Multiyear PBT Chemical Action Plan Schedule

FINAL

March 2007

Department of Ecology Publication No. 07-07-016

This report is available on the Department of Ecology home page on the World Wide Web at [*http://www.ecy.wa.gov/biblio/0607025.html*](http://www.ecy.wa.gov/biblio/0607025.html)

Multiyear PBT Chemical Action Plan Schedule

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Executive Summary

One of four current strategic priorities for the Department of Ecology (Ecology) is the reduction of toxic threats. Of particular concern are persistent, bioaccumulative toxins (PBTs), a group of chemicals whose distinctive properties pose a unique threat to our society and environment. In December, 2000 Ecology released its *PBT Strategy*, which identified actions to reduce and phase-out existing sources of risk to human health and the environment caused by PBTs. Activities to address PBTs include the development of a "PBT rule" (WAC 173-333), which was finalized earlier in 2006. Created at the direction of then-Governor Locke and the 2004 Legislature, Ecology developed this rule to establish specific criteria for identifying PBTs and a clear process for developing chemical action plans (CAPs) to address their impacts. CAPs for specific high-priority chemicals are the primary means by which specific reduction actions and activities will be developed and implemented.[1]

The PBT rule includes a list of 27 chemicals (comprised of individual PBTs, PBT chemical groups and metals of concern), referred to as the "PBT List."[2] The rule describes a requirement for Ecology, in consultation with the Department of Health (Health) to develop a "multiyear schedule" for the preparation of CAPs. A process is outlined for prioritizing the PBT List chemicals for action and explaining the rationale for their ranking, and laying out timelines for completion. The result of that process is this Multiyear Schedule.

Our overarching guideline throughout this process was the stated goal of the rule: *to reduce and phase-out PBT uses, releases and exposures in Washington*. As we worked through the evaluation factors specified in the rule (described below) we kept asking, is this a chemical for which we could really make a difference? Can we affect significant changes on the ground, in the real world? Where is the most effective use of our time and energy? And additionally, we thought about how work on specific chemicals could further advance our overall knowledge of reducing and phasing-out PBTs and other toxic chemicals.

After working through each of the evaluation factors and ranking each chemical on each factor, our final recommendations for the next three CAPs are **lead**, **polycyclic aromatic hydrocarbons (PAHs)** and **perfluorooctane sulfonates (PFOS)**. Each was ranked high on most criteria, and all are considered to have substantial opportunities for reduction.

- **Lead** consistently came out at the top of our ranking in most criteria. It is ubiquitous, and a great deal is known about how it is distributed in the environment, where it is used and how exposure occurs. There is an abundance of data on its detrimental health effects, particularly on children, and there are a wide range of known opportunities to reduce its use and impact.
- **PAHs** also came out high in most of our criteria ranking. PAHs are released during many commonplace activities, such as driving cars and burning trash in the backyard.

[1] To date, two CAPs have been produced: one for mercury (February 2003), and one for PBDEs (polybrominated diphenyl ethers) (January 2006).

[2] For ease of reading, the PBT List of individual chemicals, chemical groups and metals of concern are referred to throughout the document as "PBTs and metals of concern" or "chemicals," rather than delineating the three categories each time they are referenced.

While some of these activities are regulated to some degree, opportunities for further intervention are still substantial. There are significant human health concerns related to PAH releases, as well as environmental concerns, such as the finding of benthic invertebrate organisms in Puget Sound with increasing levels of PAHs in their tissue. PAHs are often formed as an unintended by-product of combustion. Addressing such issues in a PAH CAP will also support future work on other combustion by-products such as dioxins and furans, which also rank high.

- **PFOS** is a chemical of growing concern. It is used in a wide variety of products, including those marketed under the names Teflon, Stainmaster and Gore-Tex. Federal agencies such as the EPA and Centers for Disease Control and Prevention (CDC) are beginning to actively study its effects, and within a couple years there should substantial data with which to work. There is a lot of energy and interest around this chemical, and it is an opportunity both for us to learn a lot about it and in turn contribute to the efforts to reduce and phase-out its uses.

Evaluation factors

The PBT rule specifies five "evaluation factors" which are to guide the process of selecting which PBTs from the PBT List are of the highest priority for action (WAC 173-333-410). These factors provide the basic structure of the multiyear schedule evaluation process.

1) **Relative ranking**: the relative ranking assigned to each PBT based on Ecology's evaluation of information in eight categories:
    - Each chemical's persistence characteristics.
    - Each chemical's bioaccumulation characteristics.
    - Each chemical's human health toxicity.
    - Each chemical's ecological toxicity.[3]
    - Uses of the chemical in Washington.
    - Releases of the chemical in Washington.
    - The levels of the chemical present in the Washington environment.
    - The levels of the chemical present in Washington residents.
2) **Opportunities for reductions**: whether there are opportunities for reducing or phasing out uses, production or releases of the PBT.
3) **Multiple chemical releases and exposures**: scientific evidence on the combined effects of exposure to one or more PBTs and other substances commonly present in the Washington environment.
4) **Sensitive population groups and high-exposure populations**: scientific evidence on the susceptibility of various population groups, including the timing of the exposure and the cumulative effects of multiple exposures.
5) **Existing plans or regulatory requirements**: whether there are existing plans or regulatory requirements that reduce and phase out uses and releases of a particular PBT or group of PBTs.

Evaluation process

[3] Note that in the rule, the "toxicity" characteristic is not separated into human health and ecological toxicity; this distinction was made by Ecology, and the rationale is included in the section on PBT characteristics.

In order to effectively evaluate each chemical on each factor specified in the PBT rule, a technical committee comprised of professionals from Ecology and Health with expertise in chemistry, toxicology, environmental monitoring, public health and environmental policy was assembled. An internal Ecology and Health advisory group monitored the progress and helped oversee the process of developing this Schedule.

The first step in the multiyear schedule process was reviewing the PBT List and eliminating 11 chemicals from consideration: nine are already banned, and two have existing CAPs (mercury and PBDEs). To determine a relative ranking score (refer to #1, above), the remaining 16 PBTs were evaluated, based on extensive research in each of eight categories of information, and assigned a score. For each category, each chemical was ranked from 1 to 3 (low to high); if no information was available, they received an "NA." Note that the ranking was a *relative* ranking: each factor was only evaluated within the context of identified PBTs; it is not an evaluation of a PBT in relation to chemicals not on the PBT List. The rankings are therefore not precise, and best professional judgment often had to be relied upon.

All five evaluation factors were given equal weight. The relative ranking criteria allowed for some quantitative analysis; the remaining four evaluation factors – opportunities for reduction, multiple chemical releases and exposures, sensitive and high-exposure populations, and existing plans or regulatory requirements – were by necessity qualitative analyses. Data on multiple chemical releases and exposures were extremely limited, and ultimately we determined that there was insufficient data for this factor to assign rankings and impact our final decisions. We note throughout this document that our evaluations were often hindered by lack of data. Specific data limitations are addressed within each section.

We acknowledge that data limitations created a bias in our final ranking: those chemicals for which there was the most data are more likely to rank higher. However, this bias may be appropriate for selecting chemicals for action, since where there are more data, there are often more opportunities for reduction. More information does drive decisions. We have already developed a plan for additional research into the areas for which we are missing data, so that in three years (when we go through this process again) we will be able to make more solidly informed decisions.

Based on the available data for the evaluation factors, and using best professional judgment, the following chemicals will be the focus of the next three CAPs developed by Ecology and Health, on the schedule indicated:

PBT Chemical	CAP Development Schedule
Lead	Nov. 2006 – March 2008
Polycyclic aromatic hydrocarbons (PAHs)	Sept. 2007 – March 2009
Perfluorooctane sulfonates (PFOS)	Sept. 2008 – March 2010

Ecology will review and, as appropriate, update the multiyear schedule for chemical action plans at least once every three years (PBT rule, WAC 173-333-410(6)). The current schedule, and all subsequent ones, will be open for a 60 day public comment period before finalizing.

Glossary/Acronyms

1,2,4,5-TCB	1,2,4,5,-Tetrachlorobenzene
WQA	Water Quality Assessment List
ATSDR	Agency for Toxic Substances and Disease Registry
CalEPA	California Environmental Protection Agency
CAP	Chemical Action Plan
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation and Liabilities Act (Superfund)
ChV	Chronic Value
CPF	Cancer Potency Factor
Ecology	Washington State Department of Ecology
ECOTOX	(ECOTOXicology) EPA database which provides single chemical toxicology information for aquatic and terrestrial life
EPA	United State Environmental Protection Agency
EU	European Union
Health	Washington State Department of Health
HEAST	Health Effects Assessment Summary Tables (EPA)
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
ISIS	Integrated Site Information System – Used under the Model Toxics Control Act
LOEC	lowest-observed-effect-concentration
MTCA	Model Toxics Control Act
NGO	Non-governmental organization
NOEC	no-observed-effects-concentration
NRC	National Research Council
OEHHA	Office of Environmental Health Hazard Assessment (EPA)
PAH	Polycyclic Aromatic Hydrocarbon
PBDD/PBDF	Polybrominated dibenzodioxins and dibenzofurans
PBDE	Polybrominated diphenyl ether
PBT	Persistent bioaccumulative toxin
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran
PFOS	Perfluorooctane sulfonates
RfD	Reference dose
SEDQUAL	Sediment Quality Information System database
TSCA	Toxic Substance Control Act

Introduction

Persistent Bioaccumulative Toxins (PBTs) raise special challenges for our society and the environment because:

- PBTs remain in the environment for a long time without breaking down (*persistent*).
- Animals and people accumulate PBTs in their bodies, primarily from the food they eat. As these chemicals move up the food chain, they increase in concentration and linger for generations in people and the environment (*bioaccumulative*).
- Exposure to PBTs has been linked to a wide range of toxic effects in fish, wildlife and humans, including effects on the nervous system, reproductive and developmental problems, immune-response suppression, cancer, and endocrine disruption *(toxic).*
- PBTs can travel long distances and generally move easily between air, water and land.

This draft "Multiyear CAP Schedule" is the Washington State Department of Ecology's (Ecology) proposed schedule for developing chemical actions plans (CAPs) as part of implementing the agency's recently adopted "PBT rule" (WAC 173-333). It is a procedural rule, which establishes Ecology's process and procedures to address the subject of persistent bioaccumulative toxic substances and helps Ecology set internal priorities in addressing PBTs. The PBT rule is part of the state's efforts to protect the people and environment of Washington by reducing exposure to these chemicals. It is the first rule of its kind in the U.S.[4]

This draft document lays out the planned schedule for the next three calendar years and provides the rationale for, and supporting documentation on, how Ecology arrived at the prioritization of chemicals for action.

The document is organized sequentially around the five evaluation factors described in the PBT Rule. Beginning with a description of the initial prioritization steps, which narrowed the PBT rule's list of 27 PBTs (see Figure 1) down to 16 for consideration, the next sections examine the eight criteria that go into a Relative Ranking. These criteria include each chemical's Persistent, Bioaccumulative and Toxic characteristics, its uses and releases in Washington, and the levels present in Washington's environment and residents. The overall Relative Ranking for each chemical is then provided in a table.

Each chemical is then examined and ranked for each of the remaining four evaluation factors: opportunities for reductions, multiple chemical releases and exposures, sensitive population groups and high-exposure populations, and existing plans or regulatory requirements. Finally, a comprehensive table showing each chemical's ranking for each of the five evaluation factors is presented, with Ecology's final recommendations.

This document is the first Multiyear CAP schedule prepared under the PBT Rule. Ecology is to update the multiyear CAP schedule at least once every three years; the next update is therefore

[4] Details about the rule development process and related information can be found at: http://www.ecy.wa.gov/programs/eap/pbt/rule/index.html.

scheduled for September 2009. This document is a screening tool and as such, the analysis done during its development has not been as in-depth as what can be expected during development of Chemical Action Plans.

A draft multiyear CAP schedule was made available for 60 days of public review and comment from September 20 to November 20, 2006. Ecology reviewed all public comments received on the draft multiyear schedule and notified the public of the final decision through an announcement published in the Washington State Register and by posting on the Ecology PBT web site (http://www.ecy.wa.gov/). Written notification was provided to all to individuals or organizations who submitted comments on the draft multiyear CAP schedule.

Figure 1. Chemicals and Chemical Groups on the PBT List.

Metals	**Flame Retardants**	**Banned Pesticides**	**Organic Chemicals**
Methyl-mercury	PBDEs Tetrabromobisphenol A Hexabromocyclododecane Pentachlorobenzene	Mirex Aldrin/Dieldrin Chlordane DDT/DDD/DDE Heptachlor epoxide Toxaphene Chlordecone Endrin	1,2,4,5-TCB Perfluorooctane sulfonates Hexachlorobenzene Hexachlorobutadiene Short-chain chlorinated paraffins Polychlorinated naphthalenes

Combustion By-Products	**Banned Flame Retardant**	**Banned Organic Chemical**	**Metals of Concern**
PAHs PCDDs PCDFs PBDDs/PBDFs	Hexabromobiphenyl	PCBs	Cadmium Lead

Initial PBT Prioritization Steps

The process of preparing a multiyear schedule began with a review of the 27 PBTs listed in the PBT rule ("the PBT List"). In accordance with evaluation factors regarding existing plans or regulatory requirements as described in the PBT rule (below), 11 chemicals were eliminated from consideration.

> *(2)(a)(v)* ***Existing plans or regulatory requirements****. Whether there are existing plans or regulatory requirements that reduce and phase out uses and releases of a particular PBT or group of PBTs.*
> *(2)(b) Ecology will not prepare CAPs if the department determines:*
> *(i) All uses and releases of the PBT are prohibited under other state and federal laws or regulations;*
> *(ii) There is credible scientific information to support a conclusion that the PBT is not used, released or present in Washington; or*
> *(iii) There are no available opportunities for reducing or phasing out the uses, releases or exposures of the PBT beyond levels required under other federal or state laws or regulations.* (PBT rule, WAC 173-333-410(2))

Specific rationales for elimination of 11 PBTs
Eight pesticides were eliminated because they are all banned: their uses and releases are prohibited under state of federal laws, and they have not been in use for 17 – 30-plus years. Although still frequently detected in the environment, recent monitoring trends suggest a gradual, long term decline. Opportunities for further reductions are limited to cleanup actions and the ongoing Washington State Department of Agriculture's "Waste Pesticide Program" pesticide disposal events. The eight pesticides eliminated are:

- **Aldrin/Dieldrin** – soil insecticide. Banned 1974.
- **Chlordane** – plant insecticide used on vegetables and fruits. Banned 1976.
- **Chlordecone** – chlorinated insecticide used on tobacco, banana and citrus trees. Banned in 1978.
- **DDT/DDD/DDE** – chlorinated insecticide used in agricultural and to control malaria, typhus, and other insect-transmitted diseases. Banned in 1973.
- **Endrin** – soil insecticide used to control corn root worms, beetles, termites, and ants. Banned in 1976.
- **Heptachlor/Heptachlor Epoxide** - soil insecticide used to control corn root worms, beetles, termites, and ants, and control mosquitoes and tsetse flies. Banned in 1988.
- **Mirex** – insecticide used for fire ant control. Banned in 1978.
- **Toxaphene -** chlorinated insecticide used on cotton, cereal grains, nuts and vegetables and to control ticks and mites in livestock. Banned in 1980.

Hexabromobiphenyl was also eliminated. It was banned in 1974. Used as a brominated flame retardant in synthetic fibers and molded plastics, it has been out of production for over 30 years. Like the banned pesticides, opportunities for further reductions are limited.

Finally, **Mercury** and **PBDEs** were eliminated from further consideration because chemical action plans have already been completed for these chemicals.

These decisions will be re-evaluated in subsequent schedules.

Existing plans and regulatory requirements are evaluated for the remaining 16 PBTs under consideration later in this document.

Note: It was decided to keep PCBs in the 16 PBTs for consideration, even though it is already banned. This is because it is still present in some older light ballasts, and is still frequently detected in the environment. Hexachlorobenzene, although not produced since 1976, is still produced as a by-product.

Determination of Relative Ranking:

PBT Characteristics

WAC 173-333-410(2) ***Evaluation factors****.*
(a) Ecology will consider the following factors when preparing the multiyear schedule:
(i) ***Relative ranking****. The relative ranking assigned to each PBT based on ecology's* ***evaluation of information on PBT characteristics****, uses of the chemical in Washington, releases of the chemical in Washington, the levels of the chemical present in the Washington environment, and levels of the chemical present in Washington residents.*

Having narrowed the rule's PBT List to 16 potential chemicals for chemical action plans, the next step was to determine an appropriate and representative value for each chemical's persistence (P), bioaccumulation (B) and toxicity (T), respectively. A recent comprehensive review of literature on P, B, and T characteristics done by the Washington State Department of Ecology (Ecology) provided the overall framework and some of the basic data.[5,6] Additional data on the P, B and T values were then evaluated through review of prominent scientific databases which have been extensively peer-reviewed and have broad acceptance in the evaluation of PBT characteristics. Sources include the U.S. EPA, the World Health Association, Syracuse Research's PBT Profiler, the Organization for Economic Co-operation and Development and the Agency for Toxic Substances and Disease Registry. (References are identified in Tables 4 and 6.)

As the review began, it was noted that the toxicity of a given chemical could be quite different for human beings than for other species. Toxicity was therefore examined separately for human health and for the environment. For the nine individual PBTs and metals of concern on the PBT List, there is only one form of the chemical: the P and B values used are therefore automatically the same for both human health and environment. In the case of chemical groups (such polychlorinated biphenyls, PCBs), a representative chemical had to be chosen. The most toxic chemical from the group was selected, and then the P and B values *for that chemical* were used for ranking, to represent the group. Therefore in some cases, the chemical selected as having the highest ecological toxicity was different from the PBT with the highest human health toxicity, and the P and B values for the chemical group vary accordingly.

Each chemical received two final "PBT characteristics" scores: one for its "PBT$_{\text{(Human Health)}}$" and another for "PBT$_{\text{(Ecological Toxicity)}}$." Each chemical was ranked on each characteristic (P, B and T) as a 1, 2, or 3 (low to high), with a maximum score of 9 possible for each toxicity. This information is summarized in Table 4 (human health toxicity) and Table 6 (ecological toxicity).

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[5] WA State Dept. Ecology, *Ecology PBT Working List: Responses to Public Comments on Appendix E*. June 2002. Ecology Publication No. 02-03-030. View at: http://www.ecy.wa.gov/biblio/0203030.html.
[6] Also used as a basic reference for P, B, T values: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC),* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/

For the final relative ranking (see Table 11), those chemicals with PBT characteristics scores of 7 or 8 were reassigned a total score of "3." Those with PBT characteristics scores of 5 or 6 were assigned a ranking of "2," and those with scores of 3 or 4 assigned a total score of "1." This was to keep the ranking system consistent for all the evaluation factors, which were ranked from 1 to 3. For the two metals of concern, cadmium and lead, persistence and bioaccumulation values are not applicable (NA) for reasons discussed below, and this is reflected in Tables 4 and 6. In early 2002, the Environmental Protection Agency (EPA) established a Science Advisory Board (SAB) to develop comprehensive cross-agency guidance for assessing the hazards and risks of metals. In March, 2002, Ecology committed to remain consistent with the final EPA Metals Assessment framework. In its draft report, the SAB concluded that the use of bioaccumulation factors and bioconcentration factors for national assessment or hazard ranking procedures for metals should not be used.[7] Additionally, the SAB determined that persistence is a problematic scientific issue for assessing metals hazards and risks.[8] Therefore, until the SAB and EPA provide final guidance in their metals assessment framework, Ecology will use the NA designation for the purposes of ranking lead and cadmium for persistence and bioaccumulation.

An explanation for how persistence and bioaccumulation values were ranked follows; a detailed description of determining the human health and ecological toxicity values begins on page 8. Resources used in developing persistence and bioaccumulation rankings can be found in Appendix A.

Persistence

In the PBT rule, "persistence" is defined as *the tendency of a chemical to remain in the environment without transformation or breakdown into another chemical form. It refers to the length of time a chemical is expected to reside in the environment and be available for exposure.* A chemical is persistent if it meets the following criteria (WAC 173-333-320(2)(a)):

> The chemical or chemical group can persist in the environment based on credible scientific information that:
>
> (i) The half-life of the chemical in water is greater than or equal to sixty days; or
>
> (ii) The half-life of the chemical in soil is greater than or equal to sixty days; or
>
> (iii) The half-life of the chemical in sediments is greater than or equal to sixty days.

Persistence values were ranked as follows:

[7] Environmental Protection Agency. 2006. SAB Report, Review of EPA's Draft Framework for Inorganic Metals Risk Assessment, January 25, 2006. Viewed at: http://www.epa.gov/sab/pdf/metals_sab-06002.pdf.

[8] Environmental Protection Agency. 2002. Letter from SAB Chair Dr. William Glaze to EPA Administrator Christine Todd Whitman, October 23, 2002. Viewed at: http://www.epa.gov/sab/fiscal03.htm.

Half-life greater than 10,000 days = 3
Half-life between 1,000 and 9,999 days = 2
Half life less than 1,000 days = 1

Bioaccumulation
In the PBT rule, "bioaccumulation" is defined as *the process by which substances increase in concentration in living organisms as they take in contaminated air, water, soil, sediment or food because the substances are very slowly metabolized or excreted.* A chemical is bioaccumulative if it meets the following criteria (WAC 173-333-320(2)(b)):

> The chemical or chemical group has a high potential to bioaccumulate based on credible scientific information that the bioconcentration factor or bioaccumulation factor in aquatic species for the chemical is greater than 1,000 or, in the absence of such data, that the log-octanol water partition coefficient (log Kow) is greater than five.

As stated above, both bioaccumulation factors (BAF) and bioconcentration factors (BCF) can be considered. A chemical may have both a BAF and a BCF, although the values will usually be different. EPA defines bioaccumulation as the net accumulation of a substance by an organism as a result of uptake from all environmental sources. A bioaccumulation factor is the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water. Bioconcentration is the net accumulation of a substance by an aquatic organism as a result of uptake directly from the ambient water through gill membranes and other external body surfaces. The bioconcentration factor is defined as the ratio (in L/kg) of a substance's concentration in tissue of an aquatic organism to its concentration in ambient water.[9] Both these factors are used to estimate a chemical's ability to concentrate up the food chain. The higher the BCF or BAF value, the more likely it is that the chemical in question will build up wildlife and humans.

If a chemical had both a BAF and a BCF, the higher relative value was used.
Bioaccumulation/bioconcentration was ranked as follows:
Values greater than 40,000 = 3
Values between 10,000 and 39,999 = 2
Values between 1000 and 9,999 = 1

Toxicity
Toxicity is defined in the PBT rule as *the degree to which a substance or mixture of substances can harm humans, plants or wildlife.* A chemical is toxic if it meets the following criteria (WAC 173-333-320(2)(c)):

> The chemical or chemical group has the potential to be toxic to humans or plants and wildlife based on credible scientific information that:
> (i) The chemical (or chemical group) is a carcinogen, a developmental or reproductive toxicant or a neurotoxicant;

[9] 40CFR132.2. Revised as of July 1, 2005.

(ii) The chemical (or chemical group) has a reference dose or equivalent toxicity measure that is less than 0.003 mg/kg/day; or

(iii) The chemical (or chemical group) has a chronic no observed effect concentration (NOEC) or equivalent toxicity measure that is less than 0.1 mg/L or an acute no observed effect concentration (NOEC) or equivalent toxicity measure that is less than 1.0 mg/L.

Each chemical or chemical group was assigned a separate ranking for human health and for ecological toxicity; therefore there are two "PBT" characteristic rankings for each chemical. A detailed explanation of how human health and ecological toxicity were evaluated and ranked follows.

Human Health Toxicity Evaluation

Human health toxicity refers to the potential health impacts resulting from exposure to chemicals. The current evaluation is based on published numerical toxicity values for cancer and chronic non-cancer effects. Cancer potency factors (CPFs) and non-cancer reference doses (RfDs) were used. Primary sources include the EPA's IRIS files, ATSDR Toxicological Profiles and California's EPA Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database.

Only oral CPFs and RfDs were used in order to address exposures associated with bioaccumulation, which is most likely via ingestion of animal-derived foods. Although exposures to PBTs may occur via other routes (e.g. inhalation, dermal contact), dietary exposure is generally considered more important.

Cancer and non-cancer effects of each PBT were rated separately, and then a single overall human health toxicity ranking score was determined for each PBT (a score from low to high, 1-3 points). The ranking method is based on the ranking model developed by Ecology as part of its preparation for the PBT rule.[10,11,12]

Assigning human health ranking values for cancer endpoints

Oral cancer potency factors (CPFs), also called cancer slope factors, are generally derived from laboratory animal studies and available human studies and are used to predict cancer risk from human exposures.[13] CPFs were collected from available sources (e.g. EPA, ATSDR, California EPA OEHHA). For chemical groups, the chemical with the highest CPF within the group was chosen to represent the group in the ranking.[14] For example, 3,3',4,4',5,5'-hexachlorobiphenyl (PCB 169) has the highest CPF value among the PCBs on the PBT List, so its CPF of 1560 $(mg/kg/day)^{-1}$ was chosen to represent PCBs when assigning a cancer ranking value.

CPFs for PBT chemicals are listed in Table 1. The ten available CPFs were divided into three groups, based on relative magnitude of each CPF. Specifically, the four PBTs with the highest CPFs were assigned a ranking value of 3, the three PBTs with the middle CPFs were assigned a

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[10] Washington State Department of Ecology, *Ecology PBT Working List: Responses to Public Comments on Appendix E*, June 2002.

[11] Washington State Department of Ecology. PBT Rule Advisory Committee Meeting, October 14, 2004. *Summary: Ecology's 2002 Proposal for Ranking and Prioritizing PBT Chemicals*. View at: http://www.ecy.wa.gov/programs/eap/pbt/rule/docs/14oct04/140ct04_ranking_prioritization.pdf

[12] Washington State Department of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/

[13] EPA's IRIS Glossary of terms for definition of slope factor available at: http://www.epa.gov/iris/gloss8.htm#s. **Slope factor:** An upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg-day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100.

[14] Note that CPF values are expressed as risk per mg/kg/day, in units of $(mg/kg/day)^{-1}$, versus RfDs which are expressed as an amount ingested per day (in units of mg/kg/day). RfDs are ranked as more potent with lower values, but CPFs are more potent with higher values.

ranking value of 2, and the remaining three PBTs with the lowest CPFs were assigned a value of 1. PBTs lacking available CPFs or equivalent values were not assigned a ranking value and are designated as "NA" (data not available) in Table 1.

Table 1. Cancer ranking

Table 1. Cancer ranking		
Chemicals	**CPF (mg/kg/day)$^{-1}$**	**Value For Ranking**
Cadmium	0.38	1
Hexabromocyclododecane (HBCD)	NA	NA
Hexachlorobenzene (HCB)	1.8	2
Hexachlorobutadiene (HCBD)	0.078	1
Lead	NA (B2)	NA
Pentachlorobenzene	NA (D)	NA
Perfluorooctane sulfonates (PFOS)	NA	NA
Polybrominated dibenzodioxins + furans (PBDDs/PBDFs)	156,000	3
Polychlorinated biphenyls (PCBs)	1560	3
Polychlorinated dibenzofurans (PCDFs)	75,300	3
Polychlorinated dibenzo-p-dioxins (PCDDs)	156,000	3
Polychlorinated naphthalenes (PCNs)	624	2
Polycyclic aromatic hydrocarbons (PAHs)	120	2
Short-chain chlorinated paraffins (SCCPs)	0.089	1
Tetrabromobisphenol A (TBBPA)	NA (B2)	NA
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	NA	NA

NA = (Data) Not Available. The EPA weight of evidence classification appears in parentheses after "NA," when available.
CPF = Cancer potency factor published by EPA, CA EPA or elsewhere. The source for each CPF used is provided in Appendix B.

Assigning human health ranking values for non-cancer toxicity

Reference doses (RfDs) are used to evaluate potential non-cancer health impacts in people resulting from chemical exposures.[15] Most RfDs used in this ranking were described previously

[15] EPA's IRIS Glossary of terms for definition of reference dose available at: http://www.epa.gov/iris/gloss8.htm#s. **Reference Dose (RfD):** An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. Generally used in EPA's noncancer health assessments. [Durations include acute, short-term, subchronic, and chronic and are defined individually in this glossary].

in Ecology's Technical Background Information for the PBT List.[16] In cases where a chemical had more than one RfD (e.g., cadmium), the RfD with the lowest value (most protective) was chosen for the purposes of ranking. For chemical groups (e.g. PCBs), the chemical with the lowest RfD within the group (e.g., 0.00002 mg/kg/day for Aroclor 1254) was chosen to represent the group in the ranking. In some cases, only one chemical within a group had an available RfD, so that chemical's RfD was chosen to represent the group (e.g. fluoranthene was chosen to represent PAHs).

RfDs for PBT chemicals are listed in Table 2. The chemicals were divided into three groups, based on natural breakpoints in the RfDs values:

Lowest RfDs = Ranking of "3"
Middle range RfDs (≥ 0.0002 and ≤ 0.0008) = Ranking of "2"
Highest RfDs = Ranking of "1"

Four PBTs scored a ranking of "3," five were ranked "2," and three received a value of "1." PBTs lacking available RfDs or equivalent values were not assigned a ranking value and are designated as "NA" (Data Not Available) in Table 2.

