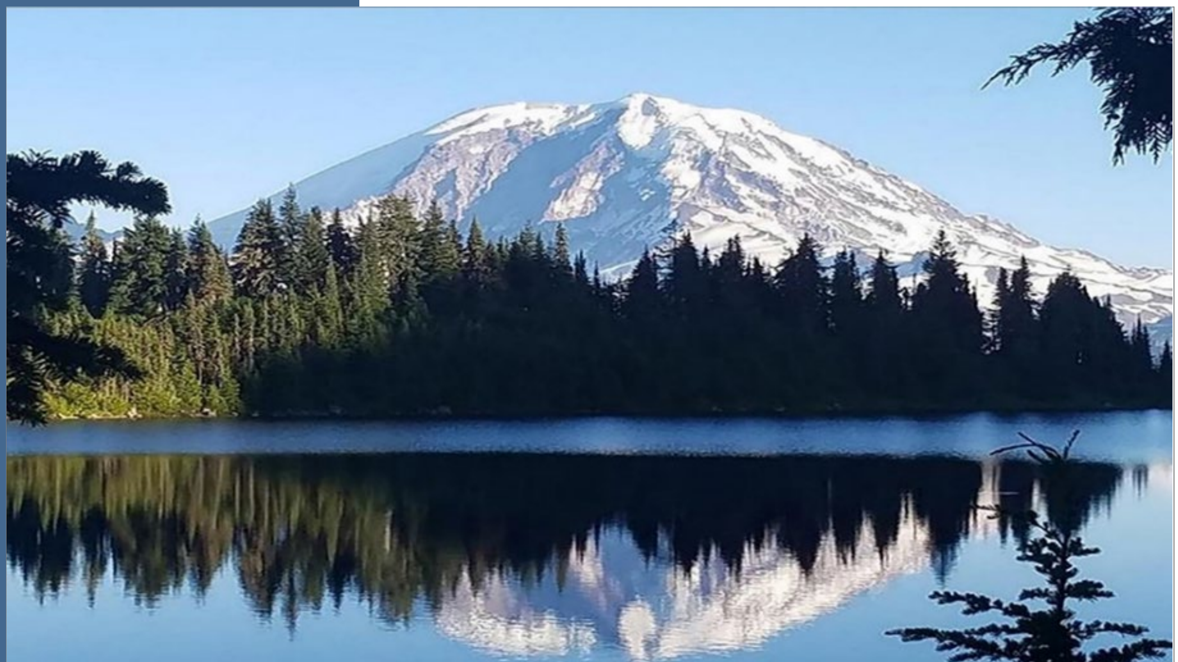

Draft Phthalates Action Plan

Hazardous Waste and Toxics Reduction Program

Washington State Department of Ecology
Olympia, Washington

May 2023
Publication 23-04-025

DEPARTMENT OF ECOLOGY
State of Washington

Washington State Department of HEALTH

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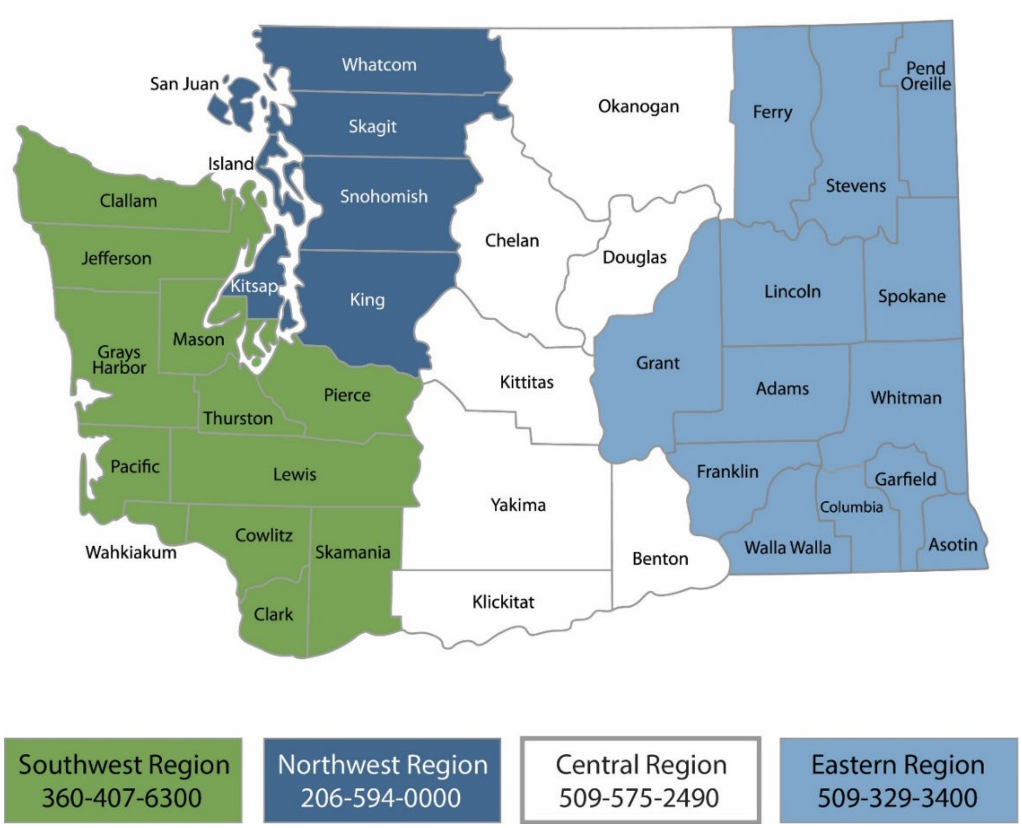
Department of Ecology's Region Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

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DEPARTMENT OF ECOLOGY
State of Washington

Participating Programs and Offices

Washington Department of Ecology programs: Air Quality, Environmental Assessment, Hazardous Waste and Toxics Reduction, Solid Waste Management, Toxics Cleanup, Water Quality

Washington Department of Health offices: Drinking Water, Environmental Public Health Sciences

Washington Department of Fish and Wildlife

Washington Department of Commerce

Washington Department of Enterprise Services

Advisory Committee

Ecology and Health created an external advisory committee to provide stakeholder input and expertise. Beginning in early 2022, we convened committee members from industry, government, non-governmental organizations, a tribal organization, and community organizations. The following organizations and government agencies were represented on the advisory committee:

- American Chemistry Council
- Association of Washington Business
- BASF Corporation
- ChemForward
- City of Tacoma
- Collaborative on Health and the Environment
- Exxon Mobil Chemical Company
- Healthy Building Network
- Household and Commercial Products Association
- King County Hazardous Waste Management Program
- Multicare Health System
- National Tribal Toxics Council
- Northwest Biosolids Board
- Public Health Seattle-King County
- Seattle Children's Pediatric Environmental Health Specialty Unit
- Snohomish County Health Department
- Spokane Regional Health
- Toxic-Free Future
- True North Public Affairs
- Vinyl Institute
- Vizient
- Washington Refuse and Recycling Association
- Zero Waste Washington

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Executive Summary

Situation

Phthalates, a class of chemicals widely used in commerce, are a health and environmental concern, both globally and in Washington state. Phthalates are synthetic chemicals derived from phthalic acid. There are several groups of phthalates, but the recommendations within this action plan focus specifically on ortho-phthalates. Ortho-phthalates will be referred to from here on as phthalates.

Some phthalates are used to make plastics more flexible (plasticizers), while other phthalates are used as dissolving agents for materials (solvents). Nearly everyone is exposed to phthalates. Consumer products release multiple phthalates into the air and dust of our homes, schools, and workplaces as they degrade. These phthalates make their way into our bodies when we inhale dust or eat food that has come into contact with them, among other avenues. Exposure to phthalates is widespread in people of all ages, genders, races, and ethnicities. Exposure is associated with endocrine disruption, impaired reproduction and prenatal development, neurodevelopmental impacts, and potentially asthma.

Similar to concerns in humans, phthalates can cause endocrine disruption, which impacts our hormones, and impair reproduction and development in wildlife and aquatic organisms. Though phthalates degrade rapidly, they are continuously released into the environment due to consistent use. This leads to the persistent presence of phthalates in built and natural environments.

A plan for action

Currently, we have an incomplete set of laws and rules related to phthalates. We need to reduce sources and eliminate exposure pathways. To address this need, the Washington State Department of Ecology (Ecology) and Department of Health (Health) developed our first action plan (AP). The recommendations in this plan will help us strengthen our efforts to protect human health and the environment from the impacts of phthalates in Washington state.

The Phthalates AP includes recommendations to reduce, investigate, and phase out or promote safer alternatives to phthalates based on scientific reviews and feedback from stakeholders. Recommendations cover phthalates in various environmental media such as air, drinking water, and aquatic habitats. The Action Plan also includes recommendations for pollution prevention efforts that reduce phthalates in consumer products. By removing phthalates from consumer products, we reduce the re-introduction of phthalates to the environment and prevent downstream impacts. State agencies, local governments, industry, non-profits, and other community partners can implement the recommendations in a short time frame to reduce the impacts of phthalates.

In developing this plan, we modeled the process loosely after Chemical Action Plan (CAP) requirements found in Washington Administrative Code (WAC) 173-333, the Persistent Bioaccumulative Toxics rule (PBT). While phthalates do not require a CAP under the PBT rule, we found it provided useful guidance for our action plan development process. We pursued an action plan because it is action-oriented and allows flexibility in planning for emerging chemicals of concern. An action plan differs from a CAP. We discuss these differences in the introduction and purpose section.

Development

The National Estuary Program (NEP) of the Environmental Protection Agency (EPA) funded the Phthalates AP project through a near term action grant. Ecology and Health began developing the Phthalates AP in 2021. The first advisory committee meetings took place in early 2022. The draft Phthalates AP was released for public review in May 2023, followed by a 45-day public comment period from May to June 2023**.** The final Phthalates AP was published in December 2023**.**

We developed the draft Phthalates Action Plan (AP) with support from other Washington State agencies to address statewide considerations. Stakeholders representing industry, government, non-governmental organizations, a tribal organization, and communities participated in an advisory committee and provided feedback for Phthalates AP scoping and drafting.

Through a combination of coordinated efforts and additional research, we will ensure that implementation partners can carry out our recommendations successfully and efficiently. In some cases, additional funding must be acquired to implement recommendations.

Overview

The Phthalates AP contains a streamlined background section with summary information about phthalates. This includes general information on chemistry, production, use, regulations, and human and environmental health effects and exposures. The background section is followed by the recommendations, which comprises most of the Phthalates AP. Each recommendation contains its own necessary background information, context, justification, and other information. Readers can refer directly to a recommendation topic of interest and find all the necessary information.

Additional background on general chemical information, uses and releases, human health and exposure, and environmental fate is included in Appendices A, B and C. Appendix D contains a glossary of abbreviations, Appendix E contains chemical data reporting, and Appendix F contains a preliminary regulatory analysis.

Recommendations are organized by topic but are not prioritized. Lead agencies will prioritize implementation recommendations with input from partner organizations and community considerations.

Table 1: Summary of the recommendations included in the action plan.

Topic	Number	Recommendation	Lead agency	Partner agency
Consumer products	Recommendation #1	SPWA should identify additional consumer products as sources or uses of phthalates.	Department of Ecology	Department of Health
Consumer products	Recommendation #2	Ecology should support increased transparency and certifications for consumer products.	Department of Ecology	None
Food contact articles	Recommendation #1	Establish a workgroup to reduce the sources of phthalates in food and beverages through technical assistance, education, and voluntary actions in food production and food service in Washington.	Department of Health	Department of Ecology
Food contact articles	Recommendation #2	SPWA should evaluate phthalate-containing food contact articles for identification as priority products in a future cycle.	Department of Ecology	None
Daycare and early childcare facilities	Recommendation #1	Ecology's Product Replacement Program should develop a swap-out program for durable products in childcare facilities that contain phthalates, such as vinyl flooring, and other products prevalent in childcare facilities.	Department of Ecology	Department of Health and Department of Children, Youth, and Families
Daycare and early childcare facilities	Recommendation #2	Develop education and outreach materials that can be used to reduce the use of phthalate-containing materials in daycares.	Department of Health	Department of Children, Youth, and Families and Department of Ecology

Topic	Number	Recommendation	Lead agency	Partner agency
Health care	Recommendation #1	SPWA should evaluate some medical products for identification as priority products containing phthalates.	Department of Ecology	None
Health care	Recommendation #2	Health should work with health care system partners to increase awareness about phthalates. Health can encourage action to reduce the use of phthalates when alternative products or processes meet standards for patient care.	Department of Health	None
Health care	Recommendation #3	Health should work to raise awareness of phthalate reduction opportunities among clinicians and other health care staff to reduce occupational and patient exposure.	Department of Health	None
Health care	Recommendation #4	Health should develop an approach to reducing phthalate exposure through menstrual and incontinence products, including a pilot product testing study.	Department of Health	None
Building materials	Recommendation #1	Ecology should leverage existing resources and contribute to standards for state-supported building projects.	Department of Ecology	None

Topic	Number	Recommendation	Lead agency	Partner agency
Building materials	Recommendation #2	Ecology should engage building design, construction, and maintenance project teams on material health in Washington and develop outreach materials for the building industry that leverage existing resources.	Department of Ecology	None
Preferred purchasing	Recommendation #1	Ecology should continue to provide Department of Enterprise Services (DES) to simplify their purchasing decisions.	Department of Enterprise Services	None
Preferred purchasing	Recommendation #2	DES should incorporate guidance and technical input from Ecology into new statewide contracts. DES should also amend existing contracts when feasible.	Department of Enterprise Services	None
Preferred purchasing	Recommendation #3	DES should work with state agencies and the State Efficiency and Environmental Performance Office to track purchasing metrics.	Department of Enterprise Services	None
Biosolids	Recommendation #1	Ecology should evaluate the transport and breakdown of upstream sources of phthalates in Washington's WWTP influent, effluent, sludge, and biosolids.	Department of Ecology	Department of Health
Biosolids	Recommendation #2	Ecology should evaluate the transfer potential of phthalates from biosolids to soil and groundwater.	Department of Ecology	Department of Health

Topic	Number	Recommendation	Lead agency	Partner agency
Biosolids	Recommendation #3	Ecology should evaluate plant uptake of phthalates in crops and fodder grown in or on biosolids-amended soils and fields in Washington state.	Department of Ecology	Department of Health
Biosolids	Recommendation #4	Ecology should evaluate the fate of phthalates in composted biosolids in Washington state.	Department of Ecology	Department of Health
Compost	Recommendation #1	Ecology should develop and implement a plan to test compostable containers and serviceware for phthalates. This will help us determine if these materials pose a risk of introducing phthalates to compost. We recommend this work be done in conjunction with the other product testing recommended earlier in this plan.	Department of Ecology	None
Compost	Recommendation #2	Ecology should develop and implement a plan to test the levels of phthalates in finished compost that comes from facilities that process municipal feedstocks.	Department of Ecology	None
Recycling products and packaging	Recommendation #1	Ecology should gather information to understand the presence of phthalates in the recycling stream.	Department of Ecology	Third-party contractor

Topic	Number	Recommendation	Lead agency	Partner agency
Recycling products and packaging	Recommendation #2	Ecology should work with consumer product and packaging industry groups to convene a workgroup. This workgroup would establish voluntary reporting and labeling protocols to identify packaging that contains phthalates.	Department of Ecology	Consumer packaging industry groups
Landfills	Recommendation #1	Ecology should perform a study to investigate phthalate occurrence in landfill leachate.	Department of Ecology	Third-party contractor
Landfills	Recommendation #2	Ecology should design a study to investigate phthalate presence in landfill gas.	Department of Ecology	Third-party contractor
Drinking water	Recommendation #1	Review data on public water systems and state health advisories and continue to work with partners to address data gaps on potential phthalate impacts to drinking water.	Department of Health	None
Drinking water	Recommendation #2	Educate partners on the use of phthalate-free sample collection and operational equipment products that could potentially contribute to sample contamination.	Department of Health	U.S. EPA, Washington State Public Water Systems, and certified drinking water laboratories

Topic	Number	Recommendation	Lead agency	Partner agency
Aquatics	Recommendation #1	Allocate resources to existing aquatic monitoring programs in the state to determine whether aquatic organisms (and the people that consume them) are impacted by phthalates.	Department of Health	Department of Fish and Wildlife and Department of Ecology
Air	Recommendation #1a	Ecology should reach out to air regulatory partners to verify and improve accuracy of emissions reporting.	Department of Ecology	Local air agencies
Air	Recommendation #1b	Pending the outcome of recommendation 1a, additional coordination with regulatory air agencies, Ecology pollution prevention staff, and facilities may be necessary to identify and address possible phthalate emissions reductions.	Department of Ecology	Local air agencies

Introduction and Purpose

This Phthalates Action Plan (AP) discusses sources of and exposures to a class of chemicals called phthalates. Phthalates are associated with hazards to human health and the environment and are used in many widely distributed materials in commerce. The Phthalates AP provides a list of recommended actions that could be undertaken to reduce exposures to and sources of phthalates in Washington. Additionally, the Phthalates AP makes recommendations for additional research to better understand the fate and transport of phthalates in Washington's environment. The lead agencies responsible for implementing each recommendation are identified later in the document. This summary is not intended to be an exhaustive review of the literature. Rather, it should be a starting point for continued work by Ecology, Health, and other interested parties.

The Phthalates AP is the first action plan developed by Ecology and Health. In developing this plan, we used the public process in WAC 173-333 as general guidance. We also assembled an advisory committee. The advisory committee reviewed and advised on the Phthalates AP scope and draft recommendations. We focused on developing recommendations that:

- Are based on existing information about phthalate toxicity and exposures.
- Help identify gaps in knowledge about specific environmental media where we know or suspect phthalates exist.
- Reduce exposures to and sources of phthalates.
- Can be implemented in a relatively short period, assuming funding is made available.
- Have the potential to extend into longer-term actions that will result in phthalates reductions over time.
- Integrate approaches to address environmental injustices (EJ) and equity concerns.

Environmental justice and equity

Throughout this plan, we propose recommended actions that include and prioritize communities experiencing environmental injustices and health inequities. Our efforts aim to directly address disproportionate exposure to toxic chemicals among minority, refugee, immigrant, and low-income communities. Lead and partner agencies implementing these recommendations will actively seek input from communities, Tribes, and other marginalized or vulnerable groups who may be disproportionately impacted.

We will build on research regarding communities with overlapping health disparities conducted under the Safer Products for Washington (SPWA) program and contact community-based organizations (CBOs) directly serving those communities. We will continue to educate ourselves about the specific EJ impacts associated with phthalates, particularly for personal care products and building materials. We will prioritize reduction of disproportionate impacts through Phthalates AP implementation and outreach materials.

As you read the recommendations in this AP you will find that some have a direct path to address EJ and equity. Other recommendations are set up to obtain information that can then be used to evaluate EJ and equity issues. For all recommendations, we expect that the implementing agencies will directly address and investigate EJ and equity linkages as implementation is considered and carried out.

Evaluation of the Action Plan

We plan to conduct a review of the Phthalates AP three years after publication. That review will inform future AP development processes, evaluate progress on implementation, and identify further needed actions. We provide more details on the three-year review later in the plan, following the recommendations.

Phthalates Background Information

Phthalates overview

Phthalates are a class of chemicals defined as diesters of phthalic acid (Figure 1). The National Library of Medicine (NLM) defines phthalic acid as "benzenedicarboxylic acid consisting of two carboxy groups at ortho positions" (National Library of Medicine (NLM), 2004). Using this definition, we focused our work on ortho-phthalates, hereby referred to as phthalates. As such, our discussion of the phthalate chemical class does not include isophthalates or terephthalates, which are based on benzenedicarboxylic acid in the meta or para configurations. Further references to phthalates will not include isophthalates or terephthalates unless specified.

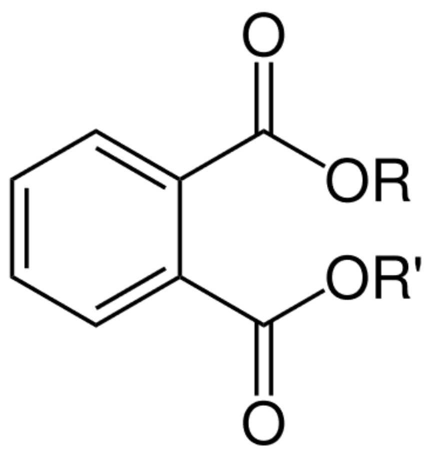

Figure 1. General chemical structure of phthalates (i.e., ortho-phthalates) with R and R' representing the variable side chains.

For this action plan, we considered the phthalate chemical class as a whole and did not examine each phthalate chemical individually. This aligns with the definition in chapter 70A.350.010 Revised Code of Washington (RCW), which defines phthalates (i.e., ortho-phthalates) collectively as a priority chemical class. This decision also aligns with past actions by Ecology under SPWA (Ecology, 2022a), driven by a need to consider cumulative impacts from all phthalate exposure.

Uses of phthalates

Most phthalates are used as plasticizers, especially in polyvinylchloride (PVC), to add softness and flexibility to materials. Phthalates are also used as solvents or fixatives in formulations. Due to these functional uses, phthalates are found in many categories of consumer products, including personal care products, cleaning products, textiles and apparel, packaging materials, automotive products, building materials, medical devices and products, food contact articles, and more. For more information on these uses, please see the dedicated section on consumer products.

Phthalates also have other reported uses. These chemicals may be used in infrastructure materials such as traffic control products, pipelines, and buried wire and cable. Phthalates are used as laboratory chemicals, in which they act as solvents or stabilizers for other chemicals (Uhl et al., 2018). They also are used as processing aids in manufacture of other materials, including both PVC and non-PVC plastics and rubber materials (Walters et al., 2020).

Production of phthalates

Examples of phthalates include dimethyl phthalate (DMP), diisononyl phthalate (DINP) and benzyl butyl phthalate (BBP). For a list of phthalates and their abbreviations used within this document, see Appendix D. Di(2-ethylhexyl) phthalate (DEHP) has historically been the most abundant phthalate plasticizer used in consumer products worldwide. However, the use of DEHP has decreased in recent years due to both voluntary efforts by the industry and regulations that have limited its use in some products due to health concerns (Nagorka et al., 2022; Nagorka & Koschorreck, 2020).

More than 20 phthalates are listed as high production volume chemicals by the EPA (US EPA, n.d.-a). The EPA defines high production volume chemicals as those manufactured or imported into the United States in amounts greater than one million pounds per year. Many commonly used phthalates are produced in volumes that far exceed this 1 million pound threshold. Approximately 8 million metric tons or 18 billion pounds were produced globally in 2015 (Y. Wang et al., 2019; Wypych, 2017).

To our knowledge, no phthalates are currently produced in Washington state. However, several facilities report phthalate releases or disposal. For additional background information on phthalates, refer to Appendix A.

Phthalates in the environment

Phthalates in consumer products can contaminate the environment throughout their lifecycle. This migration out of products into the environment occurs because phthalates used as plasticizers are not covalently bound to the polymers in which they are added, such as in PVC plastics (EC & HC, 2015a, 2015b, 2015c, 2015d). Phthalates also contaminate wastewater when phthalate-containing products, including personal care products and cosmetics, are disposed of down the drain.

Once in the environment, phthalates undergo rapid degradation. However, the widespread and continuous use of phthalates in products has caused them to become ubiquitous in the environment globally (Net et al., 2015). Failure to reduce these constant sources of phthalate release has led to recontamination of sediments in the Puget Sound area following large-scale chemical remediation efforts (Ecology, 2009a).

Human exposures and health impacts

Human exposure to phthalates is widespread. The Center for Disease Control's (CDC) national biomonitoring of urine samples shows that nearly all Americans are exposed to multiple phthalates. Children are generally more highly exposed than adults (CDC, 2022a). Even infants have multiple phthalate metabolites in their urine (Wenzel et al., 2018). Phthalates and their metabolic breakdown products can be found in urine, blood, umbilical cord blood, semen, breast milk, amniotic fluid, and placental tissues (Y. Wang et al., 2019). Phthalates are quickly processed and eliminated after intake, but because people are continually exposed, phthalates are usually present in the body.

Exposure to phthalates can occur from eating food and drinking beverages, using personal care products on skin, breathing indoor air, inadvertently ingesting dust, and medical procedures that use phthalate-containing plastics. Diet is the main source of phthalate exposure for most people. Indoor dust contaminated by phthalates impacts infants and small children who have more mouthing behaviors and spend more time on the floor (CHAP, 2014).

