroclors are no longer produced in the United States, except under exemption, and are no longer used in the manufacture of new products. Because PCBs are no longer manufactured or imported in large quantities, significant releases of newly manufactured or imported materials to the environment do not occur. Rather, PCBs predominantly are redistributed from one environmental compartment to another. Some PCBs may be released to the atmosphere from uncontrolled landfills and hazardous waste sites; incineration of PCB-containing wastes; leakage from older electrical equipment in use; and improper disposal or spills. PCBs may be released to water from accidental spillage of PCB-containing hydraulic fluids; improper disposal; combined sewer overflows or storm water runoff; and from runoff and leachate from PCB-contaminated sewage sludge applied to farmland. PCBs may be released to soil from accidental leaks and spills; releases from contaminated soils in landfills and hazardous waste sites; deposition of vehicular emissions near roadway soil; and land application of sewage sludge containing PCBs (ATSDR 2000).

Ammonia occurs at low background levels in all types of environmental media. Ammonia is released to the atmosphere in large quantities by the decay of livestock manure in CAFOs, and from volatilization during production, transport and storage of ammonia, fertilizers and biosolids. It has also been found in coal burning emissions and vehicle exhaust. Natural sources to the atmosphere include volcanoes, forest fires and decomposition. The main sources of release to water are found WWTP effluent, and runoff from fertilized fields and CAFOs. Releases to soil are primarily from fertilizer applications, but also occur from high levels of feces or decaying organic matter on the soil (ATSDR 2004).

Environmental presence

When examined as a group, there are more Oregon-specific monitoring data for PCB than any other compound on the Focus List, as well as data from outside Oregon. The local data are cited primarily in DEQ and EPA monitoring programs. Monitoring data detecting individual PCB congeners are very limited. A handful of the individual PCBs were cited in LASAR and USGS, while others have only been detected in human or osprey tissue. None of the PCBs are stored in Oregon or reported in Hazardous Waste Generation data. There are many sources of monitoring data from outside of Oregon. The ATSDR database provided thorough background information regarding production and use, as well as sources and pathways of PCBs as a whole, but did not address the congeners individually.

The environmental presence of ammonia is relatively well established, with quantitative data regarding storage, pesticide use and release in Oregon available. There was little data catalogued from outside of Oregon, but the ATSDR database provided thorough background information regarding production and use, as well as descriptions of ammonia sources and pathways to the environment.

Recommendations for Improving Catalog of Available Data

Development of a Toxics Reduction Strategy would benefit from further research on individual PCBs. Oregon-specific monitoring data for individual PCBs are also limited. While there is abundant data available that addresses large-scale use of ammonia, household and personal use could potentially make a significant contribution to the environment. A reduction strategy could benefit from further research in this area.

Legacy Pesticides

Focus List Selection

Eight pesticides were selected for inclusion on the Focus List, as well as a number of metabolites that have been detected in environmental monitoring data. While the metabolites are only listed under the Willamette Toxics monitoring program, the other pollutants in this category are priority pollutants in programs in the Land and Water Quality divisions.

Production and Use

Legacy Pesticides are no longer produced or used in the U.S. The compounds listed on the Focus List have been persistent in the Oregon environment as a result of their historic uses.

Sources, pathways, and affected media

Legacy pesticides were released to the environment during their intended use. Most can now be considered to be ubiquitous, persistent pollutants found in all types of environmental media as a result of historic widespread use.

Environmental presence

Legacy pesticides are not in use, production or storage, with the exception of Methoxychlor, which is reported to be stored in low quantities by the State Fire Marshall Database. Although they are not in use, six of the legacy pesticides are reported to release less than 1000 kg to the Oregon environment annually. All of the legacy pesticides have been detected for many years in environmental monitoring data collected in Oregon. While all of the pesticides have been reported in surface water data however, just over half have been reported in land quality data. Six of the fourteen listed legacy pesticides are reported in Hazardous Waste Generation data, several have been studied or reported in other DEQ programs, and a handful have been included in published journal articles that included research conducted in Oregon.