Table 2. Non-cancer ranking

Table 2. Non-cancer ranking

Chemicals	RfD (mg/kg/day)	Value For Ranking
Cadmium	0.0002	2
Hexabromocyclododecane (HBCD)	0.2	1
Hexachlorobenzene (HCB)	0.00005	3
Hexachlorobutadiene (HCBD)	0.0002	2
Lead	0.0005	2
Pentachlorobenzene	0.0008	2
Perfluorooctane sulfonates (PFOS)	NA	NA
Polybrominated dibenzodioxins + furans (PBDDs/PBDFs)	NA	NA
Polychlorinated biphenyls (PCBs)	0.00002	3
Polychlorinated dibenzofurans (PCDFs)	0.00000003	3
Polychlorinated dibenzo-p-dioxins (PCDDs)	0.000000001	3
Polychlorinated naphthalenes (PCNs)	NA	NA
Polycyclic aromatic hydrocarbons (PAHs)	0.04	1
Short-chain chlorinated paraffins (SCCPs)	NA	NA
Tetrabromobisphenol A (TBBPA)	0.2	1
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	0.0003	2

[16] WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/

NA = (Data) Not Available
RfD = Reference Dose, or equivalent value published by EPA, ATSDR, or other source. The reference for each RfD used in the ranking is provided in Appendix B.

Assigning an overall human health toxicity ranking; combining non-cancer and cancer rankings

Once each of the 16 PBTs under consideration were assigned two toxicity rankings (for non-cancer and cancer effects, respectively), the two scores were considered and a single ranking assigned. This single ranking is the overall human health toxicity ranking for each PBT. The single ranking, as shown in Table 3, was determined as follows:

- *If the chemical had both an RfD and a CPF ranking: the higher number was chosen.* (For example, if a chemical was ranked 3 for non-cancer and 2 for cancer, its overall ranking value is 3.)
- *If the chemical had only an RfD or a CPF ranking: the available ranking was chosen.* (For example, if a chemical has rank of 2 based on an RfD and does not have a CPF, the overall ranking value is 2.)
- *If the chemical had neither an RfD or a CPF: best professional judgment was used to determine the ranking.* PFOS chemicals currently do not have either an RfD or CPF. Using best professional judgment about the recently documented hazards of PFOS, this PBT chemical group was assigned an overall ranking value of 3, based on animal toxicity studies and occupational cancer studies.[17]

Table 3. Overall (non-cancer & cancer) human health toxicity ranking

Table 3. Overall (non-cancer & cancer) human health toxicity ranking

Chemicals **	Non-cancer ranking	Cancer ranking	Overall ranking
Cadmium	2	1	2
Hexabromocyclododecane (HBCD)	1	NA	1
Hexachlorobenzene (HCB)	3	2	3
Hexachlorobutadiene (HCBD)	2	1	2
Lead	2	NA	2
Pentachlorobenzene	2	NA	2
Perfluorooctane sulfonates (PFOS)	NA	NA	3*
Polybrominated dibenzodioxins + furans (PBDDs/PBDFs)	NA	3	3
Polychlorinated biphenyls (PCBs)	3	3	3
Polychlorinated dibenzofurans (PCDFs)	3	3	3

[17] Organization for Economic Co-operation and Development (OECD), 2002. *Co-operation on existing chemicals; Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts*.

Polychlorinated dibenzo-p-dioxins (PCDDs)	3	3	3
Polychlorinated naphthalenes (PCNs)	NA	2	2
Polycyclic aromatic hydrocarbons (PAHs)	1	2	2
Short-chain chlorinated paraffins (SCCPs)	NA	1	1
Tetrabromobisphenol A (TBBPA)	1	NA	1
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	2	NA	2

NA = (Data) Not Available
*Best professional judgment (see text above for explanation).
**Representative chemicals used for chemical groups:
1. PAHs: Fluoranthene used to represent non-cancer effects for group and dibenzo(a,h)pyrene and dibenzo(a,i)pyrene used to represent cancer effects for group.
2. PBDD/PBDFs: 2,3,7,8-tetrabromodibenzo-p-dioxin used to represent cancer effects for group.
3. PCBs: Aroclor 1254 used to represent non-cancer effects for group and 3,3',4,4',5,5' hexachlorobiphenyl used to represent cancer effects for group.
4. PCDDs: 2,3,7,8-tetrachlorodibenzo-p-dioxin used to represent non-cancer and cancer effects for group.
5. PCDFs: 2,3,4,7,8-pentachlorodibenzofuran used to represent non-cancer and cancer effects for group.
6. Polychlorinated naphthalenes: 1,2,3,4,6,7-hexachloronaphalene used to represent cancer effects for group.

Conclusion

Based on the ranking system described above for human health toxicity, the following six PBTs are ranked a "3":
- PCDDs
- PCDFs
- PCBs
- PBDD/PBDFs
- PFOS
- Hexachlorobenzene

The complete data on Persistence, Bioaccumulation and Human Health Toxicity are summarized in Table 4.

Table 4. Persistence(P), Bioaccumulation(B) and Human Health Toxicity (T) for PBT and metals of concern Chemicals *(Legend/Notes p19)*

Chemicals	CAS Number	P: Regional Half Life (Days)	P: Source	P: Rank-ing Score	B: BAF/ BCF Value	B: Source	B: Rank -ing Score	T: RfD (mg/kg/day) Non-cancer	T: CPF $(mg/kg/day)^{-1}$ cancer	T: Human Health Rank (Table 3)	TOTAL: P+B+ Human Health T
Cadmium	7440-43-9	NA	NA	NA	NA	NA	NA	0.0002	.38 (B1) *	2	2
Hexabromocyclododecane (HBCD)	25637-99-4	540	PBT Profiler	1	18,000	KemI	2	0.2	NA	1	4
Hexachlorobenzene (HCB)	118-74-1	7300	EPA 1999	2	18,620	EPA 1998	2	0.00005	1.8 (B2)	3	7
Hexachlorobutadiene(HCBD)	87-68-3	284	Howard	1	6918	EPA 1998	1	0.0002	.078 (C)	2	4
Lead	7439-92-1	NA	NA	NA	NA	NA	NA	0.0005	NA (B2)	2	2
Pentachlorobenzene	608-93-5	7800	EPA 1999	2	8314	EPA 1998	1	0.0008	NA (D)	2	5
Perfluorooctane sulfonates (PFOS) Ammonium Salt	29081-56-9	14,965	Env Can	3	5400	OECD	1	NA	NA	3	7
Polybrominated dibenzodioxins and furans (PBDD/PBDFs) (2,3,7,8 tetrabromodibenzo-p-dioxin)	50585-41-6	1600	PBT Profiler	2	3800	PBT Profiler	1	NA	156000 (B2)	3	6
Polychlorinated biphenyls (PCBs) (3,3'4,4'5,5' hexachlorobiphenyl)	32774-16-1	1600	PBT Profiler	2	74,000	PBT Profiler	3	0.00002	1560 (B2)	3	8
Polychlorinated dibenzofurans (2,3,4,7, 8 pentachlorodibenzofuran) (PCDFs)	57117-31-4	7300	EPA 1999	2	42,500	PBT Profiler	3	0.00000003	75300 (B2)	3	8
Polychlorinated dibenzo-p-dioxins (2,3,7,8 tetrachlorodibenzo-p-dioxin) (PCDDS)	1746-01-6	1600	PBT Profiler	2	34,000	PBT Profiler	2	0.000000001	156000 (B2)	3	7
Polychlorinated naphthalenes (hexachloronaphthalene) (PCNs)	1335-87-1	1600	PBT Profiler	2	240,000	PBT Profiler	3	NA	624	2	7
Polycyclic aromatic hydrocarbons (PAHs) (Fluoranthene) (PAHs)	206-44-0	540	PBT Profiler	1	1900	PBT Profiler	1	0.04	120 (2B)	2	4
Short-chain chlorinated paraffins (SCCPs)	85535-84-8	365	OSPAR	1	40,900	OSPAR	3	NA	.089 (2B)	1	5
Tetrabromobisphenol A (TBBPA))	79-94-7	1600	PBT Profiler	2	14,000	PBT Profiler	2	0.2	NA (B2)	1	5
Tetrachlorobenzene, 1,2,4,5 (1,2,4,5 TCB)	95-94-3	730	Mackay, et al.	1	4830	OSPAR	1	0.0003	NA	2	4

Ecological Toxicity Evaluation

Ecological toxicity refers to the impact chemicals have on organisms in the environment. The 16 PBTs under consideration include both individual chemicals as well as several classes of compounds, e.g. "PAHs" refers to an entire class of polyaromatic hydrocarbons. In order to provide a more detailed evaluation of ecological toxicity, 62 individual chemicals in total were researched for ecological toxicity.

Numerous criteria exist to evaluate toxicity. Initially, four common categories of toxicity values were evaluated: chronic, acute, multiple dose and reproductive. These values were determined for both aquatic and terrestrial life, for each PBT. In order to maintain consistency, a hierarchy for the target organisms was established when multiple toxicity values for a chemical existed. For terrestrial toxicity, doses administered orally to rats (oral rat tests) were used as the primary source when available, because oral rat test values are widely used for terrestrial toxicity values. If oral rat test data was not available, oral mouse tests were used, followed by oral monkey and other oral mammal test results.

For aquatic toxicity, the primary toxicity sources selected were salmonids and particular rainbow trout. If salmonid test data were not available, any other fish were used followed by fathead minnow and any other minnow species and, lastly, the highest level on the food chain of any remaining species if no fish or minnow species were available. The intent was to select organisms most commonly used for toxicity studies and to use those consistently, to minimize errors inherent in toxicity evaluations between different species. The tables in Appendix C summarize the available toxicity data for each PBT (including all PBTs within a chemical group), for chronic, acute, multiple dose and reproductive toxicity values. As is clear from the table, data gaps exist for the PBT chemicals evaluated.

Chronic toxicity impacts were selected as the best indication of overall toxicity of PBTs: they provide a good evaluation of toxicity, and are supported by the most data. Therefore, Chronic Value (ChV, the mean of the lowest-observed-effect-concentration, LOEC, and the no-observed-effects-concentration, NOEC) was used to determine relative chronic toxicity. (It is important to remind the reader that toxicity was only evaluated within the context of identified PBTs; it is not an evaluation of PBT toxicity in relation to chemicals not on the PBT List.)

For the PBT chemical groups PAHs, PBDD/PBDFs, PCBs, PCDDs, PCDFs, PCNs, and PFOSs, the lowest (most toxic) ChV was selected as the representative PBT for that group. When several of the compounds had the same ChV, all underwent a further evaluation. In those instances, the persistence (P) and bioaccumulative (B) factors were evaluated. The compound with the highest P and B was then selected as representative of the class.

Chemicals selected to represent the P, B and T (ecological toxicity) for chemical groups were:

1. PAHs: Dibenzo(a,h)pyrene (CAS # 189-64-0)
2. PBDDs/PBDFs: 2,3,7,8 tetrabromodibenzo-p-dioxin (CAS # 50585-41-6)
3. PCBs: 2,3',4,4',5,5' Hexachlorobiphenyl (CAS # 52663-72-6).
4. PCDDs: (1,2,3,7,8 pentachlorodibenzo-p-dioxin) (CAS # 40321-76-4)

5. PCDFs: 1,2,3,6,7,8 hexachlorodibenzofuran (CAS # 57117-44-9)
6. PFOSs: Ammonium Salt (CAS # 29081-56-9)
7. PCNs: Hexachloronaphthalene (CAS # 1335-87-1)

Four chemicals or groups of chemicals (hexachlorobutadiene, short-chain chlorinated parrafins, lead and cadmium) did not have ChV values; in these instances, NOEC values were used. NOEC is the highest observed PBT concentration that shows no adverse impact on the organism. NOEC values were selected as an alternative to ChV because they are typically lower figures than the ChV, and therefore are more conservative. (The lowest toxicity values, that is, the most toxic, were always used throughout this process.)

There were 11 chemicals for which no toxicity values could be found. However, there were chemicals in the same class for which toxicity values did exist. When toxicity values existed for several chemicals within each class, the lowest value (i.e. the most toxic) among the individual chemicals was assigned as the toxicity value for the whole group. If several compounds in a group possessed the same toxicity, a representative chemical was selected. In every case possible, the representative chemical for each group was the same as those selected for the persistence, bioaccumulation and human toxicity evaluation. This was to keep consistency across categories.

The results were then broken into three groups for ranking. Chemicals with:

toxicity values lower than 0.001 = 3
toxicity values between 0.01 and 0.001 = 2
toxicity values greater than 0.01 = 1.

Table 5 summarizes the ecological toxicity information.

<u>Conclusion</u>

Based on the ranking system described above for ecological toxicity, the following seven PBTs are ranked a “3”:

- Hexabromocyclododecane
- PAHs
- PBDDs/PBDFs
- PCBs
- PCDDs
- PCDFs
- Cadmium.

The complete data on Persistence, Bioaccumulation and Ecological Toxicity are summarized in Table 6.

Table 5. Ecological toxicity values and ranking.

PBT	ChV/NOEC (Mg/L)	Ranking
Individual PBTS		
Hexabromocyclododecane	0.00062	3
Hexachlorobenzene	0.01200	1
Hexachlorobutadiene	0.00650	2
Pentachlorobenzene	0.03800	1
Short-chain chlorinated paraffins	0.04000	1
Tetrabromobisphenol A	0.00300	2
Tetrachlorobenzene, 1,2,4,5-	0.12000	1
PBT Chemical Groups		
Perfluorooctane sulfonates (PFOS) (5 chemicals)	0.08600	2
Acid	0.09000	
Ammonium salt	0.00200	
Diethanolamine salt	0.00600	
Lithium salt	0.72000	
Potassium salt	NA	
Polybrominated dibenzodioxins and furans (PBDDs/PBDFs) (2 chemicals)		3
2,3,7,8-tetrabromodibenzo-p-dioxin	0.00035	
2,3,7,8-tetrabromodibenzofuran	0.00120	
Polychlorinated biphenyls (PCBs) (8 chemicals)		3
2,3',4,4',5 Pentachlorobiphenyl	0.00140	
2,3,4,4',5 Pentachlorobiphenyl	0.00140	
2,3,3',4,4' Pentachlorobiphenyl	0.00140	
3,3',4,4',5,5' Hexachlorobiphenyl	0.00044	
2,3',4,4',5,5' Hexachlorobiphenyl	0.00044	
2,3,3',4,4',5' Hexachlorobiphenyl	0.00044	
2,3,3',4,4',5 Hexachlorobiphenyl	0.00044	
2,3,3',4,4',5,5' Heptachlorobiphenyl	NA	
Polychlorinated dibenzo-p-dioxins (PCDDs) (7 chemicals)		3
2,3,7,8 Tetrachlorodibenzo-p-dioxin	0.00160	
1,2,3,7,8 Pentachlorodibenzo-p-dioxin	0.00050	
1,2,3,4,7,8 Hexachlorodibenzo-p-dioxin	NA	
1,2,3,6,7,8 Hexachlorodibenzo-p-dioxin	NA	
1,2,3,7,8,9 Hexachlorodibenzo-p-dioxin	NA	
1,2,3,4,6,7,8 Heptachlorodibenzo-p-dioxin	NA	
1,2,3,4,6,7,8,9 Octachlorodibenzo-p-dioxin	NA	
Polychlorinated dibenzofurans (PCDFs) (10 chemicals)		3
2,3,7,8 Tetrachlorodibenzofuran	0.00500	

PBT	ChV/NOEC (Mg/L)	Ranking
1,2,3,7,8 Pentachlorodibenzofuran	0.00160	
2,3,4,7,8 Pentachlorodibenzofuran	0.00160	
1,2,3,4,7,8 Hexachlorodibenzofuran	0.00025	
1,2,3,6,7,8 Hexachlorodibenzofuran	0.00025	
1,2,3,7,8,9 Hexachlorodibenzofuran	0.00050	
2,3,4,6,7,8 Hexachlorodibenzofuran	0.00025	
1,2,3,4,6,7,8 Heptachlorodibenzofuran	NA	
1,2,3,4,7,8,9 Heptachlorodibenzofuran	NA	
1,2,3,4,6,7,8,9 Octachlorodibenzofuran	NA	
Polychlorinated naphthalenes (PCNs) (5 chemicals)		2
Trichloronaphthalene	0.04400	
Tetrachloronaphthalene	0.01400	
Pentachloronaphthalene	0.00400	
Hexachloronaphthalene	0.00130	
Heptachloronaphthalene	NA	
Polycyclic aromatic hydrocarbons (PAHs) (16 chemicals)		3
3-Methyl chlolanthrene	0.00100	
7H-Dibenzo(c,g)carazole	0.02000	
Benzo(a)phenanthrene (Chrysene)	0.01900	
Benzo(b)fluoranthene	0.00600	
Benzo(g,h,i)perylene	0.00200	
Benzo(j)fluoranthene	0.00600	
Benzo(k)fluoranthene	0.00600	
Benzo(r,s,t)pentaphene	0.00074	
Dibenzo(a,e)pyrene	0.00074	
Dibenzo(a,h)pyrene	0.00074	
Dibenzo(a,h)acridine	0.01700	
Dibenzo(a,h)anthracene	0.00200	
Dibenzo(a,j)acridine	0.01700	
Fluoranthene	0.05500	
Indeno(1,2,3-cd)pyrene	0.00200	
Perylene	0.00600	

ChV = Chronic Value
NOEC = No-observed-effects-concentration
Mg/L = Milligrams per Liter
NA = (Data) Not Available.

Table 6. Persistence(P), Bioaccumulation(B) and Ecological Toxicity(T) for PBTs and metals of concern Chemicals *(Legend/Notes p 19)*

Chemicals	CAS Number	P: Regional Half Life (Days)	P: Source	P: Ranking Score	B: BAF/BCF Value	B: Source	B: Ranking Score	T: Ecological Toxicity Value (mg/L) (Table 5)	T: Rank-ing Score	T: Source	TOTAL: P+B+ Ecologi-cal T
Cadmium	7440-43-9	NA	NA	NA	NA	NA	NA	0.0007	3	ECOTOX	3
Hexabromocyclododecane (HBCD)	25637-99-4	540	PBT Profiler	1	18000	KemI	2	0.00062	3	PBT Profiler	6
Hexachlorobenzene (HCB)	118-74-1	7300	EPA 1999	2	18620	EPA 1998	2	0.012	1	PBT Profiler	5
Hexachlorobutadiene (HCBD)	87-68-3	284	Howard	1	6918	EPA 1998	1	0.0065	2	ECOTOX	4
Lead	7439-92-1	NA	NA	NA	NA	NA	NA	0.004	2	ECOTOX	2
Pentachlorobenzene	608-93-5	7800	EPA 1999	2	8314	EPA 1998	1	0.038	1	PBT Profiler	4
Perfluorooctane sulfonates (PFOS): Ammonium Salt	29081-56-9	14965	Env Can	3	5400	OECD	1	0.002	2	PBT Profiler	6
Polychlorinated biphenyls (PCB): 2,3',4,4',5,5' Hexachlorobiphenyl	52663-72-6	1600	PBT Profiler	2	56,000	PBT Profiler	3	0.00044	3	PBT Profiler	8
Polychlorinated dibenzofurans (PCDFs) (1,2,3,6,7,8 hexachlorodibenzofuran)	57117-44-9	7300	TRI	2	3600	PBT Profiler	1	0.00025	3	PBT Profiler	6
Polybrominated dibenzodioxins and furans (2,3,7,8 tetrabromodibenzo-p-dioxin) (PBDD/PBDFs)	50585-41-6	1600	PBT Profiler	2	3800	PBT Profiler	1	0.00035	3	PBT Profiler	6
Polychlorinated dibenzo-p-dioxins (1,2,3,7,8 pentachlorodibenzo-p-dioxin) ((PCDDs)	40321-76-4	7300	EPA 1999	2	26000	PBT Profiler	2	0.0005	3	PBT Profiler	7
Polychlorinated naphthalenes (hexachloronaphthalene) (PCNs)	1335-87-1	1600	PBT Profiler	2	240000	PBT Profiler	3	0.0013	2	PBT Profiler	7
Polycyclic aromatic hydrocarbons (PAHs): Dibenzo(a,h)pyrene	189-64-0	1600	PBT Profiler	2	26000	PBT Profiler	2	0.00074	3	PBT Profiler	7
Short-chain chlorinated paraffins (SCCPs)	85535-84-8	365	OSPAR	1	40900	OSPAR	3	0.04	1	EU Risk Assess	5
Tetrabromobisphenol A (TBBPA)	79-94-7	1600	PBT Profiler	2	14000	PBT Profiler	2	0.003	2	PBT Profiler	6
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5 TCB)	95-94-3	730	Mackay, et al.	1	4830	OSPAR	1	0.12	1	PBT Profiler	3

Tables 4 + 6: Legend/Notes

BAF/BCF Value: BAF = Bioaccumulation factor, the ratio of the concentration of a chemical in an organism to the concentration of the chemical in the surrounding environment (including food).
BCF = Bioconcentration factor, the ratio of the concentration of a chemical in an aquatic organism to the concentration of the chemical in water.
RfD: Reference Dose
CPF: Cancer Potency Factors. The EPA weight of evidence classification appears in parentheses after "NA," when available.
mg/L: Milligrams per Liter
NA: (Data) Not Available. For human health toxicity, the EPA weight of evidence classification appears in parentheses after "NA," when available.

Sources for Tables 4 and 6 are found in Appendix A.

Determination of Relative Ranking:

Uses of the Chemical in Washington

WAC 173-333-410(2) ***Evaluation factors****.*
(a) Ecology will consider the following factors when preparing the multiyear schedule:
(i) Relative ranking. The relative ranking assigned to each PBT based on ecology's evaluation of information on PBT characteristics, ***uses of the chemical in Washington,*** *releases of the chemical in Washington, the levels of the chemical present in the Washington environment, and levels of the chemical present in Washington residents.*

The initial interpretation of the phrase "uses of the chemical in Washington" was the PBT-containing products used in Washington State and the amount of individual PBTs or metals of concern in those products. Upon review of existing resources, it was determined that the time needed for such an analysis, if it could be done at all with available data, was beyond the scope of this multiyear CAP schedule document.[18] As part of this conclusion, it was also understood that the analysis of uses presented here could not evaluate the potential threat of certain kinds of uses over others. Those types of analyses would have to be attempted in the context of a chemical action plan. Based on available data sources, it was therefore decided that the term "uses" would be understood as synonymous with "production" and that the amount of a chemical produced would provide a general sense of the amount being used. If use data was available, it was included.

After some preliminary research, it was determined that there is very limited chemical production in Washington. Chemical manufacturers include Noveon Chemical in Kalama and several oil refineries along Puget Sound, but no information relevant to PBTs could be obtained from these facilities.

Since there is a lack of Washington-specific PBT production data, it was decided to use national production data. (These data are usually reported on a year to year basis.) Using national data seemed an appropriate extrapolation, because it is assumed that:

- the impact of PBT production and use in Washington is a microcosm of the impacts to the U.S. at large
- the annual production of each PBT chemical or chemical group ultimately ends up in products that are used or sold in Washington, and that
- Washington's residents, businesses, industries, and government agencies that use the various products with these chemicals have similar use practices to the rest of the nation.

[18] While there is general data available on what products individual PBTs are used in, determining which of those products are used in Washington and in what quantity would be a time-consuming and complex analysis that is better addressed by the CAP process. And determining the second part -- the quantity of individual PBTs used in specific products – will be difficult, given that this data is often considered to be proprietary information by manufacturers.

An internet search was conducted and many documents reviewed. Complete production data was not available for many reasons, including:

- Several of the PBTs are no longer in production. There were only numbers available from the last year of production.
- Some of the PBTs (e.g. dioxins, furans, HCB, HCBD) are not intentionally produced but are by-products of other chemical reactions.
- For some chemicals, no comprehensive production data could be found.

Sources were limited, with little uniformity in the information provided, and this made it difficult to arrive at consistent values for comparison purposes. However, production numbers were the numbers most often available; use data was used whenever obtainable.

The most recent number available was used, and if there was a range, the highest number was selected. All of the values were converted into metric tonnes to allow for appropriate comparison. The complete data, with sources, are in Appendix D.

Table 7, on the next page, shows the most recent U.S. production values. Historical production numbers are shown, when available, for comparison. Ranking was assigned as follows:

Greater than 100,000 metric tonnes = 3
Between 10,000 and 99,999 metric tonnes = 2
Less than 9,999 metric tonnes = 1
No data or no longer produced = NA

<u>Conclusion</u>

Based on the ranking method described above, Lead and PAHs were ranked as "3," and TBBPA and SSCP were ranked "2."

Table 7. Estimated annual U. S. production of PBT chemicals or chemical groups or metals of concern (in metric tonnes), with ranking.

Chemicals	CAS No.	Historic (metric tonnes)	Year	Recent (metric tonnes)	Year	Rank
Cadmium	7440-43-8	NA	NA	610	2004	1
Hexabromocyclododecane (HBCD)	25637-99-4	NA	NA	2,800*	2001	1
Hexachlorobenzene (HCB)	118-74-1	2,222	1972	NA	NA	NA
Hexachlorobutadiene (HCBD)	87-68-3	12,700	1982	NA	NA	NA
Lead	7439-92-1	NA	NA	624,000	2003	3
Pentachlorobenzene	608-93-5	1,400	1972	NA	NA	NA
Perfluorooctane sulfonates (PFOS)	--	NA	NA	680	2000	1
Polybrominated dibenzodioxins and furans (PBDDs/PBDFs)	--	NA	NA	NA	NA	NA
Polychlorinated biphenyls (PCBs)	--	38,600	1970	NA	NA	NA
Polychlorinated dibenzo-p-dioxins + dibenzofurans (PCDDs/PCDFs: total combined)	--	NA	NA	0.23	1995	1
Polychlorinated naphthalenes (PCNs)	--	320	1978	NA	NA	NA
Polycyclic aromatic hydrocarbons: Coal Tar and Coal Tar Pitches (contain PAHs)**	--	454,000	1913	816,000	1994	3
Short-chain chlorinated paraffins (SCCPs)	85535-84-8	NA	NA	44,000	2005	2
Tetrabromobisphenol A (TBBPA)	79-94-7	NA	NA	18,000*	2001	2
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	95-94-3	5,400	1980	NA	NA	NA

NA = No Data (no information available and/or may no longer produced)
1 metric tonne = 2204.62 pounds, or 1,000 kg
* Total for Americas
** High estimates, both products contain numerous chemicals including PAHs

Determination of Relative Ranking:

Releases of the Chemical in Washington

WAC 173-333-410(2) ***Evaluation factors****.*

(a) Ecology will consider the following factors when preparing the multiyear schedule:

(i) Relative ranking. The relative ranking assigned to each PBT based on ecology's evaluation of information on PBT characteristics, uses of the chemical in Washington, ***releases of the chemical in Washington****, the levels of the chemical present in the Washington environment, and levels of the chemical present in Washington residents.*

"Releases of a chemical" refers to the amounts of a toxic chemical disposed of or otherwise released by manufacturing operations and other facilities to air, water and land and injected underground, and the amounts of a chemical transferred off-site for recycling, energy recovery, treatment, and disposal or release.[19] For the purposes of examining the releases of PBTs and metals of concern in Washington, the U.S. EPA Toxics Release Inventory (TRI) was selected as the single best source of information. It is a comprehensive database which annually summarizes and tracks the amount of toxic chemicals released or transferred by certain types of facilities throughout the U.S. While only six of the 16 chemicals being evaluated in this report are TRI chemicals, it is the only database available that provides comprehensive information on releases in Washington. Evaluation of individual permits or other reports is beyond the scope of this effort.

TRI: a closer look

Facilities in specific industry categories that exceed reporting thresholds for numbers of employees and chemical use must comply with TRI reporting requirements.[20] Most of these are larger, manufacturing facilities. Many smaller facilities that release toxic chemicals into the environment do not have to report under the TRI. Only about 650 different chemicals or groups of chemicals are included in the TRI and facilities must meet thresholds of use of the chemicals. These are 10,000 or 25,000 pounds per year for most chemicals. PBTs are characterized as a class of chemicals "of particular concern,"[21] and 16 PBT chemicals and four PBT chemical compound categories are subject to TRI reporting. PBTs have use thresholds of 10 pounds or 100 pounds per year, except the dioxin category which has a threshold of 0.1 grams.

It is important to remember that a release of a TRI chemical does not indicate a violation of federal, state or local environmental laws. These facilities operate under environmental regulatory permits. TRI information includes data on permitted releases and transfers of certain chemicals. It does not indicate the rate or concentration of chemicals released, nor can it demonstrate the geographic boundaries of the chemical release. Therefore, exposures or risks to

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[19] U.S. EPA: http://www.epa.gov/tri/2002_tri_brochure.pdf

[20] *Thresholds* are specified amounts of toxic chemicals manufactured, processed, or otherwise used during the calendar year that trigger reporting requirements.