Medical products can cause very high exposure to DEHP in some people (SCENIHR, 2017). Personal care products are identified as a source of disproportionate exposure to phthalates in women of color (Chan et al., 2021). See Appendix B for more information about phthalate exposure in people.

The potential for phthalates to harm human health is widely studied in laboratory experiments with animals and in epidemiological studies of people. Phthalates can disrupt endocrine functions in the body (NIEHS, 2023). Endocrine-disrupting chemicals are substances in the environment (air, soil, or water supply), food sources, personal care products, and manufactured products that interfere with the normal function of your body's endocrine system. The endocrine system is a network of glands and organs that produce, store, and secrete hormones. When functioning normally, the endocrine system works with other systems to regulate your body's healthy development and function throughout life. Endocrine disrupting chemicals can cause adverse effects on fertility and reproductive health, thyroid function, metabolic function, and development of the nervous system (Diamanti-Kandarakis et al., 2009).

Early life is an especially vulnerable time period. Exposure to phthalates in the womb causes toxicity to male sexual development (ECCC & HC, 2017) and is linked to adverse effects on brain and behavior (Radke et al., 2020). These exposures also impact the respiratory system of children after birth (Wu et al., 2020).

When exposure occurs later in life, phthalates can affect reproductive health. Phthalates are associated with reduced semen quality and sperm count in men (Eales et al., 2022). We also see poorer pregnancy outcomes and increased risk and severity of uterine fibroids in women (Bariani et al., 2020).

Phthalates can affect the metabolic system and may cause diabetes, gestational diabetes, and insulin resistance. These chemicals are also suspected to contribute to obesity (Radke et al., 2019a). Some phthalates are toxic to the liver and kidney or are identified as carcinogens by federal or state authorities (NTP, 2021a; Weaver et al., 2020; Yu et al., 2021; X. Zhang et al., 2023). See Appendix B for more detailed summaries of the health effects that have been associated with phthalates in human epidemiological and laboratory animal studies.

Populations and health impacts of concern

Some groups of people can be more highly exposed, disproportionately exposed, or more susceptible to health harms from phthalates. These groups benefit the most from efforts to reduce exposure to phthalates. Some examples considered in our AP recommendations include:

Pregnant people: pregnant people are susceptible to health harms from phthalate exposure, including effects on the fetus, pre-term birth, and possible gestational diabetes, as described in more detail in Appendix B. Our recommendations to address dietary exposure, medical exposure, and exposure through consumer products will help reduce exposure during pregnancy.

Black women: Black women are disproportionately exposed to diethyl phthalate (DEP) compared to other adults. To help address this, Ecology and Health are currently taking action on phthalates that are used as fragrance in personal care products through our Safer Products for Washington program (SPWA) (Ecology, 2022). The consumer product recommendations of this Phthalates AP discuss personal care products that may lead to racial disparities in phthalate exposures.

Infants and unborn children: infants and unborn children are the most sensitive to health effects of phthalates. Taking action to reduce exposure to pregnant people through diet, consumer products, and from high exposures received during medical procedures can help protect unborn children. Targeting phthalates that accumulate in house dust can help protect infants with crawling and mouthing behaviors.

Young children: young children are a highly exposed sector of the general population. Their developing endocrine and nervous systems are highly vulnerable to disruption. Additionally, disproportionate exposures and impacts potentially exist for boys of color. Children are exposed to phthalates through foods, personal care products, school and art supplies, apparel, footwear and other sources. The Daycare and Early Childcare Facility section recommends reducing exposure to children in Washington day cares, with a focus on centers that serve children who are low income, tribal, unhoused, or experiencing delayed development. These children experience cumulative impacts of social stressors with chemical exposure.

People with medical exposure: exposure to phthalates during certain medical procedures and from medications containing phthalates is less common in the population but results in high exposure levels (Hernández-Díaz et al., 2013; SCENIHR, 2017). Medical exposures are addressed in the Phthalates in Health Care section. Reductions in this area would also prevent harm to a developing fetus when pregnant worm undergo critical medical procedures.

Workers exposed to phthalates: People who work with phthalate-containing products in janitorial and food service jobs, in retail settings where phthalate-containing products are sold, in salons, or in fabrication of plastic items can have workplace exposure to phthalates. Because lower economic status is a risk factor for many health conditions (U.S. Department of Health and Human Services, n.d.), disproportionate exposure to phthalates in lower income job classes has the potential to be a health equity issue.

Regulations

Washington State

Phthalates are regulated under several laws in Washington state. The Washington Children's Safe Products Act (CSPA), chapter 70A.430 RCW,[3] restricts the use of six phthalates in children's products at concentrations greater than 100 parts per million (ppm), individually or combined. CSPA also requires manufacturer reporting for six additional phthalates when used in children's products, for a total of 12 phthalates listed with a reporting requirement.

The Pollution Prevention for Healthy People and Puget Sound Act (70A.350 RCW, 2019) identified phthalates as a priority chemical class when it was passed in 2019. SPWA is the implementation program for chapter 70A.350 RCW. In 2021, the SPWA program in Ecology determined that it was necessary to restrict certain phthalates used in vinyl flooring and in the fragrances added to personal care and beauty products. Ecology published a proposed rule to implement those determinations in December 2022.

United States

Phthalates are regulated at the federal level in children's products under the Consumer Product Safety Improvement Act (CPSIA) by the Consumer Product Safety Commission (CPSC). Eight phthalates are restricted from use in any children's toy or childcare article that contains concentrations of more than 0.1 percent of any individual phthalate listed. These include DEHP, di-n-butyl phthalate (DBP), BBP, DINP, di-isobutyl phthalate (DBP), di-n-pentyl phthalate (DPENP), di-n-hexyl phthalate (DHEXP), and di-cyclohexyl phthalate (DCHP).

Seven phthalates are currently undergoing risk evaluations under the Toxic Substances Control Act (TSCA) by EPA to determine whether they present an unreasonable risk to public health or the environment under the conditions of use. Those listed are DBP, BBP, DEHP, di-isobutyl phthalate (DIBP), DCHP, di-isodecyl phthalate (DIDP), and DINP (CRE & ACC, 2003).

The FDA regulates phthalates in cosmetics, pharmaceuticals, medical devices, and in materials that come into contact with food (US EPA, 2012). In May 2022, the FDA revoked authorizations for the food contact use of 23 phthalates, while eight phthalates remained authorized for use as plasticizers and one phthalate as a monomer in food contact uses. Alongside that action, FDA issued a request for information to gather available information on the use and safety of the remaining eight phthalates authorized for use as plasticizers in food contact applications.

Phthalates are also regulated under the Resource Conservation and Recovery Act (RCRA) as hazardous waste if discarded as a commercial chemical product. DEHP is regulated under the Safe Drinking Water Act with the maximum contaminant level (MCL) set at 0.006 mg/L. DEHP, DMP and DBP are listed as hazardous air pollutants under the Clean Air Act (US EPA, 2012).

For additional background and general chemical information on phthalates, please refer to Appendix A.

[3] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430

Recommendations

The following recommendations are not listed in a ranked order or prioritized by numbering. Lead agencies, in conjunction with partner input, will prioritize actions on recommendations during the implementation phase.

Products and materials recommendations

Consumer products

Problem statement

The presence of phthalates in many consumer products contributes to the potential for human exposure and environmental contamination. Exposure to phthalates has been associated with adverse effects in both animal studies and in epidemiological studies on human health. See the section on exposure and health effects for more information. We have incomplete information about how phthalates are used in consumer products and improved transparency would identify opportunities for additional source and exposure reductions.

Relevant background information

Phthalates are a group of high production volume chemicals. Most phthalates produced are used in consumer products, predominantly as plasticizers, solvents, emollients, and fixatives. As such, consumer products represent an upstream source of human exposure to phthalates and eventual release of phthalates to the environment (CHAP, 2014; Danish EPA, 2013; EC & HC, 2015a, 2015d, 2015c, 2015b).

For this action plan, we focus on the summaries published by regulatory organizations. We supplemented this information with a subset of recent peer-reviewed and non-peer-reviewed literature to summarize phthalate use in several categories of consumer products. For product categories where we found information suggesting the potential for disproportionate exposures to phthalates, we have included references to studies on how the difference in product use patterns may contribute to those exposures. We have also included brief summaries of past product testing reports published by Ecology and manufacturer-reported data on the use in children's products in Washington.

Personal care products

Phthalates are found in many types of personal care products, including creams, perfumes, nail polishes, deodorants, face powders and foundations, bath soaps, detergents, aftershave lotions, hair spray, shampoos, conditioners, and other hair preparations (EC & HC, 2015a, 2015b, 2015c, 2015d). Phthalates have other functions in personal care and beauty products, including nail polish and hairspray. In hair spray, phthalates can be used to form flexible films on hair. In nail polish, phthalates are used as plasticizers to reduce cracking (US FDA, 2022). The presence of phthalates was also reported in a study of hair products used by Black women in the United States, including hair lotions, root stimulators, relaxer kits, anti-frizz/polish, and a hot oil treatment (Helm et al., 2018).

SPWA evaluated phthalates as a component of fragrances used in personal care and beauty products during its first implementation cycle from 2019 – 2022. After this evaluation, we determined it was necessary to restrict this use in products (Ecology, 2022a).

A study on personal care products from the United States also found phthalates in many rinse-off and leave-on products, including hair products, face cleansers, lotion, creams, lipstick, nail polish, skin toners, and deodorants (Guo & Kannan, 2013). Additionally, the same study found phthalates in baby care products, including shampoo, sunscreen, diaper cream, and powder. The concentrations in baby care products were generally lower than in other products tested.

These summaries and studies underscore the presence of phthalates in personal care products is often due to intentional use. However, the relatively lower concentrations observed in some products suggest that they are also likely present as contaminants unintentionally introduced through the manufacturing process.

Environmental justice and equity

Personal care product-use patterns may also reveal trends when considering race and ethnicity. Several categories of products containing phthalates were reported as more frequently used by women of color among studied populations of women in California (Collins et al., 2021; Dodson et al., 2021). An intervention study of adolescent Latina girls living in California in 2016 also showed that phthalate metabolites in urine were reduced when they stopped using their typical personal care products for three days and switched to phthalate-free alternatives (Harley et al., 2016). SPWA should consider these and similar findings if it evaluates additional uses of phthalates in personal care products in the context of equitably reducing exposures to people in Washington.

Cleaning products

Phthalates are used in scented cleaning products as a component of fragrances, akin to their use as fixatives in personal care products (EC & HC, 2015a, 2015b, 2015c, 2015d). There appears to be limited information and publicly-available data on the presence of phthalates in cleaning products and the amounts intentionally added to those products. A study published in 2012 reported phthalates in tub and tile cleaners, laundry detergents, stain removers, car-interior cleaners, carpet cleaners, toilet bowl cleaners, and a borax product (Dodson et al., 2012).

A study of 27 cleaning products obtained from a local supermarket in Spain found several phthalates in the following products: dishwashing detergent, laundry detergent, floor cleaner, bathroom cleaner, surface cleaner, and kitchen cleaners (Cacho et al., 2015). Another study from Spain reported measurements of phthalates in cleaning products, including glass cleaners, degreasers, floor cleaners, dishwashing detergent, laundry detergent, softener, stain remover, jam cleaner, active oxygen, de-scaler, and bath cleaner (Viñas et al., 2015).

Studies also suggest the use of cleaning products is associated with increased exposure to phthalates. For example, the frequency of use of traditional cleaning chemicals was significantly associated with urinary phthalate metabolites in a study of custodians in Connecticut, U.S. (Cavallari et al., 2015). A study of pregnant women in Spain reported that household cleaning product use (bleach, ammonia, glass cleaners, oven cleaning sprays, and degreasing products) during pregnancy was correlated with higher urinary phthalate metabolites (Valvi et al., 2015).

A study of Iranian women concluded that urinary phthalate metabolites were higher among users of household cleaning products as well (Darvishmotevalli et al., 2019). Taken together, these studies suggest that individuals who regularly use cleaning products, such as in occupational settings, may experience disproportionately high exposures to phthalates.

Textile and apparel

Phthalates are also used in textiles and apparel, where they commonly function as plasticizers in coated or synthetic fabrics and leathers, and in articles with plastic or rubber components. This includes uses in gloves, footwear, luggage, recreational gear, coated textiles, textiles with decorative prints, and non-animal leather (ACC, 2019; EC & HC, 2015a, 2015b, 2015c, 2015d). A recent review highlighted that phthalates in plasticized PVC prints are a potential source of phthalate exposure. The review suggested this finding is an important consideration with respect to textiles used by children (Rovira & Domingo, 2019).

Another recent, non-peer-reviewed study measured phthalate levels in products purchased online from Austria, Germany, Italy, Spain, and Switzerland. It also measured phthalate levels in five products purchased from a pop-up store in Germany. The study found phthalates in eight of the products included in the study (Cobbing et al., 2022). Importantly, six of those products were reported to exceed the EU REACH restriction that limits content to < 0.1 percent of certain phthalates in combination (DMP, DIBP, DBP, DEHP, DIDP). Products reported in the study as containing phthalates included footwear, jackets, and a baby bodysuit with a graphic print.

Ecology product testing studies have also included measurement of phthalates in children's apparel. For more information, please see the section below on children's products.

Packaging materials

Phthalates are found in various materials used for packaging, including PVC, nitrocellulose, cellulose acetate butyrate, cellulose acetate, acrylics, coated paper and paperboard, and in adhesives for labels (EC & HC, 2015a, 2015b, 2015c, 2015d). Packaging materials that contain phthalates have uses in both food and non-food packaging (ACC, n.d.). Phthalates also have been found in other plastics, presumably as unintentionally introduced contaminants from recycling mixed waste streams. It is unclear how widespread this is throughout packaging in commerce (Undas et al., 2023).

Ecology analyzed the packaging of 93 products purchased in 2012 for eight phthalates, resulting in 107 individual samples (Ecology, 2021). Ecology's study concluded that several phthalates are used in packaging at appreciable levels, including DEP, DEHP, DIDP, and DINP. Of the samples in the study, 12 percent contained DEHP above 100,000 ppm (parts per million), and DEHP was greater than 100 ppm in 35 percent of the samples. 6.5 percent of samples contained DIDP at concentrations greater than or equal to 100,000 ppm and DIDP was greater than 100 ppm in 27.1 percent of samples. For DINP, only 2.8 percent of samples were greater than or equal to 100,000 ppm, but concentrations were greater than 100 ppm in 30 percent of samples.

This past study by Ecology suggests that phthalates are commonly used in the packaging of consumer products; however, due to changing use patterns additional follow-up is necessary to confirm this assertion still holds true today.

Automotive products

Phthalates have many uses in automotive products, including (ACC, 2021b):

- Doors, windows, body molding.
- Upholstery, interior furnishings, and floormats.
- Adhesives, sealants, and foams.
- Wires and cables.
- Synthetic lubricants and engine oils.

An unpublished summary provided by Zero Waste Washington reported detections of phthalates in two of three brake pads they sampled, one with 6,500 ppm DEHP (Trim et al., In Progress). They also reported testing several other automotive products that did not contain phthalates, including synthetic motor oil, transmission fluid, automobile bumpers, and serpentine and v-belts. However, sample sizes for the categories in this study were relatively small, with four or fewer products per category.

Building materials

Phthalates are used in many building materials including in paints, coatings, adhesives, caulks, corrosion inhibitors, thinners, paint removers, putties, plasters, sealants, polishes and wax blends, varnishes, wire and cable insulation, flooring, tile and carpet backing, artificial turfs, roofing, wall coverings, swimming pool liners, and window shades (EC & HC, 2015a, 2015b, 2015c, 2015d).

For additional information, please refer to the dedicated section on building materials.

Medical devices and products

Phthalates are used as plasticizers in medical devices made of PVC or with PVC components, including catheters, tubing, intravenous fluid bags, respiratory devices, feeding tubes and gloves. The use of phthalates in medical devices conveys functional characteristics, such as softness and flexibility. However, there have also been concerns raised about the potential for exposure in patient populations, especially in developing children who may be more sensitive to phthalate exposures. See the section on health effects for more information. Due to the concerns raised about the use of phthalates in medical devices, significant efforts have been made to identify suitable alternatives (Nielsen et al., 2014).

For additional information, please refer to the dedicated section on medical devices and products.

Food contact articles

In addition to their use in packaging, phthalates are also used in other food contact articles including conveyer belts, tubing, and vinyl gloves (Carlos, 2018). Much of the research on phthalates suggests that the dietary route is the dominant source of exposure in people. See the sections on exposure and health effects and food contact articles for more information.

Phthalates are also used in plastic and rubber articles. These items include sporting equipment, shower curtains, bathmats, furnishings, arts and crafts supplies, jewelry, garden hoses, wires and cables, electronics, soft handles for tools, adult toys, and pet toys (ACC, 2019; Danish EPA, 2013).

Children's products

Previously, phthalates were reported in a variety of children's products, including toys, teethers, changing pads and tables, playpens, nursing pillows, baby furniture, baby mattresses, baby carriers, pajamas, footwear, crayons, slimy toys, and other rubber and plastic articles intended for use by children (CHAP, 2014; EC & HC, 2015a, 2015b, 2015c, 2015d). Due to both voluntary efforts by manufacturers and a changing regulatory environment, phthalates have been reduced or removed in many children's products. However, the use of phthalates from children's products is not regulated globally. In many countries, phthalates are still found in these products, often at concentrations that indicate intentional use (Akkbik et al., 2020; D. Y. Kim et al., 2020; H. L. Li et al., 2019; Negev et al., 2018; Tang et al., 2020).

At the federal level, the U.S. Consumer Product Safety Commission (CPSC) regulates children's products through the Consumer Product Safety Improvement Act (CPSIA). The CPSIA restricts the use of eight phthalates at concentrations greater than 0.1 percent in children's toys and childcare articles (CPSC, n.d.).

In Washington, CSPA regulates phthalates in children's products (CSPA, 2016). As part of that law, six phthalates are restricted from use in children's products individually or in combination at a concentration greater than 0.1 percent. Twelve phthalates are also included on our Chemicals of High Concern to Children reporting list. As such, manufacturers must report the presence of these phthalates in children's products reported as outlined in WAC 173-334.

High Priority Chemicals Data System (HPCDS) manufacturer reporting data on phthalates
Washington and Oregon require manufacturer reporting for commonly used phthalates in children's products. This data is in the High Priority Chemicals Data System (HPCDS). The database catalogs the number of children's products sold or manufactured in Washington that contain phthalates, as reported by the manufacturers. For example, in 2021 there were 161 products reported to contain phthalates in the Toys/Games product family.

The visualization of this reporting data, collected for all phthalates between 2012 – 2022, suggests that the use of phthalates in children's products has become less common. This is based on the number of reports for products. However, several product categories still stand out as having a higher number of reports for products containing phthalates. These products include arts and crafts supplies, clothing, footwear, personal accessories, and toys/games.

You can search product category data on the High Priority Chemical Data System (HPCDS) website.[4]

Ecology product testing studies for phthalates

Ecology analyzed 86 children's products purchased in 2012 for eight phthalates, resulting in 105 individual samples (Ecology, 2021). Ecology grouped the samples into seven product categories: art, baby, bath, cosmetics, fragrance, Halloween items, and shoes. Phthalates were detected in all product categories. DEHP was the most detected phthalate in 22.9 percent of samples, with the highest concentration reported at 1,630 ppm in a children's bath book. DINP was less frequently detected in only 11.4 percent of samples, but with the highest concentration measured for any phthalate at 443,000 ppm in a pair of baby sandals.

In 2013, Ecology performed a children's product testing study that included an analysis of phthalates (Ecology, 2014a) Ecology analyzed 40 samples for nine phthalates. Phthalates were detected in 14 of 40 samples, with the highest concentration estimated at 190,000 ppm DINP in a bendable alien figure. Eleven of the 40 products contained phthalates above 1000 ppm.

During 2014 and 2015, Ecology conducted an additional study of children's clothing, footwear and accessories (Ecology, 2015b). Fifty product-component samples from children's products purchased in 2014 were analyzed for nine phthalates. Phthalates were detected in 16 of the samples. DEHP had the highest detection frequency and sample concentration measured with 14 detections and a maximum concentration of 36,000 ppm in a children's wallet. DBP was detected in four samples with a maximum concentration of 200 ppm. DINP was also detected in one sample at 200 ppm. DEP, DHEXP, and BBP were all detected in products at concentrations below 100 ppm.

Ecology also analyzed seasonal children's products (i.e., Christmas, back to school, Valentine's Day, Easter, Halloween and Fourth of July) from the 2014 – 2015 period for nine phthalates (Ecology, 2017). This study highlights the presence of phthalates in children's products not available for purchase year-round. Phthalates were detected in 56 of 190 product samples tested, collected across seven seasons. Twelve of the 190 samples exceeded 1000 ppm, and the highest detection was for DEHP at 330,000 ppm in a "Selfie Elfie" elf from the 2015 Christmas season.

In 2018, Ecology conducted a follow-up to the 2015 study on children's clothing, footwear, and accessories (Ecology, 2020a). Ecology analyzed 29 product-component samples for nine phthalates. Phthalates were detected in nine of the samples. DEHP was again the most detected phthalate and had the highest concentrations reported at 551 ppm in the soles of a pajama suit and 516 ppm in a pair of children's slippers. DBP was the only other phthalate detected across samples and was detected in three products with a maximum concentration reported of 28.4 ppm. None of the samples tested in the 2018 study were above the CSPA restriction level for phthalates of 1000 ppm, and only two samples tested above the 100 ppm CSPA reporting threshold for phthalates.

[4] https://hpcds.theic2.org/Search

Recommendation #1

SPWA should consider identifying additional consumer products as sources or uses of phthalates.

Lead agency: Department of Ecology

Proposed Partners for Implementation: Department of Health

Justification

We need to reduce the use of phthalates in consumer products. SPWA is a regulatory program developed to implement chapter 70A.350 RCW and reduce toxic chemicals in consumer products. When the law was established in 2019, the Washington State Legislature identified phthalates as a priority chemical class. In 2020, SPWA identified fragrances in personal care, beauty, and vinyl flooring products containing phthalates as priority products. SPWA determined a restriction on phthalates in fragrances in personal care, beauty, and vinyl flooring products was necessary in 2021. A corresponding rule was proposed in 2022.

There are many remaining uses of phthalates in consumer products that have not been fully evaluated by SPWA as potential priority products.

Project description and implementation

We recommend that SPWA consider additional products to determine whether Ecology should list them as priority products in future cycles of implementation. This would allow additional product uses to be evaluated. As a result, SPWA could determine whether there are safer, feasible, and available alternatives to using phthalates in these products. Where safer, feasible, and available alternatives are not available, SPWA can also identify where innovation is needed to develop suitable alternatives.

The following product categories should be considered:

- Personal care products (non-fragrance uses)
- Cleaning products
- Textiles and apparel
- Packaging (food and non-food uses)
- Automotive products
- Building materials
- Medical devices and products
- Other food contact articles
- Additional vinyl products

Environmental justice and equity considerations

In considering these additional product categories, we will focus on products that contribute to exposures in sensitive populations, including children and populations disproportionately exposed to phthalates. During the development of the action plan, we highlighted several product categories that were of interest. These categories include building materials, medical devices and products, and food contact articles.

In addition to recommending SPWA consider these categories as priority products in their next implementation cycle, we also include discussions and recommendations that address those categories in more detail. For additional discussion, recommendations, and implementation steps specific to those categories, please see the sections on building materials, phthalates in health care, and food contact articles.

Recommendation #2

Ecology should support increased transparency and certifications for consumer products.

Lead agency: Department of Ecology

Proposed partners for implementation: None

Justification

Transparency enables consumers and organizations to make informed purchasing decisions regarding phthalate-free products. Product certifications and ingredient disclosures can help consumers identify products that do not contain phthalates and purchase alternative products instead. Thus, product certifications and ingredient disclosures accelerate efforts to reduce phthalate use.

Ecology can play a role in increasing transparency by providing information regarding the product certification process for items that do not contain phthalates. Additionally, Ecology can increase the number of publicly-available assessments that list existing phthalate alternatives. Ecology can also support outreach to communities with EJ and equity concerns by providing information about certifications, including how to use certification information when making purchasing decisions. Ecology should inform this outreach with community engagement. This will enable us to focus on products that communities facing disproportionate exposure to phthalates use most frequently.

Project description and implementation

Ecology should consider subsidizing the costs of transparency standards and product certifications as funding and opportunities allow. Ecology also should prioritize certification subsidies for phthalate-free products in categories where phthalates are commonly used. This will help consumers and state purchasers identify less toxic products, including phthalate-free products. Subsidy funding should prioritize small businesses, women and minority-owned businesses, and veteran-owned businesses.