There were several sources of data from outside Oregon. The ATSDR database provided thorough background information regarding historic production and use, as well as sources and pathways of most of the legacy pesticides. Additionally, there were several reports of environmental detections in Washington.

Recommendations for Improving Catalog of Available Data

While several sources of data consistently address each of the legacy pesticides listed on the focus list, the weight of available data is clearly skewed towards certain more well-known legacy pesticides. Abundant data were available that addressed Dieldrin individually and DDT and Chlordane each grouped with their respective metabolites. However, their individual metabolites had the least amount of available data. Two DDT metabolites, 4, 4’-DDD and 4, 4’-DDE were the exception, each having nearly as many environmental detections as the group as a whole. Several other individually listed pesticides had limited available data, including Hexachlorobenzene and 2, 4, 5- Trichlorophenol. More research for these pesticides would provide a stronger, more balanced catalog of data to inform the development of a Toxics Reduction Strategy.

Metals

Focus List Selection

Of the nine metals listed on the Focus List, six of them are listed as program priorities in all three DEQ divisions. Only copper and silver are not considered to be a concern for air quality, while only Manganese is not listed as a priority in the Land Quality Department.

Production and Use

The metals listed on the Focus list have a wide variety of long-established uses. In some applications, use of metals is declining, due mostly to limited availability and increased costs. Consumer demands have matched increases in prices, however, in most cases, and the listed metals are still regularly used in the following applications:

Mercury is used in mining operations and industrial manufacturing, as well as in dental amalgam. There are no known uses for methyl mercury (ATSDR 1999).

Arsenic compounds are used mainly in the production of wood preservatives. It was also used in fertilizers, fireworks, herbicides, and insecticides (ATSDR 2007).

Cadmium, its alloys, and its compounds are used in a variety of consumer and industrial materials. Its dominant use is in active electrode materials in Ni-Cd batteries (ATSDR 2008).

Chromium is used for metal finishing, leather tanning, wood preservation, refractory and pigments. It is commercially produced at 3,567 facilities in the U.S., and is mined in Coos County, OR (ATSDR 2008).

Copper is used in metals and metal alloys for construction, electrical supplies, transportation and automotive, industrial machinery and consumer products. Copper sulfate compounds are also used as a fungicide (ATSDR 2004).

Lead is primarily used in the production of lead-acid. Other uses include lead alloys used in bearings, pipe for nuclear and x-ray shielding, cable covering, noise control materials; chemical resistant linings; ammunition; and pigments (ATSDR 2007).

Nickel is primarily used in alloys because it imparts to a product such desirable properties as corrosion resistance, heat resistance, hardness, and strength. The alloys are used in various applications including magnets, batteries, heating elements, pigments, coinage, plumbing, pumps and electrodes (ATSDR 2005).

Manganese is used in production of metals, ceramics and dry cell batteries, in fertilizers, animal feed, fireworks, matches and as a colorant for bricks. U.S. imported 610 metric tons in 2007 (ATSDR 2008).

Silver metal and silver compounds have been and still are used in a wide variety of ways. The current uses are varied and include photographic materials electronic products, batteries, jewelry, dental amalgam, antibacterial agents and water purification (ATSDR 1990).

Sources, pathways, and affected media

Mercury occurs naturally in rocks and soil, and is distributed throughout the environment by both natural and anthropogenic processes. Pathways of mercury into the environment include air deposition, soil erosion, runoff and industrial and municipal discharge. Mercury is emitted from wrecking yards, coal fired power plants, smelting, production of cement, medical and municipal waste incinerators, and industrial/commercial boilers. Methylmercury is formed by bacterial methylation of inorganic mercury in aquatic environments (ATSDR 1999).

Arsenic occurs naturally in rocks and soils. Anthropogenic releases come primarily from Industrial wood treatment facilities, leaching from treated wood products, application agricultural products, and releases from chicken CAFOs, where it is a feed additive. It has been detected in water, sediment, landfill leachate and wastewater (ATSDR 2007).