[21] U.S. EPA, Toxics Release Inventory, http://www.epa.gov/tri/lawsandregs/pbt/pbtrule.htm.

the public cannot be determined by using TRI data alone. EPA discusses the limitations of TRI data in the brochure, "Factors to Consider When Using TRI Data."[22]

Until EPCRA (Emergency Planning and Community Right-to-Know Act) became law (in 1986), most national and local environmental laws looked at only one element of the environment at a time. The TRI has helped the public and government to better track and understand comprehensive toxic releases at specific sites across a variety of media.

PBT releases

The 2004 TRI data were published in April, 2006. In 2004, the total reported PBT releases in Washington were 3.6 million pounds, 99% of which were lead or lead compounds. This represents an increase of 2.6 million pounds over 2003, primarily due to amounts reported by the Pend Oreille Mine (which reopened in 2004) and about 850,000 pounds of lead reported by the Hanford Site. Figure 2a provides details on the lead release amounts. The "All Others" category is broken down in Figure 2b: polycyclic aromatic compounds (PAHs), mercury compounds and benzo(g,h,i)perylene (a PAH) were the next highest reported releases.

Releases of three other PBTs were reported at amounts of less than 0.5 pounds each: hexachlorobenzene, polychlorinated biphenyls and tetrabromobisphenol A. A PBT chemical may be reported but rounded to zero if less than 0.5 pounds is reported as released. Releases of dioxin and dioxin-like compounds were also reported, but could not be quantified in either figure because they are measured in grams. Dioxin releases are shown in Figure 3.

Washington State TRI PBT Releases, 2004 (in pounds)[23]

Figure 2a. Breakdown of total releases category

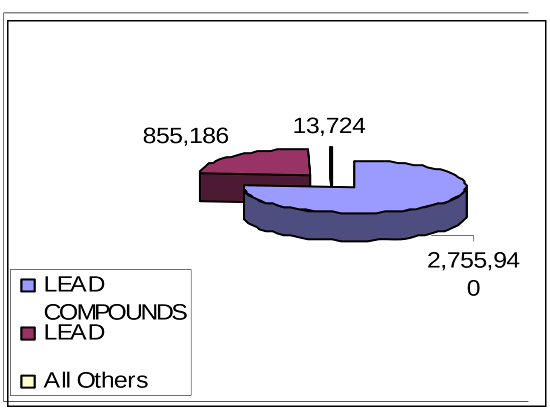
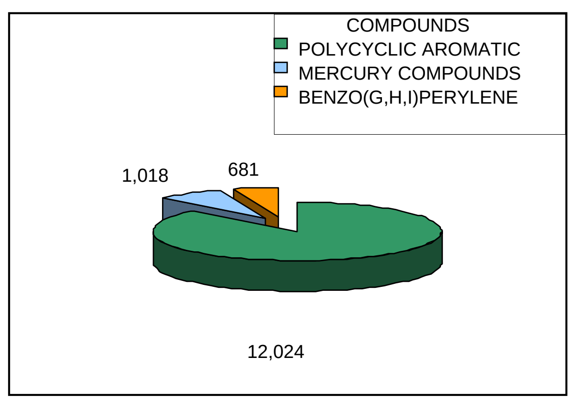


Figure 2b. Breakdown of "All Others"

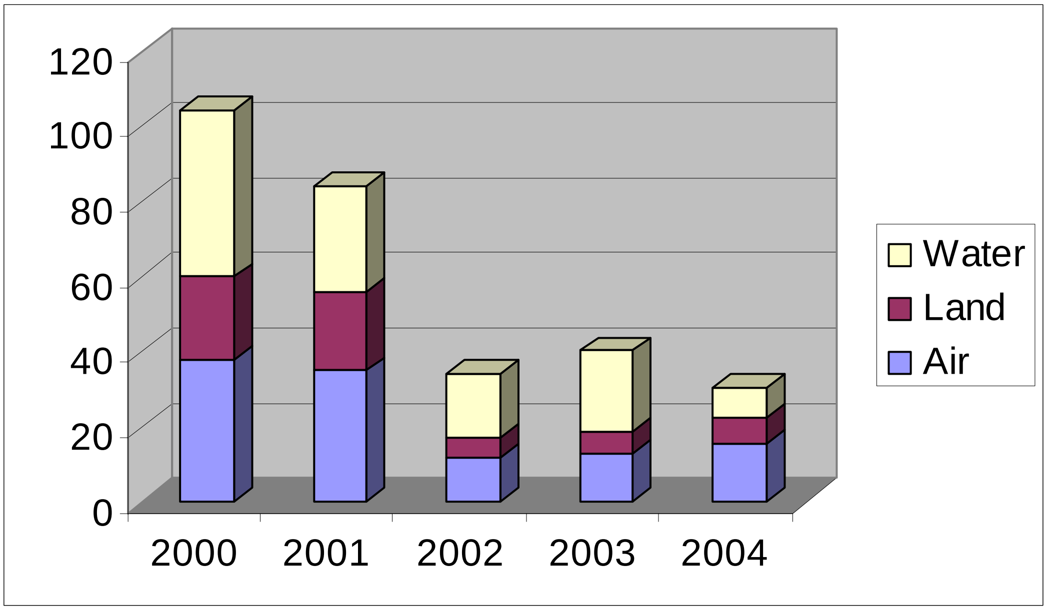


[22] U.S. EPA: http://www.epa.gov/tri/2002_tri_brochure.pdf.

[23] Source: Washington State Department of Ecology, based on data from the TRI. Does not include dioxin and dioxin-like compounds, which are measured in grams.

Figure 3 shows the dioxin trends between 2000 and 2004. Amounts to air, land and water are included.

Figure 3: TRI Dioxin Releases, 2000 - 2004 (in grams)[24]



Ranking

The TRI does not require reporting for many of the PBTs on the PBT List. For chemicals for which there was no data, no ranking number could be assigned. For several chemicals, industry reported amounts although the amounts were below the reporting thresholds; in the case of pentachlorobenzene, reporting is required but no releases were reported, so although there may have been minimal amounts, no specific data is available.

Ranking for releases was determined somewhat differently than in other relative ranking sections. It was decided to use the percentage of the release amount above the TRI reporting threshold. This approach is supported by several factors:

- the TRI reporting threshold has a relationship to toxicity (PBT thresholds are significantly lower than thresholds for other toxins; reporting thresholds are usually 10,000 – 25,000 pounds)
- relative comparisons based on actual weight became meaningless since there was such a disparity between the highest and lowest amounts reported (3.6 million pounds to 30.7 grams)
- there was very limited data (only 3 chemicals to rank).

Lead was indisputably the highest, with 3.6 million pounds of releases, or an amount 36,000 times higher than the reporting threshold. It was therefore assigned a "3." The amount of dioxins was approximately 300 times the reporting threshold, and PAHs were about 115 times

[24] Ibid.

greater than the threshold numbers. When compared to a magnitude of 36,000, dioxins and PAHs were assigned a "1." See Table 8.

Table 8. Releases of Chemicals in Washington – based on U.S. EPA's Toxics Release Inventory 2004

Chemicals	TRI Reporting Threshold	Reported TRI Release	Ranking
Cadmium	NRR	NA	NA
Hexabromocyclododecane (HBCD)	NRR	NA	NA
Hexachlorobenzene (HCB)	10 lbs	< 0.5 lbs	0
Hexachlorobutadiene (HCBD)	NRR	NA	NA
Lead	100 lbs	3.6 million lbs	3
Pentachlorobenzene	10 lbs	NA	NA
Perfluorooctane sulfonates (PFOS)	NRR	NA	NA
Polybrominated dibenzodioxins + furans (PBDDs/PBDFs)	NRR	NA	NA
Polychlorinated biphenyls (PCBs)	10 lbs	< 0.5 lbs	0
Polychlorinated dibenzo-p-dioxins + dibenzofurans (PCDDs/PCDFs)	0.1g	30.7g	1
Polychlorinated naphthalenes (PCNs)	NRR	NA	NA
Polycyclic aromatic hydrocarbons (PAHs) plus Benzo(g,h,i)perylene	100 lbs 10 lbs	12,024 lbs + 681	1
Short-chain chlorinated paraffins (SCCPs)	NRR	NA	NA
Tetrabromobisphenol A (TBBPA)	100 lbs	< 0.5 lbs	0
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	NRR	NA	NA

NRR = no reporting required (therefore, no data and could not be ranked)
Ranking of "0" = reported amount is below the reporting threshold
NA = no reported releases, therefore could not be ranked

Conclusion

Based on the ranking method described above, Lead was ranked a "3," and PAHs and Dioxins are a "1."

Determination of Relative Ranking:

Levels of the Chemical Present in Washington's Environment

WAC 173-333-410(2) ***Evaluation factors****.*

(a) Ecology will consider the following factors when preparing the multiyear schedule:

*(i) Relative ranking. The relative ranking assigned to each PBT based on ecology's evaluation of information on PBT characteristics, uses of the chemical in Washington****,*** *releases of the chemical in Washington,* ***the levels of the chemical present in the Washington environment****, and levels of the chemical present in Washington residents.*

Currently there is no single source for comprehensive information on the levels of each PBT or metals of concern in Washington's environment. Even if a complete database existed, reliable data are not available for certain PBTs or metals of concern. Extensive laboratory method development is needed for the short-chained chlorinated parraffins, PFOS, TBBPA and HBCD; method validation updates are needed for the laboratory analytical procedures for pentachlorobenzene and 1,2,4,5-TCB.

Given these limitations, Ecology chose to use the following four "measures" or "indicators" of levels of PBTs or metals of concern in Washington's environment, utilizing existing databases:

- the frequency with which a PBT was detected as part of the most recent (2004) Water Quality Assessment (WQA),
- the frequency with which a PBT is reported on Ecology's database of Model Toxics Control Act (MTCA) sites,
- the frequency that a chemical exceeds Cleanup Screening Levels or Sediment Quality Standards in Washington sediments, as reflected in Ecology's Sediment Quality Information System (SEDQUAL) database, and
- the number of Department of Health's (Health) fish consumption advisories for each PBT.

Ecology believes that these four databases provide a reasonably complete picture of the extent of PBTs and metals of concern present statewide in Washington's water, sediment, and at waste cleanup sites. Data for most PBTs and metals of concern in air are not available. Exceptions are lead, PAHs and cadmium, but the data is only available for urban areas. There is a national ambient air quality standard for lead, but attainment status has long been achieved and statewide monitoring for lead is no longer conducted.

The more detections of individual PBTs and metals of concern reported in these four databases, the more likely those PBTs and metals of concern are to be widely distributed in areas where sampling has not occurred. Washington State does have an evolving systematic monitoring program for PBTs in the environment, the Washington State Toxics Monitoring Program (WSTMP). Under its auspices, exploratory monitoring is being conducted to identify new instances and locations of toxics contamination in freshwater environments and freshwater fish

tissue. Fish tissue samples taken between 2001 and 2005 included analysis for mercury, PCBs, dioxins, PBDEs and several pesticides. Only PCBs and dioxin data are relevant to this effort, and the data are only for the time frame of 2001-2003. Given that the WSTMP sampling effort addresses only these two PBTs, the WSTMP database was not used for this evaluation. Further information on WSTMP can be found at:
http://www.ecy.wa.gov/programs/eap/toxics/wstmp.html.

Another useful database is the Puget Sound Ambient Monitoring Program (PSAMP). The PSAMP was adopted to evaluate the effectiveness of the *Puget Sound Water Quality Management* Plan and long-term trends in the environmental quality of the marine and freshwaters, fish, sediments and shellfish in Puget Sound. However, since PSAMP is focused on the Puget Sound and related drainage basins only, and is not a statewide monitoring program, it was decided not to include PSAMP data in this Multiyear PBT Chemical Action Plan Schedule. PSAMP data would be more appropriate for use in specific chemical action plan development since chemical specific data from several media are available.

Ecology recognizes that individual studies may be available that provide insight into the presence of PBTs in media not covered by these four databases (i.e. releases to air, levels present in certain wildlife species, etc.), but such a literature survey is more appropriate during preparation of a chemical action plan. It is beyond the scope of this document.

A brief description of each of these four databases follows.

Water Quality Assessment (WQA)
An assessment of the status of the state's waters is conducted biennially by Ecology. This Water Quality Assessment – often call the 303(d) list -- divides the state's water segments into five categories, shown below:

Category 1	= Standards are met
Category 2	= Waters of Concern (not known to be Impaired)
Category 3	= Data are not available to determine the status of a particular water body
Category 4a	= Impaired but already has a Total Maximum Daily Load (TMDL, or water cleanup plan)
Category 4b	= Impaired but already has a Pollution Control Project
Category 4c	= Impaired but cannot be addressed through a TMDL
Category 5	= The 303(d) List (Impaired and requires a TMDL)

Of all the impaired waters, only a small percentage is impaired because the level of a PBT exceeds standards. Of course, there are a number of PBTs for which no water quality standards exist and a number for which no sampling or testing has been done. For the purposes of the current analysis on levels present in the Washington environment, only Categories 2, 4 and 5 were considered.

MTCA/ISIS
Under the authority of the Model Toxics Control Act (MTCA), the Integrated Site Information System (ISIS) database is used by Ecology's Toxics Cleanup Program to identify and characterize contaminated sites and to track progress in cleaning them up. ISIS is linked to Ecology's Facility/Site Identification System, sharing basic site identification and site location

data with that system. Ecology's Facility/Site Identification System provides a central repository of key information for each facility/site of interest to Ecology. The system can be sorted by the chemical that is being addressed; however metals are listed simply as metals. No distinction is made between lead and chromium in the database. Therefore, the number of sites where lead is present (for this analysis) is based on best professional judgment and is believed to underestimate the likely total number of cleanup sites where lead is a concern.

SEDQUAL

SEDQUAL, the Sediment Quality Information System, was developed by Ecology. It is comprised of a database, user interface, and integrated GIS component designed to assess sediment toxicity in marine and freshwater environments. The Aquatic Lands Cleanup Unit in Ecology's Toxics Cleanup Program maintains this database. Data is collected from contaminated sediment sites in Puget Sound and elsewhere around Washington State. The value reported in Table 9 is the number of times or "hits" a specific chemical was detected in the environment as reported in the SEDQUAL data base.

Washington State Department of Health Fish Advisories

The Department of Health (DOH) and local health jurisdictions are responsible for issuing fish consumption advisories within the state. These consumption advisories provide advice to fish consumers about how to reduce exposures to contaminants that have been found in fish. Information about existing fish advisories is available at Health's Fish Facts website.[25] While the Department of Health advises limiting or avoiding certain types of fish because of contaminants, DOH continues to recommend eating fish as part of a healthy diet and to choose fish that are low in contaminants. Eating fish has many health benefits including reducing the risk of heart disease and promoting normal brain development and function.[26]

In terms of this ranking exercise, the occurrence of a fish advisory indicates the presence of a given chemical in fish tissue.

The frequency of actual detections in the WQA, MTCA/ISIS and SEDQUAL databases and the number of fish consumption advisories for each PBT are listed in Table 9.

[25] Washington Dept. of Health's, Fish Facts website is available at: http://www.doh.wa.gov/fish/. This website provides information on existing fish advisories and the health benefits of eating fish. This website is currently being revised. The revised website containing updated information will be available later this year.
[26] See Washington Dept. of Health information on the health benefits of eating fish. Available at: http://www.doh.wa.gov/fish/FishAdvBenefits.htm

Ranking
Ecology assigned scores of 1, 2, or 3 (low to high) based on the distribution of the number of detections in each category.

Water Quality Assessment (WQA)
Greater than 100 detections = 3
From 11 - 99 detections = 2
From 1-10 detections = 1

MTCA/ISIS
Greater than 100 detections = 3
From 11 -99 detections = 2
From 1 – 10 detections = 1

SEDQUAL
Greater than 100 exceedances = 3
From 10 – 99 exceedances = 2
Less than 10 exceedances = 1

Number of Fish Advisories
Greater than 5 = 3
Between 2 – 4 = 2
Below 2 = 1

Once each chemical was ranked for each database, the single highest ranking was used as the final ranking for levels of the chemical present in the Washington environment.

Table 9. "Levels present in the environment:" detections for specific PBTs and metals of concern.

Chemical	Frequency of Detection in 2004 WQA	WQA Ranking	Frequency of Detection in MTCA/ ISIS	MTCA/ ISIS Ranking	CSL and SQS Exceedances in SEDQUAL	SEDQUAL Ranking	Number of Fish Advisories	Fish Advisory Ranking	Final Ranking
Cadmium	12	2	NA	NA	123	3	None	NA	3
Hexabromocyclododecane (HBCD) (*)	NA	NA	NA	NA	NA	NA	None	NA	NA
Hexachlorobenzene (HCB)	125	3	NA	NA	79	2	None	NA	3
Hexachlorobutadiene (HCBD)	55	2	NA	NA	11	2	None	NA	2
Lead	29	2	422**	3	77	2	3	2	3
Pentachlorobenzene	NA	NA	NA	NA	NA	NA	None	NA	NA
Perfluorooctane sulfonates (PFOS) (*)	NA	NA	NA	NA	NA	NA	None	NA	NA
Polybrominated dibenzodioxins and furans (PBDDs/PBDFs)	NA	NA	NA	NA	NA	NA	None	NA	NA
Polychlorinated biphenyls (PCBs)	166	3	376	3	41	2	6	3	3
Polychlorinated dibenzofurans (PCDFs)	55(PCDD/PCDF combined)	2	NA	NA	NA	NA	None	NA	2
Polychlorinated dibenzo-p-dioxins (PCDDs)	55 (PCDD/PCDF combined)	2	54	2	NA	NA	2	2	2
Polychlorinated naphthalenes (PCNs) (*)	NA	NA	NA	NA	NA	NA	None	NA	NA
Polycyclic aromatic hydrocarbons (PAHs)	123	3	569	3	1,376	3	5	3	3
Short-chain chlorinated paraffins (SSCPs) (*)	NA	NA	NA	NA	NA	NA	None	NA	NA
Tetrabromobisphenol A (TBBPA) *)	NA	NA	NA	NA	NA	NA	None	NA	NA
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5 TCB)	NA	NA	NA	NA	NA	NA	None	NA	NA

(Legend, next page)

NA: Data not available. This indicates one of three possibilities (listed in order of likelihood):
1) the compound was not tested for
2) the compound was tested for but not detected
3) the compound was detected but did not exceed regulatory standards
(*) Analytical testing methods not yet developed.
** Indicates an estimate for the number of detections for lead. The MTCA/ISIS database has a "Metals" category, which indicates that the sample detected arsenic, cadmium, chromium, lead, mercury and zinc. Ecology conservatively estimates that at least 25% of the metal detections statewide (out of a total of 1690 metals detections) are for lead.

Conclusion

Based on the available information from the four databases evaluated, the following five PBTs and metals of concern had a ranking of "3":

- PCBs
- PAHs
- Lead
- Cadmium
- Hexachlorobenzene

The results indicate that these five PBTs in particular are widely present in Washington's environment, and routinely exceed water quality, MTCA cleanup level, and sediment quality standards. Not surprisingly, they also have resulted in area-specific fish consumption advisories issued by the Department of Health due to high levels of lead, PAHs or PCBs in fish tissue or bottom sediment in select areas. Although chlorinated dioxins and furans do not appear to be the basis of many MTCA or sediment cleanup sites, they are found at high enough levels to warrant fish consumption advisories in select areas as well. It may be that these compounds are not sampled for routinely. In the future, more comprehensive monitoring of all PBTs and metals of concern will be needed to more accurately determine the levels of all PBTs and metals of concern present in Washington's environment.

Determination of Relative Ranking:

Levels of the Chemical Present in Washington Residents

WAC 173-333(2) ***Evaluation factors****.*
(a) Ecology will consider the following factors when preparing the multiyear schedule:
*(i) Relative ranking. The relative ranking assigned to each PBT based on ecology's evaluation of information on PBT characteristics, uses of the chemical in Washington****,*** *releases of the chemical in Washington, the levels of the chemical present in the Washington environment, and* ***levels of the chemical present in Washington residents****.*

Available biomonitoring data are the basis for determining the levels of PBTs and metals of concern present in Washington residents. The U.S. Centers for Disease Control and Prevention (CDC) defines biomonitoring as the assessment of human exposure to chemicals by measuring the chemicals or their metabolites in human specimens such as blood or urine.[27] The CDC is the only ongoing source of biomonitoring data for a broad range of chemicals for the U.S. Other biomonitoring data are usually generated from one-time or short-term studies involving one or a limited number of chemicals.

Biomonitoring data can be used for a variety of purposes, including:

- determining the amount of exposure to a chemical
- tracking trends in exposures over time
- determining background or baseline levels
- understanding the contribution of different sources to total exposure (when collected in conjunction with environmental data or questionnaire data)
- identifying highly exposed (high-risk) individuals or populations
- identifying emerging human exposures
- evaluating the effectiveness of efforts to reduce exposures (e.g. worker training or protective equipment, new regulations, bans, public educational efforts).

Additionally, in limited situations, biomonitoring can be used to identify people whose exposure to certain chemicals has reached a known toxicity level and thus may require follow-up actions. This is the case for those few chemicals for which harmful tissue levels have been clearly identified. For example, the CDC has determined that a blood level of 10 µg/dl of lead in children is harmful and requires follow-up actions to reduce lead exposures.[28]

Although not discussed here, issues such as study design, biomarker validation, data interpretation and communication of results are important to address prior to collecting

[27] CDC, 2005. Third National Report on Human Exposure to Environmental Chemicals. Available at: http://www.cdc.gov/exposurereport/3rd/
[28] For additional information see May 27, 2005 MMWR reporting blood lead levels for the U.S. 1999 – 2002. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5420a5.htm

biomonitoring data.[29,30] Study planning and management, obtaining human subjects research approval, field staffing needs, participant recruitment and follow-up, and laboratory analysis can make biomonitoring studies very expensive especially when collecting data from many people.

CDC began including biomonitoring for a broad list of environmental chemicals in 1999 as part of their National Health and Nutrition Examination Survey (NHANES), an ongoing national study of randomly-selected people in the U.S.[31] This study is designed to provide data for the nation as a whole and cannot be used to generate results for specific states. CDC has reported biomonitoring data for seven PBTs or PBT groups (Table 10). PFOS chemicals will be included in the suite of chemicals in the lab analyses for samples collected in 2003-2004.

There is no ongoing program similar to NHANES that collects general population biomonitoring data for residents of Washington. In 2003, the Washington State Department of Health (Health) identified biomonitoring priorities for the state, which included the collection of samples from randomly-selected individuals.[32] To date, most of the biomonitoring priorities identified by Health have not been implemented because of insufficient resources.

Lead is the only PBT or metals of concern for which there is significant biomonitoring data in Washington. These data are available because levels of lead in blood are a "notifiable condition" (WAC 246-101), that is, they must be reported to Health by laboratories who run the test.[33] About 4% of Washington children are tested and their results tracked by Health as part of the blood lead registry. Adult blood lead reports are forwarded by Health to the Department of Labor and Industries for follow-up related to potential occupational exposures. Health has conducted studies to estimate the prevalence of elevated blood lead levels in children.[34] These studies and data from the blood lead registry suggest a low prevalence of elevated blood lead levels in the state relative to the U.S., with a higher prevalence in central Washington. However, due to the low percentage of children tested for lead, an unknown number of children with elevated blood lead levels may not be identified.

There are some Washington State biomonitoring data for other PBTs and metals of concern, but many of these PBTs and metals of concern have data for only a small number of individuals. For example, biomonitoring data for PCBs, PFOS, mercury and PBDEs have been generated from testing small numbers of volunteers conducted by environmental advocacy groups (Toxic-Free

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[29] Bates, M.N. et al., 2005. Workgroup report: Biomonitoring study design, interpretation, and communication – lesions learned and path forward. Environmental Health Perspectives, 113(11): 1615-1621.
[30] Albertini, R. et al., 2006. The use of biomonitoring data in exposure and human health risk assessment. Environmental Health Perspectives. Web release June 12, 2006.
[31] The CDC published biomonitoring results in 2003 for 116 chemicals in their report, *Second National Report on Human Exposure to Environmental Chemicals*. This report included data collected in 1999-2000. In 2005, the CDC published the *Third National Report on Human Exposure to Environmental Chemicals* that reported results from monitoring of 148 environmental chemicals for the years 2001-2002.
[32] DOH, 2003. Washington State Plan for Priorities for Biomonitoring. Available at: http://www.doh.wa.gov/ehp/oehas/publications_pdf/bio_plan_11-03.pdf
[33] DOH, 2002. Childhood Lead Poisoning. Chapter in the report, The Health of Washington State. Available at: http://www.doh.wa.gov/ehp/oehas/publications_pdf/bio_plan_11-03.pdf
[34] Ibid.

Legacy, Northwest Environment Watch and the Environmental Working Group).[35] These types of projects provide an indication of tissue levels for PBTs and metals of concern in the people who participated. However, results from these tests cannot be used to generalize to levels among the general public because of the small sample size and the non-random selection of participants.

Ranking

It is not possible to compare the different levels of PBTs and metals of concern in Washington residents, due to the lack of biomonitoring data. Biomonitoring data would be needed that was collected from randomly-selected individuals in the state or from groups known to have higher exposures such as from fish consumption (e.g. Native Americans) since many of the PBTs and metals of concern are known to accumulate in fish. At this time there are no resources or plans to conduct these types of studies.

Therefore, in order to provide some guidance for ranking, it was decided to assign ranking numbers (1-3, lowest to highest) based on available national biomonitoring data from CDC and other published studies not limited to Washington State:

- PBT chemicals included and detected in the NHANES study = 3
- PBTs that have not been included in NHANES, but for which other published biomonitoring data exist = 2
- Chemicals which lack available biomonitoring data from CDC's NHANES program or elsewhere = NA.

This ranking is based on availability of biomonitoring data and not on the number of studies or tissue levels. This approach was taken because there is a lack of biomonitoring data for many PBTs and metals of concern that prevents the direct comparison of biomonitoring results between the PBTs and metals of concern.

There are several limitations associated with this type of approach for ranking PBT and metals of concern biomonitoring data. The biomonitoring ranking does not reflect the relative accumulation of the different PBTs and metals of concern in people or the relative proportion of the population with elevated or harmful tissue levels. Instead, the biomonitoring ranking reflects only the amount of available data for each PBT or metal of concern. PBTs and metals of concern that are newly identified and less studied are given a lower rank even though they may be as likely to accumulate in human tissues as the PBTs and metals of concern with more biomonitoring data. PBTs, by definition, are bioaccumulative and it is expected that exposures to them will result in the build-up in human tissues, to some extent. This ranking also does not account for the potential health hazards associated with the measured tissue levels.

[35] Toxic-Free Legacy (2006) 10 people tested; Northwest Environment Watch (2004) 40 women tested; Environmental Working Group (2003) 20 women tested. In contract, the NHANES biomonitoring program for 2001-2002 included approximately 2700 people. The actual number of samples tested depended on the chemical and target age groups.

Conclusion

Based on the ranking system described above for presence of PBTs in Washington residents, seven PBTs, PBT groups or metals of concern are considered “3”s: Hexachlorobenzene, PAHs, PCBs, PCDDs, PCDFs, Cadmium and Lead.

Table 10. "Levels in Washington residents:" Availability and sources of biomonitoring data for PBTs and metals of concern, and final ranking

Chemicals	Included in NHANES data	Other international, U.S. or regional data	Reference*	Washing-ton State Data	Reference*	Ranking
Cadmium	Yes	Yes	ATSDR, 1999; CDC 2005	No		3
Hexabromocyclododecane (HBCD)	No	Yes	Birnbaum and Staskal, 2004	No		2
Hexachlorobenzene (HCB)	Yes	Yes	Sjodin et al., 2000; WWF, 2003; CDC 2005	No		3
Hexachlorobutadiene (HCBD)	No	No		No		NA
Lead	Yes	Yes	ATSDR, 2005; CDC 2005	Yes	DOH, 2002	3
Pentachlorobenzene	No	No		No		NA
Perfluorooctane sulfonates (PFOS) (5 chemicals)	To be included in 2003-2004	Yes	OECD, 2002	Yes	Toxic-Free Legacy, 2006	2
Polybrominated dibenzodioxins and furans (PBDDs and PBDFs) (2 chemicals)	No	Yes	Choi et al., 2003	No		2
Polychlorinated Biphenyls (PCBs) (8 chemicals)	Yes	Yes	ATSDR, 2000; CDC, 2005; WWF, 2003	Yes	NW Env. Watch, 2005; Toxic-Free Legacy, 2006	3
Polychlorinated dibenzofurans (PCDFs) (10 chemicals)	Yes	Yes	ATSDR, 1994	No		3
Polychlorinated dibenzo-p-dioxins (PCDDs) (7 chemicals)	Yes	Yes	ATSDR, 1998; CDC, 2005. Nakatina et al., 2005	No		3
Polychlorinated naphthalenes (5 chemicals) (PCN)s	No	No		No		NA
Polycyclic aromatic Hydrocarbons (PAHs) (16 chemicals)	Yes	Yes	ATSDR, 1995; CDC 2005	No		3
Short-chain chlorinated paraffins (SSCPs)	No	Yes	Thomas et al., 2006	No		2
Tetrabromobisphenol A (TBBPA)	No	Yes	EU, 2006	No		2
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5 TCB)	No	No		No		NA

NHANES: CDC **N**ational **H**ealth and **N**utrition **E**xamination **S**urvey *Detailed reference information on next page

Table 10 References

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ATSDR, 2005. Toxicological Profile for Lead. Available at: http://www.atsdr.cdc.gov/toxpro2.html

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Final Relative Ranking Determination

> *WAC 173-333-410(2)* ***Evaluation factors****.*
> *(a) Ecology will consider the following factors when preparing the multiyear schedule:*
> *(i) Relative ranking. The relative ranking assigned to each PBT based on ecology's evaluation of information on PBT characteristics, uses of the chemical in Washington****,*** *releases of the chemical in Washington, the levels of the chemical present in the Washington environment, and levels of the chemical present in Washington residents.*

Table 11 summarizes the relative ranking in each category and shows the final relative ranking score for each PBT or metal of concern. For each of the categories, the highest possible score was 3 and the lowest was 1. If no/insufficient data existed for a particular category, than a “score” of NA was assigned.