In addition to subsidizing product certifications, Ecology should continue to support efforts that promote tranparency including:

- Allocating existing resources or requests for funding to support additional product testing studies by Ecology or Health.
- Contracting phthalate product testing studies with accredited external laboratories.
- Requesting additional information on phthalates in products through manufacturer data orders as described in chapter 70A.350.030 RCW.
- Conducting outreach, with a focus on disproportionately impacted communities, to increase education and awareness on transparency tools and resources (e.g., Health Product Declarations, Declare labels).

Food contact articles

Problem statement

Phthalates are present as contaminants in a wide variety of foods. Diet is a significant and often the dominant source of phthalate exposure for most people, especially for higher molecular weight phthalates. Phthalates are not intentionally added to foods but are authorized under federal regulations for use as indirect additives to materials that are used to manufacture food contact articles.

Food contact articles containing phthalates are used at the many stages of food production, packaging, and service. Polyvinyl, rubber, and other materials that contact food and beverages before consumption can contain phthalates that are able to migrate from food contact articles into consumable food and beverage products. To reduce phthalate exposure to people, the use of phthalates in food contact articles or transfer from these articles into foods should be reduced or prevented.

Note: consumption of drinking water and wild fish from Washington waters are other possible pathways of dietary exposure to phthalates. These pathways are addressed in other recommendations in the Phthalates AP.

Relevant background information

The extensive literature on food sampling data and the epidemiology of urinary biomarkers demonstrate that dietary intake contributes to aggregate phthalate exposure. Diet may be a significant source of phthalates exposure for people who consume more highly processed foods and high-fat meat and dairy.

Food sampling data

Phthalates are detected in many different food types in the U.S. (Schecter et al., 2013; Serrano et al., 2014) and globally (Cao et al., 2015; Giuliani et al., 2020; Z. Y. Li et al., 2022; Silano et al., 2019; Sirot et al., 2021; Van Holderbeke et al., 2014). Concentrations of phthalates in food range widely. Typical levels reported are in the parts per billion to low parts per million levels, but high levels have also been reported.

Many types of foods can contain phthalates and there is limited consistency across available food sampling reports. The longer-chain phthalates, which are less water-soluble and more lipophilic, are expected to migrate more easily into fatty foods like meat, seafood, oils, and high-fat dairy. However, phthalates have been found in many different kinds of foods, not all of which are high fat.

For example, a recent paper reported phthalates in meat and grain products served at U.S. fast food restaurants (Edwards et al., 2022). An intervention study tested whether a diet of unprocessed foods would reduce phthalate exposure and reported the highest levels of phthalates in the provided foods were in spices and dairy products (Sathyanarayana et al., 2013).

A Canadian total diet study found DEHP in 111 of 159 food-composite samples. The highest levels were in fruits and vegetables (Cao et al., 2015). In a total diet study in China, cereals, legumes, and potatoes contained the highest phthalate levels (Yang et al., 2018). The varying results across selected studies illustrate that there is no single type of food that is an obvious candidate for exposure reduction. It appears that variability in how foods are produced and handled plays an important role.

Phthalates continue to be detected in infant formulas around the world (Del Bubba et al., 2018; Ge et al., 2016). An analysis of infant diets in France found both DEHP and DINP in infant biscuits (Sirot et al., 2021). Our review did not identify U.S. studies of phthalates in infant formula.

Diets associated with markers of phthalate exposure

Epidemiological studies evaluated whether urinary biomarkers of phthalate exposure correlate with dietary intake of various foods. This data helps epidemiologists identify how food consumption affects people's exposure levels. Overall, similar to the findings noted above for food sampling studies, the specific foods linked to phthalates in people's urine vary greatly across biomarker studies. No simple pattern has emerged (Carwile et al., 2022; Polinski et al., 2018).

Many studies of biomarkers and food report that fatty foods such as meat, seafood, and high-fat dairy are associated with phthalate exposure (Serrano et al., 2014). In addition, diets rich in organic fruits and vegetables, fresh fish, and spices are associated with biomarkers of exposure.

Several studies conducted with different demographic groups throughout the U.S. report that eating meals out and consuming fast food or highly processed food was associated with higher phthalate exposure. Of these exposures, there were somewhat stronger findings for metabolites of DINP (Smith et al., 2021; Steele et al., 2020; Varshavsky et al., 2018; Zota et al., 2016).

An analysis of phthalates in over 2000 participants in a National Health and Nutrition Examination Survey (NHANES) looked at the fraction of people's diets that were from ultra-processed foods (Buckley et al., 2019). The people with the highest intake of ultra-processed foods were significantly associated with urinary metabolites of DEHP, DINP, and DIDP. DINP exposure was most strongly associated with ultra-processed food intake and increased by 50 percent from the lowest to the highest quartile. In contrast, diets with lower processed food intake may result in lower phthalate exposure levels (Vieyra et al., 2023).

Several of these studies also point out that consumption of ultra-processed food varies by race and income; therefore, dietary patterns could introduce exposure disparities for people who eat more fast food.

Of note, the people in the Buckley et al. (2019) study who had the highest intake of ultra-processed food and highest phthalate exposure were more likely to be younger, non-Hispanic Black, and lower income.

Sources of phthalates in food

The presence of phthalates in fattier foods can be explained partly by the chemistry of phthalates, e.g., most of these molecules have greater affinity towards lipids than water. However, variation of phthalate concentrations in different foods is likely driven by whether the processing, packaging, and handling history of a particular food included contact with phthalate-containing materials.

Phthalates are not intentionally added to food but can enter the food supply when foods come in contact with articles that contain phthalates. Contact with phthalate-containing materials can occur at many points from farm to table. For example, phthalates may be introduced during agricultural operations, transport, food processing, manufacturing of food products, packaging, or during food preparation and service. The level of migration of phthalates from plastics into food is influenced by factors such as the chemistry of the article, chemical characteristics of the food, contact time, and temperature (Urbelis & Cooper, 2021).

Examples of food contact articles that may contain phthalates that can migrate into foods and beverages include:

- Plastic items used in agricultural production.
- Conveyor belts that move food through facilities.
- Plastic tubing that transfers food products during processing, food packaging and adhesives.
- Gloves and food serviceware used in restaurants and other food service settings.

Recent studies by FDA scientists report that phthalates are present, by volume, at up to 30 percent in conveyors and 36 percent in polyvinylchloride tubing for use in food processing (Carlos et al., 2018). Low levels of phthalates were detected in paper and paperboard food service items in this study; however, the authors speculate that the phthalates were not added for technical reasons. They may be inadvertent contaminants from the materials used to manufacture the paper-based products, possibly from recycling processes (Carlos et al., 2021). Phthalates have been found to migrate from paper and paperboard food packaging into dry goods (Urbelis & Cooper, 2021). The phthalates may be in inks and adhesives used in paper-based packaging.

Bottle cap liners are another food contact source identified in the FDA work. They were also the subject of a recent NGO report titled Capped with Toxics (Belliveau, 2021). A Swiss study (Biedermann et al., 2022) noted that plasticizers, including phthalates, migrate out of lid gaskets. Phthalates could be detected in oily foods that were in contact with the phthalate-containing lids. Another NGO project measured phthalates in 14 percent of vinyl food-handling gloves. Notably, there is wide availability of phthalate-free plasticizers (Harmon & Otter, 2022) and phthalate-free materials for use in manufacturing food contact articles.

Given these and other studies, some food contact articles that are candidates for further evaluation include:

- **Food contact items that contain the phthalates that are restricted in children's products (see Regulatory Context below) and for which there are phthalate-free alternatives already in use in food/beverage production, packaging, and service applications** (Harmon & Otter, 2022).
- **Bottle cap liners.**
- **Vinyl food service gloves.** Some reports suggest that the majority of the market for gloves has moved away from phthalate-containing products, demonstrating that there are feasible and available alternatives.
- **Conveyors used to process meat and seafood.**
- **Food service films.** Films for home use are not a concern but commercial films used for packaging could be substituted with phthalate-free alternatives.

Regulations and Policy

Policy context

A team of toxicologists, physicians, and other public health experts recommend reducing dietary exposure as a critical step toward addressing possible neurodevelopment and behavioral effects of phthalates in children (Engel et al., 2021). In 2018, the American Academy of Pediatrics issued a policy statement and technical report calling for substantial reform of the FDA's safety assessment program regarding food additives, including phthalates, in order to reduce exposure (Trasande et al., 2018).

Some argue that phthalate exposure from dietary intake is below levels of concern when compared to EPA Reference Doses or the European Food Safety Authority's total dietary intake guidance (Adenuga, 2023; HC & EC, 2015; Sirot et al., 2021). However, EPA has not updated existing reference doses (RfDs) for individual phthalates for over 30 years. Additionally, some phthalates do not have established RfDs, and EPA has not produced authoritative, cumulative health-based guidance for consumers to follow.

Further, existing health guidance values may not protect against some of the more recently characterized health effects that can occur at lower doses (Maffini et al., 2021). It is prudent public health policy to reduce dietary exposure where feasible. Other states are already moving in this direction: a recent law on food packaging in Maine restricts the use of phthalates.

Regulatory context

The U.S. Food and Drug Administration (FDA) has the authority to regulate phthalates in food contact articles. In May 2022, FDA revoked authorization of 23 rarely used phthalates but maintained authorizations for the eight phthalates most used in food contact applications (DEP, DCHP, DIOP, DEHP, DINP, DIDP, DAP, butyl phthalyl butyl glycolate, and ethyl phthalyl ethyl glycolate). Four phthalates that are still allowed in food contact articles by the FDA were restricted for use in children's products over 15 years ago under the federal CPSC (DCHP DEHP, DINP, DIBP) or CSPA (DEHP, DINP, DIDP).

While allowing continued authorization, FDA noted that safety assessments for the phthalates that remain authorized for use were based on toxicological information and dietary exposure data from 1961-1985. To address these significant data gaps FDA is currently requesting information regarding the specific food contact use, dietary exposure, and safety of each of these eight chemicals.

The FDA comment period was open through December 27, 2022. As of January 7, 2023, no public data submissions were available for review. It is possible that FDA findings and actions could alter the recommendations proposed here at a later date. With that evolving regulatory environment in mind, the recommendations below for reducing phthalate exposure from dietary sources focus on developing processes to further evaluate exposures and forming a workgroup that can respond to new information and changing regulatory requirements.

Recommendation #1

Health will establish a workgroup charged with reducing the sources of phthalates in food and beverages though technical assistance, education, and voluntary actions in food production and food service in Washington.

Lead agency: Department of Health

Proposed partners for implementation: Department of Ecology

Justification:

Diet is the major source of exposure for the humans. Efforts to characterize and reduce the important sources can and should be made, regardless of a changing regulatory landscape and possible future consideration of food contact articles by SPWA. The landscape of phthalates in food is highly complicated and will require additional evaluation and prioritization beyond the background provided here. Chemical food safety is not a traditional focus of food safety programs. To better address phthalates in food, an interagency workgroup is recommended. A field program that engages food producers and retail food businesses can promote voluntary change to safer alternatives.

Project Description and Implementation

Health and Ecology should engage existing food safety programs and seek funding to convene and staff a workgroup. The workgroup's purpose is to promote voluntary reduction in the use of phthalate-containing food contact articles in Washington's food and beverage industries. Stakeholders, including manufacturers of food contact articles, food producers, food industry trade organizations, retail food businesses, and consumers should be involved to advise and inform the workgroup.

Foods disproportionately consumed by overburdened populations will be prioritized in the workgroup's activities. Participation by consumer groups that represent low income, immigrant, and tribal populations will be important for this prioritization. While foods are imported from other states and all over the world, we will begin our work with local food producers and a focus on Washington-made foods.

Specific recommended workgroup activities:

- Survey food-industry businesses and consumer groups about their knowledge and interest of phthalates in food contact applications.
- Conduct limited product testing to determine products that should be prioritized to reduce use.
- Identify the scope of the testing efforts based on community engagement efforts and our own research to identify potential products that have disproportionate impacts.
- Work with suppliers and manufacturers of food processing equipment to identify phthalate-free food contact articles that could be promoted to food industry businesses in Washington.
- Seek funding for a technical assistance program that would support food industry businesses to identify phthalate-containing materials in their facilities and operations and opportunities for replacement. The program would:
    - Provide customers with information about phthalates and suggest alternative products on the market.
    - Evaluate technologies that could be used to screen materials for phthalates and consider purchasing such instruments. Recent peer-reviewed studies have tested handheld instruments for this purpose and we have consulted with a manufacturer (Moskowitz et al., 2022; Yakes et al., 2022).
- Develop and present informational materials to engage food industry on phthalate reduction goals. Consider a contract academic or other external contractor for educational materials development if staff resources are limited. For dissemination of education, WSDA and Health food safety programs have existing networks in different parts of the food industry that could be leveraged.
- Identify and apply for funding for the community engagement work needed.
- Consider pursuing funding product replacement program opportunities for food producers to replace more expensive, durable phthalate-containing food contact articles with phthalate-free alternatives. For example, conveyors used in many food production facilities may be common sources of phthalates in food processing (Carlos et al., 2018). Funding would provide incentive for food producers to use phthalate-free alternatives. Conveyors in seafood processing enterprises may be of particular interest given the uptake of phthalates into fatty foods and the potential impact on tribal populations.

- When requested, engage with SPWA to provide information on the prevalence of phthalate-containing food contact articles and in-use alternatives to support evaluation of food contact articles by that program.
- Monitor the FDA process on phthalates in in food contact articles and submit comment when appropriate.

Recommendation #2

SPWA should consider evaluating phthalate-containing food contact articles for identification as priority products in a future cycle.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

Reducing the presence of phthalates in food contact articles would be a powerful and efficient pathway to reducing human exposure to phthalates from food. Phthalates are already identified as a priority chemical class under SPWA, and new priority products may be evaluated during each five-year program cycle.

Project description and implementation

The workgroup established under Recommendation #1 above can support the potential evaluation of food contact articles by SPWA. As the workgroup develops new information on phthalate use in food production operations and alternative products or processes in Washington state, this information will be conveyed to SPWA for consideration. Please see Recommendation #1 in the consumer products section for discussion of the SPWA program implementation.

Daycare and early childcare facilities

Problem statement

Approximately 186,000 children under the age of six spend time in early childhood education (ECE) facilities in Washington, where they may be exposed to potentially harmful chemicals during critical periods of development. Studies indicate that children can be exposed to phthalates present in toys, air, and indoor dust.

Exposure to some phthalates (e.g., DEHP, DBP, and BBP) in children has declined since these chemicals were banned from children's products and toys. However, exposure to replacement phthalates (e.g., DINP and DIBP) has increased and biomarkers of these phthalates can be found in children's urine samples (Brown et al., 2022; Zota et al., 2014).

Studies show that phthalates are prevalent in indoor air and dust, and the concentrations can contribute to a child's total intake (Göen et al., 2011; Koch et al., 2007, 2011; W. Liu et al., 2022; Wittassek et al., 2007). Several studies in particular assessed phthalate exposure in daycare centers (Bekö et al., 2013; Fromme, Lahrz, Kraft, Fembacher, Burghardt, et al., 2013; Fromme, Lahrz, Kraft, Fembacher, Dietrich, et al., 2013; Subedi et al., 2017), and identified some phthalates in indoor dust samples collected from childcare centers. These exposures to phthalates can contribute significantly to daily intake levels that exceed current regulatory values.

A study in Delaware found a positive association with total phthalate concentrations in floor dust. This was associated with plastic flooring materials and floor care products (X. Bi et al., 2015). Another study found that vinyl flooring may be linked to potentially harmful substances at schools and daycare centers. Researchers found DBP, DEHP, and DINP in dust in daycares that had PVC flooring (W. Kim et al., 2013).

Ecology summarized some epidemiological studies in children exposed to phthalates in vinyl flooring. These studies found an association between phthalate metabolites in children's urine and vinyl flooring in the home. For more information, see Chapter 10 of the SPWA Priority Consumer Products Report to the Legislature: Safer Products for Washington Implementation Phase 2 (Ecology, 2020b).

Relevant background information

Child health considerations

The potential for phthalate exposure and subsequent adverse health effects may be higher for children than adults. Developing infants and children may be particularly susceptible to the effects of endocrine disruptors during critical periods of growth and development. In addition to their susceptibility, children are more likely to be exposed to phthalates because (US EPA, 2011):

- They have more hand-to-mouth exposures and have less strict handwashing than adults.

- They can receive higher doses of contaminants because they eat much more per body weight than adults, are smaller, crawl around, and touch many things.
- They breathe more dust and soil particles because they are shorter and, therefore, closer to the ground.
- They have underdeveloped functional capacity of various organ systems and/or metabolic pathways resulting in different rates of detoxification.

The unique vulnerabilities of infants and children to phthalate exposure may call for special attention to children who live in or attend day care in communities that are impacted by other health stressors, including exposure to air pollution and other environmental chemicals and adverse social determinants of health such as poverty and poor nutrition.

Reducing exposure to children

Key findings:

- Young children are more vulnerable to environmental phthalates than older children and adults because their rapidly developing bodies are more sensitive to the harmful effects of phthalates and because they tend to have more exposure.
- Several studies were conducted to determine if phthalates present in the air and dust inside daycare centers could contribute to the child's total intake of some phthalates. These studies showed an association between phthalate metabolites in children's urine and indoor dust. However, more data is needed to characterize which phthalates pose the greatest risk for exposure in childcare facilities.
- The NHANES biomonitoring studies found measurable levels of many phthalate metabolites in the urine of the U.S. general population, with the highest levesl in children.
- The best way to protect children from phthalates is to minimize their exposure, preferably by prevention. Removing existing sources or effectively blocking exposure can be accomplished relatively cheaply and protects the health of children and childcare staff.

Regulations and policy

Washington early care and education laws

According to the Children's Environmental Health Network,[5] there currently are no mandated national regulations related to environmental health in ECE programs. Under the Foundational Quality Standards for Early Learning Programs Chapter 110-300 WAC (Washington

[5] https://cehn.org/blog-moving-the-child-care-field-forward-updated-environmental-health-standards/

Administrative Code),[6] and WAC 199-300-0410,[7] the program space must be located on a site free from known environmental hazards (Chapter 110-300 WAC, 2020).

In Washington, current ECE licensing requirements do not comprehensively address environmental health. The law (WAC 110-300-0410)[8] states that early learning providers must prevent enrolled children from being exposed to the following known hazards within and around the licensed premises:

- Lead-based paint.
- Plumbing and fixtures containing lead or lead solders.
- Asbestos.
- Arsenic, lead, or copper in the soil or drinking water.
- Toxic mold.
- Other identified toxins or hazards.

However, ECE program sites are not currently evaluated for phthalate hazards and other harmful substances; thus, children may be at risk of exposure. The law does not say that the licensing agency must educate childcare providers against chemical hazards (e.g., phthalates), safety hazards or environmental exposures in their facility.

Childcare product laws

Several states, including Washington, have adopted laws that restrict the manufacture and sale of toys, children's articles, and other products containing phthalates within the state. While childcare regulations typically do not address the use of chemicals like phthalates, the State of Washington prohibits the use of infant bottles containing BPA or phthalates.

In 2008, Washington's Legislature passed CSPA to limit the use of six kinds of phthalates (DCHP, DEP, DIBP, DBP, DNHP, BBP), lead, and cadmium in children's products sold in Washington (CSPA, 2016). CSPA provides some reduction of phthalates in products that might be found in daycare settings, but not all products are restricted under CSPA. For example, foam craft materials can lead to exposure to children but are not currently restricted.

In 2008, the Consumer Products Safety Commission (CPSC) banned the use of six phthalates in toys and childcare articles at concentrations exceeding 0.1 percent by weight: DEHP, DBP, BBP, DINP, DIDP and Di-n-octyl phthalate (DnOP) (CPSIA, 2008). The law states that it shall be unlawful for any person to manufacture for sale, offer for sale, distribute in commerce, or import into the United States any children's toy that can be placed in a child's mouth or childcare article that contains concentrations of more than 0.1 percent phthalate compounds DINP, DIDP, DnOP. CPSIA imposes its own limits on certain phthalates in some categories of children's products (CSPA, 2016).

[6] https://app.leg.wa.gov/wac/default.aspx?cite=110-300

[7] https://app.leg.wa.gov/wac/default.aspx?cite=110-300-0410

[8] https://app.leg.wa.gov/wac/default.aspx?cite=110-300-0410&pdf=true

Recommendation #1

Ecology's Product Replacement Program should develop a swap-out program for durable products in childcare facilities that contain phthalates, such as vinyl flooring, and other products prevalent in childcare facilities.

a) Ecology should partner with Health to use existing relationships with Department of Children, Youth, and Families to help prioritize facilities for outreach and potential vinyl flooring replacement.

b) This program should be accessible to all childcare facilities.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health; Department of Children, Youth and Families (DCYF)

Justification

In general, Washington laws do not specifically include safety hazards or environmental exposures identified in childcare facilities. Ecology proposed a restriction on the sale of vinyl flooring containing phthalates in Washington during the first implementation cycle of SPWA. This would prevent facilities in Washington from purchasing vinyl flooring containing phthalates for future construction and renovation projects. However, many facilities in Washington may contain older vinyl flooring that contains phthalates. This older vinyl flooring may include some of the most toxic phthalates, such as DEHP, that have since been voluntarily phased out by many flooring manufacturers.

Project description and implementation

Staff from Ecology would lead the product replacement program for vinyl flooring in childcare facilities. Health staff would partner with Ecology to implement this recommendation. Ecology should consider implementing a vinyl flooring financial assistance program through its product replacement program to facilitate replacement of phthalate-containing vinyl flooring. The program should include proper disposal of phthalate-containing materials to avoid unintentional environmental contamination.

Health would conduct outreach to childcare facilities to identify flooring replacement opportunities and help prioritize facilities to be targeted for early implementation. To aid in identification of such facilities, Health would utilize the Washington Tracking Network and an existing relationship with the DCYF.

Environmental justice and equity

We would prioritize existing childcare facilities, particularly those with under-served populations such as communities of color, tribal populations, people with disabilities, rural populations, immigrant, low income, and populations where English is a second language. Implementation should prioritize assisting childcare facilities that are licensed, funded, or otherwise supported by the state. This includes Early Childhood Education and Assistance

Program (ECEAP) that serve children who are low income, tribal, unhoused, or experiencing delayed development.

Over burdened and low-income communities may have older facilities using phthalate containing vinyl flooring and other products. These facilities may need assistance to remove old consumer products and flooring that contain phthalates, mitigating exposures to children. Additionally, cheaper single-use plastics and products may be more prevalent and facilities may need assistance swapping to reusable and safe alternatives.

Regulatory considerations

Phthalate prevention and reducing activities can be accomplished using existing statutory authority. None of these recommendations violate existing federal (e.g., CPSIA) or state laws (e.g., CPSC and CSPA).

Recommendation #2

Develop educational and outreach materials that can be used to reduce the use of phthalate-containing materials in daycares.

a) Work with childcare facilities and providers to identify ways to reduce the use of phthalate containing materials in daycares (for example, avoiding fragranced cleaning products, using tongs to serve food instead of vinyl gloves, and avoiding single use plastic items).

b) Work with the licensing agency DCYF and local health jurisdictions to educate childcare providers, parents, and licensors about phthalate hazards.

c) Educate licensors of childcare facilities and providers to raise awareness of phthalates.

d) Disseminate information through the early achiever's quality rating & improvement system (DCYF, n.d.).

e) Collaborate with Ecology's Children's Safe Product Act staff to incorporate CSPA information into educational materials.

f) Work in partnership with local health and childcare providers to implement education in childcare facilities.

g) Build on existing programs to help the childcare industry reduce phthalate uses and releases.

Lead agency: Department of Health

Proposed partners for implementation: Department of Children, Youth and Families (DCYF), Department of Ecology

Justification

There are no laws and regulations that say childcare providers must be provided with educational and outreach materials about reducing exposure to phthalate-containing materials in daycares. Neither is it mandatory to conduct phthalates screening nor testing of products in current use at daycare facilities.

Phthalate exposure can be reduced if childcare providers avoid the use of certain items, including plastic items and fragrance-containing cleaning products (like soaps) and personal care products. While prevention strategies are the most effective ways to reduce and eliminate exposures in the long run, it is important to continue to manage and reduce releases in the short term as well.

Project description and implementation

The goal of these recommendations is to help childcare providers identify and address phthalate health concerns. We need to provide them with the resources to effectively address those concerns. Some childcare providers may fear losing their childcare license if state agencies become involved, and this could limit the success of these recommendations. Some childcare providers may be resistant to working with state agencies in general. We will need to work closely with DCYF to build trust with childcare providers.