Cadmium is naturally occurring and is also found in industrial discharge. There are 6 facilities in Oregon that produce, process, or use cadmium and 4 that produce, process, or use cadmium compounds. It has been detected surface water, stormwater, groundwater, municipal influent & effluent, industrial effluent and landfill leachate in Oregon (ATSDR 2008; DEQ LASAR).

Chromium is released to the atmosphere are from metal and steel plating industrial emissions, and via combustion of coal, oil and gas. Contamination of water occurs from industrial effluents, atmospheric deposition, land erosion, and WWTP effluents. Releases to soil come from disposal in landfills of consumer products that contain chromium, agricultural and food wastes, and underground injection of industrial waste products. It has been detected in surface water and groundwater in Oregon (ATSDR 2008).

Copper is released into the environment from natural and anthropogenic sources. Atmospheric inputs include metal and wood production, combustion of waste and petroleum products, and fertilizer production. Copper is released to water via stormwater and surface runoff, natural weathering, erosion, atmospheric deposition, WWTP effluent, landfill leachate, agricultural runoff, mine runoff, and in aquatic vegetation management in lakes and ponds. Releases to soil originate from mine tailings, municipal waste and landfills. It has been detected in surface water, groundwater, and landfill leachate in Oregon. (ATSDR 2004)

Lead occurs naturally in rocks and soils. It is released to the environment by chipping of lead-based paint on old buildings, industrial discharges, incineration of lead-containing products, improper disposal or recycling of lead-acid batteries. It has been detected in municipal influent & effluent, surface water, stormwater, groundwater, industrial effluent and landfill leachate in Oregon (ATSDR 2007).

Nickel is released to the environment by natural and anthropogenic activities. The burning of residual and fuel oil is responsible most anthropogenic emissions, followed by nickel metal refining, municipal incineration, steel production, other nickel alloy production, and coal combustion. It has been detected in surface water, sediment, and industrial effluent in Oregon (ATSDR 2005).

Manganese is ubiquitous in the environment, and human exposure arises from both natural and anthropogenic activities. It occurs naturally in more than 100 minerals. Manganese is released to the environment from industrial emissions, fossil fuel combustion, and erosion of manganese-containing soils. Manganese may also be released to the environment through the use of MMT as a gasoline additive. The general population is exposed to manganese primarily through food intake. It has been detected in surface water, groundwater, and sediment in Oregon (ATSDR 2008).

Silver is released to air and water through natural processes such as the weathering of rocks and the erosion of soils. Important sources of atmospheric silver from human activities include the processing of ores, steel refining, cement manufacture, fossil fuel combustion, municipal waste incineration, and cloud seeding. Ore smelting and fossil fuel combustion emit fine particles of silver that may be transported long distances and deposited with precipitation. The major source of release to surface waters is effluent from photographic processing. It has been detected in surface water and sediment in Oregon (ATSDR 1990).

Environmental presence

About half of the metals on the Focus List are used and stored in moderate to high levels in Oregon, and all have been reported in local environmental monitoring data. Copper, nickel and manganese were the only metals not reported in Hazardous Waste Generation data, but each of them are listed as being in high use by the State Fire Marshall database. Arsenic, Cadmium and Chromium are the only metals not reported in the USGS NWIS database in Oregon. All of the compounds were reported in the ECSI and LASAR databases. Silver was the only metal not reported in Oregon TRI or EI data, but it has been detected in the environment. Environmental monitoring data for the metals category is relatively abundant when compared to the other Focus list categories. Each of the metals on the list is cited in a number of Oregon- specific datasets, most of which have detected all of the metals in the category. In addition to environmental monitoring databases, several scientific journal articles were available that addressed metal contamination within Oregon.

There were several sources of data from outside Oregon. The ATSDR database provided thorough background information regarding production, use, sources and pathways of the metals. Additionally, there were several reports of environmental detections in Washington.

Recommendations for Improving Catalog of Available Data

There is relatively abundant research and monitoring data for metals in the Oregon environment. Additional data would strengthen a Toxics Reduction Strategy, but if limited by time, research in other Focus List categories should be prioritized.