Based on the overall scores assigned for each of these categories, the following PBTs and metals of concern ranked highest:

- PAHs
- PCDFs
- PCBs
- PCDDs
- Lead

For the final ranking (see Table 15. Final Overall Ranking), the overall scores in Table 11 were ranked as follows:

- 1 – 9 points = 1
- 10 – 15 points = 2
- 16 – 20 points = 3

These values are shown in the first column (Relative Ranking) in Table 15, on page 83.

Table 11. Summary of Relative Ranking by chemical

WAC 173-333-410(2)(i) Relative ranking. The relative ranking assigned to each PBT and metals of concern **based on Ecology and Health's evaluation of information on PBT characteristics *(columns 1, 2, 3 & 4)*, uses of the chemical in Washington *(column 5)* , releases of the chemical in Washington *(column 6)*, the levels of the chemical present in the Washington environment *(column 7)*, and levels of the chemical present in Washington residents *(column 8)*.**

Chemical or Chemical Group	1 Persistence Ranking Score	2 Bioacc. Ranking Score	3 Human Health Toxicity Score	4 Ecological Toxicity Score	5 Uses (Production Score)	6 Releases in WA (TRI)	7 Levels in WA Environ-ment	8 Levels in WA Residents	Overall Sum
Cadmium	NA	NA	2	3	1	NA	3	3	12
Hexabromocyclododecane (HBCD)	1	2	1	3	1	NA	NA	2	10
Hexachlorobenzene (HCB)	2	2	3	1	NA	0	3	3	14
Hexachlorobutadiene (HCBD)	1	1	2	2	NA	NA	2	NA	8
Lead	NA	NA	2	2	3	3	3	3	16
Polycyclic aromatic hydrocarbons (PAHs)	1	2	2	3	3	1	3	3	18
Polybrominated dibenzodioxins = furans (PBDDs/PBDFs)	2	1	3	3	NA	NA	NA	2	11
Polychlorinated biphenyls (PCBs)	2	3	3	3	NA	0	3	3	17

Chemical or Chemical Group	1 Persistence Ranking Score	2 Bioacc. Ranking Score	3 Human Health Toxicity Score	4 Ecological Toxicity Score	5 Uses (Production Score)	6 Releases in WA (TRI)	7 Levels in WA Environ-ment	8 Levels in WA Residents	Overall Sum
Polychlorinated dibenzo-p-dioxins (PCDDs)	2	2	3	3	1	1	2	3	17
Polychlorinated dibenzofurans (PCDFs)	2	3	3	3	1	1	2	3	18
Polychlorinated naphthalenes (PCNs)	2	3	2	2	NA	NA	NA	NA	9
Pentachlorobenzene	2	1	2	1	NA	NA	NA	NA	6
Perfluorooctane sulfonates (PFOS)	3	1	3	2	1	NA	NA	2	12
Short-chain chlorinated paraffins (SCCPs)	1	3	1	1	2	NA	NA	2	10
Tetrabromo-bisphenol A (TBBPA)	2	2	1	2	2	0	NA	2	11
1,2,4,5-Tetrachlorobenzene (1,2,4,5 TCB)	1	1	2	1	NA	NA	1	NA	6

Opportunities for Reduction

> *WAC 173-333-410(2)* ***Evaluation factors****.*
> *(a) Ecology will consider the following factors when preparing the multiyear schedule:. . . .*
> *(ii)* ***Opportunities for reductions****. Whether there are opportunities for reducing or phasing out uses, production or releases of the PBT in Washington. In reviewing available information, the agencies shall consider whether more than one PBT is present in particular products, generated in particular processes or released from particular sources (co-occurring chemicals).*

"Reduction opportunities" are opportunities for reducing or phasing-out uses, production or releases of a PBT chemical or metal of concern. Ideally, reduction opportunities would be "custom fit" for each PBT or metal of concern, however, there is a great deal about many PBTs and metals of concern that has not yet been studied. Therefore, discussions here will, of necessity, be more general than those in the relative ranking evaluations.

For most releases, one or more of the following strategies could be applied to reduce or prevent the release:

1) *Chemical substitution* assumes the manufacturing process remains essentially the same, but a non-PBT chemical is substituted for the PBT or metal of concern.
2) *Product redesign* assumes that simple substitution is not possible or cost-effective and therefore the product itself is redesigned (e.g. a different type of plastic is considered) to eliminate the use of the PBT or metal of concern. Redesign options could also include reducing the amount of a PBT or metal of concern used in a given product.
3) *Product elimination* is a ban of the use of the chemical and can be product- or chemical-specific depending on the nature of the release mechanism and the toxicity of the PBT or metal of concern in question. For example, in 2003 the state Legislature found that mercury was a sufficient threat to the state's fish that it banned the sale of a number of mercury containing products. (Labeling was required for those essential products for which a viable substitute was not available, i.e. fluorescent light bulbs).
4) *Consumer education* can supplement the above actions or stand alone, and is intended to provide consumers with information regarding PBT or metal of concern -containing products. It can be designed to change consumer behavior or to provide sufficient information (i.e. product labeling) to allow consumers to make their own (better) choices.
5) *Pollution control improvements* are technologies that can be employed to directly reduce the release of a PBT or metal of concern at a manufacturing or treatment facility.
6) *Reevaluating recycling/disposal practices* may be appropriate in cases where the release of the PBT or metal of concern occurs as a result of such practices.
7) *Cleanup actions* are actions to directly clean up releases, which typically include removing or treating contamination that has accumulated at a given site, exceeding established standards. As seen in the previous chapter, PBT or metal of concern releases have resulted in many polluted sites, some of which are now being addressed by Ecology. (Refer to the earlier "Levels of the Chemical Present in the Washington

Environment" section for more detailed information on existing cleanup databases and programs.)

The first four actions are designed to prevent releases from occurring. The fifth option aims to minimize releases by improving treatment technologies. The final two strategies deal with materials that have already been released. Reduction opportunities for PBTs and metals of concern were prioritized as follows:

prevention > management/recycling > cleanup.

Prevention strategies can clearly have the most impact in *reducing or phasing out uses, production or releases* of a PBT or metal of concern. Simply put, not using, producing or releasing the chemical in the first place is the best bet. Once a chemical has already been used, produced or released, the next most effective approaches are management and recycling opportunities. Cleanup opportunities are important but, in the colloquial, much of the damage has already been done; therefore cleanup strategies were ranked lowest.

Broader considerations

Evaluating "reduction opportunities" does not lend itself to a quantitative analysis; it is a qualitative analysis, often based on best professional judgment and limited data. A detailed examination of reduction opportunities for a given chemical would be done in the context of a chemical action plan; it is not possible for this multiyear CAP schedule. Specific reduction opportunities have been identified and considered for each chemical. In addition, chemicals were considered within a broader framework: choosing chemicals for which Ecology can really have some on-the-ground impact, and meet the overarching goal of the PBT rule to identify actions that will reduce and eliminate threats to human health and the environment.

In order to make meaningful reduction recommendations, sufficient data is needed. Therefore, there is a bias towards chemicals for which there is a lot of data (such as lead), but also where there is currently a lot of interest, energy and focus. A good example is PFOS. One major company has already stopped producing it; the EPA is actively engaged in studies and information-gathering and has already taken some actions to reduce and eliminate it, the Centers for Disease Control and Prevention (CDC) are collecting biomonitoring information. Working on PFOS is an opportunity to work in partnership with other agencies and groups, which will inform Ecology's work, and in turn, Ecology will be contributing to the wider efforts. Put in very simple terms, it may provide "the most bang for the buck."

Co-occurring chemicals

The PBT rule includes seven groups of chemicals (PFOS, PAHs, PCBs, chlorinated dioxins, chlorinated furans, brominated dioxins and furans and polychlorinated naphthalenes). For the purposes of this evaluation, all individual chemicals within a group were considered together. There are PBTs and metals of concern which co-occur, that is if one is present another will probably also be present. In such cases it makes sense to consider them together, which was done here in the case of chlorinated dioxins and furans (PCDD/PCDFs). Both chemical groups are likely to occur as a result of combustion of organic matter in the presence of chlorine.

Addressing combustion by-products as a group was considered; in addition to the PCDD/PCDFs this could include the brominated and chlorinated dioxins and furans and PAHs. However PAHs are not only formed unintentionally through combustion but are made intentionally to produce asphalt and tars, so treating them simply as a combustion product would not be appropriate. The precursors of brominated dioxins and furans are likely to be somewhat different than the chlorinated forms and while it may make sense to consider them in combination, for this exercise, they were considered separately.

Note: Another factor to consider when evaluating reduction opportunities is whether there are already plans or regulations in existence for reducing or eliminating a given chemical. For example, PCBs, in addition to the fact that they are already banned, have extensive existing regulations around them. In such a situation, Ecology's capacity to really make a difference appears very limited, and therefore PCBs are ranked low. Existing plans or regulatory requirements are examined in detail in a later section of this document.

The 16 PBTs and metals of concern under consideration are each examined for reduction opportunities, following.

Cadmium

Cadmium is a natural element, usually extracted during the production of other metals such as zinc, lead, and copper. All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Cadmium has many uses, including batteries, pigments, metal coatings and plastics.[36]

Reduction opportunities can be focused on reducing the use of cadmium in products, and in substituting safer, effective and affordable alternatives. In February 2003, the Restriction of Hazardous Substances Directive (RoHS) 2002/95/EC was adopted by the European Union (EU). This directive restricts the use of cadmium as well as five other hazardous materials in the manufacture of various types of electronic and electrical equipment. The RoHS directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC which sets collection, recycling and recovery targets for electrical goods and is part of a legislative initiative to solve the problem of huge amounts of toxic e-waste.[37] Although the Directive was passed in 2003, it did not become effective until July, 2006, allowing companies time to make the necessary production changes to meet the new standards. It may therefore be assumed that opportunities to prevent releases through chemical substitution, product redesign, and to better manage cadmium through recycling, are already available and utilized by companies that sell electronics in Europe.

Public education programs to explain the impacts that improper disposal of cadmium-containing products has on both the environment and public health might be effective in changing consumer behavior. Guidance could be provided on the importance of recycling Ni-Cd batteries and the proper management and storage of such products, especially where young children are present.

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[36] Agency for Toxic Substances and Disease Registry. 1999. ToxFAQs for Cadmium (CAS # 7440-43-9). Division of Toxicology - Atlanta, Georgia 30333. View at: http://www.atsdr.cdc.gov/tfacts5.html
[37] European Commission. 2003. Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS). View at:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML.

There may be recycling opportunities for a variety of cadmium-containing products such as nickel-cadmium storage batteries, power transmission wire, unused pigments used in ceramic glazes, photography and lithography, and electrodes for cadmium-vapor lamps and photoelectric cells.

There are cleanup opportunities for cadmium given that there are 10 listings for cadmium in the 2004 Water Quality Assessment (WQA) list and an additional 123 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for cadmium in the Ecology SEDQUAL database. In addition, there are a number of MTCA sites where cadmium contamination exceeds MTCA cleanup levels.

Hexabromocyclododecane (HBCD)

HBCD is a brominated flame retardant, one of several on the PBT List. It is used primarily in expanded polystyrene foams and other styrene resins, in latex binders, unsaturated polyesters and polyvinyl chloride wire, and cable and textile coatings.[38] Since HBCD is not a listed chemical for the U.S. EPA Toxic Release Inventory (TRI), no release data are currently available.[39] In addition, HBCD has not been found in Washington's environment; this finding may be because HBCD has not been well studied rather than as an indication that HBCD is not present. Some studies have detected it in people. Regarding cleanup opportunities, there are no known toxic waste sites or WQA listings based on HBCD contamination in Washington. Additional monitoring is needed to determine if HBCD is present and if it exceeds any existing criteria or standards. Therefore, opportunities to prevent or manage releases cannot be evaluated at this time: all potential reduction actions could be of use.

Hexachlorobenzene (HCB)

Commercial production of HCB was discontinued in 1976.[40] It was used as a seed-treatment fungicide. There are no known current commercial uses of HCB as an end-product; nevertheless, it continues to be produced as a by-product from the manufacture of other chlorinated chemicals and persists in the environment from past releases.[41]

As commercial U.S. production has ceased, current potential exposure is limited for the general population. The most recent (2004) reported TRI release in Washington for HCB was less than 0.5 pounds, well under the 10-pound reporting threshold. Therefore, opportunities to prevent

[38] Toxicological Risks of Selected Flame Retardants, 2000. National Academies Press: http://darwin.nap.edu/books/0309070473/html/53.html
[39] University of Massachusetts, Lowell. An Overview of Alternatives to Tetrabromobisphenol A (TBBPA) and Hexabromocylododecane (HBCD). March 2006.
[40] Environmental Protection Agency. 2000. Draft Report of Hexachlorobenzene (HCB) Reduction Options. (http://www.epa.gov/grtlakes/bns/baphcb/HCB_Rdcn.html)
[41] National Toxicology Program. Report on Carcinogens, Eleventh Edition. 2005. Substance profiles – Hexachlorobenzene CAS # 118-74-1. Web address: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s093hexa.pdf

releases are very limited. In addition, HCB is a priority PBT currently being addressed under the EPA's PBT initiative, and a final version of a national action plan is currently in development.[42]

There are some possible cleanup opportunities. There are 125 listings for HCB on the WQA list and an additional 79 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for HCB in the Ecology SEDQUAL database. Any known MTCA sites will be cleaned up to further reduce environmental releases of HCB.

Hexachlorobutadiene (HCBD)

According to a 2000 EPA report, HCBD is used mainly as an intermediate in the manufacture of rubber compounds. It is also used in the production of lubricants, as a fluid for gyroscopes, as a heat transfer liquid, and in hydraulic fluids.[43]

Current information on this chemical is limited; one of the only readily available sources is an ATSDR Toxicological Profile from 1994. At that time, it was reported that commercial quantities of HCBD had never been produced in the United States. The primary source was inadvertent production as a waste by-product of the manufacture of certain chlorinated hydrocarbons. An estimated 100,000 pounds of this by-product were released to the environment each year, according to that same report. The majority of HCBD-containing waste was disposed of by incineration, with lesser amounts disposed by deep well injection and landfill. HCBD was identified in at least 45 of the 1,350 hazardous waste sites that were proposed for inclusion on the EPA National Priorities List (NPL). (However, the number of sites evaluated for hexachlorobutadiene was not provided.) In 1993, there were 3-4 NPL sites with hexachlorobutadiene contamination in Washington (only two U.S. states were higher, with 5 sites).[44]

HCBD is not currently on the TRI PBT Chemical List. There were 55 "hits" (actual detections) for this chemical reported in the WQA list, and 11 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for HCBD in Ecology's SEDQUAL database: so cleanup actions may be useful. However, given the general current lack of data, no conclusions can be drawn as to opportunities to prevent or manage releases of HCBD. Any or all of the potential actions might be applicable.

Lead

Today's major use of lead is in lead-acid storage batteries. The electrical systems of vehicles, ships, and aircraft depend on such batteries for startup, and, in some cases, batteries provide the actual power. Other batteries provide standby electrical power for emergencies, and very large lead-acid systems are designed to provide "peaking" power in such applications as commercial

[42] Environmental Protection Agency. 1999. Priority PBT Profiles. (http://www.epa.gov/opptintr/pbt/pubs/cheminfo.htm)
[43] EPA: http://www.epa.gov/ttn/atw/hlthef/hexa-but.html. Last updated in 2000.
[44] Agency for Toxic Substances and Disease Registry. May 1994. Toxicological Profiles – Hexachlorobutadiene. Web address: http://www.atsdr.cdc.gov/toxprofiles/tp42-c5.pdf

power networks and subway systems. An increasing use is in the uninterruptible power supply systems necessary for voltage control and emergency power in critical computer storage systems. Lead in gasoline, once the second largest use of lead in the United States, has been virtually phased out.[45]

Non-transportation uses for lead include increasing use for soundproofing in office buildings, schools, and hotels. It is widely used in hospitals to block X-ray and gamma radiation and is employed to shield against nuclear radiation both in permanent installations and when nuclear material is being transported.[46]

According to statistics from 2004, industries in the U.S. used an estimated 1.52 million metric tons of lead. Lead-acid battery production accounted for 83 percent of reported industrial lead use in 2004.[47] The remaining industrial uses of lead cover a range of products that are not easily categorized. Examples included ammunition (3.5 percent); oxides for paint, glass, pigments, and chemicals (2.6 percent); and sheet lead (1.7 percent).

Besides being a major user of lead, the United States is the world's leading lead producer. Missouri is the main producing state. Because of the great number of scrap batteries that become available each year, recycled lead supplies more than 60% of our annual demand. The leading foreign mine producers, with output about equal to that of the United States, are Australia and the former U.S.S.R.[48]

Opportunities to reduce lead can be focused on reducing its use in products and substituting safer, effective and affordable alternatives. In February 2003, the Restriction of Hazardous Substances Directive (RoHS) 2002/95/EC was adopted by the European Union (EU). This directive restricts the use of lead and 5 other hazardous materials in the manufacture of various types of electronic and electrical equipment. It is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC which sets collection, recycling and recovery targets for electrical goods and is part of a legislative initiative to solve the problem of huge amounts of toxic e-waste.[49] Although the Directive was passed in 2003, it did not become effective until July, 2006, allowing companies time to make the necessary production changes to meet the new standards. It may therefore be assumed that opportunities to prevent releases through chemical substitution, product redesign, and to better manage lead through recycling, are already available and utilized by companies that sell electronics in Europe.

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[45] Ibid.
[46] Ibid.
[47] United States Geological Survey, 2006. View at: http://minerals.usgs.gov/minerals/pubs/commodity/lead/lead_mcs05.pdf.
[48] Ibid.
[49] European Commission. 2003. Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS). View at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML.

Many substitution opportunities exist. For example, the following are already being produced: lead-free solder, lead-free plating and coating systems, lead-free polyvinyl chloride (PVC), lead-free ammunition, lead-free traffic paint, lead-free tire weights, and lead-free sinkers and jigs.[50]

The development and implementation of public education programs that explain the impacts of improper disposal of lead-containing products on the environment and public health might be effective in changing consumer behavior and reducing exposures. Public education could also be utilized to communicate the importance of recycling lead acid batteries and the proper management and storage of such products, especially where young children are present.

These approaches have already been put into practice by the departments of Ecology and Health as part of efforts to reduce exposures to lead from specialty products such as imported candy, jewelry, toys and lunch boxes. These products are particularly important because they are directly marketed to children, who are often the most vulnerable to lead poisoning.

There are cleanup opportunities for lead: there are 29 listings for lead on the WQA list and an additional 77 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for approximately for lead in the Ecology SEDQUAL database. In addition, there are an unknown number of MTCA sites where lead contamination exceeds MTCA cleanup levels. A conservative estimate, given the extent of lead-arsenic contamination throughout Washington, is that there are at least 400 sites where lead amounts exceed MTCA cleanup levels.

Pentachlorobenzene

Pentachlorobenzene is a man-made substance used to make pentachloronitrobenzene, a fungicide. In addition, it has been and is currently used as a flame retardant.[51] In 1972, 1,400 metric tons were produced in the U.S.; this was down to 1.25 metric tons in 2001. Pentachlorobenzene has not been found in Washington's environment nor in its residents, though this finding may occur because pentachlorobenzene has not been well studied rather than an indication that pentachlorobenzene is not present. Regarding cleanup opportunities, there are no known toxic waste sites or WQA listings based on pentachlorobenzene contamination in Washington. Additional monitoring is needed to determine if pentachlorobenzene is present and if it exceeds any existing criteria or standards. Therefore, opportunities to prevent or manage releases cannot be evaluated at this time: all potential reduction actions could be of use.

Perfluorooctane sulfonates (PFOS) or Perfluoro Compounds

Perfluorooctane sulfonate (PFOS), and its related salts, belong to the broad group of chemicals know as perfluorinated compounds. PFOS has been used in the past in cleaning products, in fire fighting foams and in products such as carpets, furniture, paper, textiles and leather. The uses

[50] Inform. 2006. Industrial Lead Use Fact Sheet. View at: http://www.informinc.org/fs_chp_IndustrialLeadUse.FINAL.pdf
[51] Environmental Protection Agency. Date Unknown. Priority Chemical and Fact Sheets – Pentachlorobenzene. (http://www.epa.gov/epaoswer/hazwaste/minimize/chemlist.htm)

today are in metal plating industry, semiconductor industry and in hydraulic fluids for the aviation industry.[52]

Perfluorooctanoic acid (PFOA) is one of the most widely used forms of the perfluorinated compounds. PFOA is used to make fluoropolymers such as polytetrafluoroethylene (PTFE), which is sold under the brand name "Teflon" by DuPont. Another application of PFOS/PFOA is in the fabrication of water- and stain-resistant clothes and other materials, including products sold under the brand names Stainmaster and Gore-Tex. PFOA is also used to make aqueous film forming foam (AFFF), a component of fire-fighting foams.[53]

Fluorotelomer compounds (such as Zonyl RP by DuPont) are used in food packaging to make them resistant to grease; and while PFOA is not used to make fluorotelomers, they may degrade to form PFOA. These compounds have been used in fast food and candy wrappers, pizza box liners and microwave popcorn bags. Popcorn bags have the most fluorotelomers of any food wrapper, and the high cooking temperatures increase the migration of these chemicals into the popcorn oil. It is estimated that microwave popcorn may account for more than 20% of the average PFOA levels measured in American residents.[54]

In 2000, 3M, the company which makes Scotchgard™ carpet, textile and leather products, decided to phase out PFOA, PFOS and PFOS-related products.[55] The EPA has been looking into PFOA and its potential risks since the late 1990's and released a draft risk assessment in January 2005. That assessment is, as of this writing, still under review by the EPA Science Advisory Board (SAB), which provides independent scientific and engineering advice to the EPA. Three-quarters of the SAB Panel judged that PFOA was consistent with the hazard descriptor "likely to be carcinogenic" (as described in the EPA's cancer guidelines).[56]

Reduction opportunities for PFOS are available. Given that 3M has already successfully replaced PFOS/PFOA in their products, opportunities for substitution and product redesign clearly exist that are still competitive in the marketplace. There are already actions underway in various sectors directed at the reduction and elimination of PFOS/PFOA. For example, in January, 2006, EPA announced a long-term, voluntary program to reduce PFOS/PFOA emissions and product content by 95% no later than 2010, and to work toward eliminating PFOA from emissions and product content no later than 2015. The Environmental Working Group (http://www.ewg.org/) has gone on record as supporting a ban on PFOA and related substances. Materials to raise public awareness regarding potential exposure to PFOS is already readily available; for example, the Toxic Free Legacy Coalition has published information on its website on ways to avoid purchasing or limiting use of products containing perfluorinated compounds.[57]

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[52] KemI: http://www.kemi.se/templates/PRIOEngFrames.aspx?id=4144&gotopage=4216
[53] Environmental Protection Agency. 2006. Basic Information on PFOA. View at: http://www.epa.gov/opptintr/pfoa/pubs/pfoainfo.htm#long.
[54] Science News. November 16, 2005. It's in the microwave popcorn, not the Teflon pan. View at: http://pubs.acs.org/subscribe/journals/esthag-w/2005/nov/science/rr_popcorn.html.
[55] 3M: http://solutions.3m.com/wps/portal/3M/en_US/Scotchgard/Home/Resources/Environmental/
[56] EPA-SAB-06-006. SAB Review of EPA's Draft Risk Assessment of Potential Human Health Effects Associated with PFOA and Its Salts. Available at: http://www.epa.gov/sab/pdf/sab_06_006.pdf
[57] Toxic Free Legacy Coalition. Pollution in People. 2006. View at: http://www.pollutioninpeople.org/toxics/pfcs

In addition, the Centers for Disease Control and Prevention have now included perfluoro compounds in their nationwide biomonitoring program (NHANES). Data from these ongoing studies will become increasingly available over the next several years. With that data, significant opportunities to prevent releases and exposure are also likely to emerge.

Polybrominated Dioxins and Furans (PBDDs and PBDFs)

PBDDs/PBDFs are not known to occur naturally. They are not intentionally produced (except for scientific purposes) but rather are byproducts of various processes.[58]

PBDDs/PBDFs have been found as contaminants in brominated organic chemicals (e.g. bromophenols) and, in particular, in flame retardants, such as PBDEs, decabromobiphenyl decaBB or DBB), 1,2-bis(tribromophenoxy)ethane, TBBPA, and others. They have been detected in distillation residues of some bromophenols and bromoanilines and in wastes from chemical laboratories. PBDFs and, to a lesser extent, PBDDs have been detected as photochemical degradation products of brominated organic chemicals, such as PBDEs and bromophenols.[59]

The most common source of PBDDs/PBDFs is the combustion of bromine-containing products. This most often occurs during house or building fires where products treated with brominated flame retardant (BFR) materials burn. There are also data indicating that PBDDs/PBDFs are released during various end-of-life practices, such as the incineration of plastics containing BFRs.

The best reduction opportunity to prevent or significantly decrease polybrominated dioxin and furan releases is to phase out the uses and applications of brominated flame retardants such as Deca-BDE, HBCD and TBBPA over time. Penta-BDE and Octa-BDE were phased out of commercial production in many parts of the world in December 2004. Viable product redesign and chemical substitutions are already in use. (Refer to Ecology and Health's PBDE Chemical Action Plan for related information.)[60]

Polychlorinated Biphenyls (PCBs)

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products still in existence (made prior to 1977) that may contain PCBs include old fluorescent lighting fixtures (ballasts) and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.[61]

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[58] World Health Organization, International Program on Chemical Safety INCHEM. Environmental Health Criteria 205. 1998. View at: http://www.inchem.org/documents/ehc/ehc/ehc205.htm#PartNumber:1
[59] Ibid.
[60] Washington State Department of Ecology, Polybrominated Diphenyl Ether (PBDE) Chemical Action Plan: Final Plan. January 2006. Available at: http://www.ecy.wa.gov/biblio/0507048.html.
[61] ATSDR. ToxFAQs: Polychlorinated Biphenyls. February 2001. View at: http://www.atsdr.cdc.gov/tfacts17.pdf

Although PCBs have not been manufactured in the U.S. since 1977, they are still found in Washington's environment, especially in lakes, rivers, streams and in marine mammals. According to the EPA, sources of PCB releases include municipal and industrial incinerators from the burning of organic wastes. (Note: according to the most recent TRI report, releases of PCBs in Washington were reported at amounts of less than 0.5 pounds each; the reporting threshold is 10 pounds).

Additional sources to the environment include illegal/improper dumping of PCB wastes such as transformer fluids, leaks or releases from electrical transformers containing PCBs, improper disposal of PCB-containing consumer products, old microscope oil and hydraulic fluids, old TVs and refrigerators, lighting fixtures, electrical devices, or appliances containing PCB capacitors made before 1977. Other sources are poorly maintained hazardous waste sites containing PCBs, and sediments in the bottom of water bodies constantly release small amounts of PCBs into the environment.[62]

PCBs are one of the EPA's Priority PBTs, and are being addressed through a national action plan, a draft of which is currently in development.

Reduction opportunities for PCBs would be best focused around end-of-life practices and cleanup. While there is some regulation at the federal level, management of the remaining PCB-containing products, such as transformers, capacitors, and lighting ballasts, which were manufactured and installed prior to 1977, is not air-tight. Such products are required to be properly managed and disposed of in accordance with existing Toxics Substances Control Act regulations. However there are no phase-out deadlines that require removal of this equipment. The EPA does not regulate all items that potentially contain PCBs. The most well-known example is fluorescent light ballasts, where the ballasts manufactured prior to 1979 contained small PCB capacitors. EPA does not regulate disposal of these items. Instead, EPA encourages proper disposal so that owners avoid potential future Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) liability.

The major source of exposure to PCBs today is the redistribution of PCBs already present in soil and water.[63] There are cleanup opportunities in Washington, with 166 listings for PCBs on the WQA list and an additional 41 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for PCBs identified in the Ecology SEDQUAL database. Additionally, there are 376 MTCA sites where PCBs exceed cleanup levels.