Implementing these recommendations requires action by other state agencies over the next several years. Additional funding would be needed to coordinate the efforts of these agencies, which include DCYF, Ecology, and Health. Health can leverage its relationship with DCYF to reduce phthalate hazards in daycares.

The existing Washington Choose Safe Places[9] (WCSP) program and the current staff resources in that program would help implement these recommendations. The Site Assessment Program and WCSP were recently funded by a grant from the Agency for Toxic Substances and Disease Registry (ATSDR) for the next 5-year cycle. Renewal of the grant funding would support the implementation of these recommendations.

These recommendations also require education and outreach. Existing staff would complete these activities. Health would work with stakeholders to develop support for assessing phthalate hazards in childcare facilities and reducing the use of phthalates in children's products. Health would support DCYF, Ecology, and other agencies in outreach. Health would also lead the effort to develop guidelines for childcare providers to assess phthalate-exposures in their facilities. Translation and interpretation should be provided to all childcare facilities in need of this service.

[9] https://doh.wa.gov/about-us/programs-and-services/environmental-public-health/environmental-public-health-sciences/about-site-assessment-program/washington-choose-safe-places

Regulatory considerations

Phthalate prevention and reduction activities can be accomplished using existing statutory authority. None of these recommendations violate existing federal (e.g., CPSIA) or state laws (e.g., CPSC and CSPA).

Environmental justice and equity considerations

As mentioned under Recommendation #1, we would prioritize existing childcare facilities, particularly those with under-served populations such as communities of color, tribal populations, people with disabilities, rural populations, immigrant, low income, and populations where English is a second language. As such, outreach and engagement efforts may need to be translated into several languages besides English.

Additionally, we would work with local community groups to establish best methods of engagement and trusted avenues of information. Communities with limited access to digital format messaging may require outreach in the form of workshops, community events and other activities.

Phthalates in health care

Problem statement

Many health care products can contain phthalates. Medical devices such as catheters, tubing, intravenous fluid bags, respiratory devices, feeding tubes, and gloves have received the greatest attention as sources of phthalate exposure in health care, but some medications also have phthalate-containing coatings. Additionally, some items used primarily outside of health care settings, such as breast pumps and menstrual products, are of concern.

Phthalates exposure during medical procedures is often much higher than background levels of exposure. Further, patients undergoing critical medical procedures have compromised health status and may be more vulnerable to phthalate toxicity. Manufacturers are working to provide new products that can meet performance needs without phthalates. Hospitals have reduced the use of some phthalate-containing medical equipment and supplies. Despite progress, medical uses and exposures continue.

Relevant background information

Phthalates in medical products

Phthalates are added to a wide range of health care products to confer useful and sometimes critical characteristics such as softness, durability, and flexibility. Medical items that are common sources of phthalate exposures include:

- Exam gloves
- Flexible bags for intravenous fluid and blood
- Catheters of different sorts
- Endotracheal tubes
- Blood pressure cuffs
- Respiratory masks

Additionally, flexible tubing that may contain phthalates is used in a variety of medical applications. These applications include hemodialysis, cardiopulmonary bypass, extracorporeal membrane oxygenation (ECMO), invasive and non-invasive respiratory support, and administration of fluids, including blood, medications, and nutrition.

Most of the DEHP that is produced in the U.S. today is used for the manufacture of medical devices (Eastman Chemical Company, pers. comm., 2022). Other phthalates may be present in medical supplies too: DINP is used in vinyl exam gloves and was identified in transfusion sets in a study of neonatal intensive care units (NICUs) in France (Bernard et al., 2021, 2023).

Biomarkers in urine and blood show that medical devices used for surgical and other procedures result in some of the highest documented human exposures to phthalates. Some reports have found ECMO procedures and kidney dialysis can deliver high exposures to adults that are 100-1000 times the background exposure to the general population (Huygh et al., 2015; Kaestner et al., 2020; SCENIHR, 2017).

Most investigations have focused on exposure to critically ill infants in NICUs because of the sensitivity of the developing infant to the toxic effects of phthalates. Indwelling medical devices, lipid-containing nutrition, infusion sets, cardiopulmonary bypass tubing, and bubble continuous positive airway pressure (CPAP) respiratory equipment all significantly raise exposure to DEHP in a wide variety of NICU studies. Exposure levels can be 10-26 times higher than background population exposures (Calafat et al., 2004). One study estimated exposure at as much as 16 mg/kg/day based on a survey of published studies (Mallow & Fox, 2014). For comparison, average daily exposure in the general population has been estimated in the low microgram per kg per day range.

In infants exposed to DEHP in the NICU, urinary metabolites dropped 16-fold after leaving NICU care (Bernard et al., 2023). In 2001, FDA estimated that combined exposure from just parenteral nutrition, transfusion and intravenous (IV) medication could be 3mg/kg/d for an infant (CDRH, 2001). With by-pass or ECMO-treated patients, the exposure could be much higher. Based on these high exposures and the established toxicity of DEHP to reproductive development in males, the FDA concluded there were “serious” concerns for the exposure of male infants and recommended that measures be taken to reduce exposures (CDRH, 2001).

Importantly, some studies have attempted to identify associated health effects despite the challenges in detecting effects in critically ill populations who are undergoing highly individual treatments. Effects that have been associated with DEHP exposure levels in infants undergoing medical procedures include increased post-operative complications generally (Guerrelli et al., 2022), cholestasis (Von Rettberg et al., 2009) and hypertension (Jenkins et al., 2019).

Many hospitals and other health care providers have reduced the use of phthalate-containing medical devices in the NICU in the last two decades. Kaiser Permanente is a leader in this area. After beginning to eliminate DEHP from certain NICU products in 2001, Kaiser announced a commitment to DEHP-free IV solution bags and IV tubing in 2012. Regulations in the European Union that restrict the use of DEHP in medical devices have accelerated the development of alternatives. In France, DEHP has been restricted to 0.1 percent by weight in tubing used for maternity, pediatric, and neonatal hospital care since 2015.

Manufacturers now provide a wide range of products that can meet high-performance standards for medical care without the use of DEHP (Den Braver-Sewradj et al., 2020). Tubing and IV bags that incorporate alternative, non-phthalate plasticizers are available; however, in some cases, DEHP has been replaced with other phthalates, such as DINP (Malarvannan et al., 2019; Marie et al., 2017). The use of DEHP in PVC blood bags is one medical application for which alternatives do not yet meet performance standards. DEHP has a stabilizing effect on red blood cells and allows for longer stable storage of blood products. This benefit is critical for maintaining adequate blood supplies, despite the risk of high exposure during transfusion procedures.

Phthalates in health care environments

Additionally, other phthalate-containing products that have broader non-medical purposes are commonly found in health care settings. These products also contribute to phthalate exposures in patients, staff, and family members.

Vinyl furnishings, flooring, and wall coverings are durable and easy to sanitize, which are important characteristics for medical facilities. However, if these vinyl materials are softened with phthalates, they can contribute to phthalates in air and on surfaces in health care settings, just as they would in residential or other indoor environments.

The issue of phthalates used in packaging has been raised elsewhere in this report. It is worth noting that the use of packaging is especially high in hospital and clinical settings, where many medical products are packaged individually. PVC offers hygiene advantages for medical packaging because it is holds up under common sterilization procedures.

Medications containing phthalates

Phthalates in the coatings of oral medications and dietary supplements can help promote extended release. In some cases, the purpose is to target medication to the bowel (Hernández-Díaz et al., 2013; Kelley et al., 2012). People taking medication with DBP-containing coatings are chronically exposed to levels significantly above population averages (Hait et al., 2013; Hernández-Díaz et al., 2013). A recent study suggested that this exposure could contribute to reduced sperm motility (Nassan et al., 2016) and thyroid hormone disruptions (Nassan et al., 2019).

In 2012, the FDA recommended, but did not require, that pharmaceutical manufacturers avoid the use of DBP or DEHP in medications. A Canadian consensus statement for the management of inflammatory bowel disease recommended medication formulated with DBP should not be offered to pregnant women because of potential risks to fetal development (Nguyen et al., 2016).

Another medication related exposure of concern was identified in a recent study of endocrine disruptor exposures in a cohort of Black women in Detroit. The use of vaginal ring devices for hormonal contraception was strongly associated with phthalate exposure in both a statistical analysis of mixed phthalate exposures (Schildroth et al., 2022) and a prior analysis that looked at individual phthalates (Wesselink et al., 2020).

A study of childhood cancers in Denmark noted that children who developed osteosarcoma were more likely to have exposure to phthalates via medications than children without osteosarcoma (Ahern et al., 2022). The authors note that, in Denmark, there were phthalate-free formulations available for all medication classes tracked for the study.

Menstrual and incontinence products

Chemical exposure from products designed to absorb menstrual flow or urine has been the focus of a small but potentially relevant set of studies reviewed by Upson et al. (Upson et al., 2022). Several investigators found phthalates in tampons and sanitary pads, although some reports sampled products from outside the U.S. (Park et al., 2019).

In a U.S. study of 77 different feminine hygiene products, all the pads, tampons, and wipes tested contained multiple phthalates, with the highest concentrations present in panty liners (C.-J. Gao & Kannan, 2020). While exposure levels are relatively low compared to some other sources, the application of these products to tissues near the uterus, a key target tissue for phthalate toxicity, raises concern, especially because such products are used repeatedly over many years of reproductive life.

Exposure estimates are complicated by the limited data available to calculate the absorption of phthalates by vaginal and vulvar tissues, but some of these membranes are highly permeable. While phthalate levels in adult incontinence products are unknown, some limited data on baby diapers suggests that these may also contain phthalates at low levels. These products need more investigation.

Occupational exposures

Occupational exposures of hospital and clinical staff are a concern. Vinyl can be used in goggles and other protective items worn by medical staff. Vinyl exam gloves are often plasticized with DINP. For some occupations, these gloves may be worn for much of the shift. IV bags, tubing, packaging, and vinyl curtains can presumably all contribute to exposure through air, dust, and dermal contact. This has also been shown for PVC consumer products with phthalate plasticizers.

The role of procurement processes

Medical devices and supplies comprise a large, complex business sector. Group purchasing organizations (GPOs) play an important role by screening and vetting vendors of medical products and negotiating bulk contracts that make products available to purchasers at favorable prices. Many U.S. hospitals participate in at least one GPO.

Recently, some GPOs (e.g., Vizient) worked to improve disclosure of the chemical ingredients in health care products. This includes working with manufacturers to compile information about which products contain phthalates and other chemicals. When chemical ingredients are disclosed, health care providers can better evaluate the phthalate content of health care products and make decisions about this information in their purchasing criteria.

Additionally, non-governmental organizations, such as Practice Greenhealth, offer purchasing guides and assist health care providers to implement policies that reduce the use of phthalate-containing products in their facilities. Still, the majority of DEHP that is produced in the U.S. is used in the manufacture of medical devices and results in exposure to patients, staff, and family members.

Regulation of phthalates in medical devices

A new Medical Device Regulation (EU Regulation 2017/745, 2020) went into effect in the European Union in 2020. This regulation restricts the use of any reprotoxic chemicals in category 1A or 1B, or any endocrine disruptors with evidence of serious effects in humans to 0.1 percent by weight, unless a specific justification, which requires an evaluation of exposure and risk, is submitted and an exception is granted. Several phthalates are listed as endocrine disruptors or classified as 1B reproductive toxicants in Europe. France has stricter regulations, having banned DEHP from medical devices used in neonatal, pediatric, and maternity care in 2015.

Recommendation #1

SPWA should consider evaluating some medical products for identification as priority products containing phthalates. Recommended products for consideration include breast pumps and accessories and medical exam gloves. Phthalate-free alternatives for these items are currently available on the market.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

Elimination of sources is the simplest way to prevent exposure. For medical products where phthalate-free alternatives are already in widespread use, the SPWA program is well-suited to evaluate products and alternatives.

Project description and implementation

See Recommendation #1 under consumer products for implementation through SPWA. Health staff working on recommendations #2 through #4 would collaborate with the SPWA program, when requested, to identify possible candidate products for further evaluation.

Recommendation #2

Health and Ecology should work with health care system partners to increase awareness about phthalates. Health and Ecology can encourage action to reduce the use of phthalates when alternative products or processes meet standards for patient care.

Lead agency: Department of Health

Proposed partners for implementation: Department of Ecology

Justification

Hospital patients undergoing surgical procedures have vulnerable health and experience some of the highest phthalate exposures. There are currently alternative products available on the market and under development. There are also extensive resources that can assist medical facilities in developing phthalate reduction policies. Given this momentum, Health could accelerate implementation of voluntary phthalate reduction plans by actively engaging hospitals.

Working with providers of kidney dialysis to reduce exposure is potentially important from a health equity perspective. African Americans, Native Americans, and people of Hispanic ethnicity have higher rates of kidney disease that requires dialysis as compared to non-Hispanic whites (USRDS, 2022). Thus, these populations may have disproportionate exposure to phthalates received through dialysis procedures. Exposure levels from dialysis can be significantly higher than background levels of phthalate exposure.

Developing fetuses and infants are the most highly susceptible to toxicity from phthalate exposure; therefore, health care exposures to pregnant women and infants are a priority in this action plan. Raising awareness among both hospital and non-acute perinatal care providers about ways to reduce patient exposure to phthalate-containing products (both in and out of the health care sector) has the potential for high impact.

Health care workers are a population of concern for phthalate exposure. Although their exposures are not as high in the acute timeframe as patients undergoing medical procedures, medical staff can be exposed over their working lifetime.

Project description and implementation

The recommendation is intentionally broad to allow for flexibility during implementation of this plan. At this time, we recommend the following as priority areas to focus on phthalate reduction in plastic health care products: hospitals, kidney dialysis providers, and perinatal care providers. We also recommend a focus on occupational exposure of health care workers. A final priority to be considered is reducing exposure to phthalates through medications. Implementation activities to achieve high priority exposure reduction would need to be tailored to different kinds of health care providers.

Health and Ecology should identify opportunities to increase adoption of phthalate reduction measures in Washington hospitals and hospital systems. This includes adopting sustainability and chemical safety policies for procurement. Activities could include:

- Conduct outreach to large hospitals in Washington to learn which have existing sustainable procurement policies and procedures that prioritize reduction of phthalate-containing products, supplies, and medications.
- Engage hospitals who do not have such policies in place. Outreach possibilities include identifying and working directly with hospital sustainability directors and purchasing committees, collaborating with the Washington State Hospital Association, and connecting with interested hospital staff.
- Provide information and materials to support new phthalate-reduction policies. This effort can leverage existing resources at large Washington hospitals (e.g., Kaiser Permanente, Seattle Children's) that already have existing safer chemicals policies and procurement practices. Guidance from established health care sustainability organizations can also be leveraged.
- Meet with medical product manufacturers to learn about alternative products available now and under development that could be promoted.
- Work with GPOs to increase phthalate content disclosure by contracted vendors. GPOs who do business with Washington hospitals (and with smaller or non-acute providers too) that do not currently promote disclosure of phthalate content should be identified and prioritized for educational outreach.

- For phthalates in medications, further evaluation is needed to identify available alternatives for gastrointestinal medications that use phthalates to localize effects. This requires input from medical professionals. Similarly, the published finding that vaginal rings may be a source of high phthalate exposures should be further investigated to determing if there are available alternatives.

Environmental justice and equity considerations

Small hospitals and non-acute care providers may be less likely to have dedicated sustainability officers. They may also be less likely to participate in the national group purchasing organizations that provide access to information about phthalate content of products. For these providers, outreach would focus on raising awareness of phthalate hazards and available alternatives to phthalate-containing products and medications. High priority specialties include:

- Providers of perinatal care, since the developing fetus is highly susceptible to phthalate exposure (see Appendix B).
- Free standing dialysis centers, since hemodialysis can result in considerable, repeated exposure and the need for dialysis is disproportionate by race/ethnicity.

Health should prioritize working with perinatal and hemodialysis providers who care for patients from tribal communities and other communities that experience health disparities, especially health disparities that could be linked to, or exacerbated by, phthalate exposure.

For phthalates in medications, further evaluation is needed to identify available alternatives for gastrointestinal medications that use phthalates to localize effects. This requires input from medical professionals. Similarly, the published finding that vaginal rings may be a source of high phthalate exposures should be further investigated.

Recommendation #3

Health should conduct education and outreach to raise awareness of phthalate reduction opportunities among clinicians and other health care staff to reduce occupational and patient exposure.

Lead agency: Department of Health

Proposed partners for implementation: None

Justification

Clinicians who are directly involved in patient care are uniquely positioned to advocate for a reduction of toxic hazards in health care to protect both themselves and their patients. While limited peer-reviewed information was found on this subject, some reports suggest that knowledge about phthalate hazards is uneven among clinicians (Marie et al., 2019). We met with stakeholders who agreed that raising awareness of phthalate uses and hazards among clinicians is an essential component of reducing phthalate exposure in health care.

Project description and implementation

Health should partner with clinician professional organizations to arrange presentations and other educational opportunities. Examples of organizations that Health could engage are the Washington Nurses Association, the Midwives Association of Washington State, the Washington section of the American College of Obstetricians and Gynecologists (ACOG), and the Pediatric Environmental Health Specialty Unit at the University of Washington. Recommendations in the 2021 ACOG Committee on Obstetric Practice opinion identify phthalates as a target chemical class for exposure reduction.

Recommendation #4

Health should investigate phthalate exposure from menstrual and incontinence products, and share results with Department of Ecology to confer on next steps.

Lead agency: Department of Health

Proposed partners for implementation: Department of Ecology

Justification

Exposure to absorbent health care products, such menstrual and incontinence pads and undergarments, affects a large portion of the adult population. Despite this, little is known about the hazard level posed by phthalates and other chemicals in these absorbent health care items.

Menstrual products are used for decades throughout the reproductive lifespan. Incontinence products are typically used every day for varying durations, but people with certain medical conditions use these products for many years. Research shows that women are more highly exposed to phthalates generally. Given this, it makes sense to investigate the role menstrual products may play in this exposure.

Project description and implementation

a. Address the need for more information on chemical content in products through a focused product testing project. Testing for phthalates would be one element of a broader multi-chemical approach under development.
b. Enlist health educators to engage with users of these products to learn their concerns and product usage patterns.
c. Produce reports and published papers on the results of the product testing project.
d. Convey findings to SPWA program so it may consider identifying menstrual/incontinence products as priority products. SPWA has authority to request additional data from manufacturers.

Environmental justice and equity considerations

Menstrual and incontinence products are important necessities for certain groups of our population. The regular use of these products are required by many individuals and could inadvertently lead to increased exposure of phthalates. Should these products be found to contain phthalates that result in added exposure routes to consumers, SPWA may consider limiting their manufacture, distribution, and sales in Washington. However, we recognize restricting or reducing access to these products may create an equity issue. In the event SPWA considers to add these and similar products as priority products, they will identify safer and feasible alternatives before proposing restrictive regulations.

Building materials

Problem statement

Phthalates are used in a variety of building materials. Studies suggest these materials may expose humans to phthalates and release phthalates into the environment. For many applications, building materials are available that do not contain phthalates. These may be suitable alternatives for building projects.

State-supported building programs may not have existing standards or requirements that specify the use of phthalate-free materials when possible. Project decision makers also need information and resources so they can consider material health in early design conversations.

Relevant background information

Phthalates are used in many building materials, including in paints, coatings, adhesives, caulks, corrosion inhibitors, thinners, paint removers, putties, plasters, sealants, polishes and wax blends, varnishes, wire and cable insulation, flooring, tile and carpet backing, artificial turfs, roofing, wall coverings, swimming pool liners, and window shades (ACC, 2021a; EC & HC, 2015a, 2015b, 2015c, 2015d).

Several studies suggest that phthalates in building materials can contribute to the presence of phthalates indoors and the potential for human exposure. For example, a house dust study in Canada found that hardwood flooring was a source of phthalates with the presence of a range of synthetic products (adhesives, extenders, fillers, coatings, and binders). This suggests that other manufactured wood products may also act as indoor sources of phthalates (Rasmussen et al., 2022). Another study found that, depending on the type of flooring and temperature, phthalates may volatilize from flooring materials and affect indoor air quality (Lin et al., 2021).

Additionally, emissions of phthalates have been characterized from vinyl floorings and wallpaper products (Shinohara Id et al., 2019). In a study of Japanese dwellings, researchers also found higher phthalate concentrations in dust associated with multiple surfaces, compressed wooden floors, and a high number of PVC materials (Ait Bamai et al., 2014).

A study monitoring personal exposures in office environments in the United States, the United Kingdom, China, and India found that building materials contributed to increased exposure to phthalates (Young et al., 2021). Once building materials are delivered to construction sites, phthalate levels in the air increase. This is because phthalates released from the materials adhere to particular matter in the air. This has implications for phthalates exposure to both workers and future occupants of buildings (Gallon et al., 2020).

In Norway, a study examining indoor air quality observed differences in phthalate concentrations between households and school classrooms. This investigation found that, for some phthalates, the use of carpet and the number of TVs present was positively associated with phthalate air concentrations (Sakhi et al., 2019). The same authors also estimated the amount of phthalates humans uptake through indoor air. They found similar phthalate intake through air as through diet. Diet is generally understood to be the predominate exposure route for phthalates. The researchers acknowledged that these findings contrast with previously reported estimates (Giovanoulis et al., 2018; Sakhi et al., 2019).

Environmental justice and equity

Reducing the presence of phthalates in building materials has important implications for improving equity and environmental justice in the built environment. The green building industry has largely focused on energy efficiency to date. Environmental health and healthy building research should consider methods to reduce chemical contaminants, such as phthalates, that are widely present in building materials (Goodwin Robbins et al., 2020).

This is made evident by a study that recently examined renovated "green" low-income housing units in the U.S. The indoor air in these homes had significant impacts from phthalates (Dodson et al., 2017). The same study measured the presence of phthalates in air and on wipe samples, both prior to occupants moving in and after they had been living in the units for one to nine months. The results suggest that some phthalates were associated with building-related sources while others originate from both building and occupant sources (Dodson et al., 2017).

Based on biomonitoring data from Japanese children from 2012 – 2017, being part of a low-income family and living in older buildings was associated with higher levels of urinary phthalate metabolites, indicating increased exposure to phthalates (Ketema et al., 2021). This agrees with results from a biomonitoring study in France, which reported that having low income and renting were both associated with increased phthalate exposures (Bastiaensen et al., 2021). In a study of low-income homes in the U.S., higher phthalate concentrations in dust were associated with the use of vinyl flooring and carpets. Additionally, the authors reported a significant association between DEHP concentration in HVAC filter dust in the summer and the severity of childhood asthma (C. Bi et al., 2018).

Phthalates in building materials are also thought to contribute to phthalate levels in the outdoor environment. Studies by Müller et al., which identified chemicals in runoff from building surface materials, suggest that phthalate release from PVC roofing materials may contribute to stormwater pollution, aided by adsorption to suspended solids (Müller et al., 2019, 2021). However, in a previous study conducted by Ecology, phthalates did not leach into runoff from the roofing materials after the first few months of the study (Ecology, 2014b). Together, such conflicting findings highlight the need for additional research to further investigate the contribution of these materials to phthalates in stormwater runoff.

Recommendation #1

Ecology should leverage existing resources and contribute to standards for state-supported building projects.

Lead agency: Department of Ecology

Proposed partners for implementation: To be determined during implementation.

Justification

Building and construction projects in Washington should use materials that are phthalate-free when reasonable to do so. One way this can be accomplished is by incorporating material health considerations into standards and criteria that state-supported projects must follow. Several standards already exist for state programs. Existing requirements focus on environmental sustainability, energy efficiency, and the use of less toxic building materials. However, there are still opportunities for improvement in how these state standards incorporate material health considerations in building projects. These opportunities should be pursued.

Additionally, some state-supported building programs may not have existing standards or requirements that specify use of less-toxic building materials. In these cases, project design teams should consider material health in early planning. Design teams should connect with professionals and resources to help them select less toxic building materials (including phthalate-free materials) when there are suitable alternatives.

Ecology can play an important role and facilitate progress on material health in state-supported building projects by engaging with state programs that are updating existing state standards. This effort should focus on the incorporation of additional material health considerations into those standards, including minimizing the use of materials that contain phthalates.