Volatile Organic Compounds

Focus List Selection

There are seven different pollutants on the Focus List that are categorized as Volatile Organic Compounds (VOCs). All are listed in multiple programs and divisions. Only Toluene is not considered a priority for the Air Quality division, while only Formaldehyde is not listed under a Water Quality Program.

Production and Use

Tetrachloroethylene is commercially important as a solvent and as a chemical intermediate. It is used in textile processing, dry cleaning, and to clean metal products (ATSDR 1997).

Trichloroethylene is used as a solvent and degreaser and as a chemical intermediate. Trichloroethylene is used by the textile processing industry and in adhesives, lubricants, paints, pesticides, and cold metal cleaners. Various consumer products also contain trichloroethylene (ATSDR 1997).

Benzene has been used extensively as a solvent in the chemical and drug industries, as a starting material and intermediate in the synthesis of numerous chemicals, and as a gasoline additive. Benzene recovered from petroleum and coal sources is used primarily as an intermediate in the manufacture of other chemicals and end product (ATSDR 2007).

Ethylbenzene manufactured in the United States is primarily used in styrene production, while the remainder is exported or sold in solvent applications. Minor uses of ethylbenzene include use as a solvent, as a constituent of asphalt and of naphtha, and in fuels (ATSDR 2010).

1,4- Dichlorobenzene has been used principally as a space deodorant for toilets and refuse containers, and as a fumigant for control of moths, molds, and mildews. It is also used as a chemical intermediate (ATSDR 2006).

Formaldehyde has been used for many years in consumer goods to deter spoilage caused by microbial contamination. It has been used as a preservative in household cleaning agents and detergents. In the agricultural industry, formaldehyde has been used in fumigants, pesticides and fertilizers (ATSDR 1999).

Toluene is widely used and produced for use as a fuel additive. About one-third toluene is used as a solvent in paints, coatings, adhesives, inks, and cleaning agents. Small amounts of toluene go into the production of polymers used to make nylon, plastic soda bottles, and polyurethanes. Toluene is also used as a starting material in the synthesis of trinitrotoluene (TNT). The remainder is used for pharmaceuticals, dyes, nail polish, and the synthesis of organic chemicals (ATSDR 2000).

Sources, pathways, and affected media

Tetrachloroethylene is released to the environment via industrial emissions, notably dry cleaning, and from building and consumer products. Releases of tetrachloroethylene to the atmosphere account for 99% of all environmental releases. Emissions to the atmosphere may occur in disposal and incineration. Aqueous wastes front dry cleaning and solvents containing the compound end up at waste treatment facilities, and it also enters the environment in landfill leachate (ATSDR 1997).

Trichloroethylene is emitted to the atmosphere primarily in degreasing operations and gaseous emissions from landfills. Other emission sources include manufacturing and solvent evaporation losses from adhesives, paints, coatings, and miscellaneous uses. Release of trichloroethylene also occurs at treatment and disposal sites. Water treatment facilities may release trichloroethylene from contaminated water through volatilization and air-stripping procedures Trichloroethylene is released to aquatic systems from industrial discharges of waste water streams and in landfill leachate (ATSDR 1997).

Benzene is released to the environment by both natural and industrial sources, although the anthropogenic emissions are undoubtedly the most important. Emissions of benzene to the atmosphere result from gasoline vapors, auto exhaust, and chemical production and user facilities. Benzene is released to water and soil from industrial discharges, landfill leachate, and gasoline leaks from underground storage tanks. Benzene is released to water from the discharges of both treated and untreated industrial waste water, gasoline leaks from underground storage tanks, accidental spills during marine transportation of chemical products, and leachate from landfills and other contaminated soils. Major anthropogenic sources of benzene include environmental tobacco smoke, automobile exhaust, automobile refueling (ATSDR 2007).

Ethylbenzene is an aromatic hydrocarbon naturally present in crude petroleum. It is also a combustion byproduct of biomass. It is widely distributed in the environment because of human activities such as the use of fuels and solvents and through chemical manufacturing and production activities. It is also present in trace amounts in some water supplies and food items. Ethylbenzene releases to the air especially in indoor environments can occur with the use of consumer products, cigarettes, pesticides and other fuels. It is also released to soil and water from leaking petroleum tanks and fuel spills (ATSDR 2010).