Polychlorinated Dioxins and Furans (PCDDs and PCDFs)

Dioxins and furans are the popular names for a group of chlorinated organic compounds, the most common consisting of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Dioxins and furans are inadvertently generated and released into the

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[62] EPA. PBT Chemical Program. PCBs. View at: http://www.epa.gov/opptintr/pbt/pubs/pcbs.htm
[63] EPA. Technology Transfer Network, Air Toxics Website. Hazard Summary, January 2000. View at: http://www.epa.gov/cgi-bin/epaprintonly.cgi

environment as by-products of various combustion and chemical processes. While the PBT rule lists dioxins and furans separately, they are considered together here because they almost always co-occur and the process of formation is identical.

Due to their toxicity, tendency to bioaccumulate, and persistence in the environment, dioxins and furans have long been the subject of ongoing public health and environmental concern. Despite existing controls, they are distributed widely in the environment, sometimes at levels which may pose risk. EPA has recently estimated that the risks for the general population based on dioxin exposure could be as high as the range of a 1 in 100 to 1 in 1,000 increased chance of experiencing cancer related to dioxin exposure.[64]

Likely sources of dioxin and furan releases in Washington currently include:

- Backyard burning of domestic trash
- Cement kilns
- Crematoria
- Forest, brush and grass fires
- Industrial wood combustion (via hogged-fuel boilers)
- Land-applied biosolids
- Pulp and paper mills
- Residential wood combustion
- Sewage sludge incineration
- Utility coal combustion
- Vehicle fuel combustion

Over the past decade the pulp and paper industry, once one of the major sources of dioxin and furan releases, has replaced chlorine-based technologies with "elemental-chlorine free" technologies resulting in substantially reduced dioxin and furan releases.

Because dioxins and furans are not created intentionally, there are fewer opportunities to prevent their formation through chemical substitution or elimination. There may be some opportunities to prevent their formation through process changes such as was done in the pulp and paper industry. Public awareness and education campaigns may also be of use in changing behavior around many of the practices related to the sources listed above. For example, there could be great value in increasing public awareness on the need to further restrict residential burning of domestic trash, and educating them as to the impact this activity has on the environment and public health. Additionally, promoting the purchase of domestic wood stoves and fire places which meet current industry standards for clean burning will go a long way to further reduce dioxin and furan releases in Washington. Ecology's air quality program has an ongoing initiative to reduce pollutants associated with smoke. Success in this arena will reduce the production of dioxins and furans as well.

[64] EPA. 2000b. Exposure and Human Health Reassessment of 2,3,7,8-Tetrechlorodibenzo-p-Dioxin (TCDD) and Related Compounds (SAB Review Draft). National Center for Environmental Assessment, Office of Research and Development, U.S, Environmental Protection Agency. Washington, D.C. Access: www.epa.gov/ncea/dioxin.htm. June, 2000.

Some opportunities to better manage the production of dioxins and furans during combustion might include:

- Working with EPA, forest and paper interests, and representatives of wood-fired boilers to examine options for more reductions in dioxin emissions from wood-fired boilers.
- Developing emission factors and dioxin emission testing requirements for wood-fired boilers, cement kilns, crematoria.
- Restricting the common practice of "backyard" burning of domestic garbage.

The current end-of-life practice is to dispose of residual ash from incineration practices at municipal solid waste incinerators, cement kilns, and utility coal combustion facilities, in permitted landfills. No other alternative is considered feasible at this time.

There are potential cleanup opportunities for dioxins and furans given that there are 55 (combined) listings for dioxins and furans on the WQA list. Additionally, there are 54 MTCA sites where dioxins and furans exceed cleanup levels.

Polychlorinated Naphthalenes (PCNs)

PCNs are structurally similar to PCBs and, consequently, have had similar uses (e.g. cable insulation, in capacitors). Examples of PCN uses include wood preservatives, engine oil additives, in electroplating and in dye production. Until the 1970's, PCNs were high volume chemicals. In the 1920's the world-wide production was approximately 9000 metric tons per year. Production of PCNs decreased significantly since 1977 and U.S. production ceased in 1980.[65]

There was a lag of about forty years between disclosure of PCN hazards and government regulation. In the U.S., exposure to PCNs was drastically reduced after 1976 following enactment of the Toxic Substances Control Act (TSCA). Major equipment manufacturers banned PCNs in their products, and major PCN producers discontinued operations. By 1983 worldwide PCN production had almost halted except for small amounts used in testing and research. Today PCNs are offered commercially by only a few companies, including Ukrgeochem of Simferopol, Ukraine.

PCNs have not been found in Washington's environment or people, but this finding may be more indicative of the fact that PCNs have not been well studied than an indication that PCNs are not present. Regarding cleanup opportunities, there are no known toxic waste sites or WQA listings based on PCN contamination in Washington. Additional monitoring is needed to determine if PCNs are present and if they exceed any existing criteria or standards. Therefore, opportunities to prevent or manage releases cannot be evaluated at this time: all potential reduction actions could be of use.

[65] van de Plassche, E. & Schwegler, A. *Polychlorinated naphthalenes,* Preliminary Risk Profile, Ministry of VROM/DGM, The Netherlands, 6 August 2002.

Polyaromatic Hydrocarbons (PAHs)

PAHs are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are manufactured for use or are naturally occurring in products such as coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides.[66]

A number of opportunities to reduce or prevent PAH releases are available. Petroleum-based lubricating oils, greases and hydraulic fluids can be replaced with vegetable-based oils, greases and hydraulic fluids in vehicles and equipment with hydraulic lifts and other features.[67] Vegetable-based oils pose a greatly reduced threat to human health and the environment and corn, canola, soy, and other vegetable oils are being used to produce a wide range of lubricants, many of which meet Original Equipment Manufacturer's performance and warranty requirements. Locally, King County is looking to use vegetable-based oils: the King County Renton Equipment Shop now specifies that new turf equipment be filled by the manufacturer with vegetable-based oils and is moving ahead with the purchase of these hydraulic oils for all their equipment.[68]

Another promising area of substitution is the use of recycled plastic lumber instead of creosote treated and preserved wood for retaining walls, piers, and park benches.[69] Product redesign opportunities for two-stroke engines such as those used in lawn mowers may produce significant reductions in PAH releases. Reducing the sulfur content of fuels helps reduce PAH releases.

There are also opportunities to minimize PAH production using existing technologies. For example, for older diesel vehicles, retrofit technologies are available that can reduce the amount of PAHs released, and catalytic converts reduce emissions from standard gasoline powered engines. Compressed natural gas (CNG) buses are also fully commercial, are cleaner and result in reduced PAH releases.[70]

Legislation to further restrict outdoor burning of domestic trash statewide could result in reduced PAH emissions, since current laws only prohibit such actions in the more populated areas in Washington. There are a number of opportunities for consumer education, such as providing

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[66] ATSDR. ToxFAQs: Polycyclic Aromatic Hydrocarbons. September 1996. Viewed At: http://www.atsdr.cdc.gov/tfacts69.html

[67] Inform, Inc. 2003. Public Works and Vehicle Maintenance – Products Containing Persistent, Bioaccumulative Toxics Chemicals (PBTs). Viewed at: http://www.informinc.org/fspubworks.pdf#search=%22replacing%20PAHs%20with%20vegetable%20oils%22

[68] King County Environmental Purchasing Program. 2001. Environmental Purchasing Bulletin #59: Vegetable Oil-Based Hydraulic Fluids. Viewed at: http://www.metrokc.gov/procure/green/bul59.htm#4

[69] Inform, Inc. 2003. Public Works and Vehicle Maintenance – Products Containing Persistent, Bioaccumulative Toxics Chemicals (PBTs). Viewed at: http://www.informinc.org/fspubworks.pdf#search=%22replacing%20PAHs%20with%20vegetable%20oils%22

[70] Inform, Inc. 2000. Bus Futures – New Technologies for Cleaner Cities. Viewed at: http://www.informinc.org/busfuturesintro.pdf

information on the importance of owning domestic wood stoves and fire places which meet current industry standards for clean burning. Additionally, providing information on the importance of recycling used motor oil and re-refining used oils (versus draining such waste oils onto the ground or into a storm drain) would further reduce PAH releases and emissions.

There are also cleanup opportunities for PAHs: there are 123 listings for PAHs on the WQA list and an additional an additional 1,376 exceedances of the Sediment Quality Standards or Cleanup Screening Levels for PAHs in the Ecology SEDQUAL database. In addition, there are 569 documented MTCA sites where PAH contamination exceeds PAH cleanup levels. While many PAH cleanups have likely already occurred, since PAHs are often found with other contaminants, many additional cleanups are expected for PAHs.

Short-chained Chlorinated Paraffins (SSCPs)

SCCPs are mainly used in metal working fluids, sealants, as flame retardants in rubbers and textiles, in leather processing and in paints and coatings.[71] In 2005, 44,000 metric tons of SCCPs were produced.[72]

There are some indications that SCCP releases could be prevented through chemical substitution, including the use of alkyl phosphate esters and sulfonated fatty acid esters that may be suitable as replacements for SCCPs as extreme pressure additives in metal working fluids. Natural animal and vegetable oils may be appropriate substitutes for use in the leather industry. In paint and coatings, phthalate esters, polyacrylic esters, diisobutyrate as well as phosphate and boron containing compounds have been suggested as replacements. Phthalates esters are alternatives for use in sealants. Alternatives for use as flame retardants in rubber, textiles and PVC are antimony trioxide, aluminum hydroxide, acrylic polymers and phosphate containing compounds. All these alternatives would have to be evaluated in the process of developing a chemical action plan to determine whether they were less harmful than SCCPs and meet other cost and production requirements.[73]

SSCPs have not generally been looked for in routine environmental practices. Additional monitoring is needed to determine if SCCPs are present and if they exceed any existing criteria or standards.

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[71] European Commission, DG Environment. August 2005. Risk Profile and Summary Report for Short-chained Chlorinated Paraffins (SCCPs). Available at: http://www.unece.org/env/popsxg/docs/2005/EU%20SCCPs.pdf
[72] The Innovation Group (TIG). 2002. Chemical Profiles – Chloroparaffins. Viewed at: http://www.the-innovation-group.com/ChemProfiles/Chloroparaffins.htm
[73] European Commission, DG Environment. August 2005. Risk Profile and Summary Report for Short-chained Chlorinated Paraffins (SCCPs). Available at: http://www.unece.org/env/popsxg/docs/2005/EU%20SCCPs.pdf

Tetrabromobisphenol A (TBBPA)

Commercial TBBPA is the largest globally produced brominated flame retardant. The demand for TBBPA and its derivatives accounts for over 60,000 metric tons per year. TBBPA is primarily used as a reactive flame retardant in epoxy and polycarbonate resins.[74]

Opportunities to prevent releases of TBBPA should be focused on reducing its use in products and on replacing its use with safer, effective and affordable alternatives. "Safer" alternatives is emphasized here: many large companies in the electronics industry have phased out the use of PBDEs and PBBs (polybrominated biphenyls) as part of their corporate environmental strategy and replaced them with TBBPA, which is, of course, also a PBT. This is a questionable improvement. Halogen-free flame retardants are also being considered. For several of the halogen free alternatives, however, little data are available on their potential environmental and health effects and some of the alternatives are themselves of environmental concern.[75]

The disposal practices of expanded TBBPA-containing polymers, such as ABS, epoxy and polycarbonate resins, may need to be further evaluated to see if current recycling and disposal practices need to be modified.

There are no known toxic waste sites with TBBPA in Washington. Additional environmental monitoring is needed to determine if TBBPA is present in Washington's environment and if it exceeds any criteria or standards.

1,2,4,5-Tetrachlorobenzene (1,2,4,5-TCB)

1,2,4,5-TCB is used as a component of dielectric fluids and in chemical synthesis, as an intermediate or building block to make herbicides, insecticides and defoliants and other chemicals like 2,4,5-trichlorophenol and 2,4,5-trichlorophenoxyacetic acid.[76] 1,2,4,5-TCB is used in the production of herbicide 2,4,5-T, a component of Agent Orange. It has also been used as an insecticide, for electrical insulations, and as an impregnate for moisture resistance.[77]

5,400 metric tonnes were produced in 1980; commercial production of 1,2,4,5-TCB stopped in the U.S. in 1983.[78] Therefore reduction opportunities would most likely be limited to cleanup practices.

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[74] http://www.inchem.org/documents/ehc/ehc/ehc172.htm#SectionNumber:1.3

[75] Stuer-Lauridsen, F., S. Havelund and M. Birkved. 2000. *Alternatives to brominated flame retardants. Screening for environmental and health data*. Working Report 17/2000. Danish EPA, Copenhagen.

[76] Agency for Toxic Substances and Disease Registry. 1,2,4,5-Tetrachlorobenzene Fact Sheet (CAS # 95-94-3). Division of Toxicology - Atlanta, Georgia 30333. http://www.epa.gov/epaoswer/hazwaste/minimize/factshts/tetchlben.pdf

[77] Great Lakes Water Quality Board, International Joint Commission. March 1997. Report on Application of Voluntary, Beyond Compliance Programs to the Virtual Elimination Strategy. Washington/Ottawa.

[78] National Toxicology Program, U.S. Dept. of Health and Human Services. *Toxicity Studies of 1,2,4,5-Tetrachlorobenzene in F344/N Rats and B6C3F1 Mice (Feed Studies).* January 1991. View at: http://ntp.niehs.nih.gov/files/Tox07.pdf

TCB has been found in 37 local sediment samples, but otherwise has not been detected in Washington's environment or people, nor have releases been reported. There are no known toxic waste sites or WQA listings based on TCB contamination in Washington. Additional monitoring is needed to determine if TCB is present and if it exceeds any existing criteria or standards.

Ranking

In looking at the reduction opportunities identified in this section, Ecology compared the types of potential opportunities and evaluated them against the PBT rule's stated purpose: *to reduce and phase-out PBT uses, releases and exposures in Washington*. Points were assigned based on the assumption that opportunities to prevent releases and exposures are the most effective strategy when available; management or recycling provide a good opportunity; and cleanup the least potent overall. The ranking was therefore as follows:

If there are prevention opportunities = "3"
If there are management or recycling opportunities = "2"
If there are cleanup opportunities = "1"
If there was insufficient data = NA

Table 12. Opportunities for Reduction: Final Rankings

Chemical	Prevention Opportunities Likely?	Management or Recycling Opportunities Likely?	Cleanup Opportunities Likely?	Rank
Cadmium	yes	yes	yes	3
Hexabromocyclododecane(HBCD)	NA	NA	NA	NA
Hexachlorobenzene (HCB)	no	no	yes	1
Hexachlorobutadiene (HCBD)	NA	NA	yes	1
Lead	yes	yes	yes	3
Pentachlorobenzene	NA	NA	NA	NA
Perfluorooctane sulfonates (PFOs)	yes	NA	NA	3
Polybrominated dibenzodioxins +furans (PBDDs/PBDFs)	no	NA	NA	1
Polychlorinated biphenyls (PCBs)	no	yes	yes	2
PCDFs/PCDDs	no	yes	yes	2
Polychlorinated naphthalenes (PCNs)	NA	NA	NA	NA
Polycyclic aromatic hydrocarbons (PAHs)	yes	yes	yes	3
Short Chain chlorinated paraffins (SSCPs)	NA	NA	NA	NA
Tetrabromobisphenol A (TBBPA)	NA	NA	NA	NA
Tetrachlorobenzene, 1,2,4,5 (1,2,4,5 TCB)	no	no	yes	1

Conclusion

At this time, the chemicals with highest prevention opportunities appear to be cadmium, lead, PAHs and PFOS releases. PCBs and the chlorinated dioxins and furans releases are less likely to be prevented but opportunities to minimize these releases are likely to be available. Brominated dioxins and furans, hexachlorobenzene hexachlorbutadiene and 1,2,4,5-TCB are present in the environment and can be cleaned up, but opportunities to prevent or manage these releases appear to be minimal.

Multiple Chemical Releases and Exposures

WAC 173-333-410(2) ***Evaluation factors***.
(a) Ecology will consider the following factors when preparing the multiyear schedule: . . . .
(iii) ***Multiple chemical releases and exposures.*** *Scientific evidence on the combined effects of exposure to one or more PBTs and other substances commonly present in the Washington environment.*

The PBT rule does not specify whether "the combined effects of exposure" are to be examined in connection to effects on human health, the environment, or both; it is assumed to be the latter. However, in the course of Ecology's research, it was found that data are very limited on human health impacts, as well as impacts to the environment.

Human Health

"Scientific evidence on the combined effects of exposure" is interpreted here as available toxicology or epidemiology information on how different chemicals (including PBTs and metals of concern) may interact to produce health impacts.

Although people are generally exposed to many chemicals in their lives, most toxicity testing is performed on single chemicals. As a result, there is limited information on how chemicals may interact to modify toxicity. A comprehensive review of all possible interactions between PBTs and metals of concern themselves, and between PBTs and metals of concern and other chemicals, is outside the scope of this document, as is any detailed quantification of the incidence and severity of effects of certain chemicals on particular human health systems.

Several governmental organizations have provided or recommended methods to evaluate chemical mixtures, e.g. EPA, National Academy of Sciences (NAS), Agency for Toxic Substances and Disease Registry (ATSDR). In particular, ATSDR has developed a series of assessments for defined chemical mixtures.[79] Known as Interaction Profiles, these assessments succinctly characterize the toxicological and adverse health effects information for mixtures of hazardous substances. Interaction Profiles evaluate data on the toxicology of the "whole" mixture (if available) and on the joint toxic action of the chemicals, the latter of which is characterized as additive, interactive, synergistic and antagonistic. (These terms are defined below.)

The Profiles include information on several PBTs and metals of concern including lead, cadmium, methylmercury, PCBs, hexachlorobenzene and chlorinated dibenzo-p-dioxins.[80] These assessments predict the types of interactions between chemicals in mixtures based on toxicology, mechanistic and modeling information (e.g., pharmacokinetics, pharmacodynamics). These assessments are mainly focused on predicting impacts of mixtures on human health.

[79] ATSDR's Interaction Profiles are available at: http://www.atsdr.cdc.gov/interactionprofiles/
[80] Information on final and draft Interaction Profiles available at: http://www.atsdr.cdc.gov/interactionprofiles/

Standard terms are used to describe how chemicals affect each other to produce toxicity. *Additivity* of chemicals in a mixture refers to summing the exposure levels or toxic effects for each individual chemical to predict the toxicity of the mixture. *Interaction* refers to chemical mixtures that do not exhibit additivity.[81] One type of interaction, called *synergy*, occurs when the combination of two or more chemicals is more toxic than would be expected from their individual toxicities. *Antagonism* occurs when the effect of a mixture is less than what is expected from the toxicity of each individual chemical.

ATSDR reviewed information on the possible interactions among persistent chemicals found in fish and breastmilk.[82,83] The chemicals included in these assessment are chlorinated dibenzo-p-dioxins, hexachlorobenzene, p,p'DDE, methylmercury and PCBs. The analysis by ATSDR indicated additive, synergist and antagonistic effects and indeterminate interactions between chemicals depending on the toxic effect (human health endpoint). For example, a slight synergistic effect between hexachlorobenzene and PCBs was identified for one endpoint (increase in body and thymus weight). A synergistic effect was identified between PCBs and methylmercury for neurological effects. Four additive effects and two antagonistic interactions were also found between the chemicals.[84] Eleven other possible interaction effects among these persistent chemicals were classified as indeterminate because of the lack of information.

PCBs are also included in an ATSDR Interaction Profile with cesium, cobalt, strontium and trichloroethylene.[85] This profile identifies synergistic effects between PCBs and trichloroethylene for hepatic and neurological effects. Interactions between cesium, cobalt and strontium were indeterminate due to lack of information. Lead is included in three of ATSDR Interaction Profiles (1. arsenic, cadmium, chromium, and lead; 2. lead, manganese, zinc, and copper; and 3. chlorpyrifos, lead, mercury and methylmercury). Synergistic effects were identified involving lead and cadmium and lead and manganese for neurological effects, and lead and mercury for reproductive effects. Other effects involving lead in combination with other metals were identified as additive or less than additive.

Non-Human Biota

There are no known compilations or summaries of data available on the combined effects of PBTs and metals of concern and other substances on the environment and non-human biota. Considerable data does exist on the effects, in whole or in part, of contamination from PBT or metals of concern pollutants. For example, scientists have associated individual PBT and metals of concern substances with a wide range of effects in animals in natural and laboratory situations. Behavioral changes, mortality, reproductive failure, eggshell thinning, developmental abnormalities, impaired growth and development, altered blood chemistry, increased rate of

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[81] ATSDR, 2004. ATSDR guidance manual for the assessment of joint toxic action of chemical mixtures. Available at: http://www.atsdr.cdc.gov/interactionprofiles/ipga.html

[82] ATSDR, 2004. ATSDR Interaction Profile for Persistent Chemicals found in fish. Available at: http://www.atsdr.cdc.gov/interactionprofiles/ip01.html .

[83] ATSDR, 2004. ATSDR Interaction Profile for Persistent Chemicals found in breast milk. Available at: http://www.atsdr.cdc.gov/interactionprofiles/ip03.html

[84] See Table 34, Matrix of BINWOE determinations for repeated simultaneous oral exposure to chemical of concern. Interaction Profile for Persistent Chemicals found in fish.

[85] ATSDR, 2004. Interaction profile for cesium, cobalt, polychlorinated biphenyls, strontium, and trichloroethylene. Available at: http://www.atsdr.cdc.gov/interactionprofiles/ip07.html

disease outbreaks, organ and central-nervous-system damage, and impaired immune-system response are just some of the reported effects of PBTs and metals of concern in wildlife.[86]

Depending on data availability, ecological risk assessment of chemical mixtures has used a component-based approach or a whole mixture approach. For example, some studies have used a component-based approach to predict the toxicity of PAH or chlorinated dioxin and furan mixtures.[9,10] Other studies have evaluated the toxicity of the whole mixture (certain bioassays as well as whole effluent toxicity, WET, testing). Combinations of the two approaches have also been used.[11,12]

Conclusion

Overall, Ecology concludes that there is a general scarcity of information on both human health and ecological effects with which to predict the toxicity of mixtures of PBTs and metals of concern and of mixtures of PBTs or metals of concern and other chemicals. Recently developed information from ATSDR for human health indicates that lead and PCBs in particular can produce greater than additive effects for some human health systems when combined with certain chemicals. Lead and PCBs are already ranked high in terms of human health (refer to Table 3, p 11), and are high in the combined overall relative ranking. Data for ranking the remaining 14 PBTs are not available for human health. Similarly, information on chemical mixture ecotoxicity represents a major data gap.

Therefore, Ecology has decided that information on multiple chemical releases and exposures is too limited to be used to evaluate PBTs and metals of concern in this multiyear CAP schedule. However, Ecology will continue to track literature on issues related to multiple chemical releases and exposures.

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[86] Wisconsin Dept. of Natural Resources. View at: http://dnr.wi.gov/environmentprotect/pbt/howdo.htm

[9] Swartz, RC et al. 1995. ΣPAH: A model to predict the toxicity of PAH mixtures in field-collected sediments. Environ. Toxicol. Chem. 14:1977-1987.

[10] EPA.. 2001. Workshop report on the application of 2,3,7,8-TCDD toxicity equivalence factors to fish and wildlife. EPA/630/R-01/002.

[11] Landis, WG and MH Yu. 1995. Introduction to environmental toxicology. Lewis Pub, Boca Raton, FL.

[12] Samoiloff, MR et al. 1983. Combined bioassay-chemical fractionation scheme for the determination and ranking of toxic chemicals in sediments. Environ. Sci. Technol. 17:329-334.

Sensitive Population Groups and High-Exposure Populations

WAC 173-333-410(2) ***Evaluation factors****.*
(a) Ecology will consider the following factors when preparing the multiyear schedule:. . . .
(iv) ***Sensitive population groups and high-exposure populations****. Scientific evidence on the susceptibility of various population groups including the timing of the exposure and the cumulative effects of multiple exposures.*

"Sensitive population groups and high-exposure populations" are defined here as groups that are particularly susceptible to the effects of PBTs and metals of concern, whether due to personal factors such as stage of life or genetics, or because of the intensity of the particular exposure. In general, the groups known to be the most sensitive to exposure to PBTs and metals of concern are fetuses (through the placenta), infants and children.

Several diverse groups could be considered high-exposure populations. One group is persons who eat large amounts of fish from waters contaminated with certain PBTs and metals of concern. (Note: eating a variety of fish is still an important part of a healthy diet.[87]) Industry workers are at risk (e.g. those involved in PBT or metal of concern chemical production, or in the manufacture or disposal of products containing PBTs), and populations that live in close proximity to industrial properties, hazardous waste sites or other localized sources of PBTs and metals of concern. And babies and young children who are breast-fed may be high recipients of PBTs and metals of concern via breast milk. PBTs and metals of concern have been shown to accumulate in breast milk as a result of the mother's exposures. (Note: the state Department of Health and other health agencies continue to promote breast milk as the healthiest option for feeding babies.[88])

The two populations that are widely represented in Washington for which there are compelling data are fetuses/children ("sensitive") and populations with a high fish intake ("high-exposure"). Ecology has therefore chosen to focus on these two groups for the purposes of this multiyear schedule evaluation.

Workers could also be considered high-exposure populations in the case of occupational exposures to PBTs and metals of concern. Workplace conditions/exposures are managed at the state and federal levels. The Washington Industrial Safety and Health Act (WISHA) is Washington State's occupational safety and health program, which guides the preparation and

[87] While some of the higher levels of PBTs have been detected in fish, the Washington State Dept. of Health continues to encourage people to eat a variety of fish as part of a healthy diet. Fish are an excellent source of protein and beneficial fatty acids. Choose fish that are low in contaminants, and prepare fish and meats in ways that reduce fat. Check to see if there is a Fish Advisory in the area where you plan to go fishing. For additional information on the health benefits of eating fish and existing fish consumption advisories and recommendations, visit Health's "Fish Facts" website at http://www.doh.wa.gov/fish.

[88] The known health benefits of breast feeding outweigh any possible health risks from PBTs in breast milk. Breast milk contains factors that boost the immune system and develop brain tissue, and may well protect the infant from the effects of prenatal exposure.

adoption of standards governing workplace safety and health conditions. The federal Occupational Safety and Health Administration (OSHA) approves, monitors and partially funds "state plan" programs. OSHA requires state plans to be at least as effective as federal standards.[89] Because of the existing state and federal oversight of worker exposures under these workplace regulations, Ecology will not evaluate workers as a potentially highly exposed group.

Fetuses/Children

A wide range of research supports the fact that fetuses and children are at high risk from exposure to toxic chemicals, such as PBTs and metals of concern. In one of many reports by the Agency for Toxic Substances and Disease Registry (ATSDR) on this subject, it is stated that "developing human beings in the womb and through puberty can be uniquely vulnerable to environmental toxicants" and describes several reasons for this "different susceptibility." Fetuses can be exposed via the placenta, and are the most susceptible to chemical injury since body organs are being formed. After birth, children may have greater exposures to toxic chemicals than adults, since pound for pound of body weight, children drink more water, eat more food, and breathe more air than adults. Two characteristic behaviors of young children increase their likelihood of exposure (through ingestion of toxicants in dust or soil): their hand-to-mouth behavior, and their play activities, which are close to the ground. Children are undergoing rapid growth and development, and therefore are particularly vulnerable to exposures that disrupt the developmental process. Development of the nervous system, for example, continues all through childhood, and if cells in the developing brain are destroyed by chemicals, or if the formation of vital connections between the cells is interfered with, there is a high risk of permanent neurobehavioral dysfunction.[90,91]

The EPA reports that childhood lead poisoning remains a major environmental health problem in the U.S.; even children who appear healthy can have dangerous levels of lead in their bodies.[92] Lead may cause a range of health effects, from behavioral problems and learning disabilities, to seizures and death. Children 6 years old and under are most at risk, because their bodies are growing quickly.[93] Lead reduction is the focus of extensive efforts in the EPA, under the Office of Pollution Prevention and Toxics (OPPT) and elsewhere at the federal level.[94] Washington State has a blood level registry which includes blood lead data for children (see "Levels of Chemical Present in Washington Residents" section, p 33.)

PCBs have been shown to impact normal brain development in addition to producing other toxic effects.[95] PCBs have been well studied in laboratory animal and human epidemiological studies. These studies indicate that exposures to PCBs are associated with impairments in brain function resulting in deficits in IQ, memory, language and school performance. Other PBTs with possible

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[89] WA State Dept. of Labor and Industries website link: http://www.ufcw1105.com/wisha.htm

[90] ATSDR. *Healthy Children—Toxic Environments*. 1997. View at: http://www.atsdr.cdc.gov/child/chw497.html

[91] Rice, D. and S. Barone Jr., 2000. Critical periods of vulnerability for the developing nervous system: evidence from human and animal models. Environmental Health Perspective, 108 (suppl. 3): 511-33.

[92] EPA data?, Basic Information on Lead in Paint, Dust and Soil. View at: http://www.epa.gov/lead/pubs/leadinfo.htm.