Implementation and additional considerations

Rather than developing new guidance, Ecology should leverage existing resources that can facilitate the identification of less-toxic building materials, including phthalate-free materials. Examples of existing resources include:

- U.S. EPA's Recommendations of Specifications, Standards and Ecolabels
- Healthy Building Network's HomeFree
- International Living Future Institute's Living Building Challenge Framework

Ecology can use these and similar resources to inform potential revisions to state program standards. Ecology can also provide additional technical expertise related to toxics in building materials as appropriate. This could include proposing additional requirements to use materials that do not contain phthalates when phthalate-free alternatives are suitable for the project and application. This would require partnerships with other state agencies who are responsible for revising and maintaining those standards. This process is ongoing and would need to continue throughout implementation.

Another approach that should be explored for implementation is contracting with partner organizations that have material health expertise. These organizations can engage with state agencies and provide training and technical assistance.

Recommendation #2

Ecology should engage building design, construction, and maintenance project teams on material health in Washington and develop outreach materials for the building industry that leverage existing resources.

Lead agency: Department of Ecology

Proposed partners for implementation: To be determined during implementation.

Justification

Project teams involved in construction and renovation projects that take place in state-owned or occupied buildings, or in buildings that are supported by state government programs, should receive training and resources on ways to avoid using phthalate-containing building materials, including using alternatives when available. This is particularly important for buildings that serve vulnerable populations, including children and overburdened populations.

Project description and implementation

When funding and opportunities exist, Ecology should engage project teams that design, build, and maintain buildings. Ecology should also involve local government programs to encourage the inclusion of material health considerations in early conversations with project architects. Ecology should connect the project leads with training, resources, and professional expertise to help them identify and choose less toxic building materials, including phthalate-free alternatives.

As previously mentioned, when possible, Ecology should consider partnering with organizations that have existing expertise in material health when applying for funding. These organizations can provide technical assistance to building project teams. Ecology should also consider partnering with community based organizations, trade or vocational schools, and community housing or building programs.

Environmental justice and equity considerations

We may consider initial focus areas for implementation that would benefit sensitive and overburdened populations. Areas that should be considered for early implementation efforts include affordable housing projects, childcare and early learning facility projects, and other programs that serve lower income community members.

Affordable housing is an important area for focus. People who live in affordable housing should not be exposed to more toxic building materials than those who do not live in affordable housing. Working with childcare and early learning facility projects is also crucial, as studies show that children are more susceptible to harmful environmental exposure, especially those linked to endocrine disruption such as phthalates. See Appendix B for more information on exposures and health impacts.

Preferred purchasing

Problem statement

Many organizations, including local governments and non-profits, use statewide contracts managed by the Department of Enterprise Services (DES) to simplify their purchasing decisions. These contracts include environmentally preferred purchasing requirements focused on areas such as energy efficiency, reducing greenhouse gas emissions, and toxics and solid waste reduction.

However, DES contract specialists do not always have the technical expertise required to incorporate requirements for material health in statewide contracts. Contract specialists need assistance to identify less-toxic products, such as phthalate-free products. Similarly, purchasers who use statewide contracts need adequate training to help them choose less-toxic products, including those that do not contain phthalates.

Relevant background information

For relevant background please refer to the section on consumer products.

Recommendation #1

Ecology should continue to provide DES with technical input focused on material health for preferred purchasing guidance. Ecology should also share relevant resources that DES can incorporate into related training for purchasers and contract specialists.

Lead agency: Department of Enterprise Services (DES)

Proposed partners for implementation: Department of Ecology

Justification

DES reached out to Ecology in a public comment during development of the Phthalates AP. DES requested assistance in developing guidance for products purchased through statewide contracts and sought education and training materials for contract specialists and purchasers.

Implementation and additional considerations

DES has recently released a Green Purchasing Guide (Washington State Department of Enterprise Services, n.d.). When guidance is updated, Ecology should continue to provide technical advice to Department of Enterprise Services (DES) by reviewing and editing future revisions. This should include a focus on reducing or eliminating use of products and materials that contain phthalates when alternatives are available.

Ecology should also share outreach materials on phthalates to support DES as they continue to develop their environmentally preferred purchasing training materials for contract specialists and purchasers who use statewide contracts. This includes sharing information focused on products and materials that may contain phthalates to supplement content in the purchasing guide.

Recommendation #2

DES should incorporate guidance and technical input from Ecology into new statewide contracts. DES should also amend existing contracts when feasible.

Lead agency: Department of Enterprise Services (DES)

Proposed partners for implementation: None

Justification

The preferred purchasing guidance developed with technical assistance from Ecology needs to be incorporated into statewide contracts, when possible, to reduce the volume of products purchased through those contracts that contain phthalates.

Project description and implementation

DES should incorporate the environmentally preferred purchasing guidance, developed with technical input from Ecology, and related laws or policies into new statewide contracts. This guidance should also be incorporated into applicable rebids as part of part of their normal review. This may include adding information to help purchasers choose phthalate free products. It may also include specific incentives or requirements for replacing phthalate containing products in Washington with phthalate free alternatives.

Recommendation #3

DES should work with state agencies and the State Efficiency and Environmental Performance Office to track purchasing metrics and reduce purchasing phthalates containing products.

Lead agency: Department of Enterprise Services (DES)

Proposed partners for implementation: None

Justification

Purchasing metrics will help DES measure progress in reducing purchases of phthalate-containing products through statewide contracts. These metrics would also enable DES to prioritize the types of products and contracts that will have the most impact in reducing use of phthalate containing products purchased through statewide contracts.

Project description and implementation

DES should work with state agencies and the State Efficiency and Environmental Performance Office to develop and use metrics, such as dollars spent, to track progress toward environmentally preferred purchasing goals. These goals including reducing the purchase of products that contain phthalates through statewide contracts (Commerce, 2022). This effort could initially focus on a product category such as cleaning and janitorial supplies, where there are existing certifications that can be used to identify preferred products (e.g., ECOLOGO®, Green Seal®, EPA's Safer Choice Certified), with the goal of expanding to other categories over time.

Solid waste media recommendations

Biosolids

Problem statement

Biosolids from composting and wastewater treatment plants (WWTPs) can serve as continued sources of phthalate emissions into the environment and pose a risk to human health. Phthalates leach or transfer from consumer products, building materials, plastics, and industrial discharge. This contaminates wastewater, sewage sludge, and biosolids. Different phthalate esters will partition to biosolids or effluent in WWTPs depending on their physicochemical properties. Scientists have not conducted studies characterizing the lifecycle of phthalates through the WWTP process, the land application of biosolids, uptake into crops, or composted biosolids in Washington state.

Note: Exposure to phthalates in nonbiosolid-compost is included in the recommendations for Compost.

Relevant background information

Biosolids are semisolid products rich in organic matter that preserve nutrients from the wastewater treatment process. They can replace commercial fertilizers as a soil amendment. In Washington, Ecology is mandated to maximize the beneficial use of biosolids. This helps return valuable nutrients back to the land, including micronutrients which are not always restored during typical agricultural practices. When applied following state and federal regulations, biosolids improve soil health, enhance vegetative growth, and sequester carbon.

Currently, about 85 percent of biosolids generated in Washington are beneficially used for soil amendment. An estimated 10-15 percent of biosolids used beneficially in Washington state produce exceptional quality biosolids by composting.

Before beneficial use, biosolids are treated to remove pathogens and reduce odor, and are screened for nine metal pollutants. However, it is possible that biosolids contain phthalates resulting from pre-WWTP sources (King County, 2021).

In keeping with federal rules, Ecology does not track the land application of composted biosolids. There is a considerable knowledge gap concerning the behavior of phthalates in composted biosolids. However, it has been shown that longer alkyl side-chain phthalates, such as DEHP, degrade into shorter alkyl side-chain phthalates, such as DEP and DMP, during sludge composting (Amir et al., 2005). The extent of human exposure to composted biosolids in Washington state is unknown because of the data gaps.

Experts measured phthalates esters in biosolids from WWTPs in Washington state (King County, 2021). From additional studies we know phthalate esters will partition to water or solids depending on their physicochemical properties (ATSDR, 2022; Bergé et al., 2013; Clara et al., 2010; Salaudeen et al., 2018). Short-chain phthalates preferably partition to water, whereas long-chain phthalates preferably partition to solids (Dargnat et al., 2009; Gustafsson et al., 2020). Branched-chain phthalates are more soluble in water than linear phthalates (Gustafsson et al., 2020).

Phthalates will biodegrade in WWTPs, and biodegradation rates are dependent on treatment conditions, such as oxygen levels, microorganisms, and temperature. For example, the biodegradation of DEHP is slower under anaerobic conditions compared to aerobic conditions (NRC, 2008). Additionally, phthalates with shorter alkyl side chains (such as DBP and BBP) have shorter half-lives and almost negligible degradation lag phases under anaerobic conditions. In contrast, longer alkylated phthalates (such as DEHP and DiNP) are degraded with lag phases of 5 to 30 days and have longer half-lives (Lertsirisopon et al., 2006).

The different partitioning and biodegradation behavior of individual phthalate esters underscores the necessity to sample multiple esters and media (i.e., influent, effluent, sludge, and biosolids) when characterizing the lifecycle of phthalates through the WWTP process.

Phthalates in land-applied biosolids will partition to the soil depending on the ester, but limited studies have characterized this behavior. A study conducted in semiarid Colorado showed DEP was detected in soil a year after biosolids containing DEHP were applied (Yager et al., 2014). Humans can be exposed to phthalates in land-applied biosolids while handling the soil or through consumption of plants grown in this soil.

Phthalate partitioning behavior in plants depends on the phthalate ester, the plant species, and the part of the plant (i.e., roots, leaves, edible fruit) (Sablayrolles et al., 2013; J. Sun et al., 2015). These studies were conducted using plant containers, which are not representative of land-application practices because the containers tend to exaggerate the bioavailability of contaminants. Furthermore, phthalates will metabolize into other esters inside plants (Cheng et al., 2020). The human health implications of phthalate levels in plants, particularly in crops grown in Washington state, have not been studied.

Environmental justice and equity

The presence of phthalates in WWTPs and land-applied biosolids and interactions with soils and surrounding communities is not fully clear. Some of the recommendations are aimed at clarifying the relationship between phthalates in WWTPs, presence in biosolids, transport into groundwater, and uptake into plants and crops.

Results of these future studies could highlight areas of environmental justice concerns. For example, if phthalates are found to be prevalent within land-applied biosolids and leaching into groundwater, this could increase exposure risk for certain populations. Workers dealing with biosolids or migrant agricultural communities could be impacted more intensely. Sensitive populations, such as pregnant women and children may experience disproportionate impacts if phthalate uptake into crops or garden compost is demonstrated through Recommendations #3 and #4.

Ecology’s Water Quality Program implements priority pollutant scans for some municipal wastewater treatment plants, and these scans include testing for some phthalates. Priority pollutant scans must utilize EPA-approved sampling methods. Additionally, Whole Effluent

Toxicity (WET) sampling must be used during the permit writing process, as governed by WAC 173-205.

There are no existing laws, regulations, or policies that could take the place of the studies proposed by the recommendations.

Recommendation #1

Ecology should evaluate the transport and breakdown of upstream-sourced phthalates in Washington's WWTP influent, effluent, sludge, and biosolids. This will provide insights about the pathways phthalates take after they are added to WWTP systems, including how phthalates end up in the wastewater solids that are used to produce biosolids.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

This data would help inform how phthalates move through a WWTP and which treatment processes are potentially more effective at transforming and removing phthalates.

Project description and implementation

Ecology is the lead agency that manages biosolids in Washington state. The Environmental Assessment Program (EAP) within Ecology would conduct sampling. Health would partner with Ecology using financial assistance from the interagency agreement that funds CAP work and other future funding sources. As needed, Ecology and Health would work with relevant agencies and academic institutions to develop and implement this work.

Ecology would conduct a study to evaluate the fate of phthalates through Washington state wastewater treatment processes in the production of biosolids that meet standards for land application. This study would:

- Include treatment plants that utilize the following treatment technologies: aerobic digestion, anaerobic digestion, heat drying, lime stabilization, facultative lagoon, and extended aeration.
- Include at least six wastewater treatment plants that employ these treatment processes and produce biosolids fit for land application, but ideally include multiple facilities that employ each type of treatment process.
- Include WWTPs that serve sensitive and overburdened populations, as well as urban, rural, large, and small populations.
- Sample influent, effluent, sludge, and final biosolid products at each facility for the phthalate esters identified below.
- Consider study results alongside the analysis completed as part of Recommendation #4. This would enable us to comprehensively measure and characterize the full fate of

different phthalate esters, from wastewater treatment plan influent to composted biosolids.

- This study can also be partnered with the studies in Recommendations #2 and #3 to characterize the fate of phthalates from the wastewater treatment plant influent to land application and plant uptake.

The length of the project would depend on the number of facilities involved and whether we receive sufficient funding for longer-term monitoring to identify phthalate concentration trends in biosolids. Initial sampling is estimated to take one year, followed by annual monitoring (if funding supports long-term monitoring). Work would include:

- Writing a Quality Assurance Project Plan (QAPP) (Ecology)
- Studying sampling (EAP)
- Analyzing and writing a report (Ecology and Health)

The anticipated costs would primarily be upfront and associated with the design and initial implementation of the project. We recommend taking samples of phthalate esters including, but not limited to: DEHP, DMP, DEP, DBP, BBP, DnOP, DINP, DIDP, DPP, Mono(2-ethylhexyl) phthalate (MEHP), and Monobutyl phthalate (MBP).

EPA Method 1625C covers DEHP, DMP, DEP, DBP, BBP, DnOP. Additional standards for DINP, DIDP, DPP, MEHP, and MBP can be purchased and analyzed using EPA Method 1625C; however, this protocol would not be considered a validated EPA method for these compounds.

Recommendation #2

Ecology should evaluate the transfer potential of phthalates from biosolids to soil and groundwater.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

The information gaps regarding the transfer of phthalates from biosolids to soil are significant. These information gaps make it difficult assess the risks of land-applied phthalates in biosolids in Washington. No sampling has been conducted to determine phthalate levels in biosolid-amended field soil in Washington state. Additionally, no studies have examined the leaching potential of phthalates from biosolid-amended soils to groundwater. This study would be specific to Washington state soil and field conditions.

Project description and implementation

A study would evaluate the transfer potential and transfer time of phthalates from biosolids to soil and groundwater in Washington state. Researchers would sample biosolid amended fields in Washington state to characterize phthalate concentrations. A full literature review would identify knowledge gaps in phthalate transfer of different soil conditions. This would help determine which Washington state fields need to be sampled. Ecology would also need to develop a QAPP.

Analysis of this study should be combined with studies in recommendations #1 and #3 to allow the full fate of different phthalate esters from influent to crop uptake to be measured and characterized. We could potentially combine the sampling protocol and fields included in this study with those proposed in Recommendation #3. This would include testing phthalate-levels in crops grown in the same fields as those sampled in this recommendation. Researchers would sample fields that use multiple land applications of biosolids to characterize phthalate loading and persistence in these soils/fields. Sample sites would include fields located within overburdened communities. To accomplish this, Ecology would need to work with farmers to plan and coordinate sampling efforts in biosolid-amended fields.

It would take a year or more to complete this project, including QAPP writing, study sampling, and analysis. Additional sampling time may be required to monitor and track phthalate loading and persistence in fields with multiple land applications. Most costs would likely be upfront during design and initial implementation.

The phthalate esters to be sampled include, but are not limited to, DEHP, DMP, DEP, DBP, BBP, DnOP, DINP, DIDP, DPP, MEHP, and MBP. EPA Method 1625C covers DEHP, DMP, DEP, DBP, BBP, DnOP. Additional standards for DINP, DIDP, DPP, MEHP, and MBP can be purchased and analyzed using EPA Method 1625C, but this protocol won’t be considered a validated EPA method for these compounds.

Recommendation #3

Ecology should evaluate plant uptake of phthalates in crops and fodder grown in or on biosolids amended soils and fields in Washington state.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

The information gaps regarding the transfer of phthalates from soil to crops are significant. These data gaps impede risk assessments of phthalates in biosolids that are land applied in Washington. Plants have different uptake potentials of phthalates depending on the plant species, type of phthalate ester, and the portion of the plant, such as the roots or the fruit. We do not have phthalate concentration data for crops grown on biosolid amended soils in Washington state.

Project description and implementation

Ecology would conduct a study to evaluate the plant uptake of phthalates from biosolids to crops and fodder, including plants grown for human consumption in Washington state. Crops and fodder grown on biosolid amended fields in Washington state would be sampled to characterize phthalate concentrations. A QAPP would need to be developed.

Partnering this study with the studies in recommendations #1 and #2 would allow us to measure and characterize the full fate of different phthalate esters, from influent to crop uptake. This study would sample crops from fields that use multiple land applications of biosolids to characterize phthalate loading and persistence in crops. To accomplish this, Ecology would work with farmers to plan and coordinate sampling efforts for crops/fodder grown on biosolid-amended soil.

The length of the project would be one year or more until completion, which includes QAPP writing, study sampling, and analysis. Additional sampling time may be required for monitoring crops grown on fields with multiple land applications. This sampling would help track phthalate loading and persistence in these crops. Most costs would likely be upfront during design and initial implementation.

Esters to be sampled for (but not limited to): DEHP, DMP, DEP, DBP, BBP, DnOP, DINP, DIDP, DPP, MEHP, MBP, MEHHP, MEOHP, MECPP, MCMHP. The methodologies used for each phthalate type will be based on the following:

- Wei at al. (2020) for DEHP, DMP, DEP, DBP, BBP, DnOP.
- Sun et al. (2015) for MBP and MEHP.
- Cheng et al. (2020) for MEHHP, MEOHP, MECP, and MCMHP.

Recommendation #4

Ecology should evaluate the fate of phthalates in composted biosolids in Washington state.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Health

Justification

This data would help inform the fate of phthalates in biosolids during the composting procedure. Ideally, facilities included in the first recommendation would also be included in this recommendation if operations are appropriate to evaluate the fate of phthalates from WWTP influent through to composted biosolids. We do not have phthalate concentration data for composted biosolids in Washington state. If phthalates are found in biosolids, further consideration of impacts to drinking water wells in areas where biosolids are applied may be needed.

Project description and implementation

Ecology would conduct a study to evaluate the fate of phthalates through Washington state wastewater treatment processes and the production of composted biosolids that meet exceptional quality standards. Researchers would sample sludge and final exceptional quality biosolids products for phthalate esters, identified below, at each facility. Analyzing the findings of this study in tandem with Recommendation #1 will allow us to measure and characterize the full fate of different phthalate esters from wastewater treatment plant influent to composted biosolids. This study can also be partnered with the studies in recommendations #2 and #3 to characterize the fate of phthalates from the wastewater treatment plant influent through to composted biosolids and land application followed by plant uptake.

The estimated length of the project would be one year. Work would include writing a QAPP and conducting sampling. Ecology and Health would partner for analysis and report writing. The phthalate esters we want to sample for include, but are not limited to: DEHP, DMP, DEP, DBP, BBP, DnOP, DINP, DIDP, DPP, MEHP, and MBP. EPA Method 1625C covers DEHP, DMP, DEP, DBP, BBP, DnOP. Additional standards for DINP, DIDP, DPP, MEHP, and MBP can be purchased and analyzed using EPA Method 1625C but this protocol won't be considered a validated EPA method for these compounds.

Compost

Problem statement

Since many materials contain phthalates, and compost is manufactured from waste materials, waste that contains phthalates has the potential to enter the compost stream. Compost is used in a wide variety of applications that could result in human health exposure or release into the environment. We lack data regarding the risks that waste materials at compost facilities may pose for phthalate contamination. We also do not have data on whether finished compost products may contain phthalates.

Relevant background information

Compost is the product of biological degradation and transformation of organic waste under controlled aerobic conditions. The resulting product is a stable, recycled material that can be applied to improve soil porosity and fertility, sequester carbon, and increase moisture-holding capacity. Compost can also be used as a mulch to reduce weed growth and insulate soils against extremes of heat and cold.

We use compost in agricultural applications but most compost goes to commercial and residential applications. These uses include:

- Landscaping as mulch.
- Topdressing on lawns, parks, ballfields, and golf courses.
- Soil stabilization during construction and road building.
- Restoration projects around streams and wetlands.
- Hydroseeding after earth disturbance.

These uses create exposure pathways to children and adults through recreation and food systems, and to terrestrial and aquatic environments.

The materials used to produce compost are called feedstocks. While agricultural materials and biosolids may be used as feedstock, this portion of the action plan focuses on composting municipal organic waste. Municipal feedstocks are comprised mostly of yard debris with or without food waste. Municipal composting with food waste is the fastest growing segment of the industry in Washington.

Municipal feedstocks invariably contain physical contaminants. These materials include, but are not limited to, plastic containers of all kinds, textiles, shoes, garden hoses, rope, paper packaging with tape and labels, produce stickers, garden gloves, and many forms of food packaging and serviceware. Facilities that accept food waste see more contamination than facilities that only accept yard debris, but even strictly yard debris facilities have contamination issues. That contamination could potentially include phthalate-containing materials.

In addition to these unwanted wastes, some compost facilities intentionally accept compostable food containers and serviceware such as hot and cold cups, deli containers, plastic clamshell containers, paper plates, and plastic flatware. Many of these compostable materials look similar or identical to non-compostable materials; therefore, when compost facilities accept composable serviceware, contamination with non-compostable materials unavoidably increases. Additionally, non-compostable labels, like coffee cup labels, may not get removed prior to compostable wastes being added to the feedstock stream.

In 2022, the state legislature passed House Bill 1799, a massive organics bill which mandated diversion of organic waste from landfills. We'll refer to this bill as the Organics Management law throughout the rest of this report. Most local governments must address collection and processing of organic materials, including food waste. We expect a large increase in all composting operations across the state, particularly for food waste composting. Local governments may wish to meet diversion goals by making food waste collection easy. They may want their partner compost facility to accept compostable serviceware. Many governments have already implemented or are considering local ordinances that require takeout food and beverage containers to be compostable.

The growth in food waste composting and the addition of compostable serviceware both provide opportunities to advance sustainability efforts and create risks for more contamination in compost facilities. Compostable containers make it easier for consumers to engage in compost program use. Although compostables do not in and of themselves provide significant value as a feedstock, they increase the total volume of material that can be managed through composting. This helps governments meet diversion goals to reduce total landfill waste. That value must be weighed against drawbacks.

As stated, facilities that take food waste also generally have more contamination than facilities that only accept yard debris. Facilities that accept compostables have more look-alike contamination than those that do not accept containers or packaging. Adding this stream has another downside for facilities: compost made with compostables are not eligible for organic certification and cannot be applied on organic agriculture.

We do not know the impact that physical contaminants, which may contain phthalates, would have on finished compost. We also do not know if phthalates are making their way intentionally or unintentionally into compostable serviceware.

Recommendation #1

Ecology should develop and implement a plan to test compostable containers and serviceware for phthalates. This will help us determine if these materials pose a risk of introducing phthalates to compost. We recommend this work be done in conjunction with the other product testing recommended earlier in this plan.

Lead agency: Department of Ecology

Proposed partners for implementation: None

Justification

Our rational is as follows:

- All municipal compost feedstocks contain some level of contamination, such as plastic serviceware, plastic film wrapping, etc.
- There is a growing use of compostable containers and other serviceware that may contain phthalates.
- Consumer confusion over look alike containers leads to non-compostable materials ending up in feedstocks.
- The Organics Management law may increase the prevalence of such materials entering compost feedstocks.

Project description and implementation

Please see discussion in both the consumer products and biosolids sections as we recommend this work be tied together.

Recommendation #2

Ecology should develop and implement a plan to test the levels of phthalates in finished compost that comes from facilities that process municipal feedstocks.

Lead agency: Department of Ecology

Proposed partners for implementation: None

Justification

Since phthalate contamination in compost has not been widely studied, we recommend collecting additional data. We already know that phthalates may be present in common physical contaminants but we do not know whether phthalates may be found in some feedstocks that are intentionally accepted at facilities. We also do not know if phthalates can actually be measured in finished compost products.

In addition:

- Very little data is available about phthalates in compost.
- We do not know what risk, if any, finished compost poses from phthalates.
- We expect more municipal compost will be manufactured due to the Organics Management law and used in settings that provide pathways to exposure if phthalates are present.

Project description and implementation

We recommend using the same sampling protocols, test methods, and testing criteria for phthalates in municipal compost as in the biosolids compost recommendation. This will enable us to easily compare these two forms of compost. We recommend sampling from multiple facilities. The sample would consist of facilities that accept containers and packaging of any kind and those that do not. We anticipate a single round of representative sampling encompassing multiple sites across the industry would prove sufficient for this recommendation.

Existing laws and regulations

Phthalates are not currently regulated in compost in Washington State.