1,4- Dichlorobenzene is primarily released to the atmosphere. It is also released to land in the disposal of industrial waste in landfills, application of sewage sludge containing 1,4-DCB to agricultural land, and atmospheric deposition (ATSDR 2006).

Formaldehyde is released to outdoor air from both natural and industrial sources. Atmospheric releases are primarily a result of combustion. Pressed wood products contribute to indoor formaldehyde levels. Common indoor combustion sources include gas burners and ovens, kerosene heaters, and cigarettes. Formaldehyde is released to water from the discharges of both treated and untreated industrial waste water from its production and from its use in the manufacture of formaldehyde-containing resins. Formaldehyde is released to soils through industrial discharges and through land disposal of formaldehyde-containing wastes (ATSDR 1999).

Toluene is released primarily during the production, transport, and use of gasoline. Significant quantities are also released in association with the production, use, and disposal of industrial and consumer products that contain toluene. Small amounts are released in industrial waste water discharges and land disposal of sludge and petroleum wastes. Toluene used in paints, solvents, adhesives, inks, and similar products is also released to air upon use. Toluene may also be released during disposal processes, notably medical waste incineration. Toluene may be released to water from industrial discharges and urban wastes, or by spills and leaks of gasoline. Release of toluene to land may occur in association with gasoline spills, leaking underground gasoline storage tanks, or land disposal of municipal sludge or refinery wastes (ATSDR 2000).

Environmental presence

Each of the VOCs on the Focus List is used, stored and released in moderate to high levels in Oregon, and reported in environmental monitoring data. Releases to the environment of all VOCs with the exception of Dichlorobenzene were reported by the TRI and EI. The most significant releases are from benzene, which exceed the releases of other VOCs by one to four orders of magnitude. Over 20 million kilograms of VOCs are reported to be released to the Oregon environment annually. All of the compounds were reported in the USGS NWIS, ECSI and LASAR databases, while all but ethylbenzene have been reported in Hazardous Waste generation data. As a whole, there is only a moderate level of environmental monitoring data available for the VOC category; however, the bulk of the data are specific to Oregon. Most of the data sources overlap for many or all of the chemicals on the list.

There were several sources of data catalogued from outside of Oregon. The ATSDR database and EPA reports provided thorough background information regarding production, use, sources and pathways of the VOCs. Additionally, there were several reports of environmental detections in Washington.

Recommendations for Improving Catalog of Available Data

There is relatively abundant research and monitoring data for VOCs in the Oregon environment. Additional data would strengthen a Toxics Reduction Strategy, but if limited by time, research in other Focus List categories should be prioritized.

Synthesis

The compilation of research for this product provided a good starting point to inform the development of the Toxics Reduction Strategy. More monitoring and research will be necessary as the strategies for individual chemicals are formed. These documents will help DEQ to decide where the priorities lie for program development, continued research, new monitoring programs. By compiling all available data into a consolidated, accessible format, DEQ will be able to more easily identify and prioritize the steps needed to complete the Toxics Reduction Strategies for each of the listed categories.

While each category revealed unique data gaps, a deficiency that all categories have in common are quantifiable estimates of the release of each pollutant to the environment. The toxics reduction strategies will be much more effective if DEQ can identify not only how a toxic compound enters the environment, but in what quantity. With that information, DEQ will be able to more easily identify reduction priorities. However, in most cases, that information was either incomplete or unavailable. In addition to this deficiency, the other gaps in data became apparent as the tables were compiled for each category.

Combustion and Petroleum By-Products

Combustion and petroleum by-products are produced in a variety of regular activities throughout Oregon, and the majority of the listed chemicals in this category have been detected in the Oregon environment. There is a relatively large amount of research available that addresses combustion by-products as a group, but limited information exists about individual PAHs, particularly petrogenic PAHs. More research about the behavior of individual PAHs once they enter the environment may be necessary. It also may be necessary to collect more monitoring data on the handful of individual PAHs that are not currently being tested for in monitoring studies.