[93] EPA, Basic Information on Lead in Paint, Dust and Soil. View at: http://www.epa.gov/lead/

[94] For more information on EPA-related activities and studies on lead, go to: http://www.epa.gov/lead/pubs/leadtpbf.htm or http://www.epa.gov/opptintr/lead/pubs/resources.htm

[95] ATSDR, 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs). Available at: http://www.atsdr.cdc.gov/toxprofiles/phs17.html

human neurodevelopmental or other developmental effects include PCDD/PCDF, hexachlorobenzene and PFOS.[96,97,98]

Populations with diets high in fish

Because of the persistent and bioaccumulation properties of PBTs and metals of concern, PBTs and metals of concern released into the environment tend to build up in fish and several PBTs and metals of concern have been found in fish throughout Washington (see "Levels of the Chemical Present in the Washington Environment" section, p 27 that discusses fish levels measured in Washington). For many PBTs and metals of concern, such as PCBs and methylmercury, fish consumption has been identified as a main route of exposure for the general public.[99,100]

Several groups in Washington State have been identified as having diets high in fish and are therefore at risk from increased exposures to PBTs and metals of concern. Fish consumption surveys have been used to characterize the fish eating patterns of several tribes in Washington including the Umatilla, Nez Perce, Yakama, Warm Springs, Tulalip, Squaxin and Suquamish tribes.[101,102,103] Fish consumption surveys ask how much fish people eat, how often, and what types of species are eaten. For the surveys of Native Americans, fish consumption information was collected during interviews with tribal members. These surveys show that Native Americans eat approximately five to ten times, and in one survey, up to almost 30 times more fish than the general U.S. population based on comparing the average amount of fish eaten.[104,105]

A fish consumption survey conducted in the Asian and Pacific Islander community in the Seattle area indicates high fish consumption among this population.[106] This survey, along with an

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[96] ATSDR, 1998. Toxicological Profile for Chlorinated Dibenzo-p-dioxins (CDDs). Available at: http://www.atsdr.cdc.gov/toxprofiles/phs104.html

[97] ATSDR, 2002. Toxicological Profile for hexachlorobenzene. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp90.html

[98] Organization for Economic Co-operation and Development (OECD), 2002. Co-operation on existing chemicals; Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts. ENV/JM/RD(2002)17/Final Available at: http://www.oecd.org/document/58/0,2340,en_2649_34379_2384378_1_1_1_1,00.html

[99] Tee et al., 2003. A longitudinal examination of factors related to changes in serum polychlorinated biphenyl levels. Environmental Health Perspectives 111(5):702-707.

[100] National Academy of Sciences (NAS), 2000. Toxicological effects of methylmercury. National Academy Press, Washington D.C.

[101] CRITFC (Columbia River Inter-Tribal Fish Commission), 1994. A fish consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin. CRITFC Technical Report No. 94-3. Portland, Oregon.

[102] Toy, K.A., Polissar, N.L., Liao, S. and Middelstaedt, G.D., 1996. A fish consumption survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region. Tulalip Tribes, Department of Environment, 7615 Totem Beach Road, Marysville, WA 98271.

[103] The Suquamish Tribe, 2000. Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region. The Suquamish Tribe. 15838 Sandy Hook Road, Post Office Box 498, Suquamish, WA 98392.

[104] EPA, 2000. Guidance for assessing chemical contaminant data for use in fish advisories, volume 2. See Appendix B, Table B-7 for general population estimates.

[105] Personal communication Lon Kissinger August, 2006. Table summarizing Region 10 seafood consumption rates used for risk analysis.

[106] EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003. Available at: http://www.epa.gov/r10earth/offices/oea/risk/a&pi.pdf

ongoing study of fish consumption among Japanese and Korean women in the Seattle area, indicate that Asian and Pacific Islanders are high consumers of fish.[107] People who catch fish recreationally have also been identified as high fish consumers. Fish consumption surveys have shown high fish consumption among recreational fishermen in the Puget Sound area.[108]

Ranking

PBTs and metals of concern were ranked on a scale of 1-3, lowest to highest. As with the sections on reduction opportunities and existing plans or regulatory requirements, the ranking system is subjective, since the material does not easily lend itself to a quantitative analysis. As is true throughout this multiyear CAP schedule evaluation, the ranking is biased towards those chemicals for which there is the greatest amount of data.

For fetuses/children, the representative "sensitive population:" the ranking is based on the degree to which exposure to a given chemical can have neurodevelopmental impacts. Chemicals for which detrimental effects have been observed in human studies received a "3." Chemicals for which there is some laboratory animal or other data indicating negative developmental effects were given a "2." A ranking of "1" was assigned to chemicals that have not shown developmental effects in human or animal studies.

For groups with a diet high in fish, the representative "high-exposure population:" the number of Dept. of Health fish advisories was used, as well as data from the Water Quality Assessment.[109] While there is no way to assess how much fish from contaminated sources was consumed by any particular group, it can be assumed that populations that consume relatively high amounts of fish are more likely to be exposed to contaminated fish. Fish Advisories are one of the few indicators available. Therefore, if there is a Health Fish Advisory, then a chemical was ranked "3."

If there are detections of a chemical recorded in the Water Quality Assessment, this is an indicator of potential future problems, if left unattended. In this case, a chemical was ranked a "2."

If there was no information on possible exposures, the chemical was assigned "NA," since there was no data with which to determine a ranking.

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[107] UW Dept. of Environmental and Occupational Health Sciences, Environmental Health News. Spring-Summer 2006.

[108] Landolt M, Hafer F, Nevissi A, van Belle G, Van Ness K, and Rockwell C. 1985. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound. NOAA Technical Memorandum NOS OMA 23. Rockville, MD.
Landolt M, Kalman D, Nevissi A, van Belle G, Van Ness K, and Hafer F. 1987. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound: Final Report. NOAA Technical Memorandum NOS OMA 33. Rockville, MD.

[109] See the "Levels of the Chemical Present in the Environment" section earlier in this document, p 27 for specifics on both Health Fish Advisories and the WQA detections. For more information on Dept. of Health Fish Advisories, visit their website at: http://www.doh.wa.gov/ehp/oehas/EHA_fish_adv.htm.

Final ranking score: The rankings for developmental effects and fish consumption were reviewed and the higher of the two was used as the overall "sensitive population groups and high-exposure populations" ranking. See Table 13.

Table 13. Rankings for sensitive population groups and high-exposure populations.

Chemicals	Developmental Effects -- Sensitive Populations (infants and children)	Fish Consumption (high fish consumers)	Overall Sensitive/High-Exposure Ranking
Cadmium	1	2	2
Hexabromocyclododecane (HBCD)	1	NA	1
Hexachlorobenzene (HCB)	2	2	2
Hexachlorobutadiene (HCBD)	1	2	2
Lead	3	3	3
Pentachlorobenzene	1	NA	1
Perfluorooctane sulfonates (PFOS)	2	NA	2
Polybrominated dibenzodioxins + furans (PBDDs/PBDFs)	1	NA	1
Polychlorinated biphenyls (PCBs)	3	3	3
Polychlorinated dibenzo-p-dioxins + dibenzofurans (PCDDs/PCDFs)	2	3	3
Polychlorinated naphthalenes (PCNs)	1	NA	1
Polycyclic aromatic hydrocarbons (PAHs)	1	3	3
Short-chain chlorinated paraffins (SCCPs)	1	NA	1
Tetrabromobisphenol A (TBBPA)	1	NA	1
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	1	NA	1

Conclusion
Lead, PCBs, PCDD/PCDFs and PAHs all received "3"s, the highest ranking: these chemicals have the most (known) detrimental effects on sensitive and high-exposure populations. Cadmium, HCB, HCBD and PFOS all ranked "2."

Existing plans or regulatory requirements

WAC 173-333-410(2) ***Evaluation factors****.*
(a) Ecology will consider the following factors when preparing the multiyear schedule: . . . .
(v) ***Existing plans or regulatory requirements.*** *Whether there are existing plans or regulatory requirements that reduce and phase out uses and releases of a particular PBT or group of PBTs.*

The PBT rule includes a list of 27 PBTs and metals of concern. At the start of developing the multiyear schedule, the list was reviewed and 11 chemicals eliminated from consideration. The majority of these were excluded because they are no longer produced: eight pesticides have been banned, as has Hexabromobiphenyl, which was used as a flame retardant. The remaining two (mercury and PBDEs) already have CAPs developed for them. These 11 were therefore eliminated because existing plans and regulatory requirements already existed for their management.

Existing plans and regulatory requirements were reviewed for the remaining 16 PBTs and metals of concern under consideration, including the following state and national regulations and plans/programs:

Washington State regulations

Model Toxics Control Act Cleanup Levels (WAC 173-340)[110]

Washington's hazardous waste cleanup law, the Model Toxics Control Act (RCW 70.105D), mandates that cleanups of hazardous waste sites be protective of public health and the environment. To implement this statutory mandate, Ecology established cleanup levels and requirements for the cleanup of hazardous waste sites, which provide a uniform, statewide approach to cleanup that can be applied on a site-by-site basis. PBTs and metals of concern that have numerical Method A cleanup levels are lead, PAHs, PCBs and cadmium.[111] If there is a reference dose or cancer potency factor available for the other chemicals, then a Method B cleanup level can also be calculated, by using the Cleanup Levels and Risk Calculation (CLARC) tool database.[112,113]

There are four additional PBTs looked for in the context of terrestrial ecological evaluation procedures (also part of MTCA): PCDD, PCDF, HCB and pentachlorobenzene. The purpose of

[110] Department of Ecology. 2006. Chapter 173-340 WAC, Model Toxics Control Act Cleanup Regulation. Viewed at: http://www.ecy.wa.gov/pubs/wac173340.pdf
[111] Ibid.
[112] Ibid.
[113] Additional information on the CLARC database is available at the following link: https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx

a Terrestrial Ecological Evaluation is to protect land-based plants and animals from exposure to contaminated soil.

Controls for New Sources of Toxic Air Pollutants (WAC 173-460)[114]

The Controls for New Sources of Toxic Air Pollutants regulation establishes the systematic control of new sources emitting toxic air pollutants in order to prevent air pollution and maintain levels of air quality to protect human health and safety. PBTs and metals of concern that are listed in this rule as "Class A" toxic air pollutants (known and probable carcinogens) include cadmium, chlorinated dioxins and furans, lead, PAHs, PCBs, and hexachlorobenzene. Hexachlorobutadiene is listed as a "Class B" toxic air pollutant.

Control of Particulate Matter (PM)

The following air quality regulations result in the indirect reduction of PAHs, (and to a lesser degree PCDD, PCDF, PBDD and PBDF) because particulate matter is often the carrier or method by which these PBTs are emitted into the air. Compounds such as PAHs have a high affinity for particulate matter, therefore, control of particulates results in reductions of these PBTs as well.

Airborne particulate matter (PM) consists of many different substances suspended in air in the form of particles (solids or liquid droplets) that vary widely in size. The particle mix is usually dominated by fine particles (less than 2.5 micrometers in diameter) generated by combustion sources, with smaller amounts of coarse dust (between 2.5 and 10 micrometers in diameter).[115] Particles less than 10 micrometers in diameter, include both fine and coarse dust particles. These particles pose the greatest health concern because they can pass through the nose and throat and get into the lungs.[116] Particles larger than 10 micrometers in diameter that are suspended in the air are referred to as total suspended particulates (TSP). These larger particles can cause irritation to the eyes, nose and throat in some people, but they are not likely to cause more serious problems since they do not get down into the lungs.[117]

Motor Vehicle Inspection Emission (WAC 173-422)[118]

The purpose of this regulation is to implement the Washington Clean Air Act, chapter 70.94 RCW, as supplemented by the motor vehicle emission inspection provisions codified as chapter 70.120 RCW.[119] Gasoline motor vehicles are the primary emitters of carbon monoxide and emit significant quantities of hydrocarbons and oxides of nitrogen. Diesel motor vehicles primarily

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[114] Department of Ecology. 2006. Chapter 173-460 WAC, Controls for New Sources of Toxic Air Pollutants. Viewed at: http://www.ecy.wa.gov/pubs/wac173340.pdf

[115] Environmental Protection Agency. 2006. PM-10 Fact Sheet. Viewed at: http://www.epa.gov/wtc/pm10/pm_fact_sheet.html

[116] Ibid.

[117] Ibid.

[118] Department of Ecology. 2002. Chapter 173-422 WAC, Motor Vehicle Emission Inspection. Viewed at: http://www.ecy.wa.gov/pubs/wac173422.pdf

[119] Ibid.

emit particulates, hydrocarbons, and oxides of nitrogen. Therefore, emission controls specific to the type of engine are required by the federal government and are designed to reduce motor vehicle related air pollution.[120] However, the effectiveness of these controls is substantially reduced through deterioration, maladjustment and tampering of individual motor vehicles. Washington's motor vehicle emission inspection program serves to identify high polluting vehicles and vehicles with tampered or missing emission controls. These regulations establish the emission standards, testing procedures, and associated activities necessary to implement a program of air pollution prevention and control resulting from motor vehicle emission inspections.[121]

Outdoor Burning (WAC 173-425)[122]

Combustion processes produce both particulate matter and PAHs. Open burning is, by definition, uncontrolled and often results in significant releases of both particulate and PAHs. The purpose of this regulation is to implement the limited burning policy authorized by sections 743 through 765 of the Washington Clean Air Act (chapter 70.94 RCW) and other provisions of the act that pertain to outdoor burning (except any outdoor burning related to agricultural burning or any burning within federally recognized Indian Reservations.[123] This rule requires Ecology and other agencies to: (1) reduce outdoor burning to the greatest extent practical, especially by prohibiting it in certain circumstances; (2) establish a permit program for limited burning, one that requires permits for most types of outdoor burning; and (3) foster and encourage development of reasonable alternatives to burning.[124]

Solid Fuel Burning Devices (173-433 WAC)[125]

This regulation establishes emission standards, certification standards and procedures, curtailment rules, and fuel restrictions for solid fuel burning devices such a wood burning stoves, purchased after January 1, 1995 to comply with 40 CFR 60 Subpart AAA – Standards of Performance for Residential Wood Heaters.[126]

Ambient Air Quality Standards for Particulate Matter (173-470 WAC)[127]

The purpose of this regulation, promulgated under RCW 70.94.305 and 70.94.331, is to establish maximum acceptable levels for particulate matter in the ambient air. Particulate matter is characterized in criteria developed by the United States Environmental Protection Agency. The

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[120] Ibid.
[121] Ibid.
[122] Department of Ecology. 2000. Chapter 173-425 WAC, Outdoor Burning. Viewed at: http://www.ecy.wa.gov/pubs/wac173425.pdf

[123] Ibid.
[124] Ibid.
[125] Department of Ecology. 1993. Chapter 173-433 WAC, Solid Fuel Burning Devices. Viewed at: http://www.ecy.wa.gov/pubs/wac173433.pdf
[126] Ibid.
[127] Department of Ecology. 1989. Chapter 173-470 WAC, Ambient Air Quality Standards for Particulate Matter. Viewed at: http://www.ecy.wa.gov/pubs/wac173470.pdf

level of the 24-hour ambient air quality standard for PM-10 is 150 micrograms per cubic meter (over a 24 hour average concentration).[128]

Regulations applicable to Lead

Vehicle Battery Recycling (173-331 WAC)[129]

The purpose of this regulation is to establish procedures to accomplish the recycling of used vehicle batteries through a system of exchanging batteries at the point of sale, as authorized by RCW 70.95.610 through 70.95.660.[130] Vehicle batteries are defined as batteries which are used in any vehicle, truck, mobile home, recreational vehicle, boat, airplane, or utility vehicle, having a core of elemental lead, with the capability to produce six or more volts.[131]

National Ambient Air Quality Standards (40 CFR part 50)[132]

The Clean Air Act requires EPA to set national ambient air quality standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings[133].

The EPA Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards for six principal pollutants, including lead, which are called "criteria" pollutants. The primary standard for lead is 1.5 micrograms per cubic meter (1.5 ug/m3)[134]. In Washington, attainment status has long been achieved and statewide monitoring for lead is no longer conducted.

Sediment Management Standards (WAC 173-204)[135]

The Sediment Management Standards regulation (WAC 173-204) establishes marine, low salinity and freshwater surface sediment management standards for the state of Washington. The purpose of this regulation is to reduce and ultimately eliminate adverse effects on biological resources and threats to public health from surface sediment contamination. This is accomplished by establishing standards for the quality of surface sediments and to apply those

[128] Ibid.
[129] Department of Ecology. 1991. Chapter 173-331 WAC, Vehicle Battery Recycling. Viewed at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-331&full=true
[130] Ibid.
[131] Ibid.
[132] Environmental Protection Agency. 2006. National Ambient Air Quality Standards (NAAQS). Viewed at: http://www.epa.gov/air/criteria.html
[133] Ibid.
[134] Ibid.
[135] Department of Ecology. 2006. Chapter 173-204 WAC, Sediment Management Standards. Viewed at: http://www.ecy.wa.gov/pubs/wac173204.pdf

standards as a basis for management and reduction of pollutant discharges and to provide management and decision process for contaminated sediment cleanup. PBTs and metals of concern that are listed in the Sediment Management Standards rule with a numeric listing criteria include lead, PAHs, PCBs, dibenzofurans, cadmium, hexachlorobenzene and hexachlorobutadiene.

Dangerous Waste Regulations (WAC 173-303)[136]

The Dangerous Waste regulation implements the Hazardous Waste Management Act (RCW 70.105) and also implements Subtitle C of Public Law 94-580 (The Resource Conservation and Recovery Act). The purposes of this regulation are to:

1. Designate those solid wastes which are dangerous or extremely hazardous to the public health and environment
2. Provide for surveillance and monitoring of dangerous and extremely hazardous wastes until they are detoxified, reclaimed, neutralized, or disposed of safely
3. Provide the form and rules necessary to establish a system for manifesting, tracking, reporting, monitoring, recordkeeping, sampling, and labeling dangerous and extremely hazardous wastes
4. Establish the siting, design, operation, closure, post-closure, financial, and monitoring requirements for dangerous and extremely hazardous waste transfer, treatment, storage, and disposal facilities
5. Establish design, operation, and monitoring requirements for managing the state's extremely hazardous waste disposal facility
6. Establish and administer a program for permitting dangerous and extremely hazardous waste management facilities
7. Encourage recycling, reuse, reclamation, and recovery to the maximum extent possible.

PBTs and metals of concern that are listed in the Dangerous Waste Regulations Constituents List include lead, PAHs, chlorinated dioxins and furans, PCBs, cadmium, hexachlorobenzene, hexachlorobutadiene, pentachlorobenzene, and 1,2,4,5 tetrachlorobenzene. In addition, Washington's dangerous waste regulations include a requirement to evaluate all wastes for certain criteria above and beyond the federal requirements. Two of these criteria are toxicity and persistence. Therefore, all wastes are evaluated for persistence and toxicity separately. Depending upon concentration, it is likely that all of the PBT and metals of concern chemicals could cause wastes to designate as dangerous wastes in Washington State.

Notifiable Conditions (WAC 246-101)[137]

The purpose of the notifiable conditions reporting rule is to provide necessary information for public health officials to protect public health by tracking communicable diseases and other conditions. These data are critical to local health departments and the state Departments of Health and Labor and Industries in their efforts to prevent and control the spread of diseases and

[136] Department of Ecology. 2006. Chapter 173-303 WAC, Dangerous Waste Regulations. Viewed at: http://www.ecy.wa.gov/pubs/wac173303.pdf
[137] Department of Health. 2006. Chapter 246-101 WAC, Notifiable Conditions. Viewed at: http://apps.leg.wa.gov/WAC/default.aspx?cite=246-101

other conditions.[138] The "blood lead level," which is a measurement of lead content in whole blood, is one of several notifiable conditions that are required to be reported to Health or to the local health jurisdiction.[139]

Lead is the only PBT or metal of concern that is required to be reported as a notifiable condition according to WAC 246-101. Elevated levels of lead must be reported to Health by laboratories who run the test.[140] About 4% of Washington children are tested and their results tracked by Health as part of the blood lead registry. Adult blood lead reports are forwarded by Health to the Department of Labor and Industries for follow-up related to potential occupational exposures.

National regulations and plans

EPA TRI -- PBT Reporting Requirements[141]

The Emergency Planning and Community Right-to-Know Act (EPCRA), was passed by the U.S. Congress in 1986. Under EPCRA, certain businesses are required to submit reports every year on the amounts of toxic chemicals their facilities release into the environment, either routinely or by accident. This information, known as the Toxic Release Inventory (TRI) keeps the government and public informed of toxic chemicals released into the environment.[142] TRI reports are submitted to the U. S. EPA, and to state and tribal governments. There are 16 PBT chemicals and 4 PBT chemical compound categories which are subject to reporting under the EPCRA section 313.[143] PBTs and metals of concern identified on the TRI PBT List and that are part of this multiyear CAP schedule review include lead, PAHs, chlorinated dioxins and furans, PCBs, hexachlorobenzene, tetrabromobisphenol A and pentachlorobenzene.

EPA's PBT Chemical Program[144]

In November 1998, EPA released a draft PBT Strategy, "A Multimedia Strategy for Priority Persistent, Bioaccumulative, and Toxic (PBT) Pollutants." The initial focus for action is 12 PBTs considered Level 1 substances under the Binational (U.S. and Canada) Toxics Strategy: aldrin/dieldrin, benzo(a)pyrene, chlordane, DDT, hexachlorobenzene, alkyl-lead, mercury and compounds, mirex, octachlorostyrene, PCBs, dioxins and furans, and toxaphene. EPA is developing chemical action plans designed to use a full range of tools to prevent and reduce releases of these 12 (and later other) PBTs. These tools include international, voluntary, regulatory, programmatic, remedial, compliance monitoring and assistance, enforcement,

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138 Ibid.
139 Ibid.
140 DOH, 2002. Childhood Lead Poisoning. Chapter in the report, The Health of Washington State. Available at: http://www.doh.wa.gov/ehp/oehas/publications_pdf/bio_plan_11-03.pdf
141 Environmental Protection Agency. 2006. TRI PBT Chemical List. Viewed at: http://www.epa.gov/tri/chemical/pbt_chem_list.htm
142 Department of Ecology. 2006. HWTR TRI Web page. Viewed at: http://www.ecy.wa.gov/epcra/index_trids.html
143 Environmental Protection Agency. 2006. Toxic Release Inventory Program – TRI PBT Chemical List. Viewed at: http://www.epa.gov/tri/chemical/pbt_chem_list.htm
144 Environmental Protection Agency. 2006. PBT Action Plans. Viewed at: http://www.epa.gov/opptintr/pbt/pubs/epaaction.htm

research, and outreach tools. EPA will analyze PBT pollutant sources and reduction options as bases for grouping pollutants, activities, and sectors to maximize efficiencies in achieving reductions. To date, EPA has finalized CAPs for mercury and alkyl-lead, and there are draft CAPs completed for hexachlorobenzene, octachlorostyrene, and the pesticides aldrin/dieldrin, chlordane, DDT, mirex, and toxaphene. CAPs for PCBs and PAHs (as benzo(a)pyrene) are still in development. A CAP for dioxins and furans has not been started.

EPA: National Primary Drinking Water Regulations[145]

The National Primary Drinking Water Regulations are legally enforceable standards that apply to public water systems. These standards protect public health by limiting the levels of contaminants in public drinking water supplies. PBTs and metals of concern that have primary drinking water standards (maximum contaminant levels, MCLs) include lead, PAHs, chlorinated dioxins and furans, PCBs, cadmium and hexachlorobenzene.

EPA Strategies

Global Stewardship Program on PFOA and Related Chemicals

In January 2006, the EPA Administrator invited fluoropolymer and telomer manufacturers to participate in a global stewardship program on PFOA and related chemicals. Participating companies were asked to commit to reducing PFOA from emissions and product content by 95 percent no later than 2010. This is to be measured from a year 2000 baseline, and includes both facility emissions to all media of PFOA, precursor chemicals that can break down to PFOA and related higher homologue chemicals, *and* product content levels of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals.[146] Participating companies are to work toward eliminating PFOA from emissions and product content no later than 2015.[147] Eight companies have committed to the PFOA stewardship program.[148]

EPA Lead in Paint, Dust and Soil Abatement Strategy

Research suggests that the primary sources of lead exposure for most children are: deteriorating lead-based paint, lead contaminated dust, and lead contaminated residential soil.[149] EPA is playing a major role in addressing these residential lead hazards. In 1978, there were three to four million children with elevated blood lead levels in the U. S. By 2002, that number had dropped to 310,000, and continues to decline. While there is still a significant challenge

[145] Environmental Protection Agency. 2006. List of Drinking Water Contaminants & MCLs. Viewed at: http://www.epa.gov/safewater/mcl.html
[146] Environmental Protection Agency. 2006. 2010/15 PFOA Stewardship Program. Viewed at: http://www.epa.gov/opptintr/pfoa/pubs/pfoastewardship.htm.
[147] Ibid.
[148] Ibid.
[149] Environmental Protection Agency, 2006. Lead in Paint, Dust and Soil. Viewed at: http://www.epa.gov/lead/index.html

ahead, federal, state, tribal, and private sector partners have coordinated efforts with the public to better protect children.[150]

EPA Pulp, Paper, and Paperboard Cluster Rule

The combined air and water "cluster rule" for the pulp and paper industry protects human health and the environment by reducing toxic pollutant releases to the air and water. The technology standards in the rule cut toxic air pollutant emissions by almost 60 per cent from current levels and virtually eliminate all dioxin discharged from pulp, paper, and paperboard mills into rivers and other surface waters.[151] The rule also provides individual mills with incentives to adopt Advanced Pollution Control Technologies that will lead to further reductions in toxic pollutant discharges beyond the water discharge limits set in the rule. This is the first time EPA issued an integrated, multi-media regulation (or "cluster rule") to control the release of pollutants to two media (air and water) from one industry.[152]

Ranking

Each chemical was assigned a ranking between 1 and 3, based on the number of identified applicable plans or regulations. The *more* existing plans and regulations, the *lower* the ranking, because actions in Washington State are less likely to have a significant impact on chemicals which are already being evaluated and regulated by other agencies.

The ranking breakdown is as follows:

Chemicals with none, or 1 identified applicable plan or regulation = "3
Chemicals with two to four identified plans or regulations = "2"
Chemicals with between five and seven identified plans or regulations = "1"

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[150] Ibid.
[151] Environmental Protection Agency. 1997. EPA's Final Pulp, Paper, and Paperboard "Cluster Rule" – Overview. Viewed at: http://www.epa.gov/waterscience/pulppaper/jd/fs1.pdf
[152] Ibid.

Table 14. Existing plans, and regulations with applicable standards or limits established

Chemical or Chemical Group	MTCA Cleanup levels and/or terrestrial evaluation (WAC 173-340)	Air Toxics Standards (WAC 173-460)(1)	Sediment Management Standards(3) (WAC 173-204)	TRI/PBT Reporting Require-ment	Dangerous Waste Constituents List (WAC 173-303-9905)	EPA CAP(4)	Drinking Water Standards (Maximum Contami-nant Levels, MCLs)	Speci-fic EPA Stra-tegies	Rank
Cadmium	Y*	Y	Y	N	Y	N	Y		1
Hexabromocyclodo-decane (HBCD)	N	N	N	N	N	N	N		3
Hexachlorobenzene (HCB)	Y	Y	Y	Y	Y	Y	Y		1
Hexachlorobutadiene (HCBD)	N	Y(2)	Y	N	Y	N	N		2
Lead	Y*	Y	Y	Y	Y	Y	Y	Y(6)	1
Pentachlorobenzene	Y	N	N	Y	Y	N	N		2
Perfluorooctane sulfonates (PFOs)	N	N	N	N	N	N	N	Y(7)	3
Polybrominated dibenzo-p-dioxins +dibenzofurans (PBDDs/PBDFs)	N	N	N	N	N	N	N		3
Polychlorinated biphenyls (PCBs)	Y*	Y	Y	Y	Y	Y	Y		1
Polychlorinated dibenzofurans (PCDFs)	Y	Y	Y	Y	Y	N	Y	Y(8)	1

Chemical or Chemical Group	MTCA Cleanup levels and/or terrestrial evaluation (WAC 173-340)	Air Toxics Standards (WAC 173-460)(1)	Sediment Managemen t Standards(3) (WAC 173-204)	TRI/PBT Reporting Require-ment	Dangerous Waste Constituents List (WAC 173-303-9905)	EPA CAP(4)	Drinking Water Standards (Maximum Contami-nant Levels, MCLs)	Speci-fic EPA Stra-tegies	Rank
Polychlorinated dibenzo-p-dioxins (PCDDs)	Y	Y	N	Y	Y	N	Y	Y(8)	1
Polychlorinated naphthalenes (PCNs)	N	N	N	N	N	N	N		3
Polycyclic aromatic hydrocarbons (PAHs)	Y*	Y	Y	Y	Y	Y(5)	Y		1
Short-chain chlorinated paraffins (SCCPs)	N	N	N	N	N	N	N		3
Tetrabromobis-phenol A (TBBPA)	N	N	N	Y	N	N	N		3
Tetrachlorobenzene, 1,2,4,5 (1,2,4,5-TCB)	N	N	N	N	Y	N	N		3

Legend:
* PBTs with numerical cleanup levels established – see text for explanation of cleanup levels and terrestrial ecological evaluation procedures
(1) = Class A Toxic Air Pollutants (Known and Probable Carcinogens)
(2) = Class B Toxic Air Pollutants
(3) = Numeric Criteria listed in the rule
(4) = Only CAPs for Mercury and Alkyl-Lead have been completed (under the EPA's PBT Program); all other CAPs are still in draft form or under development.
(5) = Draft CAP in development for Benzo(a)pyrene
(6) = EPA Lead Abatement Strategy
(7) = EPA global stewardship program on PFOA and related chemicals (2006)
(8) = EPA Pulp, Paper, and Paperboard Cluster Rule

Conclusion

Based on review of Table 14, the following PBT chemicals were ranked "3" (i.e they had a low number of existing regulations or plans specific to them):

- HBCD
- PBDDs/PBDFs
- PCNs
- SCCPs
- PFOS
- TBBPA
- 1,2,4,5-TCB

PBT chemicals that were ranked a "2" are:

- HCBD
- Pentachlorobenzene

PBT and metals of concern chemicals ranked a "1" (i.e. they had a high number of existing regulations or plans specific to them) include:

- Cadmium
- HCB
- Lead
- PCDDs
- PCDFs
- PCBs
- PAHs

Conclusions and Recommendations

Table 15 provides the Final Overall Ranking for each of the 16 PBTs and metals of concern under consideration. Each PBT or metal of concern was ranked from 1 to 3 (low to high) on four out of five evaluation factors, specified in the PBT rule (WAC 173-333):

- Relative ranking (a total ranking based on eight criteria). (See note below.)
- Opportunities for reductions.
- Sensitive population groups and high-exposure populations.
- Existing plans or regulatory requirements.