Recycling products and packaging

Problem statement

A circular economy keeps materials, products, and services in circulation for as long possible. (US EPA, 2022c). The packaging industry is built upon a linear model of design, production, use, and disposal. Due to the burden that waste plastics place on marine and terrestrial environments, there is pressure to move plastic production towards a circular economy. The plastics circular economy is a model where plastics remain in circulation longer, and are reused and recycled at the end of their lifespan (Hahladakis & Iacovidou, 2018).

However, the circular use of plastics could lead to the accumulation of a variety of contaminants in recycled products. Due to their widespread use in consumer products, phthalates present in original products and packaging likely carry over when those materials are remanufactured into new products and packaging. Thus, more study is needed.

Relevant background information

Phthalates can be added to products through external components of packaging, such as labels and adhesives, or during the reprocessing of recycled plastics (Hahladakis & Iacovidou, 2018). Manufacturers who use recycled content plastic are unaware of the phthalate content of their recyclable material. There is no requirement for plastic recycling companies to test and report on the chemicals present in the recyclable plastics sold to end users. There is also no requirement for manufacturers to attest to the chemical makeup of their product or packaging.

In an effort to replace the need for virgin plastic, the use of recycled content plastics is increasing. Materials collected for recycling include consumer products (e.g., batteries, computers, televisions, and paint) and the packaging used for consumer products (e.g., beverage bottles, plastic and cardboard packaging, cans, and glass bottles).

Phthalates may be present in the original plastic container. They may be introduced during the manufacture of the container or through the addition of labels, inks, adhesives and caps, and closures (K. Pivnenko, 2016). Any phthalates present in the recycled plastic will be present in the remanufactured product or packaging (Hahladakis et al., 2018). Phthalates can also be introduced via cross-contamination with other materials and through the waste collection process (Undas et al., 2023).

An Ecology study suggests that phthalates are commonly used in consumer product packaging. We analyzed the packaging of 93 products purchased in 2012 for eight phthalates, resulting in 107 individual samples. We concluded that several phthalates are used in packaging at appreciable levels, including DEP, DEHP, DIDP, and DINP. 12 percent of samples in the study contained DEHP above 100,000 ppm, and DEHP was greater than 100 ppm in 35 percent of the samples. 6.5 percent of samples contained DIDP at concentrations greater than or equal to 100,000 ppm and DIDP was greater than 100 ppm in 27.1 percent of samples. For DINP, only 2.8 percent of samples were greater than or equal to 100,000 ppm but concentrations were greater than 100 ppm in 30 percent of samples. Given that we conducted this study in 2012 and there have since been rapid changes in packaging forms, additional follow-up is necessary to confirm this assertion still holds true today (Ecology, 2021).

There are four methods used to recycle plastics: mechanical, chemical, thermal, and biological. The majority of plastic recycling occurs using the mechanical method. In this method, plastic is mechanically chopped up, cleaned, melted, and reformed into pellets that can be used to make new plastics (Englund et al., 2021). Phthalates are not removed during the mechanical recycling processes and will remain in new products or packaging using recycled plastic content (Pivnenko et al., 2016). Few studies have examined the potential impact of plastics recycling on phthalate content, including the potential for plastic contamination and increased presence of phthalates (Pivnenko et al., 2016).

Additional analysis of phthalates in the recycling stream is recommended to identify the appropriate actions to reduce or phase out the use of phthalates.

Recommendation #1

Ecology should gather information to understand the presence of phthalates in the recycling stream.

Lead agency: Department of Ecology

Proposed partners for implementation: Ecology would likely hire an independent third-party contractor to conduct this study.

Justification

We have limited information about the presence of phthalates in specific forms and the composition of packaging that is collected for recycling in Washington. To determine which packaging types contain phthalates, we recommend that resources are allocated to study the issue.

There is evidence that phthalates are not removed through mechanical recycling processes. Given this, it makes sense to evaluate phthalate concentrations in plastic packaging collected in the recycling system. A clear determination of the extent and magnitude of phthalate migration through the circular reprocessing of plastics would inform future mitigation actions.

Project description and implementation

The study would identify which plastic packaging and plastic durable goods that are recycled and used to remanufacture other products or packaging used in Washington contain phthalates.

This study includes:

1. Synthesizing the existing literature on phthalates in packaging to establish, where possible, the specific types and prevalence of packaging containing phthalates that is collected for recycling.
2. Identifying or developing suitable analytical methods for testing phthalates in packaging to quantify their prevalence in the packaging that is collected for recycling in Washington State.

3. Evaluate the extent and magnitude of phthalate prevalence and consumer exposure in packaging types.

Questions that need to be considered in the analysis include:

a. What plastic packaging contains phthalates?
b. Where are phthalates introduced into the packaging?
    - Are phthalates in packing more derived from the container itself or from later stages of manufacturing (labelling, adhesives and glues, etc.)?
c. What is the reason for adding phthalates to the packaging?
    - What is its purpose in the packaging, or durable product?
d. Are phthalates a commonly used chemical in the materials collected for recycling?
e. Who manufacturers plastic packaging materials in the United States and Washington?
f. What products are sold in phthalate-containing packaging?
g. Who are the consumers that use these products?
h. Are certain communities disproportionately using products more likely to be packaged in phthalate containing packages? (Are vulnerable or overburdened populations more likely to use materials in packaging that contains phthalates?)
i. What is the prevalence of packaging containing phthalates in recycling collection systems?

Additional considerations include:

a. Consumer products that contain phthalates and enter the recycling system at end of life should be considered. This action should be considered in conjunction with the presence of phthalates in consumer products of this AP.
b. Secondary research should include assessing plastic bales at material recovery facilities to gauge the amount of phthalate-containing plastic being sold to recyclers for processing. Where do the bales go? How much is remade into packaging products?
c. Ecology cannot provide public health guidance on the usage of recycled content materials without knowledge of the extent of contaminates within the recycling material stream.

Environmental justice and equity considerations

Implementing this recommendation should include considerations for environmental justice, such as:

- Who are the consumers that use these products?
- Are vulnerable or overburdened populations more likely to use materials in packaging that contains phthalates?

- Are socioeconomically disadvantaged individuals or communities using or consuming more of the products?
- Are certain industries or low-wage workers receiving more exposure?

We would use the Washington Environmental Health Disparities Map[10] to focus sample collections in areas with high risk, as determined by cumulative environmental health impact scores.

Recommendation #2

Ecology should work with consumer product and packaging industry groups to convene a workgroup. This workgroup would establish voluntary reporting and labeling protocols to identify packaging that contains phthalates.

Lead agency: Department of Ecology

Proposed partners for implementation: Consumer packaging industry groups, such as the Sustainable Packaging Coalition or other groups.

Justification

Post-consumer recycled content has the potential to replace virgin plastics as a source of raw materials in plastic packaging manufacturing. We need a better understanding of the landscape of plastic products and packaging. There is a lack of transparency and data in the supply chain of phthalates in the manufacturing of packaging.

Ecology would establish a voluntary labeling and reporting program for manufacturers to disclose packaging and products that contain phthalates and other chemicals. We recommend this voluntary framework be considered for both virgin and recycled content packaging and products.

This program would request that manufacturers:

- Identify packaging and products that contain phthalates.
- Disclose their use of priority chemicals in product ingredients.
- Release information on exposure and chemical hazard.
- Describe the amount and function of PFAS in the packaging and products.
- Inform customers of the chemical ingredients. This includes informing users of recycled content plastics of the presence of toxics – including those using the resulting PCR pellets to make new products

[10] https://fortress.wa.gov/doh/wtn/WTNIBL/

Project description and implementation

This work project would promote a voluntary reduction in the use of phthalates. The workgroup should include representatives from recycling processors and brokers, food producers, manufacturers of products containing post-consumer recycled content, local trade organizations, the retail food industry, and consumers.

Existing laws and regulations

Phthalates within the recycling system are not regulated in Washington State.

SPWA implements chapter 70A.350 RCW and is a regulatory program developed to reduce toxic chemicals in consumer products. Phthalates were identified by the Washington State Legislature as a priority chemical class when the law was established in 2019.

Landfills

Problem statement

The United States produces approximately 300 million tons of municipal solid waste (MSW) per year. Approximately half of all MSW produced in the United States is landfilled. Nearly 20 percent by weight, or 30 million tons, of landfilled MSW is plastic (US EPA, 2022c). Phthalates are a common component of plastics and landfilling is the ultimate disposal method for the majority of plastic produced in the United States. As a result, understanding the fate of phthalates in landfill leachate and gas is a critical step in developing management criteria to reduce health and environmental risks of phthalates released from landfills.

Relevant background information

Rainwater percolating through waste in landfills interacts with the waste and carries suspended and dissolved materials through the waste. The liquid, produced as water, that interacts with solid waste is called leachate. Physical, chemical and microbial processes in the waste transfer chemicals from the waste to the leachate (Christensen & Kjeldsen, 1989). Leachate typically exhibits high chemical oxygen demand (COD), high total organic carbon (TOC), volatile fatty acids, total dissolved solids (TDS), metals, and anthropogenic organic compounds such as aromatic hydrocarbons, chlorinated aliphatics, pesticides, and plasticizers (Kjeldsen et al., 2002).

Leachate is collected and can be transported to wastewater treatment plants for treatment or, in sufficiently arid locations, allowed to evaporate in evaporation lagoons. Studies outside the United States have identified phthalates, such as DEHP, DEP, DMP, DBP, DIBP, in leachate (Wowkonowicz & Kijeńska, 2017). Ecology is unaware of any similar studies in Washington State.

Decomposing organic material in landfills produces landfill gas. Landfill gas is composed of primarily methane, carbon dioxide, and minor amounts of non-methane organic compounds. Some of the non-methane organic compounds in landfill gas are hazardous air pollutants and volatile organic compounds. These can include benzene, toluene, and vinyl chloride. Several studies have demonstrated that building materials containing phthalates can release phthalates in indoor air (Lin et al., 2021; Shinohara Id et al., 2019).

Landfill conditions have the potential to accelerate phthalate off-gasing from plastics and could produce elevated concentrations of phthalates in landfill gas. Modern landfills are designed with landfill gas collection systems. The gas is commonly flared or collected for energy generation. Older landfills may vent the landfill gas to the atmosphere. Since phthalates are a common component of plastics, landfill gas may represent a potential pathway of phthalates into the environment. Ecology is unaware of any studies that have assessed the presence of phthalates in landfill gas.

While modern landfills are designed with geo-composite liners and leachate collection systems, these systems are designed based on known characteristics of leachate and gas as well as existing regulatory requirements. Leaks do occur, and groundwater monitoring requirements are based on existing understanding of leachate constituents.

Recommendation #1

Ecology should perform a study to investigate phthalate occurrence in landfill leachate.

Lead agency: Department of Ecology

Proposed partners for implementation: Ecology would likely hire an independent third-party contractor to conduct this study.

Justification

Landfill design, operation, and regulations are based on known information about waste characteristics, degradation processes, and risk. Understanding the composition of landfill leachate is critical to developing effective waste management and environmental sampling criteria. A clear determination of the phthalate presence and composition in leachate across the state would inform future mitigation actions.

Project description and implementation

To characterize phthalate occurrence in landfill leachate in Washington, we recommend that resources are allocated to study the issue. The study would identify which phthalates are present in leachate in landfills across the state.

Questions that need to be considered in the analysis include:

1. Which phthalates are present in landfill leachate and at what concentrations?
2. Are there differences in phthalate type and concentration in different landfills?
3. Are differences in phthalate concentration related to landfill age, climate, waste stream, or other factors?

Ecology does not have regulatory authority to collect the samples from landfill and the cooperation of landfill operators would be required to conduct this study. Ecology does not have existing funding to assess phthalates in landfill leachate.

Environmental justice and equity considerations

Site location is potentially the most sensitive topic for environmental justice considerations related to landfills. This study involves sampling of leachate from existing landfills, and there will be future opportunity to review current landfill sites' potential impacts on nearby communities and if there are environmental justice considerations. Data from these studies could help community environmental justice efforts, or elevate awareness of possible hazards. Additionally, understanding potential risks from these facilities can help inform environmental justice considerations for future landfill site locations.

Recommendation #2

Ecology should design a study to investigate phthalate presence in landfill gas.

Lead agency: Department of Ecology

Proposed partners for implementation: Ecology would likely hire an independent third-party contractor to conduct this study.

Justification

Landfill design, operation, and regulations are based on known information about waste characteristics, degradation processes, and risk. Understanding the composition of landfill gas is critical to developing effective waste management and environmental sampling criteria. A clear determination of the phthalate presence and composition in landfill gas across the state would inform future mitigation actions.

Project description and implementation

The study would identify which phthalates are present in leachate in landfills across the state.

Questions that need to be considered in the analysis include:

1. Which phthalates are present in landfill gas and at what concentrations?
2. Are there differences in phthalate type and concentration in different landfills?
3. Are differences in phthalate concentration related to landfill age, climate, waste stream, or other factors?

Ecology does not have regulatory authority to collect the samples from landfill and the cooperation of landfill operators would be required to conduct this study. Ecology does not have existing funding to assess phthalates in landfill leachate.

Environmental Justice and Equity Considerations

Site location is potentially the most sensitive topic for environmental justice considerations related to landfills. Because this study involves sampling of gas from existing landfills, there will be future opportunity to review current landfill sites' potential impacts on nearby communities and if there are environmental justice issues/considerations. Data from these studies could help community environmental justice efforts, or elevate awareness of possible hazards. Additionally, understanding potential risks from these facilities can help inform environmental justice considerations for future landfill site locations.

Environmental media recommendations

Drinking water

Problem statement

Phthalates may occur in impact drinking water sources through several pathways. These pathways include discharge to air or surface water from manufacturing facilities, stormwater runoff carrying phthalates, atmospheric deposition of airborne phthalates, or areas of land where biosolids have been applied. Another pathway of phthalate exposures is through the flexible black plastic pipes and tubing components used in the operation of public water supply wells.

Relevant background information

The Washington State Department of Health, Office of Drinking Water (ODW) has required phthalate monitoring in drinking water since February 1993. Additionally, the EPA requires this monitoring under the Safe Drinking Water Act (SDWA, 2019). ODW requires public drinking water systems to monitor sources for five phthalate compounds (see Table 2). Table 2 represents a statewide data set of over 51,000 drinking water samples.

Table 2: ODW Phthalate Monitoring in Drinking Water

Contaminant	Acronym	CAS#	MCL	Samples Tested
Di (2-Ethylhexyl) Phthalate	DEHP	117-81-7	6 ppb	12,899
Butyl Benzyl Phthalate	BBP	85-68-7	NA	9,584
Di-n-butyl Phthalate	DBP	84-74-2	NA	9,478
Diethyl Phthalate	DEP	84-66-2	NA	9,566
Dimethyl Phthalate	DMP	131-11-3	NA	9,588

Public water systems are required to collect drinking water samples (US EPA, n.d.-b). ODW provides a detailed schedule of monitoring requirements via an online tool called the Water Quality Monitoring Schedule (WQMS). The WQMS is specific to each public water system. When samples are due to be collected, the water system collects the appropriate sample and delivers it to a certified drinking water laboratory for analysis. After the samples are analyzed, the laboratory sends the results to ODW for entry into the ODW's Sentry data system.

Drinking water standards are developed by EPA or the State Board of Health and apply to all public water systems. Maximum Contaminant Levels (MCLs) are the highest level that a contaminant is allowed in drinking water and are enforceable standards (US EPA, 2023). The phthalate DEHP has an established primary MCL drinking water standard of 6 parts per billion (ppb) (US EPA, 2023). The other five phthalates lack enforceable regulatory drinking water standards.

Historical phthalate drinking water monitoring

Evaluation of the ODW public water system drinking water sample dataset from 1993 to present indicates no confirmed MCL violations for phthalates in public drinking water sources. Although there have been a few detections of phthalates in drinking water, phthalate detections are thought to be the results of either sample collection technique, select plastic piping and tubing, or issues relating to the sample analysis within the laboratory setting.

Since 2012, only DEHP and DBP have been detected in drinking water samples (Figure 2 and Figure 3). In addition, no phthalate detections occurred above the state reporting limit of 1 ppb for three of the five phthalates. Of the phthalate detections above the state reporting limit, the detection rate was low, with the detection of DEHP in 1.5 percent and DBP in 1.2 percent of the samples (Table 3).

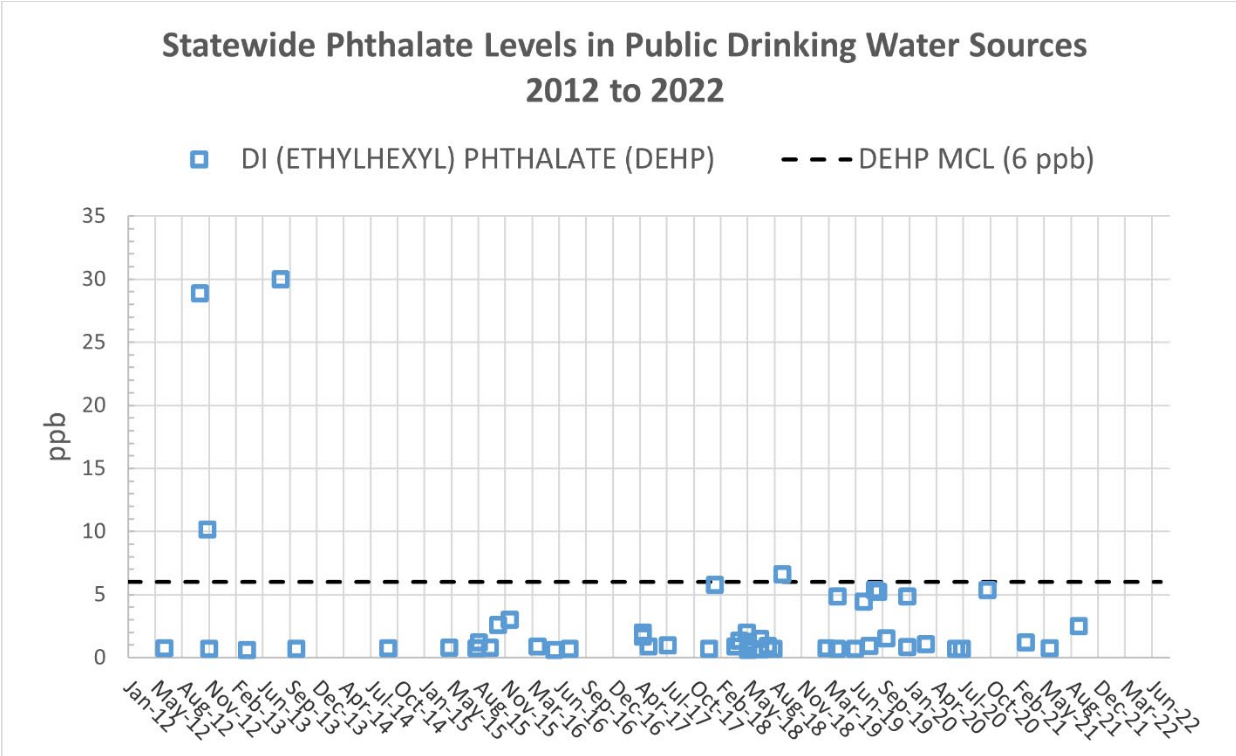

Figure 2. Statewide Phthalate Levels (DEHP)

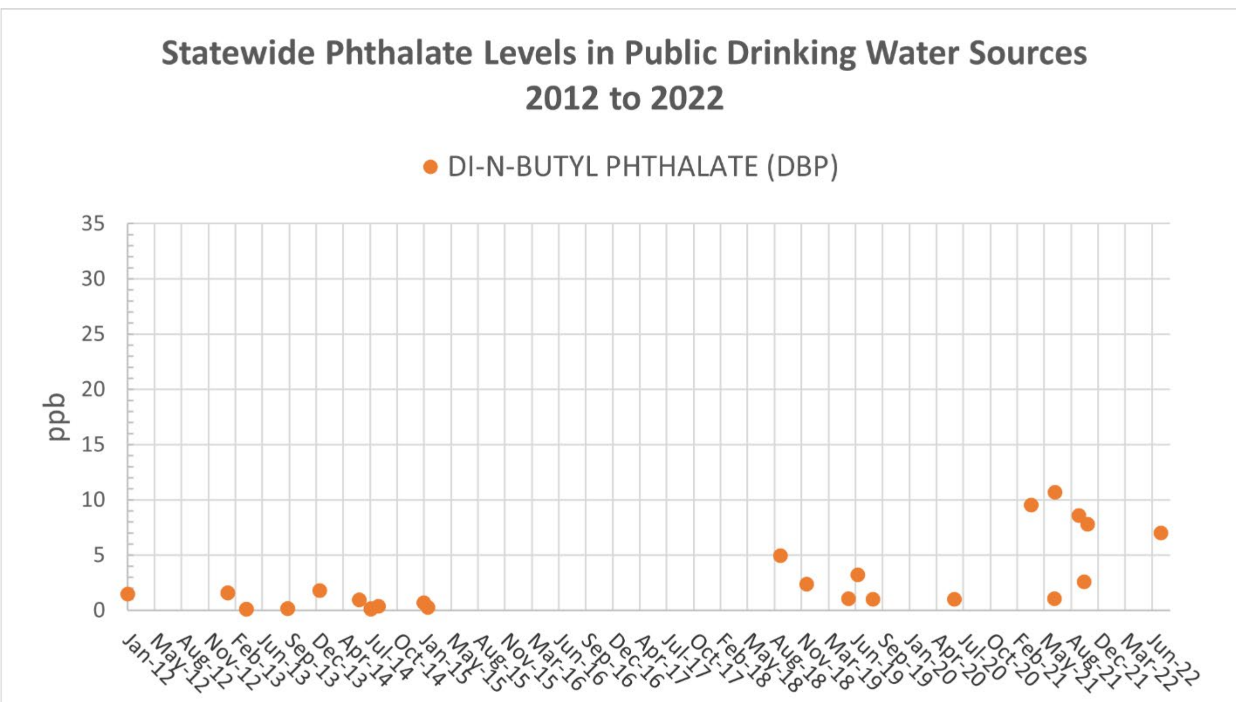

Figure 3. Statewide Phthalate Levels (DBP)

Table 3: Detections of five phthalates since 1993 and 2012, all samples.

Phthalate	Time period	Number samples	Number detects	Percent detected
DEHP	Since 1993	12,899	267	2.1
DEHP	Since 2012	3,673	56	1.5
BBP	Since 1993	9,584	52	0.5
BBP	Since 2012	2,302	0	0
DBP	Since 1993	9,478	146	1.5
DBP	Since 2012	2,272	27	1.2
DEP	Since 1993	9,566	64	.67
DEP	Since 2012	2,300	0	0
DMP	Since 1993	9,588	11	.11
DMP	Since 2012	2,298	0	0

Table 4: Detection levels (ppb) of phthalates found in samples since 1993 and 2012.

Phthalate	Time period	Min	Max	Median	95th percentile
DEHP	Since 1993	0.0003	40.3	0.56	5.74
DEHP	Since 2012	0.613	30	0.9595	7.53
BBP	Since 1993	0.01	0.44	0.037	0.24
BBP	Since 2012	0	0	0	0
DBP	Since 1993	0.02	26.4	0.235	4.80
DBP	Since 2012	0.113	10.7	1.05	9.26
DEP	Since 1993	0.01	1.1	0.058	0.41
DEP	Since 2012	0	0	0	0
DMP	Since 1993	0.01	3.8	0.047	2.81
DMP	Since 2012	0	0	0	0

Between October 2012 and August 2013, there were three detections of DEHP above the MCL for an individual public water system source. However, these are not considered representative. The phthalate detections of the samples were attributed to either sample collection or laboratory analysis. Subsequent monitoring of this source since 2013 resulted in no detections of DEHP. There does not appear to be any observable pattern of phthalate detections within the state.

To screen Washington state drinking water data for phthalates that do not have an MCL, the MCL for DEHP was applied as a surrogate screening value. This represents a conservative, protective public health evaluation, as DEHP is considered more toxic than the other five phthalates.

Data gaps

Currently, EPA does not require monitoring of longer-chain phthalates such as DINP and DIDP. These phthalates are produced in high volumes and addressed in further detail in other sections of this action plan. These phthalates are less soluble in water than the five currently monitored in public water system drinking water and may be less likely to impact drinking water sources.

Recommendation #1

Review data on public water systems and state health advisories and continue to work with partners to address data gaps on potential phthalate impacts to drinking water. Steps include:

a) Continue collaboration with Phthalate AP partners to evaluate scientific literature to assess other phthalates that may have the potential to impact drinking water.

b) Evaluate other state's health advisory guidelines for phthalates in drinking water.

c) Assess national public water system phthalate occurrence data.