Consumer Product Constituents

Consumer product constituents are generally released to the environment during their intended use in household products, or their subsequent disposal. As a result, it is difficult to estimate the quantity of these contaminants entering the environment, especially when manufacturers do not always have to report the quantity of the chemical used. Despite the lack of quantifiable release data, every one of the chemicals in the category has been detected in the Oregon environment. However, most of the detections come from a very limited range of studies. Scientific literature covering the listed consumer product constituents is available, though much of it is from Europe. As these are considered emerging contaminants, it might be productive to continue the literature review to see if new research is available. In addition, it would be beneficial to collect more monitoring data. It would also be helpful to quantify the release to the environment, perhaps through a market-based study of the consumer products known to contain these contaminants.

Current Use Pesticides

Much of Oregon's land use is agricultural, as such there are significant quantities of pesticides used throughout the state. Generally these pesticides are released to the environment during their intended use. The purchase, storage and use of the pesticides for agricultural use is heavily regulated, and thus carefully tracked and reported. Some of the pesticides are contained in household products, which may be a source of release worth quantifying, if possible. Each of the listed pesticides has been reported in environmental monitoring data in Oregon. For the most part, abundant research is available that addresses each of the pesticides listed in this category. When compared with the other categories on the Focus List, this category is supported by a fairly complete set of data to inform the Toxics Reduction Strategy.

Flame Retardants

This category is populated entirely by PBDEs, for which the available data are limited. Data that addresses PBDEs as a group are somewhat available, but research that addresses them individually is very limited. Chemicals listed individually in this category need significantly more research to properly inform a Toxics Reduction Strategy.

Industrial Chemical and Intermediates

This category is populated with mostly PCBs. Unlike the PBDEs, each of the individual PCBs listed has been detected in Oregon environmental monitoring data. However, there is no quantifiable data describing release to the environment, nor is there much literature describing the pathways through the environment, for the individual PCBs. As it is established that each of the PCBs are present in Oregon, the focus of future research should include estimates of release, and the behavior of individual PCBs in the environment.

Legacy Pesticides

Although no longer in use, many legacy pesticides persist in the local environment. Each of the legacy pesticides and listed metabolites has been detected in the Oregon environment. Abundant research is available on the behavior and impacts of most of the pesticides, with the exception of the chlordane metabolites. Since legacy pesticides are no longer in use, it is not necessary to assess the quantity of release to the environment for this category.

Overall, DEQ has a relatively large amount of monitoring data and scientific research available to inform a toxics reduction strategy for the legacy pesticides.

Metals

Metals are present in Oregon both naturally, and due to a variety of anthropogenic activities. Each of the listed metals has been thoroughly researched, with plenty of scientific literature available, as well as Oregon-specific monitoring data. Further research in this category should not be prioritized if resources are limited, as a toxics reduction strategy for metals is currently well supported by literature and data.

Volatile Organic Compounds

Volatile organic compounds are released to the Oregon environment from solvents, consumer products, petroleum products, fumigants, and other uses. Like the metals category, the VOC category is also well supported by both scientific literature and monitoring data. This category also has specific release data for major sources available through the air toxics assessment program, which could help narrow down the focus of a targeted reduction strategy.

Moving Forward

The completed *Table of Data Sources* will help direct future research and planning for the Toxic Reduction Strategy. The narrative descriptions of *Uses, Sources, and Pathways* provides a foundation for general discussions and interaction with outside parties, such as the stakeholder groups developed to participate in the development of the Toxics Reduction Strategy. The *Environmental Presence* data provides a starting point for the more detailed planning, as it helps to illustrate potential health concerns, the relative magnitude of environmental releases, the affected environmental compartments, and the relative abundance of available research addressing each Focus List chemical.

The successful implementation of an agency-wide Toxics Reduction Strategy would have lasting impacts on environmental integrity and human health, as well as improve the coordination and efficiency of DEQ resources. A coordinated approach to management of toxics, throughout all environmental compartments, could produce a more efficient, successful strategy to improving the quality of the Oregon environment.