Note: The original Relative Ranking totals, (See Table 11, pages 41-42) which were between 20 and 6, were reassigned to be consistent with the 1 to 3 ranking system of the other evaluation factors. The Relative Ranking totals were refigured as follows:
Between 16 and 20 = "3"
Between 10 and 15 = "2"
Less than 10 = "1"

No rankings were assigned based on multiple chemical releases and exposures due to insufficient data.

Based on Ecology's overall assessment, the following PBTs and metals of concern ranked highest for action (chemical action plans):

- Lead
- PAHs
- PFOS

As discussed throughout the document, a great deal of the evaluations and corresponding ranking was based on qualitative analysis and best professional judgment. This was due to several factors: limited data; the type of data available often did not lend itself to a quantitative analysis (e.g. opportunities for reduction, sensitive population groups); and the limitations of scope and time appropriate for this document (in-depth research would be done in the context of a CAP). Ecology will develop a plan for additional research to address data gaps prior to development of the next CAP schedule.

Recommendations
In the process of working through the evaluation factors, several recommendations for future CAPs emerged.

1. Combine the chlorinated dioxins and furans, because they almost always co-occur and the process of formation is identical.
2. Combine all the brominated and chlorinated dioxins and furans, since they are all combustion products.

3. Combine all the bromine-based PBTs: TBBPA, HBCD and Hexabromobiphenyl (flame retardant banned in 1974) and the PBDDs/PBDFs. (Note: There has already been a CAP prepared for PBDEs.)
4. Combine all the banned pesticides: Aldrin/Dieldrin, Chlordane, Chlordecone, DDT, Endrin, Heptachlor, Mirex, & Toxaphene, plus any additional pesticides that may be banned between now and 2009 that exceed the PBT criteria (i.e. Lindane).

The Final Overall Ranking table follows.

Table 15. Final Overall Ranking

Chemical or Chemical Group (in order by final ranking)	Relative Ranking	Opportunities for Reduction	Multiple Chemical Releases and Exposures	Sensitive Groups & High Exposure Populations	Existing Plans & Regulatory Requirements	Final Ranking
Lead	3	3	NA	3	1	10
Perfluorooctane sulfonates (PFOS)	2	3	NA	2	3	10
Polycyclic aromatic hydrocarbons (PAHs)	3	3	NA	3	1	10
Polychlorinated biphenyls (PCBs)	3	2	NA	3	1	9
Polychlorinated dibenzofurans (PCDFs)	3	2	NA	3	1	9
Polychlorinated dibenzo-p-dioxins (PCDDs)	3	2	NA	3	1	9
Cadmium	2	3	NA	2	1	8
Polybrominated dibenzodioxins and furans (PBDDs/PBDFs)	2	1	NA	1	3	7
Hexabromocyclododecane (HBCD)	2	NA	NA	1	3	6
Hexachlorobenzene (HCB)	2	1	NA	2	1	6
Hexachlorobutadiene (HCBD)	1	1	NA	2	2	6
Short-chain chlorinated paraffins (SSCPs)	2	NA	NA	1	3	6
Tetrabromobisphenol A (TBBPA)	2	NA	NA	1	3	6
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5-TCB)	1	1	NA	1	3	6
Polychlorinated naphthalenes (PCNs)	1	NA	NA	1	3	5
Pentachlorobenzene	1	NA	NA	1	2	4

NA = (Data) Not Available

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Appendixes

Appendix A. Resources used to determine persistence and bioaccumulation rankings

Table A-1 Persistence and Bioaccumulation Resources For Table 4

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Cadmium	N/A - Not applicable since cadmium is an element.	N/A - Not applicable since cadmium is an element.
Hexabromocyclododecane (HBCD)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	Swedish National Chemicals Inspectorate/Swedish Environmental Protection Agency (KemI/EPA). 2002. Prioritisation of POP Candidates. Interim Report. November 29, 2002
Hexachlorobenzene (HCB)	EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.
Hexachlorobutadiene (HCBD)	Howard, et al. 1990. Handbook of Environmental Degradation Rates. Lewis Publishers.	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.
Lead	N/A - Not applicable since lead is an element.	N/A - Not applicable since cadmium is an element.

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Pentachlorobenzene	EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.
Perfluorooctane sulfonates (PFOs)	Environment Canada. 2004. Environmental Screening Assessment Report on Perfluorooctane Sulfonate, Its Salts and Its Precursors that Contain $C_8F_{17}SO_2$ or $C_8F_{17}SO_3$ Moiety. April 2004.	Organization of Economic Cooperation and Development (OECD). 2002. Hazard Assessment of Perfluorooctane Sulfonate (PFOS) and its Salts. ENV/JM/RD(2002)17/FINAL. November 21, 2002.
Polybrominated dibenzodioxins (PBDD/PBDFs) (2,3,7,8 tetrabromodibenzo-p-dioxin)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Polychlorinated biphenyls (PCBs) (3,3'4,4'5,5' hexachlorobiphenyl)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Polychlorinated dibenzo-p-dioxins (PCDDs) (2,3,7,8 tetrachlorodibenzo-p-dioxin) --------------------------------- **Polychlorinated dibenzofurans (PCDFs)** (2,3,4,7,8 pentachlorodibenzofuran)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/ --------------------------------------- EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	PBT Profiler. Viewed at: http://www.pbtprofiler.net/ --------------------------------------- EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).
Polychlorinated naphthalenes (PCNs) (hexachloronaphthalene)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Polycyclic aromatic hydrocarbons (PAHs) (Fluoranthene)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Short-chain chlorinated paraffins (SCCPs)	OSPAR Commission. 2004. Fact Sheet for short-chained chlorinated paraffins.	OSPAR Commission. 2004. Fact Sheet for short-chained chlorinated paraffins.
Tetrabromobisphenol A (TBBPA)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Tetrachlorobenzene, 1,2,4,5 (1,2,4,5 TCB)	Mackay, D., et. al. 1991. Illustrated Handbook of Physical Chemical Properties and Environmental Fate for Organic Chemicals. Volume I: Monoaromatic Hydrocarbons, Chlorobenzenes and PCBs. Lewis Publishers.	OSPAR Commission. 2004. Fact Sheet for 1,2,4,5 Tetrachlorobenzene.

Table A-2 Persistence and Bioaccumulation Resources for Table 6

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Cadmium	N/A - Not applicable since cadmium is an element.	N/A - Not applicable since cadmium is an element.
Hexabromocyclododecane (HBCD)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	Swedish National Chemicals Inspectorate/Swedish Environmental Protection Agency (KemI/EPA). 2002. Prioritisation of POP Candidates. Interim Report. November 29, 2002
Hexachlorobenzene (HCB)	EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.
Hexachlorobutadiene (HCBD)	Howard, et al. 1990. Handbook of Environmental Degradation Rates. Lewis Publishers.	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.
Lead	N/A - Not applicable since lead is an element.	N/A - Not applicable since cadmium is an element.
Pentachlorobenzene	EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	EPA. 1998. Waste Minimization Prioritization Tool Spreadsheet Document for the RCRA Waste Minimization PBT Chemical List Docket (#F-98-MMLP-FFFFF). September 1998.

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Perfluorooctane sulfonates (PFOs)	Environment Canada. 2004. Environmental Screening Assessment Report on Perfluorooctane Sulfonate, Its Salts and Its Precursors that Contain $C_8F_{17}SO_2$ or $C_8F_{17}SO_3$ Moiety. April 2004.	Organization of Economic Cooperation and Development (OECD). 2002. Hazard Assessment of Perfluorooctane Sulfonate (PFOS) and its Salts. ENV/JM/RD(2002)17/FINAL. November 21, 2002.
Polybrominated dibenzodioxins (PBDD/PBDFs) (2,3,7,8 tetrabromodibenzo-p-dioxin)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Polychlorinated biphenyls (PCBs) (2,3'4,4'5,5' hexachlorobiphenyl)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Polychlorinated dibenzo-p-dioxins (PCDDs) (1,2,3,7,8 pentachlorodibenzo-p-dioxin) -------------------------------- **Polychlorinated dibenzofurans (PCDFs)** (1,2,3,6,7,8 hexachlorodibenzofuran)	EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666). --- EPA. 1999. Persistent Toxic (PBT) Chemicals; Lowering of Reporting Thresholds for Certain PBT Chemicals; Addition of Certain PBT Chemicals; Community Right-to-Know Toxic Chemicals Reporting. Final Rule. October 29, 1999 (64 FR 58666).	PBT Profiler. Viewed at: http://www.pbtprofiler.net/ --- PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Polychlorinated naphthalenes (PCNs) (hexachloronaphthalene)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/

Chemical	Source of Persistence Information	Source of Bioaccumulation Information
Polycyclic aromatic hydrocarbons (PAHs) (Dibenzo(a,h)pyrene)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Short-chain chlorinated paraffins (SCCPs)	OSPAR Commission. 2004. Fact Sheet for short-chained chlorinated paraffins.	OSPAR Commission. 2004. Fact Sheet for short-chained chlorinated paraffins.
Tetrabromobisphenol A (TBBPA)	PBT Profiler. Viewed at: http://www.pbtprofiler.net/	PBT Profiler. Viewed at: http://www.pbtprofiler.net/
Tetrachlorobenzene, 1,2,4,5 (1,2,4,5 TCB)	Mackay, D., et. al. 1991. Illustrated Handbook of Physical Chemical Properties and Environmental Fate for Organic Chemicals. Volume I: Monoaromatic Hydrocarbons, Chlorobenzenes and PCBs. Lewis Publishers.	OSPAR Commission. 2004. Fact Sheet for 1,2,4,5 Tetrachlorobenzene.

Appendix B - Resources used to determine human health toxicity rankings

Table B-1. Summary of references for non-cancer and cancer toxicity values.

Chemical or Chemical Group	Non-cancer toxicity value (RfD or equivalent) (mg/kg/day)	Reference	Cancer toxicity value (CPF or equivalent) $(mg/kg/day)^{-1}$	Reference
Cadmium	0.0002	ATSDR	0.38	CA EPA
Hexabromocyclododecane (HBCD)	0.2	NRC, 2000	NA	-
Hexachlorobenzene (HCB)	0.00005	ATSDR, 2002	1.8	CA EPA
Hexachlorobutadiene (HCBD)	0.0002	ATSDR, 1994	0.078	EPA, IRIS
Lead	0.0005	CA EPA	NA	-
PAHs (16 chemicals)	0.04	EPA, IRIS	120	CA EPA
PCBs (8 chemicals)	0.00002	ATSDR, 2000	1560	EPA, IRIS; WHO, 1998
Pentachlorobenzene	0.0008	EPA, IRIS	NA	-
PFOS (5 chemicals)	NA	OECD, 2002	NA	OECD, 2002
Polybrominated dibenzodioxins and furans (PBDDs/PBDFs) (2 chemicals)	NA	-	156,000	WHO, 1998
Polychlorinated dibenzo-p-dioxins (PCDDs) (7 chemicals)	0.000000001	ATSDR, 1994	156,000	EPA, IRIS; WHO 1998
Polychlorinated dibenzofurans (PCDFs) (10 chemicals)	0.00000003	ATSDR, 1994	75,300	EPA, IRIS; WHO, 1998
Polychlorinated naphthalenes (5 chemicals)	NA	-	624	van de Plassche et al., 2002
Short-chain chlorinated paraffins (SSCPs)	NA	-	0.089	CA EPA
Tetrabromobisphenol A (TBBPA)	0.2	EU RA, 2006	NA	-
Tetrachlorobenzene, 1,2,4,5- (1,2,4,5 TCB)	0.0003	EPA, IRIS	NA	-

NA = (Data) Not Available.

ATSDR = ATSDR Toxicological Profiles for individual chemicals or chemical group. Toxicity values compiled using ATSDR MRL table, dated Dec. 2005.

CA EPA = California EPA Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database, dated 8/10/2005.

EPA IRIS = EPA's IRIS databases. Available at: http://www.epa.gov/iris/subst/index.html.

EU RA, 2006 = European Union Risk Assessment Report, 2006. 2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol (tetrabromobisphenol-A or TBBP-A), Part II – human health. European Chemical Bureau.

HEAST, 1997 = EPA Health Effects Assessment Summary Tables (HEAST), FY 1997 Update.

NRC, 2000 = National Research Council, 2000. Toxicological Risks of Selected Flame Retardant Chemicals. National Academy Press.
OECD, 2002 = Organisation for Economic Co-operation and Development (OECD), 2002. Co-operation on existing chemicals; Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts.
van de Plassche, E. and A. Schwegler, 2002. Polychlorinated Naphthalenes (Royal Haskoning, The Netherlands). Available at: http://www.unece.org/env/popsxg/docs/2000-2003/pcn.pdf.
WHO, 1998. World Health Organization-International Programme of Chemical Safety (WHO-IPCS), 1998. Environmental Health Criteria 205: Polybrominated dibenzo-p-dioxins and dibenzofurans. Geneva, World Health Organization.

<u>Documentation of toxicity values used for each PBT chemical</u>
Listed in alphabetical order, with chemicals first and metals of concern last

1. Hexabromocyclododecane

<u>Non-cancer:</u> The National Research Council (NRC) established an oral RfD of 0.2 mg/kg/day for hexabromocyclododecane as part of their evaluation of flame retardants.[153] This RfD value is used for human health ranking.

<u>Cancer:</u> CPFs are not established for hexabromocyclododecane and no cancer classification by EPA or IARC is available.

2. Hexachlorobenzene

<u>Non-cancer:</u> EPA has established an oral RfD of 0.0008 mg/kg/day.[154] ATSDR has established MRLs for hexachlorobenzene associated with acute exposures (0.008 mg/kg/day), intermediate duration exposures (0.001 mg/kg/day) and chronic exposures (0.00005 mg/kg/day). The chronic MRL of 0.00005 mg/kg/day was chosen to assign a human health ranking value to hexachlorobenzene.

<u>Cancer:</u> EPA classifies hexachlorobenzene as a probable human carcinogen (Group B2), and IARC classifies hexachlorobenzene as possible carcinogenic to humans (Group 2B). EPA has established a CPF for hexachlorobenzene of 1.6 $(mg/kg/day)^{-1}$. California EPA has established a CPF of 1.8 $(mg/kg/day)^{-1}$ for hexachlorobenzene. The highest CPF of 1.8 $(mg/kg/day)^{-1}$ is used to assign the human health ranking value for hexachlorobenzene.

3. Hexachlorobutadiene

<u>Non-cancer:</u> ATSDR has established an MRL of 0.0002 mg/kg/day for chronic oral exposure to hexachlorobutadiene. This value was used to assign a human health ranking value for hexachlorobutadiene.

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[153] National Research Council, 2000. Toxicological Risks of Selected Flame Retardant Chemicals. National Academy Press, Washington DC. See also WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC)*. Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/. .
[154] EPA, IRIS database.

Cancer: EPA classifies hexachlorobutadiene as a Group C carcinogen (possible human carcinogen), and IARC classifies it as a Group 3 carcinogen (not classifiable as to carcinogenicity in humans). EPA publishes a CPF of 0.078 $(mg/kg/day)^{-1}$ for hexachlorobutadiene.[155] This CPF was used to assign a human health ranking value for hexachlorobutadiene.

4. Pentachlorobenzene

Non-cancer: EPA has established an RfD of 0.0008 mg/kg/day for pentachlorobenzene.[156] This RfD was used to assign a human health ranking for pentachlorobenzene.

Cancer: EPA classifies pentachlorobenzene as a Group D carcinogen (not classifiable as to human carcinogenicity).

5. Perfluorooctane sulfonates (PFOS) [chemical group of 5 PBT chemicals]

Non-cancer: There are no available RfDs or equivalent values published by EPA, ATSDR, or California EPA for the acid or four salts of PFOS included in the PBT list. Regulatory and health agencies have had insufficient time to develop RfD values, based on the relatively new toxicity studies. Several effects have been reported in animal studies, including liver toxicity and developmental toxicity. Developmental effects have been reported in rats and rabbits exposed to PFOS at levels as low as 0.4 - 1.0 mg/kg/day (LOAELs) and at maternal doses as low as 1.0 – 5.0 mg/kg/day (LOAELs).[157] Based on professional judgment in the absence of an established RfD or equivalent value, PFOS was assigned the highest value of 3 points for the non-cancer ranking, based on multiple endpoints observed in toxicity studies involving multiple species.

Cancer: Bladder cancer has been reported in exposed workers.[158] Liver tumors have been observed in animal studies. Based on professional judgment in the absence of an established CPF, PFOS was assigned the highest value of 3 points for the cancer ranking, based on the observation of bladder tumors in exposed workers and liver tumors in rat studies.

6. Polybrominated dibenzodioxins and furans (PBDDs and PBDFs) [chemical group of 2 PBT chemicals]

Non-cancer: Animal studies indicate that these compounds have similar toxicity as chlorinated dibenzodioxins and furans. However, there are no established RfDs or equivalent non-cancer toxicity values for polybrominated dibenzodioxins and furans.[159]

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155 EPA IRIS Database.
156 EPA IRIS Database.
157 Organization for Economic Co-operation and Development (OECD), 2002. Co-operation on existing chemicals; Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts. ENV/JM/RD(2002)17/Final.
158 Ibid.
159 For further information: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/.

Cancer: Based on similarities in toxic mechanism with chlorinated dioxins and furans, CPFs have been estimated for 2,3,7,8 tetrabromodibenzo-p-dioxin (CPF = 156,000 $(mg/kg/day)^{-1}$) and 2,3,7,8-tetrabromodibenzofuran (CPF = 15,600 $(mg/kg/day)^{-1}$). These CPFs are estimated, relative to the CPF for chlorinated dioxins and furans, and are based on the toxicity equivalency factor (TEF) approach.[160] The highest CPF of 156,000 is used to assign a human health cancer ranking to represent this group of chemicals.

7. Polychlorinated dibenzo-p-dioxins (PCDDs) [chemical group of 7 PBT chemicals]

Non-cancer: EPA has not established RfDs for PCDDs. ATSDR has developed oral MRLs for one PCDD, i.e., 2,3,7,8-TCDD. The MRLs are 0.0000002 mg/kg/day (acute), 0.00000002 mg/kg/day (intermediate) and 0.000000001 mg/kg/day (chronic). The chronic MRL of 0.000000001 mg/kg/day is used to assign a human health non-cancer ranking to represent the PCDDs.

Cancer: IARC classifies PCDDs as Group 2A carcinogens (probably carcinogenic to humans). The National Toxicology Program (NTP) classifies PCDDs as "known to be a human carcinogen." EPA classifies 2,3,7,8-TCDD as a Group B2 carcinogen (probable human carcinogen). EPA has developed a CPF for 2,3,7,8-TCDD of 156,000 $(mg/kg/day)^{-1}$. CPFs for other PCDDs on the PBT list have been calculated with the TEF method (i.e., relative to 2,3,7,8-TCDD) and range from 15.6 – 156,000 $(mg/kg/day)^{-1}$. The highest CPF of 156,000 is used to assign a human health cancer ranking to represent the group of PCDDs.

8. Polychlorinated dibenzofurans (PCDFs) [chemical group of 10 PBT chemicals]

Non-cancer: ATSDR has developed an MRLs for one PCDF congener, 2,3,4,7,8-PDCF, for acute and chronic exposures. These MRLs are 0.000001 mg/kg/day (acute) and 0.00000003 mg/kg/day (chronic). The chronic MRL of 0.00000003 mg/kg/day is used to assign a human health non-cancer ranking to represent the PCDFs.

Cancer: CPFs for PCDFs have been calculated with the TEF method (i.e., relative to 2,3,7,8-TCDD). CPFs for PCDFs on the PBT list range from 15.6 – 75,300 $(mg/kg/day)^{-1}$. The highest CPF of 75,300 $(mg/kg/day)^{-1}$ is used to assign a human health cancer ranking to represent PCDFs.

9. Polychlorinated naphthalenes [chemical group of 5 PBT chemicals]

Non-cancer: Studies suggest that some chlorinated naphthalenes exhibit dioxin-like toxicity, including non-cancer effects. However, no established RfDs are currently available for polychlorinated naphthalenes.

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[160] For further information, see: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC), February 2006.* Table 8. Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/. .

Cancer: CPFs for polychlorinated naphthalenes range from 0.25 - 624 $(mg/kg/day)^{-1}$, based on the TEF method (relative to 2,3,7,8-TCDD).[161] The highest CPF of 624 is used to assign a human health cancer ranking to represent PCDFs.

10. Polychlorinated biphenyls (PCBs) [chemical group of 8 PBT chemicals]

Non-cancer: EPA has established oral RfDs for Aroclor 1254 and Aroclor 1016 (commercial PCB mixtures). The RfDs are 0.00002 mg/kg/day and 0.00007 mg/kg/day, respectively. ATSDR has developed MRLs for Aroclor 1254 of 0.00003 mg/kg/day (intermediate exposures) and 0.00002 mg/kg/day (chronic exposures). The lowest non-cancer chronic toxicity value of 0.00002 mg/kg/day was chosen to represent PCBs in assigning a ranking value for non-cancer health effects.

Cancer: EPA classifies PCBs as probable human carcinogens (Group B2). IARC classifies PCBs as Group 2A carcinogens (probably carcinogenic to humans). EPA has established a CPF of 2 $(mg/kg/day)^{-1}$ for PCBs. Based on similarities of some PCBs with chlorinated dioxins, CPFs are available for dioxin-like PCB congeners, based on the TEF method (i.e., relative to 2,3,7,8-TCDD).[162] CPFs calculated for dioxin-like PCBs on the PBT list range from 1.6 – 1560 $(mg/kg/day)^{-1}$. The highest CPF of 1560 is used to represent PCBs in assigning a human health cancer ranking.

11. Polycyclic aromatic hydrocarbons (PAHs) [chemical group of 16 PBT chemicals]

Non-cancer: Chronic animal toxicity studies involving exposures to PAHs have resulted in a variety of health effects.[163] Of the 16 PAHs included on the current PBT list, only one of them, fluoranthene has an RfD published by EPA (0.04 mg/kg/day). Since this is the only PAH on the PBT list with an RfD, this RfD was chosen to represent the PAH group in the ranking of non-cancer effects.

Cancer: PAHs have been classified as Group 2A and Group 2B by IARC and as probable human carcinogens (Group B2) by EPA. The two PAHs on the PBT list with the highest CPF (120 $(mg/kg/day)^{-1}$) are benzo(r,s,t)pentaphene (or dibenzo(a,i) pyrene) and dibenzo(a,h)pyrene, based on the TEF method (i.e., relative to benzo(a)pyrene).[164] This CPF was used to represent the PAH group in the ranking of cancer effects.

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[161] For further information, see E. van de Plassche and A. Schwegler, 2002. Polychlorinated Naphthalenes (Royal Haskoning, The Netherlands), and WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/. .
[162] For further information: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC), February 2006.* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/. .
[163] Ibid.
[164] Oral slope factors are from California EPA's OEHHA Toxicity Criteria Database.

12. Tetrabromobisphenol A (TBBPA)

Non-cancer: There is no established RfD or equivalent value published for tetrabromobisphenol A by EPA or ATSDR. The European Union (EU) recently completed their risk assessment on tetrabromobisphenol A.[165] The risk assessment identifies a highest adult exposure estimate of 0.19 mg/kg/day and compares this to a NOAEL of 40 mg/kg/day for nephrotoxicity from animal studies resulting in a "margin of safety" of 210. This margin of safety is reported to be sufficient to account for interspecies and intraspecies differences. Because this approach can be analogous to the method used to derive an RfD (i.e. similar to using safety factors), a dose of 0.19 mg/kg/day was used as a surrogate for an RfD (rounded to 0.2 mg/kg/day) and used to assign a non-cancer ranking to TBBPA.

Cancer: EPA classifies tetrabromobisphenol A as a Group 2B carcinogen. However, there is no established CPF developed by EPA or another agency with which to rank cancer effects of tetrabromobisphenol A.

13. Tetrachlorobenzene, 1,2,4,5-

Non-cancer: EPA established an RfD of 0.0003 mg/kg/day that is used to assign the non-cancer ranking value for tetrachlorobenzene.

Cancer: There is no available CPF or cancer classification available for tetrachlorobenzene, 1,2,4,5-.

14. Short-chain chlorinated paraffins

Non-cancer: There is no established RfD or equivalent value with which to rank non-cancer effects of short-chain chlorinated paraffins.

Cancer: IARC classifies short-chain chlorinated paraffins as a Group 2B carcinogen. California EPA has established an oral CPF of 0.089 $(mg/kg/day)^{-1}$.[166] This CPF was used to assign a human health ranking score to short-chain chlorinated paraffins.

15. Cadmium

Non-cancer: EPA has published an oral RfD value for cadmium in water of 0.0005 mg/kg/day and for cadmium in food of 0.001 mg/kg-day. ATSDR has developed a Minimal Risk Level (MRL) of 0.0002 mg/kg/day for chronic oral exposures.[167] The lowest of these non-cancer toxicity values, 0.0002 mg/kg/day, was chosen to use in assigning a human health ranking value for cadmium for non-cancer health effects.

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[165] European Union Risk Assessment Report. 2006. 2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol (tetrabromobisphenol-A or TBBP-A), Part II – human health. European Chemical Bureau.

[166] See California EPA, OEHHA Toxicity Criteria Database (dated 8/10/05).

[167] For further information: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/. .

Cancer: EPA classifies cadmium as a probable human carcinogen (Group B1). IARC classifies cadmium as a Group 2A carcinogen. EPA has developed a unit risk value of 1.8×10^{-3} $(ug/m^3)^{-1}$ from inhalation exposure[168] (which extrapolates to 6.3 $[mg/kg/day]^{-1}$), using standard conversion factors). The California EPA, Office of Environmental Health Hazard Assessment (OEHHA) has developed an oral CPF of 0.38 $(mg/kg\text{-}day)^{-1}$ for cadmium.[169] The oral CPF from California EPA is used in assigning a ranking value for cadmium for cancer.

16. Lead

Non-cancer: Lead exposure affects many organ systems, including impacting brain development and function. Infants and children are especially sensitive to the toxic effects of lead, because their brain is still developing.[170] EPA and ATSDR have not developed RfDs for lead. Excessive lead exposure has been evaluated through blood tests and CDC has established a "level of concern" of 10 ug/dL in blood. Recently, California EPA has proposed a child-specific benchmark blood lead concentration for school site risk assessment that is currently in draft form.[171] This assessment includes a proposed daily intake of lead of 6 ug of ingested soluble lead, associated with a 1 ug/dL blood lead level. This is equivalent to an RfD of 0.0005 mg/kg-day assuming a 12 kg bodyweight for infants between 6 months and 2 years of age.[172] This RfD is used in assigning a ranking value for lead for non-cancer health effects.

Cancer: EPA classifies lead as a B2 carcinogen. IARC classifies lead as a group 2B carcinogen. A CPF has not been established by EPA or ATSDR.

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[168] EPA IRIS file for Cadmium.

[169] CA EPA, OEHHA Toxicity Criteria Database dated 8/10/2005. Available online at: www.oehha.ca.gov/risk/ChemicalDB/index.asp .

[170] For further information: WA State Dept. of Ecology, *Summary Technical Background Information for the PBT List Found in the Persistent Bioaccumulative Toxins Regulation (Chapter 173-333 WAC).* Draft version available at: http://www.ecy.wa.gov/programs/eap/pbt/rule/.

[171] California EPA OEHHA, 2006. Development of health criteria for school site risk assessment pursuant to health and safety code section 901(g): Proposed child-specific benchmark blood lead concentration for school site risk assessment. Public Review Draft Report, March 2006.

[172] Bodyweight for a young child (12 kg) is used to calculate an RfD of 0.0005 mg/kg-day. Alternatively, a child body weight of 16 kg could be used per standard MTCA assumptions to yield a slightly lower RfD of 0.0004 mg/kg-day. Choice of bodyweight would not change ranking value for lead.