Lead agency: Department of Health

Proposed partners for implementation: None

Justification

Monitoring of public water system drinking water sources is required under the EPA Safe Drinking Water Act. Continued oversight and comparisons: 1) help identify data gaps that could be filled with enhanced monitoring in the future; and 2) allow timely identification of situations that might merit additional public health review.

Project description and implementation

Partners would review and evaluate national health advisory guidelines and nationwide results for the five phthalates with testing requirements in public drinking water systems. These results would be compared with Washington state data. If changes in water quality are observed for either regulated or unregulated drinking water contaminants, ODW would partner with the Health Office of Environmental Public Health Sciences to evaluate the potential public health significance of drinking water sample results.

Additional considerations:

- There may be additional unregulated phthalates that require evaluation, assessment, and characterization within the drinking water environmental media.
- There may be challenges developing analytical methods for unregulated phthalates.
- One of the five phthalates ODW monitors (DEHP) has an established drinking water standard of 6 ppb.

We expect that Health would conduct the tasks in Recommendation #1 as a single project. However, that project could be broken into different tasks. The PRA in Appendix F has costs for the three main components of Recommendation #1 broken out separately and examined as separate costs for Recommendations #1, #3, and #4.

Recommendation #2

Educate partners on the use of phthalate-free sample collection and operational equipment products that could potentially contribute to sample contamination.

Lead agency: Department of Health

Proposed partners for implementation: U.S. Environmental Protection Agency, Washington State Public Water Systems, and Certified Drinking Water Laboratories

Justification

Samples can be contaminated by DEHP contained in sampling devices and laboratory containers. Since DEHP is a common laboratory contaminant, laboratory and field blanks often show concentrations similar to those in the media under study (ATSDR, 2022).

Project description and implementation

ODW would continue to educate and inform partners that drinking water samples can become contaminated with phthalates via sample collection methods, sample collection equipment, sample collection location, and within laboratory settings during analysis. ODW can also assist with developing sampling plans and sample collection.

Environmental justice and equity considerations

When implementing these recommendations, the lead agency and partners should consider environmental justice and equity, such as ongoing collaboration with EPA for tribal public water systems.

Aquatics: surface water, sediment, and biota

Problem statement

Phthalates have become ubiquitous environmental contaminants due to widespread use. However, critical knowledge gaps still exist about phthalates in aquatic environments and ecosystems. The scope of phthalate contamination in the environment has not been determined for Washington state, nor has existing data been evaluated to understand phthalates effects on aquatic biota.

It is unknown if exposures to phthalates at concentrations observed in water, sediment, and stormwater are negatively impacting the health of aquatic organisms. It is also unclear whether phthalates and their relevant metabolites accumulate in tissue. Data and analyses are needed to understand the impacts on the health of aquatic organisms and humans that consume these organisms.

Relevant background information

A widely held historical perspective is that phthalates do not pose a risk to aquatic organisms because they are rapidly metabolized and not expected to bioaccumulate or persist in the environment. However, monitoring data in stormwater and sediment throughout Puget Sound indicate there are regions where marine organisms may be continuously exposed to phthalates (Ecology, 2009a, 2015a, 2022b; Herrera Environmental Consultants Inc., 2011; Meador et al., 2016; USGS, 2018). Continuous inputs to the environment may result in chronic exposures to aquatic organisms, even as the parent chemicals are degraded and metabolized.

Loading estimates from the Puget Sound Toxics Loading Assessment concluded that surface runoff was the primary pathway of phthalates to Puget Sound, followed by wastewater treatment plant discharges and groundwater (Ecology & King County, 2011).

The Sediment Phthalates Work Group (2007) also identified the primary pathway by which phthalates make their way into marine sediments. As plastic ages, phthalates volatilize into the air, attach to particulates, and deposit on surface water or the ground. The phthalates are subsequently transported via stormwater to marine waters and finally to sediments. It is unknown whether phthalates adsorb to biota in the planktonic microbial food web before sedimentation. Microplastics introduced via stormwater and wastewater may also transport phthalates to the marine environment (T. Wang et al., 2020).

Water and sediment monitoring

Ecology has conducted long-term monitoring of six phthalates in Puget Sound sediments since 1989 (Ecology, 2018). The monitoring program detects DEHP the most frequently, often in urban bays. BBP is the second most detected phthalate in Puget Sound sediments and is detected primarily in urban bays. Between 1989 and 2015, the monitoring program did not observe any trends in phthalate concentrations, except for one station near Anderson Island, where DEHP concentrations have decreased.

Other environmental monitoring in the state, not tied to cleanup sites, included:

- Sediments in Puget Lowland streams (King County, 2018)
- Stormwater and stormwater sediments in the Puget Sound area and Clark County (Ecology, 2015a, 2018)
- Surface water and suspended particulate matter in tributaries to the Puget Sound (Ecology, 2011; Herrera Environmental Consultants Inc., 2011).

DEHP generally is the predominant phthalate analyzed. It is found at the greatest frequency and concentration in sediments, stormwater, and storm-event sampling of rivers and streams. BBP, DEP, and DnOP are detected as well, at lower frequencies. Overall, commercial and industrial land use areas contribute the greatest concentrations of phthalates.

A recent statewide survey of 16 phthalates in rivers, lakes, and marine sediments showed few detections of newly tested phthalates (Ecology, 2022b). Many were not detected at or above levels of predicted aquatic toxicity concern. Reporting limits were too high to assess several of the analytes. DINP was tentatively identified at concentrations higher than DEHP in marine sediments. We need thresholds of concern to determine whether additional monitoring and lower reporting limits of the newly tested phthalates are warranted.

Ecology intends to continue marine sediment monitoring of six phthalates throughout Puget Sound. Other phthalates, such as DINP, could be considered. Phthalates would be identified and prioritized following a literature review, establishing thresholds of concern, and improving analytical methods. Ongoing environmental monitoring of phthalates in ambient freshwater sediments and surface water are considered a low priority. Future work should be targeted to areas of likely contamination and sampling conducted on a less frequent basis.

Aquatic biota monitoring

Researchers have not conducted monitoring for phthalates in Puget Sound's marine organisms since 1995. Those historical sampling efforts are not considered reliable due to uncontrolled phthalate contamination of tissue samples from equipment containing plastics.

Recent studies beyond Puget Sound detected phthalates in the liver, gonads, and eggs of endangered sea turtles (Savoca et al., 2018, 2021). Primary metabolites of phthalates (monoalkyl phthalate esters) were detected in harbor porpoises, baleen whales, fish, prawns, and molluscs (X. Hu et al., 2016; Rian et al., 2020; Routti et al., 2021; Savoca et al., 2018, 2021). While legacy contaminants, such as polychlorinated biphenyls (PCBs), continue to represent a priority threat to the health of marine life throughout the Sound, the Washington State Department of Fish and Wildlife (WDFW) is working to identify risks and prioritize monitoring for a broad suite of emerging contaminants. We recommend this future work include testing for phthalates and their metabolites in sentinel marine species.

Species that inhabit or feed in the sediments, water column, or undergo sensitive life stages in the nearshore environments that experience frequent stormwater runoff would be expected to be most exposed. English sole (*Parophrys vetulus*), juvenile Chinook salmon (*Oncorhynchus tshawytscha*), Pacific herring (*Clupea pallasii*) and bay mussels (*Mytilus trossulus*) are existing indicator species used by WDFW to examine contaminants in these habitat types.

Toxicity

Decades of research indicate that exposures to low concentrations of ortho-phthalates can affect human reproduction and development via the endocrine system (CHAP, 2014; ECCC & HC, 2017; NICNAS, 2019; Radke et al., 2018). One key mechanism is the inhibition of the synthesis of androgen hormones (referred to as an anti-androgenic effect), which causes reductions in male fertility. These effects can be additive when humans are exposed to more than one phthalate and are concerning because effects also occur at low concentrations.

Similar effects are observed in freshwater fish, where exposure to DEHP causes a reduction in sperm quality and fertilization (Golshan & Alavi, 2019). While fewer studies are available on marine fish (Forner-Piquer et al., 2019; Kaplan et al., 2013; Ye et al., 2014; Y. Zhang, Jiao, et al., 2021) and none in marine mammals, comparable effects would be expected to occur because the endocrine system is highly conserved across vertebrates.

Studies examining the toxicity of phthalates to marine and freshwater invertebrates, plankton, and macroalgae are more limited. However, it is notable that the abalone was one of the most sensitive aquatic organisms, when exposed to DMP, identified in the Environment and Climate Change Canada's (ECCC) draft screening assessment (Environment and Climate Change Canada & Health Canada, 2017; Zhou et al., 2011). A review of the existing data for freshwater and marine species would be informative to see if any data gaps have since been filled. Overall, the unanswered question is whether documented exposures in stormwater and sediment are negatively affecting aquatic organisms in Washington state.

Nationally, the EPA prioritized seven ortho-phthalates for risk evaluations under the amended TSCA. These include DBP, BBP, DEHP, DIBP, DCHP and DINP. A total of 218 studies on the effects to vertebrates (non-human health model) and invertebrates and 49 pertaining to plants are identified in the final scope documents[11].

All studies captured in the systematic review process under TSCA describing phthalate fate, exposure, and toxicity are publicly available via the EPA's Health Assessment Workspace Collaborative (HAWC).[12] When completed, the TSCA risk evaluations provide a synthesis of the human health and environmental data and, where possible, toxicity thresholds, called Concentrations of Concern, relevant for understanding risks to aquatic organisms.

Human health risk from consumption of aquatic organisms

For humans, diet is recognized as a significant exposure pathway for phthalates (Serrano et al., 2014). Phthalates are identified in a number of foods including fish. Fish consumption is recognized as an exposure route (Serrano et al., 2014). Two phthalate metabolites, MiBP and MEHP, measured in humans have been correlated with fish consumption (Colacino et al., 2010). Presently, human health risk due to consumption of phthalate contaminated fish is not well understood.

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[11] Final Scope Documents for High-Priority Chemicals Undergoing Risk Evaluation | US EPA

[12] https://hawc.epa.gov/

Studies from Tawain (Lu et al., 2021), China (Cheng et al., 2013; Y. Zhang, Jiao, et al., 2021), and Cambodia (Cheng et al., 2016) indicate that concerns, if any, will be species and location specific. Hu et. Al. in 2020 showed phthalate hazard quotients of less than 0.1 for fish species in China, indicating that human health risk is low (H. Hu et al., 2020). Other studies would suggest that seafood packaging, such as canning, is the greater indicator of exposure rather than the tissue itself (Pacyga et al., 2019; Sugeng et al., 2020). A number of phthalates have the same non-cancer toxic endpoint, such as endocrine disruption, and were evaluated cumulatively in prior risk assessments.

The European Food Safety Administration developed a tolerable daily intake (TDI) for five phthalates relative to DEHP (Silano et al., 2019). Alternately, the Chronic Hazard Advisory Panel (CHAP), Health Canada, Environment Canada, Australian Department of Health, and Danish EPA have all used dose addition frameworks (CHAP, 2014; Danish EPA, 2013; HC & EC, 2015; NICNAS, 2019; NRC, 2008). Health's fish consumption advisory process is based upon the EPA Guidance for Developing Fish Advisories (US EPA, 2000). This advisory process uses an additive approach for multiple contaminants with similar toxic endpoints to calculate recommended meal limits. In the past, Health implemented this approach for several fish consumption advisories, typically when evaluating combined exposure to PCBs and mercury.

Health also considers aggregate exposure for contaminants where multiple exposure pathways exist by using a relative source contribution (RSC). Since multiple exposure pathways exist for phthalates, we will need to consider RSCs to adequately frame fish consumption risks in the context of other exposure pathways.

Health does not currently have fish consumption advisories related to phthalates or metabolites. We do, however, have fish consumption advisories for other contaminates in several waterbodies through the state. While health would use a similar process as these advisories, we do not currently have sufficient data to indicate an advisory is necessary. Currently, Health has provision screening levels for five phthalates (DEP, DEHP, BBP, DBP, and DMP). When fish tissue data is available, we will evaluate these phthalates according to the Health fish advisory process.

Recommendation #1

We have limited information about the toxicity and presence of phthalates in aquatic organisms in Washington state. To determine whether aquatic organisms, and the people that consume them, are impacted by this class of chemicals, we recommend allocating resources to existing monitoring programs in the state so those programs can perform the following tasks:

a) Synthesize the existing literature for aquatic species to establish, where possible, environmental concentrations of phthalates expected to cause adverse impacts.

b) Identify or develop suitable analytical methods for phthalates as needed, depending on the outcome of the literature review.

c) Evaluate the extent and magnitude of phthalate/metabolite exposure in aquatic species.

d) Examine biomarkers of endocrine disruption in wild fish, as needed.

e) Evaluate fish tissue data for human health risk, when available.

The steps that are envisioned to implement this recommendation are outlined in Figure 4.

Lead agency: Department of Ecology

Proposed partners for implementation: Department of Fish and Wildlife, Department of Health

Justification

Organisms in Puget Sound are exposed to mixtures of phthalates in sediment and water. We have evidence that phthalates exposure can produce anti-androgenic effects in vertebrates at concentrations that might be found in the environment. A clear definition of the extent and magnitude of phthalate exposure and effects would inform mitigation efforts to protect impacted species. This includes evaluating exposure and toxicity to aquatic indicator species. Evaluations would also allow the state to measure success as the chemical action plan is implemented. Fish tissue data would also provide the information needed by Health to evaluate human health risks.

Project description and implementation

- Implementation of this recommendation would follow the steps outlined in Figure 4.
- WDFW Research Scientists are available to assist with the literature review, but funding for staff time devoted to the review is dependent on the success of pending funding. The WDFW's Toxics Biological Observation System (TBiOS) has requested this funding to expand monitoring of contaminants of emerging concern (CECs) in marine biota. Likewise, a toxicologist within Ecology would need to be funded and assigned the task of determining thresholds of concern in multiple matrices using the information gathered in the literature review.
- Currently, there are no commercial laboratories that offer analyses of phthalates and their metabolites in fish tissue. Funding would need to be obtained to develop appropriate analytical methods.
- As additional steps are added, we would need to identify new sources of funding to implement analytical method development and the addition of phthalate analytes to existing monitoring programs. Health could complete analysis of fish tissue data with existing staff resources.
- In the past, collecting and analyzing tissues without contaminating samples from plastics has been a barrier to monitoring phthalates in biota. Adopting rigorous blank controls in the field and lab, combined with recent advances in analytical procedures focusing on phthalate metabolites, alleviate some of these issues. If funding is identified to advance

analytical methods in tissue, WDFW and Ecology would work with the other implementation partners to develop a quality assurance project plan.

- Neither WDFW nor Ecology have existing funding to routinely screen for phthalates in fish tissue. If a lab capable of measuring phthalates/metabolites in biota were identified, implementation would depend on the success of pending funding requests. The WDFW's Toxics Biological Observation System (TBiOS) has requested this funding to expand monitoring of contaminants of emerging concern (CECs) in marine biota. Alternatively, other new sources of funding would need to become available.
- Health cannot provide public health guidance before it evaluates reliable fish tissue data.

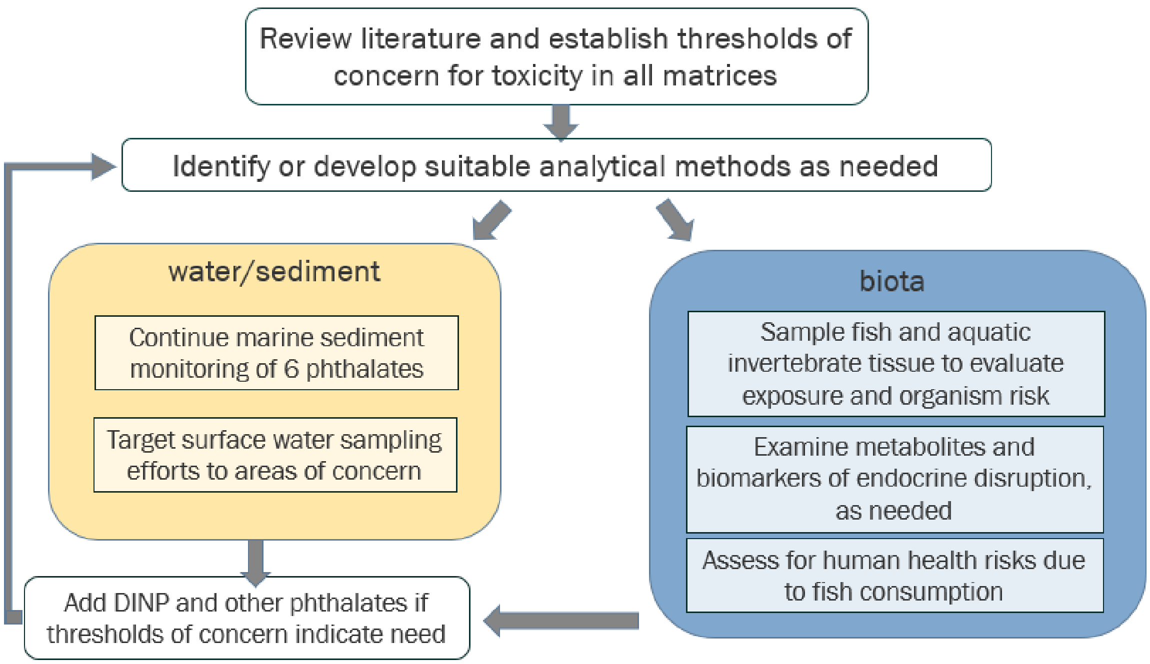

Figure 4. Flow chart outlining the steps needed to implement the recommendation for surface water, sediment, and biota.

The steps needed to implement the recommendation for surface water, sediment, and biota are as follows:

1. Review literature and establish thresholds of concern for toxicity in all matrices.
2. Identify or develop suitable analytical methods as needed.
3. For water/sediment:
    a. Continue marine sediment monitoring of 6 phthalates.
    b. Target surface water sampling efforts to areas of concern.
4. For biota:

   a. Sample fish and aquatic invertebrate tissue to evaluate exposure and organism risk.
   b. Examine metabolites and biomarkers of endocrine disruption, as needed.
   c. Assess for human health risks due to fish consumption.
5. Add DINP and other phthalates if thresholds of concern indicate need.
6. Begin the process of identifying or developing suitable analytical methods again, as needed.

Environmental justice and equity

Implementing this recommendation should include considerations for environmental justice, such as:

- Developing thresholds of concern that are protective of sensitive populations.
- Testing species and tissues that are most likely to be eaten by overburdened communities and sensitive populations.
- Using the Washington Environmental Health Disparities Map[13] to target sample collections in areas with high risk, as determined by cumulative environmental health impact scores.

[13] https://fortress.wa.gov/doh/wtn/WTNIBL/

Outdoor air

Problem statement

Some commercial and industrial sources in Washington emit phthalates to the ambient air. Exposure to phthalates in outdoor air is generally considered to contribute very little to the overall phthalate exposures. However, some commercial and industrial source's emissions to ambient air may increase exposures in localized areas near the sources.

Relevant background information

Relative to indoor air, phthalates in outdoor air are expected to be found at relatively low levels (Lunderberg et al., 2019; Rudel et al., 2010; Rudel & Perovich, 2009). Compared to other exposure pathways like dietary intake, use of personal care products, and indoor dust and indoor air, exposure to phthalates in outdoor air is expected to represent a very low contribution to total phthalate exposure (CHAP, 2014).

The bulk of phthalates in outdoor air in non-industrial areas originates from various consumer and building products. That said, commercial and industrial sources may emit phthalates that contribute to higher outdoor phthalates exposures among nearby communities. For example, EPA's AirToxScreen estimates ambient concentrations of air toxics based on estimated emissions. This tool showed higher ambient concentrations of DEHP in 2019 originating from sources located in Skagit and Snohomish Counties (Figure 5) (US EPA, 2019). These estimated concentrations near key sources are higher than those measured in outdoor air in California and Toronto (Table 5).

Table 5: DEHP concentrations measured in air at select North American locations.

Environment	Median DEHP concentration (ng/m3) inside and outside several nonsmoking homes in CA (Rudel et al., 2010)	Average DEHP concentration (ng/m3) inside and outside single family residence CA (Lunderberg et al., 2019)	Geometric mean DEHP concentration (ng/m3) near traffic in Greater Toronto urban area (Vasiljevic et al., 2021)
Indoor	68	9.0 (occupied) 4.1 (unoccupied)	NA
Outdoor	< MRL (40)	3.4 (occupied) 3.9 (unoccupied)	3.1

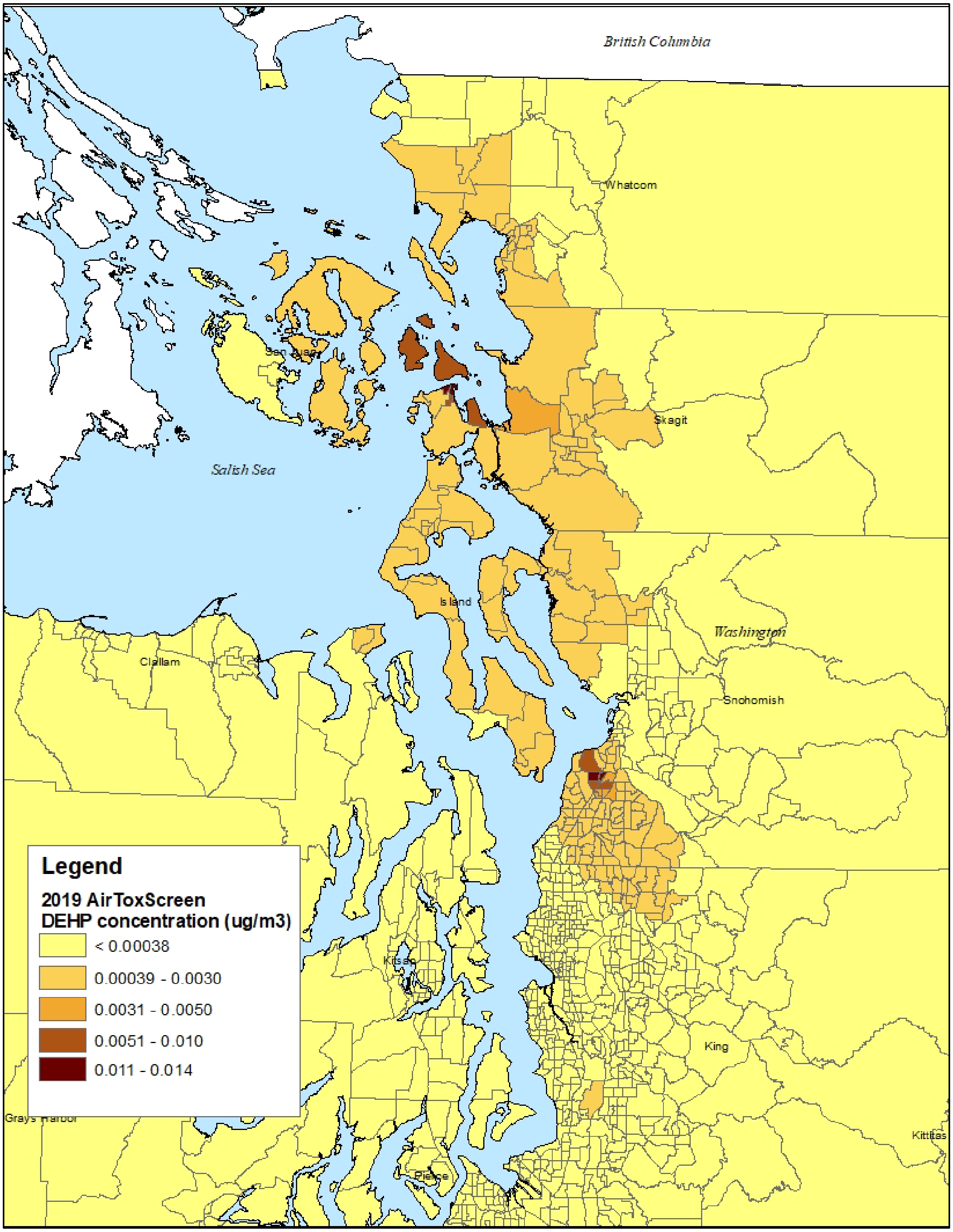

Figure 5. EPA's AirToxScreen, which estimates ambient concentrations of air toxics based on estimated emissions, showed higher ambient concentrations of DEHP in 2019 originating from a couple sources located in Skagit and Snohomish Counties.