Appendix C - Resources used to determine ecological toxicity rankings

References used for ecological toxicity

In order to evaluate the impact of the selected PBTs or metals of concern upon the environment, ecological toxicity was evaluated using information from three primary sources:

- Registry of Toxic Effects of Chemical Substances (RTECS) which is maintained by a number of paid services. Ecology used the Canadian Centre for Occupational Health and Safety at http://ccinfoweb.ccohs.ca/retecs/search.html.
- Ecological Toxicity (ECOTOX) provided free by the US Environmental Protection Agency (US EPA) at http://mountain.epa.gov/ecotox.
- The PBT Profiler provided free by the US EPA. The PBT Profiler was designed to be an easy to use, widely available, no-cost tool to screen chemicals for a number of parameters. It is available at http://www.pbtprofiler.net.

RTECS is a good source of information on the toxicity of chemicals toward terrestrial organisms. ECOTOX provides extensive information on toxicity of chemicals toward aquatic organisms. The PBT Profiler provides an assessment of the ecological impacts of PBTs or metals of concern including extrapolations where laboratory results are not available.

Toxicity values could not be found for all chemicals as no data was listed in the sources identified. There were also some PBTs for which no toxicity values could be found in the sources identified earlier. In those instances, an internet search was conducted and values obtained from a variety of sources. Those additional sources are listed at the end of the tables.

Table C-1. Acute toxicity for PBT or metals of concern chemicals.

Chemicals	**CAS Number**	**Acute (mg/kg)**					
		LC_{50}	**Species**	**LD_{50}**	**Species**	**EC_{50}**	**Species**
Hexabromocyclododecane	25637-99-4					0.0110000	Daphnia[b]
Hexachlorobenzene	118-74-1	0.0300000	rainbow trout	3,500.000000	oral-rat	0.0160000	water flea
Hexachlorobutadiene	87-68-3	0.1210000	rainbow trout			0.0800000	rainbow trout
Pentachlorobenzene	608-93-5	0.2580000	rainbow trout	1,080.000000	oral-rat	0.1020000	rainbow trout
Short-chain chlorinated paraffins	85535-84-8	0.3400000	rainbow trout[a]				
Tetrabromobisphenol A	79-94-7	0.0600000	fathead minnow			0.9600000	Daphnia[h]
Tetrachlorobenzene, 1,2,4,5-	95-94-3	1.2000000	rainbow trout	1,500.000000	oral-rat	46.8000000	green algae
Perfluorooctane sulfonates (PFOS)		3.3000000	fish[d]				
Acid	1763-23-1			154.000000	oral-rat		
Ammonium salt	29081-56-9						
Diethanolamine salt	70225-14-8						
Lithium salt	29457-72-5	4.2000000	rainbow trout	154.000000	oral-rat		

Potassium salt	2795-39-3			
Polycyclic aromatic hydrocarbons (PAHs)				
3-Methyl chlolanthrene	56-49-5			
7H-Dibenzo(c,g)carazole	194-59-2			
Benzo(a)phenanthrene (Chrysene)	218-01-9	1.0000000 polychaete worm		
Benzo(b)fluoranthene	205-99-2			
Benzo(g,h,i)perylene	191-24-2			
Benzo(j)fluoranthene	205-82-3			
Benzo(k)fluoranthene	207-08-9			
Benzo(r,s,t)pentaphene	189-55-9			
Dibenzo(a,e)pyrene	192-65-4			
Dibenzo(a,h)pyrene	189-64-0			
Dibenzo(a,h)acridine	226-36-8			
Dibenzo(a,h)anthracene	53-70-3			
Dibenzo(a,j)acridine	224-42-0			
Fluoranthene	206-44-0	0.0077000 rainbow trout	2,000.000000 oral-rat	
Indeno(1,2,3-cd)pyrene	193-39-5			
Perylene	198-55-0			
Polybrominated dibenzodioxins and furans				
2,3,7,8-tetrabromodibenzo-p-dioxin	50585-41-6		0.000158 rainbow trout	
2,3,7,8-tetrabromodibenzofuran	67733-57-7			
Polychlorinated biphenyls (PCBs)				
2,3',4,4',5 Pentachlorobiphenyl	31508-00-6			
2,3,4,4',5 Pentachlorobiphenyl	74472-37-0			
2,3,3',4,4' Pentachlorobiphenyl	32598-14-4		6.970000 rainbow trout	
3,3',4,4',5,5' Hexachlorobiphenyl	32774-16-6		7.110000 rainbow trout	
2,3',4,4',5,5' Hexachlorobiphenyl	52663-72-6			
2,3,3',4,4',5' Hexachlorobiphenyl	69782-90-7			
2,3,3',4,4',5 Hexachlorobiphenyl	38380-08-4		115.000000 rainbow trout	
2,3,3',4,4',5,5' Heptachlorobiphenyl	39635-31-9	3.0000000 oral-guinea pig		

Table C-1. Acute toxicity for PBT or metals of concern chemicals (con't)

Chemicals	CAS Number	Acute (mg/kg)					
		LC_{50}	Species	LD_{50}	Species	EC_{50}	Species
Polychlorinated dibenzo-p-dioxins						0.2500000	oysters[e]
2,3,7,8 Tetrachlorodibenzo-p-dioxin	1746-01-6	0.0000057	high eyes	0.000230	rainbow trout	0.0000135	high eyes
1,2,3,7,8 Pentachlorodibenzo-p-dioxin	40321-76-4	0.0000270	high eyes	0.000566	rainbow trout	0.0000044	high eyes
1,2,3,4,7,8 Hexachlorodibenzo-p-dioxin	39227-28-6			0.887000	oral-rat		
1,2,3,6,7,8 Hexachlorodibenzo-p-dioxin	57653-85-7	0.0029000	high eyes	0.001427	rainbow trout	0.0002000	high eyes
1,2,3,7,8,9 Hexachlorodibenzo-p-dioxin	19408-74-3			0.060000	oral-guinea pig		
1,2,3,4,6,7,8 Heptachlorodibenzo-p-dioxin	35822-46-9			0.110000	rainbow trout		
1,2,3,4,6,7,8,9 Octachlorodibenzo-p-dioxin	3268-87-9			1.000000	oral-rat		
Polychlorinated dibenzofurans						0.2500000	oysters[e]
2,3,7,8 Tetrachlorodibenzofuran	51207-31-9	0.0000160	high eyes	0.001500	rainbow trout	0.0000070	high eyes
1,2,3,7,8 Pentachlorodibenzofuran	57117-41-6			0.007340	rainbow trout		
2,3,4,7,8 Pentachlorodibenzofuran	57117-31-4			0.000700	rainbow trout		
1,2,3,4,7,8 Hexachlorodibenzofuran	70648-26-9			0.000990	rainbow trout		
1,2,3,6,7,8 Hexachlorodibenzofuran	57117-44-9						
1,2,3,7,8,9 Hexachlorodibenzofuran	72918-21-9						
2,3,4,6,7,8 Hexachlorodibenzofuran	60851-34-5			0.120000	oral-guinea pig		
1,2,3,4,6,7,8 Heptachlorodibenzofuran	67562-39-4						
1,2,3,4,7,8,9 Heptachlorodibenzofuran	55673-89-7						
1,2,3,4,6,7,8,9 Octachlorodibenzofuran	39001-02-0						
Polychlorinated naphthalenes		0.0080000	fish[f]				
Trichloronaphthalene	1321-65-9						
Tetrachloronaphthalene	1335-88-2						
Pentachloronaphthalene	1321-64-8						
Hexachloronaphthalene	1335-87-1					0.0075000	Daphnia[g]
Heptachloronaphthalene	32241-08-0						
Metals							
Lead	7439-92-1	0.2000000	rainbow trout			1.8800000	Fleshy prawn
Cadmium	7440-43-9	0.0021000	rainbow trout	0.500000	blue mussel	0.0720000	Fleshy prawn

LC_{50} – Lethal concentration. PBT concentration that kills 50% of the organisms.
LD_{50} – Lethal dose. PBT dose that kills 50% of the organisms.
EC_{50} – Equivalent concentration. PBT equivalent concentration that kills 50% of the organisms.

Table C-2. Multiple Dose and Reproductive Toxicity for PBT or metals of concern chemicals.

Chemicals	CAS Number	Multiple Dose (mg/L)		Reproductive (mg/kg)	
		TD_{Lo}	Species	TD_{Lo}	Species
Hexabromocyclododecane	25637-99-4				
Hexachlorobenzene	118-74-1	3.500000	oral-rat	88.00000	oral-rat
Hexachlorobutadiene	87-68-3	80.000000	oral-rat	5.00000	oral-rat
Pentachlorobenzene	608-93-5	0.001500	oral-rat	1,802.00000	oral-rat
Short-chain chlorinated paraffins	85535-84-8	95.200000	oral-rat		
Tetrabromobisphenol A	79-94-7	5,250.000000	oral-rat	250.00000	oral-rat
Tetrachlorobenzene, 1,2,4,5-	95-94-3	12.000000	oral-rat		
Perfluorooctane sulfonates (PFOS)					
Acid	1763-23-1	19.000000	oral-rat	17.00000	oral-mouse
Ammonium salt	29081-56-9				
Diethanolamine salt	70225-14-8				
Lithium salt	29457-72-5	27.000000	oral-rat	120.00000	oral-rat
Potassium salt	2795-39-3	136.500000	oral-monkey		
Polycyclic aromatic hydrocarbons (PAHs)					
3-Methyl chlolanthrene	56-49-5	20.000000	oral-rat	63.00000	oral-mouse
7H-Dibenzo(c,g)carazole	194-59-2				
Benzo(a)phenanthrene (Chrysene)	218-01-9	180.000000	unknown-mouse		
Benzo(b)fluoranthene	205-99-2				
Benzo(g,h,i)perylene	191-24-2				
Benzo(j)fluoranthene	205-82-3				
Benzo(k)fluoranthene	207-08-9				
Benzo(r,s,t)pentaphene	189-55-9				
Dibenzo(a,e)pyrene	192-65-4				
Dibenzo(a,h)pyrene	189-64-0				
Dibenzo(a,h)acridine	226-36-8				
Dibenzo(a,h)anthracene	53-70-3	180.000000	unknown-mouse		
Dibenzo(a,j)acridine	224-42-0			2,520.00000	oral-mouse
Fluoranthene	206-44-0	67,500.000000	oral-rat		
Indeno(1,2,3-cd)pyrene	193-39-5				
Perylene	198-55-0				
Polybrominated dibenzodioxins and furans					
2,3,7,8-tetrabromodibenzo-p-dioxin	50585-41-6	0.090000	oral-rat	0.00300	oral-mouse
2,3,7,8-tetrabromodibenzofuran	67733-57-7			0.02500	oral-mouse

Polychlorinated biphenyls (PCBs)					
2,3',4,4',5 Pentachlorobiphenyl	31508-00-6	15.470000	oral-rat	0.37500	oral-rat
2,3,4,4',5 Pentachlorobiphenyl	74472-37-0				
2,3,3',4,4' Pentachlorobiphenyl	32598-14-4				
3,3',4,4',5,5' Hexachlorobiphenyl	32774-16-6	58.800000	oral-mouse	0.20000	oral-rat
2,3',4,4',5,5' Hexachlorobiphenyl	52663-72-6				
2,3,3',4,4',5' Hexachlorobiphenyl	69782-90-7				
2,3,3',4,4',5 Hexachlorobiphenyl	38380-08-4	7.371000	oral-rat	80.00000	oral-mouse
2,3,3',4,4',5,5' Heptachlorobiphenyl	39635-31-9				

Table C-2. Multiple Dose and Reproductive Toxicity for PBT or metals of concern chemicals (con't)

Chemicals	CAS Number	Multiple Dose (mg/L)		Reproductive (mg/kg)	
		TD_{Lo}	Species	TD_{Lo}	Species
Polychlorinated dibenzo-p-dioxins					
2,3,7,8 Tetrachlorodibenzo-p-dioxin	1746-01-6	0.000045	oral-rat	0.00002	oral-rat
1,2,3,7,8 Pentachlorodibenzo-p-dioxin	40321-76-4	0.125000	oral-rat	0.00050	oral-rat
1,2,3,4,7,8 Hexachlorodibenzo-p-dioxin	39227-28-6	0.002500	oral-rat		
1,2,3,6,7,8 Hexachlorodibenzo-p-dioxin	57653-85-7	0.140000	unknown-mouse		
1,2,3,7,8,9 Hexachlorodibenzo-p-dioxin	19408-74-3				
1,2,3,4,6,7,8 Heptachlorodibenzo-p-dioxin	35822-46-9	0.018500	oral-rat		
1,2,3,4,6,7,8,9 Octachlorodibenzo-p-dioxin	3268-87-9	6.675000	oral-rat		
Polychlorinated dibenzofurans					
2,3,7,8 Tetrachlorodibenzofuran	51207-31-9	0.003000	oral-guinea pig	0.12000	oral-mouse
1,2,3,7,8 Pentachlorodibenzofuran	57117-41-6	18.200000	oral-rat	0.12000	oral-mouse
2,3,4,7,8 Pentachlorodibenzofuran	57117-31-4	0.000900	oral-rat	0.00100	oral-rat
1,2,3,4,7,8 Hexachlorodibenzofuran	70648-26-9	0.400000	oral-mouse	0.40000	oral-mouse
1,2,3,6,7,8 Hexachlorodibenzofuran	57117-44-9	0.910000	oral-rat		
1,2,3,7,8,9 Hexachlorodibenzofuran	72918-21-9				
2,3,4,6,7,8 Hexachlorodibenzofuran	60851-34-5				
1,2,3,4,6,7,8 Heptachlorodibenzofuran	67562-39-4				
1,2,3,4,7,8,9 Heptachlorodibenzofuran	55673-89-7				
1,2,3,4,6,7,8,9 Octachlorodibenzofuran	39001-02-0	20.005000	oral-rat		
Polychlorinated naphthalenes					
Trichloronaphthalene	1321-65-9				
Tetrachloronaphthalene	1335-88-2				
Pentachloronaphthalene	1321-64-8	22.000000	oral-mammal		
Hexachloronaphthalene	1335-87-1	13,500.000000	oral-rat		
Heptachloronaphthalene	32241-08-0	16.600000	oral-mammal		
Metals					
Lead	7439-92-1	1.050000	oral-rat	520.00000	oral-rat
Cadmium	7440-43-9	37.500000	oral-rat	21.50000	oral-rat

TD_{Lo} – Lethal dose low. The lowest observed dose that has a toxic effect on the organism based on laboratory tests which include multiple PBT doses.

Table C-3. Chronic toxicity for PBT or metals of concern chemicals.

Chemicals	CAS Number	Chronic (mg/L)				
		NOEC	Species	LOEC	Species	ChV
Hexabromocyclododecane	25637-99-4	0.00300000	Daphnia[b]			0.00062
Hexachlorobenzene	118-74-1	0.00480000	fathead minnow			0.01200
Hexachlorobutadiene	87-68-3	0.00650000	fish[b]			NA
Pentachlorobenzene	608-93-5	0.01800000	sheepshead minnow	0.0320000	sheepshead minnow	0.03800
Short-chain chlorinated paraffins	85535-84-8	0.04000000	rainbow trout[a]			
Tetrabromobisphenol A	79-94-7	0.16000000	fish[h]			0.00300
Tetrachlorobenzene, 1,2,4,5-	95-94-3	0.06900000	fish[i]	0.0850000	Flag fish	0.12000
Perfluorooctane sulfonates (PFOS)		0.08600000	fish[c]			
Acid	1763-23-1					0.09000
Ammonium salt	29081-56-9					0.00200
Diethanolamine salt	70225-14-8					0.00600
Lithium salt	29457-72-5					0.72000
Potassium salt	2795-39-3					
Polycyclic aromatic hydrocarbons (PAHs)						
3-Methyl chlolanthrene	56-49-5					0.00100
7H-Dibenzo(c,g)carazole	194-59-2					0.02000
Benzo(a)phenanthrene (Chrysene)	218-01-9					0.01900
Benzo(b)fluoranthene	205-99-2					0.00600
Benzo(g,h,i)perylene	191-24-2					0.00200
Benzo(j)fluoranthene	205-82-3					0.00600
Benzo(k)fluoranthene	207-08-9					0.00600
Benzo(r,s,t)pentaphene	189-55-9					0.00074
Dibenzo(a,e)pyrene	192-65-4					0.00074
Dibenzo(a,h)pyrene	189-64-0					0.00074
Dibenzo(a,h)acridine	226-36-8					0.01700
Dibenzo(a,h)anthracene	53-70-3					0.00200
Dibenzo(a,j)acridine	224-42-0					0.01700
Fluoranthene	206-44-0	0.00140000	fathead minnow	0.0048000	fathead minnow	0.05500
Indeno(1,2,3-cd)pyrene	193-39-5					0.00200
Perylene	198-55-0					0.00600
Polybrominated dibenzodioxins and furans						
2,3,7,8-tetrabromodibenzo-p-dioxin	50585-41-6					0.00035
2,3,7,8-tetrabromodibenzofuran	67733-57-7					0.00120

Polychlorinated biphenyls (PCBs)				
2,3',4,4',5 Pentachlorobiphenyl	31508-00-6			0.00140
2,3,4,4',5 Pentachlorobiphenyl	74472-37-0			0.00140
2,3,3',4,4' Pentachlorobiphenyl	32598-14-4			0.00140
3,3',4,4',5,5' Hexachlorobiphenyl	32774-16-6			0.00044
2,3',4,4',5,5' Hexachlorobiphenyl	52663-72-6			0.00044
2,3,3',4,4',5' Hexachlorobiphenyl	69782-90-7			0.00044
2,3,3',4,4',5 Hexachlorobiphenyl	38380-08-4			0.00044
2,3,3',4,4',5,5' Heptachlorobiphenyl	39635-31-9			NA

Table C-3. Chronic toxicity for PBT or metals of concern chemicals (con't)

Chemicals	CAS Number	Chronic (mg/L)				
		NOEC	Species	LOEC	Species	ChV
Polychlorinated dibenzo-p-dioxins						
2,3,7,8 Tetrachlorodibenzo-p-dioxin	1746-01-6	0.000000038	rainbow trout	0.0000018	rainbow trout	0.00160
1,2,3,7,8 Pentachlorodibenzo-p-dioxin	40321-76-4					0.00050
1,2,3,4,7,8 Hexachlorodibenzo-p-dioxin	39227-28-6					NA
1,2,3,6,7,8 Hexachlorodibenzo-p-dioxin	57653-85-7					NA
1,2,3,7,8,9 Hexachlorodibenzo-p-dioxin	19408-74-3					NA
1,2,3,4,6,7,8 Heptachlorodibenzo-p-dioxin	35822-46-9					NA
1,2,3,4,6,7,8,9 Octachlorodibenzo-p-dioxin	3268-87-9					NA
Polychlorinated dibenzofurans						
2,3,7,8 Tetrachlorodibenzofuran	51207-31-9	0.00000041	rainbow trout			0.00500
1,2,3,7,8 Pentachlorodibenzofuran	57117-41-6					0.00160
2,3,4,7,8 Pentachlorodibenzofuran	57117-31-4					0.00160
1,2,3,4,7,8 Hexachlorodibenzofuran	70648-26-9					0.00025
1,2,3,6,7,8 Hexachlorodibenzofuran	57117-44-9					0.00025
1,2,3,7,8,9 Hexachlorodibenzofuran	72918-21-9					0.00050
2,3,4,6,7,8 Hexachlorodibenzofuran	60851-34-5					0.00025
1,2,3,4,6,7,8 Heptachlorodibenzofuran	67562-39-4					NA
1,2,3,4,7,8,9 Heptachlorodibenzofuran	55673-89-7					NA
1,2,3,4,6,7,8,9 Octachlorodibenzofuran	39001-02-0					NA
Polychlorinated naphthalenes						
Trichloronaphthalene	1321-65-9					0.04400
Tetrachloronaphthalene	1335-88-2					0.01400
Pentachloronaphthalene	1321-64-8					0.00400
Hexachloronaphthalene	1335-87-1					0.00130
Heptachloronaphthalene	32241-08-0					NA
Metals						
Lead	7439-92-1	0.00400000	rainbow trout	0.0670000	rainbow trout	
Cadmium	7440-43-9	0.00070000	rainbow trout	0.0015000	rainbow trout	

NOEC – No observed effects concentration. The highest observed PBT concentration which showed no adverse impact on the organism.

LOEC – Lowest observed effect concentration. The lowest observed PBT concentration which showed an adverse impact on the organism.

ChV – Chronic value. Geometric mean of the LOEC and NOEC.

[a]From: *Risk Profile and Summary Report For Short-Chained Chlorinated Paraffins, European Commission, Aug. 2005*

[b]KemI/EPA (2002)

[c]Environment Canada (2004a)

[d]OECD (2002)

[e]EPA (1998a)

[f]Van Paasche and Schwegler (2002)

[g]OSPAR (2004x)

[h]OSPAR Commission fact sheet for TBBPA (OSPAR, 2004dd)

[i]OSPAR Commission fact sheet for 1,2,4,5-tetrachlorobenzene (OSPAR, 2004ee)

Appendix D - Resources used to determine production and use rankings

Chemicals	CAS #	U.S. Production & Use Info	Notes	Reference
Hexabromocyclododecane	25637-99-4	2001: 2,800 MT (total for Americas)		Bromine industry estimates reported in '*Brominated Flame Retardants-Rising Levels of Concern*, by Sara Janssen, M.D., PhD, M.P.H., June 2005, Health Care Without Harm
Hexachlorobenzene	118-74-1	Production- 1972: 2.5 - 4.9 million pounds, 1984: 8-25,000 pounds. Imports-1982: 38,000 pounds	Not produced in US since late 70's. Produced as by-product or impurity during production of chlorinated compounds	Substance Profile, Report on Carcinogens, Eleventh Edition
Hexachlorobutadiene	87-68-3	Production: 1982: 28 million pounds, additional TRI data. Import: 1970, 500,000 pounds/yr, 1981 145,000 lbs	Never commercially produced in US. Occurs as byproduct from production of other chlorinated hydrocarbons.	*Toxicological Profile for Hexachlorobutadiene*, US Dept. of Health and Human Services, May 1994
Pentachlorobenzene	608-93-5	Production: 1972-1,400,000 kg	No longer produced or imported into the US since 1982	*Toxicity Studies of Pentachlorobenzene (Feed Studies), Margarita M. Mc Donald, National Toxicology Program, US Dept. Of Health & Human Services, Jan. 1991*
Short-chain chlorinated paraffins	85535-84-8	2005: 97 million pounds used in US: Export of 11-16 million pounds	Total paraffins including short, medium and long-chain	Chemical Profile produced by TIG and published in the Chemical Market Reporter
Tetrabromobisphenol A	79-94-7	Production: 1997 34,550 to 48, 140 million gallons. 1998: 100-500 million pounds (45,400-227,000 million gallons). Import: 2001-1,132,750 kg (2,497,286 lb)		*Tetrabromobisphenol A [79-94-7] Review of Toxicological Literature*, Karen Haneke, prepared for National Institute of Environmental Health Sciences, June 2002
Tetrabromobisphenol A	79-94-7	2001: 18,000 MT (total for Americas)		Bromine industry estimates reported in '*Brominated Flame Retardants-Rising Levels of Concern*, by Sara Janssen, M.D., PhD, M.P.H., June 2005, Health Care Without Harm

Chemicals	CAS #	U.S. Production & Use Info	Notes	Reference
Tetrachlorobenzene, 1,2,4,5-	95-94-3	1999: no longer produced or imported into US		Letter from Chlorobenzene Producers Association to US EPA requesting delisting of tetrachlorobenzene from HPV program due to no longer produced or imported, April 2003
Tetrachlorobenzene, 1,2,4,5-	95-94-3	Production: 1980-5,400,00 kg.	1983: No longer produced	*Toxicity Studies of 1,2,4,5-Tetrachlorbenzene in F344/N Rats and B6C3F1 Mice (Feed Studies), National Toxicology Program, US Dept. Of Health and Human Services, Jan 1991*
Perfluorooctane sulfonates (PFOS)		2000: 1.5 million pounds		*Perfluoroalkyl Sulfonates; Proposed Significant New Use Rule*, US EPA Federal Register March 10, 2006 (Vol. 71, Nr. 47), pp. 12311-12324
Polycyclic aromatic hydrocarbons (PAHs)			Not produced in significant amounts commercially. Mainly from combustion and natural sources (volcanoes, forest fires, crude oil and shale oil).	*Toxicological Profile for Polycyclic Aromatic Hydrocarbons*, US Dept. of Health and Human Services, Aug. 1995
PAHs found in Coal Tar and Coal Tar Pitches		over 1 billion pounds in 1913. 168.6 milgal in 1986, 188.5 in 1987 and 1.8 billion pounds in 1994	Both products contain numerous chemicals including PAHs. Most produced by steel industry.	*Coal Tars and Coal Tar Pitches',* NIH Substance Profiles, Report on Carcinogens, eleventh edition
Benzo(a)phenanthrene (Chrysene)	218-01-9	Import: 1984 79,200 kg		*Toxicological Profile for Polycyclic Aromatic Hydrocarbons*, US Dept. of Health and Human Services, Aug. 1995
Fluoranthene	206-44-0	Import: 1985 1,040 kg		*Toxicological Profile for Polycyclic Aromatic Hydrocarbons*, US Dept. of Health and Human Services, Aug. 1995
Polychlorinated biphenyls (PCBs)		1970: 85 millions pounds: 1930-1975: total production-1,400, imports 3, domestic sales 1,253 and exports 150 million pounds	1980: PCBs banned, PCB containing materials restricted & discharge prohibited, disposal regulated and import or export only allowed by grant from	*Toxicological Profile for Polychlorinated biphenyls (PCBs)*, US Dept. of Health and Human Services, Nov. 2000

Chemicals	CAS #	U.S. Production & Use Info	Notes	Reference
			EPA	
PCBs		More than 1.5 billion pounds cumulative production before cessation in 1977		*US Fish & Wildlife, The Division of Environmental Quality* website at http://www.fws.gov/contaminants/Definitions.html
Polychlorinated dibenzo-p-dioxins			Not manufacture commercially except for use in chemical and tox research	*Toxicological Profile for Chlorinated Dibenzo-p-dioxins*, US Dept. of Health and Human Services, Dec. 1998
Polychlorinated dibenzofurans			Deposits into oceans not known. Reported values only for industrialized countries so may be low.	*Dioxin and Furan Inventories, National and Regional Emissions of PCDD/PCDF,* UNEP Chemicals, May 1999. Can be downloaded from the UNEP web site in .pdf format (102 pages, 616 kB). Results reported at http://home.scarlet.be/chlorophiles/Eng/ChlorineDiSrc.html
PCDD/PCDF total		1995: 20 in water, 208 in land and 25,050 in products for a total of 25,278 (g TEQ/a)	Values are in g TEQ/a	*Sources and Environmental Impact of PCDD/PCDF* by Dr. Hedelore Fiedler for EU. Values from US EPA reported at http://www.chem.unep.ch/pops/POPs_Inc/proceedings/slovenia/FIEDLER1.html
Polychlorinated naphthalenes		1910-1960: 50-150,000 MT; 1978 320 tonnes/yr	1980: Production stopped in US, 1989 in Germany, 1960's in UK	*Polychlorinated Naphthalenes*, July 2002, National Industrial Chemicals Notification and Assessment Scheme, Australia
				Polychlorinated Naphthalenes, E. van de Plassche and A. Schwegler, Preliminary Risk Profile, Netherlands
Metals				
Lead	7439-92-1	Production: TRI data (not useful). Imported: 2003 - 175,000 MT, 1999 - 413,00 MT. Exported: 1999-196,500, 2003: 378,000 MT also 92,800 MT of lead scrap		*Draft Toxicological Profile for Lead*, US Dept. of Health and Human Services, Sep. 2005

Chemicals	CAS #	U.S. Production & Use Info	Notes	Reference
Lead	7439-92-1	1999: 826,390 MT; 2003: 624,000 MT	Table 1: sum of mine production and imports	*Lead*, Gerald R. Smith, US Geological Survey Minerals Yearbook-2003
Cadmium	7440-43-9	Production: TRI data (not useful). Imported: 1991: 1,110 MT, 1998: 650 MT. Exports: 1993: 38 MT, 1994: 1,450 MT, 1997: 550 MT.	Mostly by-product of zinc processing	*Toxicological Profile for Cadmium,* US Dept. of Health and Human Services, July 1999
Cadmium	7440-43-9	2000: 2,315 MT, 2004: 610 MT.	Values for years in between as well	US Geological Survey, Mineral Commodity Summaries, Jan 2005, prepared by Jozef Plachy
Cadmium	7440-43-9	1999: 20,000 MT gross	Produced as by-product from Zn manufacture. Many not all be refined or used	*Cadmium Facts and Handy Comparisons*, Ken Zweibel, National Renewable Energy Laboratory and Vasilis Fthenakis, Brookhaven National Laboratory
Cadmium	7440-43-9	2004: 602 MT		*Mineral of the Month*, in Geotimes, August 2005. Can be found at http://www.agiweb.org/geotimes/aug05/resources.html
Cadmium	7440-43-9	2004: 588 MT	Table 1, sum of production and imports	*Cadmium*, by E. P Limasauskas et al. US Geological Survey Minerals Yearboo-2004.