A review of EPA Toxic Release Inventory (TRI) and local air agency emissions inventories from 2012 to 2021 show about nine facilities that reported phthalate emissions of greater than 100 pounds per year to outdoor air. These sources may pose a localized increase in exposures to phthalates in ambient air.

Current laws and regulations

In Washington, local clean air agencies manage air quality within much of the state. Tribal governments regulate air quality within tribal reservations using technical assistance from EPA Region 10. Ecology regulates air quality in all other areas.

Three phthalate chemicals are considered federal hazardous air pollutants: DEHP, DBP, and DMP. EPA develops national emission standards for hazardous air pollutants (NESHAPs), which may apply to certain source categories that emit hazardous air pollutants. Individual phthalate chemicals do not appear to be the target of any existing NESHAPs for any type of source category.

Recommendation #1a

Ecology should contact air regulatory partners to verify and improve accuracy of emissions reporting.

Lead agency: Department of Ecology

Proposed partners for implementation: Local air agencies and Ecology regional offices (where no clean air agency exists)

Justification

Emissions reports submitted to TRI and air regulatory agencies for specific Toxic Air Pollutants (TAPs) or Hazardous Air Pollutants (HAPs) may be inaccurate. Agencies can work with sources in their respective jurisdictions to verify the accuracy of emissions reports.

Project description and implementation

Ecology asked air regulatory partners to verify emissions estimates from several facilities. Local air agency staff may need to contact the individual facilities to discuss phthalate emissions. Some facilities have not reported emissions in several years, so the local agency needs to determine if phthalate emitting activities still occur. In other cases, agencies need to verify latest emission reports to determine accuracy. Ecology staff would then follow up to determine if local agencies have made progress in verifying emissions.

Implementing this recommendation is contingent upon cooperation from local air agencies and the sources they regulate. Workload constraints at the local agency and facility may determine how quickly these emissions reports can be verified.

Recommendation #1b

Pending the outcome of Recommendation #1a, Ecology pollution prevention staff and facilities may be necessary to identify and address possible phthalate emissions reductions.

Lead agency: Department of Ecology

Proposed partners for implementation: Local air agencies

Justification:

Local air agencies are best positioned to understand the sources that they regulate. They will be able to determine if permit conditions and regulations apply to a particular facility's phthalate emissions. If there are no regulatory options for reducing existing phthalate emissions, voluntary efforts may be the only way to address on-going phthalate emissions. Ecology's pollution prevention staff may be consulted if a facility is interested in voluntary phthalate emission reductions.

Project description and implementation

The local air agency can identify if the facility meets the requirements of existing permits or other regulations (e.g., NESHAPs). In the event no regulatory options are available for controlling emissions, regulatory authorities can help identify if voluntary controls are possible or if the facility has an interest in pursuing pollution prevention assistance from Ecology. The greatest barrier to implementation would likely be the willingness of facilities to voluntarily reduce phthalate emissions.

We do not anticipate Ecology Air Quality Program staff would be directly involved in implementing this recommendation. This is because none of the sources that report phthalate air emissions are located within Ecology's regulatory jurisdiction.

3-Year Review of Recommendations and Implementation

In order to gauge the effectiveness of this Action Plan, Ecology intends to conduct a review of the Action Plan three years after publication. The 3-year review will focus on the following:

- Have we requested and obtained funds to implement the recommendations?
- Have lead agencies and proposed partners implemented recommendations?
- What barriers to implementation did we discover?
- Have we directly or indirectly addressed environmental justice and equity concerns during implementation?
- What are the results of implementation?
- Have new laws or regulations replaced the need for any of the recommended actions?
- Are additional recommendations needed? Are there recommendations that we did not make in the original plan that we now have enough information to act on (e.g. work on microplastics)?

This review will help us understand:

1. Whether the intent of the action plan – to develop actionable recommendations – has been successful in the short term; and
2. Where future work should be focused in order to best reduce phthalates exposures and sources. Ecology will share the results of this review with the public.

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Appendix A. Phthalates Background Information

General chemical information

Physical and chemical properties

A phthalate's chemical structure may impact how hazardous it is to human health with regard to carcinogenicity, reproductive and developmental toxicity, and endocrine activity. The differences also impact hazard endpoints relative to environmental fate and toxicity in other aquatic and terrestrial organisms. You can read more about these impacts in the sections on exposure, health impacts, and phthalates in the environment.

In general, phthalates have relatively low vapor pressures and low water solubility, although there is variability between specific members of the class (Table 6) (CPSC, 2010). At room temperature, most phthalates are colorless, viscous liquids with low odor.

The size of substituents attached to the phthalic acid scaffold, and consequently the molecular weight of that specific phthalate, influences the water solubility and vapor pressure of that phthalate. For example, DMP has the smallest substituents, comprised of one carbon each, and molecular weight of the phthalates. Consequently, it has the highest vapor pressure and water solubility of the phthalates. In contrast, DINP has longer substituents, consisting of nine carbons, and almost twice the molecular weight. As such, it has much lower vapor pressure and water solubility.

Substituents attached to the phthalic acid scaffold can also be the same or different depending on the specific phthalate. For example, benzyl butyl phthalate (BBP) has one substituent that is four carbons in length, while the second substituent is an aromatic ring comprised of six carbons.

Table 6: Chemical properties of some common phthalates (Consumer Products Safety Commission, 2010).

Phthalate	Molecular Weight	Chain Length	Vapor Pressure (Torr)	Partition Coefficient (LogP)	Water solubility (mg/L)
Dimethyl phthalate (DMP)	194.2	1	$6.0*10^{-3}$	1.5-2.1	4.3
Diethyl phthalate (DEP)	222.2	2	$1.6*10^{-3}$	2.5	1
Di-n-butyl phthalate (DBP)	278.3	4	$7.3*10^{-5}$	4.6	$1*10^{-2}$
Benzyl Butyl phthalate (BBP)	298.3	4, 6	$6.0*10^{-7}$	4.8	$2.8*10^{-3}$
Di(2-ethylhexyl) phthalate (DEHP)	390.6	6	$1.0*10^{-7}$	7.5	$3.0*10^{-3}$
Di-n-octyl phthalate (DnOP)	390.6	8	$1.0*10^{-7}$	8.1	$5.0*10^{-4}$
Diisononyl phthalate (DINP)	418.6	8-10 (C9-rich)	$4.5*10^{-7}$	8.8	$6*10^{-5}$
Diisodecyl phthalate (DIDP)	447.0	9-11 (C10-rich)	$3.8*10^{-7}$	8.8	$2*10^{-7}$

Terephthalates

While phthalates are the most well studied isomer and most often associated with environmental and human health hazards, the use of structurally-related terephthalates appears to be increasing. The most prominent terephthalate in use, diethylhexylterephthalate (DEHT), has a more favorable hazard profile than phthalates.

As a result, we identified DEHT as a safer alternative to phthalates for use in vinyl flooring products (Ecology, 2022a). However, we know less about the safety of other terephthalates, and the related isophthalates, that may be used in consumer products.

Historical information

Phthalates were first introduced in the 1920's as plasticizers. Their production and use in consumer products rapidly increased over time, owing in part to the commercial development of polyvinylchloride (PVC) in the 1930's. By the early 1970's, over 1 billion pounds of 20 different phthalates were manufactured in a single year (Graham, 1973). Since that time, use of phthalates has continued to grow. Studies report that 4.7 million metric tons, 10 billion pounds, of phthalates were produced globally in 2006 and approximately 8 million metric tons, 18 billion pounds, were produced globally in 2015 (Y. Wang et al., 2019; Wypych, 2017).

Production, uses, and regulation summary information

Current uses of phthalates

Phthalates are used as laboratory chemicals, where they act as solvents or as stabilizers for other chemicals (Uhl et al., 2018). They also are used as processing aids in the manufacture of other materials, including both PVC and non-PVC plastics and rubber materials (Walters et al., 2020). For example, phthalates used as plasticizers add softness and flexibility to these materials.

Due to these functional uses, phthalates are found in many categories of consumer products, including personal care products, cleaning products, textiles and apparel, packaging materials, automotive products, building materials, medical devices and products, food contact articles, and more. For more information on these uses, please see the dedicated section on consumer products.

Phthalates have other reported uses, including in infrastructure such as traffic control products, pipelines, and buried wire and cable.

Use of specific phthalates has shifted over time, often in response to increased regulatory scrutiny for some members of the chemical class. DEHP has historically been the most abundant phthalate plasticizer used in consumer products worldwide. However, use of DEHP has decreased in recent years due to: 1.) voluntary efforts by industry; and 2) regulations that have limited its use in some products due to health concerns.

As a result, use of other plasticizers, including other phthalates, has increased. This has led to changes in the distributions of phthalates observed in the environment in countries which regulate their use (Nagorka et al., 2022; Nagorka & Koschorreck, 2020).

Changing use patterns are also reflected in biomonitoring data, which show decreases of phthalate metabolites reported in U.S. and Canadian populations between 2009 and 2019 (Domínguez-Romero et al., 2022). These changing use patterns highlight the need for continued action to reduce the potential for regrettable or unfortunate substitution, where one phthalate associated with adverse health effects is replaced with another related phthalate chemical with health risks (Birnbaum & Bornehag, 2021; Engel et al., 2021).

Production volume

Appendix E shows production volumes of phthalates reported in the Chemical Data Reporting inventory published by the EPA from 2016 – 2019 (U.S. EPA, 2020). In recent years, DINP and DIDP have had the largest national aggregate production volumes. Between 2016 and 2019, both of these phthalates had a production volume range of 100 million pounds to 1 billion pounds (Appendix E).

Releases to the environment

Releases from consumer products

To address phthalates in Washington's environment, Ecology participated in a Sediment Phthalates Work Group in 2006 and 2007, along with representatives from the City of Tacoma, City of Seattle, and King County (Sediment Phthalates Work Group, 2007). This work group convened to respond to phthalate accumulations in sediments of areas that had recently undergone cleanups, including the Thea Foss Waterway and Lower Duwamish River. The work group published a summary of findings and recommendations in 2007. In that report, we concluded that the primary source of phthalates in sediments was release of phthalates from plasticized PVC products.

In 2011, Ecology published a report that estimated the primary sources of select chemicals, including phthalates, in Puget Sound (Ecology, 2011). In that report, we estimated that 34 metric tons of phthalates are released annually into Puget Sound. The primary sources were emissions from cosmetics, personal care products, and plasticized PVC products. These estimates were based on the population size in the Puget Sound study area, which was approximately 4.5 million people.

If we adjust this estimate to reflect the current Washington state population, the estimated number of phthalates released statewide would be approximately 59 metric tons per year (based on a current state population of approximately 7.8 million) (U.S. Census Bureau, n.d.).

We estimated that cosmetics and personal care products were the largest contributor to phthalate releases in the study, representing approximately 33 percent of the total estimated releases. At the time of the study, DEHP was thought to be the primary phthalate used as a plasticizer. As a result, estimates for releases from plasticized PVC products focused on DEHP, which accounted for approximately 20 percent total estimated release volume for phthalates.

Although there would likely be differences in the estimated source contributions for phthalate emissions statewide today, it is reasonable to assume that consumer products would remain the dominant source. We estimated that they accounted for over half of phthalates releases in the Puget Sound study.

For additional information on the presence of phthalates of Washington's environment, please see the recommendations for Aquatics – surface waters, sediment, and biota.

Industrial releases in Washington

Our 2011 study estimated that point source air emissions from industrial, commercial, and institutional sources accounted for 9.6 metric tons, or 28 percent of total phthalate release, in the study area per year (Ecology, 2011). Additionally, we estimated the average annual release from industrial commercial and institutional facilities—as reported in EPA's Toxic Release Inventory (TRI)—was 0.98 metric tons. This included reported air emissions. More recent TRI reporting data shows that the average reported emissions have increased since then.

During 2012 to 2021, seven facilities in Washington reported phthalate releases to TRI. The average annual reported release was 9922.2 pounds, or approximately 4.5 metric tons per year (1 metric ton is approximately 2,204 pounds) (US EPA, n.d.-c). Most phthalate releases throughout this time were to air; however, there was one outlier in 2020 where the largest reported release was listed as an off-site transfer for disposal or release at 44,304 pounds for the year (Figure 6).

In terms of trends, for all years in the period except 2013, air releases were reported as between 1,433 pounds (2017) and 9,419 pounds (2021); air releases reported in 2013 were 27,529 pounds. Three phthalates were included in the reports: dimethyl phthalate (DMP), dibutyl phthalate (DBP), and Di(2-hexylethyl) phthalate (DEHP). The total releases for each during the same period were listed as 42,933 pounds, 30,056 pounds, and 26,233 pounds, respectively.

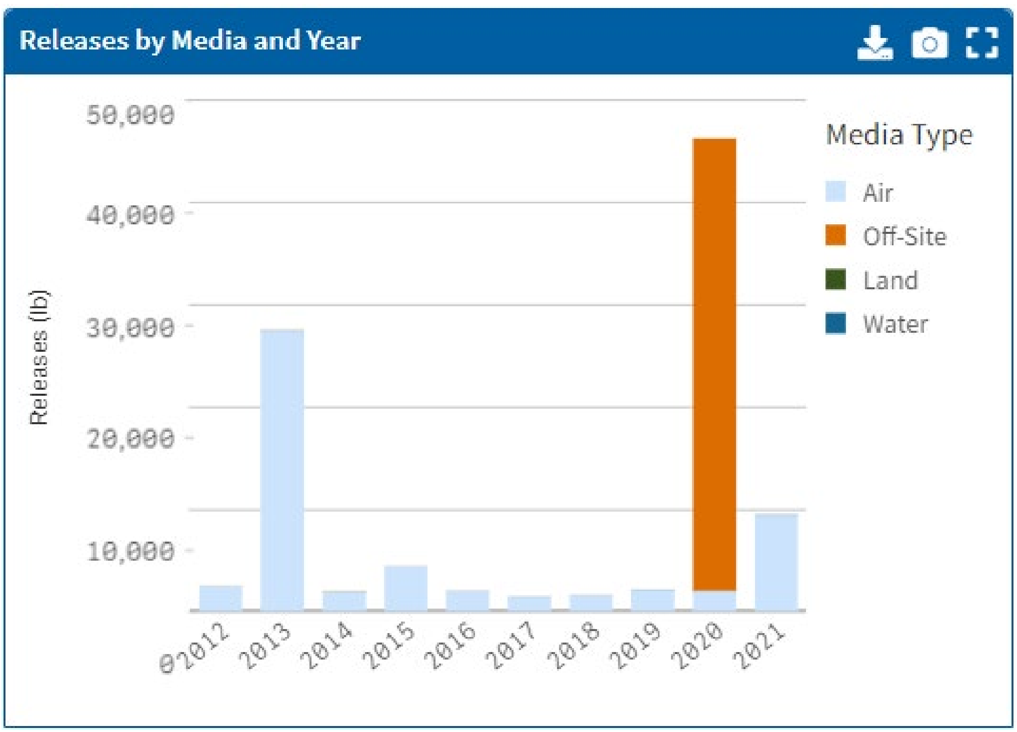
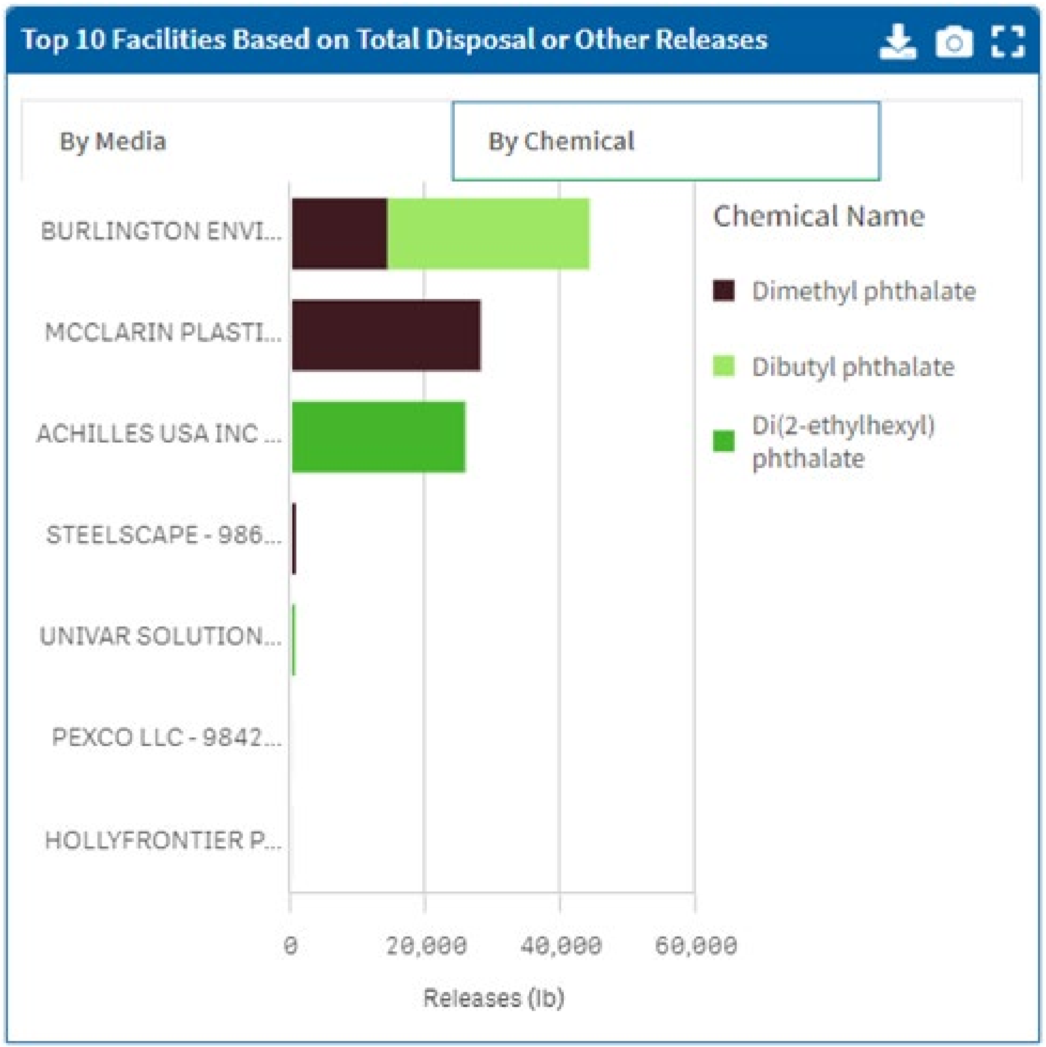


Figure 6. Total phthalate releases reported in EPA Toxics Release Inventory (TRI) for Washington state by year between 2012 – 2021. Image generated using EPA TRI Toxics Tracker.

The total releases reported for each phthalate listed by reporting facility for the period between 2012 – 2021 is shown in Figure 7 (top). Three facilities reported the majority of phthalate releases: Burlington Environmental LLC, McClarin Plastics LLC, and Achilles USA Inc. Additionally, there was also 36,777 pounds DMP, 60,574 pounds DBP, and 1,500 pounds DEHP reported as waste managed through preferred methods which includes recycling, combusting for energy recovery, and treatment for destruction (Figure 7, bottom). Two facilities reported most of the managed waste: Burlington Environmental LLC, which reported 48,463 pounds of treated waste, and Steelscape, which reported 36,292 pounds of waste used for energy recovery.



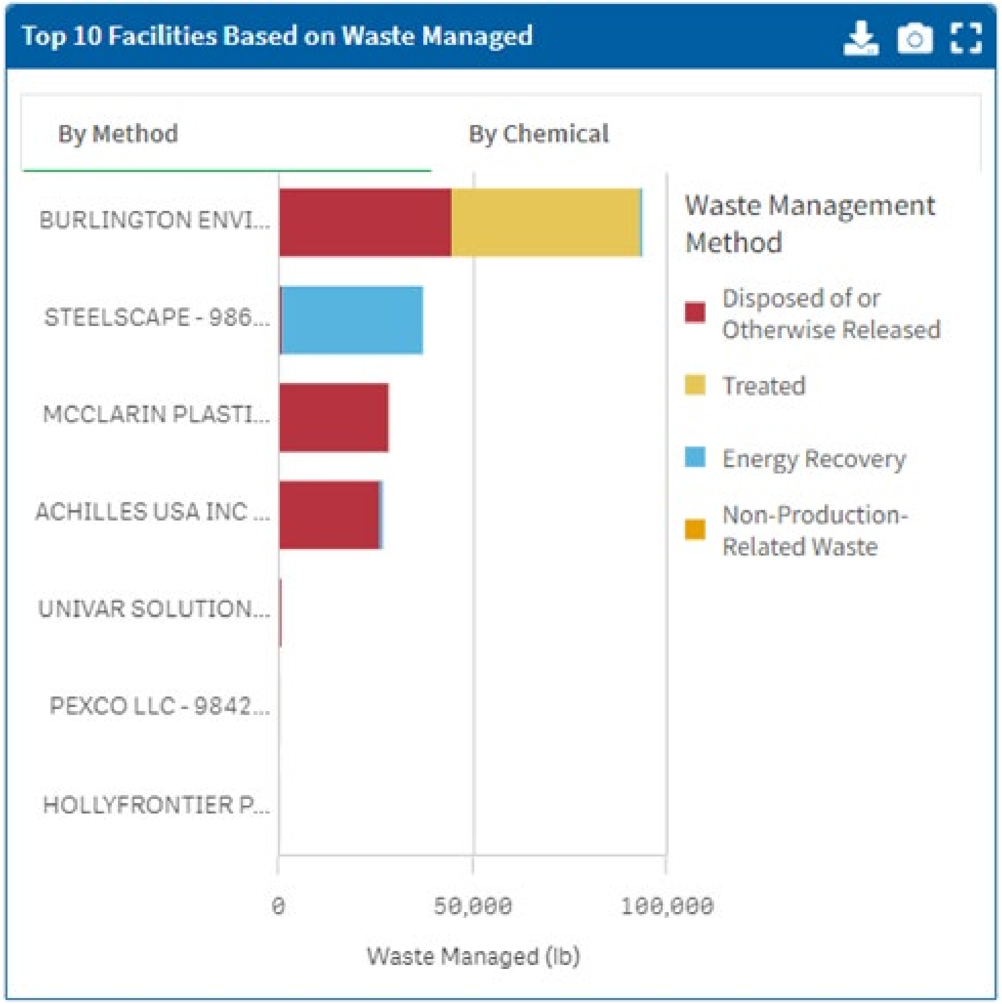


Figure 7. Total phthalates release by reporting facility for the period between 2012 – 2021 (top). Total phthalate waste managed by reporting facility for the period between 2012 – 2021 (bottom). Images generated using EPA TRI Toxics Tracker.

Regulations

Washington state

Phthalates are regulated under several laws in Washington state. CSPA restricts the use of six phthalates in children's products at concentrations greater than 100 ppm individually or combined. CSPA also requires manufacturer reporting for six additional phthalates when used in children's products, for a total of 12 phthalates listed with a reporting requirement.

In 2019, Washington state passed the Pollution Prevention for Healthy People and Puget Sound Act, which identified phthalates as a priority chemical class. SPWA is the implementation program for chapter 70A.350 RCW. In 2021, this program determined a restriction was necessary for phthalates in vinyl flooring and fragrances used in personal care and beauty products. The program published a corresponding draft rule in 2022. If adopted, the rule will restrict the use of phthalates in fragrances in beauty and personal care products and the presence of phthalates above 1000 ppm in vinyl flooring products sold, manufactured, or distributed in Washington starting January 1, 2025.

United States

Phthalates are regulated at the federal level in children's products under the Consumer Product Safety Improvement Act (CPSIA) by the Consumer Product Safety Commission (CPSC). Eight phthalates are restricted from use in any children's toy or childcare article that contains concentrations of more than 0.1 percent of any individual phthalate listed: DEHP, DBP, BBP, DINP, DIBP, DPENP, DHEXP, and DCHP.

Seven phthalates are currently undergoing risk evaluations under the Toxic Substances Control Act (TSCA) by EPA to determine whether they present an unreasonable risk to public health or the environment under the conditions of use. Those listed are DBP, BBP, DEHP, DIBP, DCHP, DIDP, and DINP (CRE & ACC, 2003).

The FDA regulates phthalates in cosmetics, pharmaceuticals, medical devices, and food contact substances (US EPA, 2012). In May 2022, the FDA revoked authorizations for the food contact use of 23 phthalates, while eight phthalates remained authorized for use as plasticizers and one phthalate as a monomer in food contact uses. Alongside that action, FDA issued a request to gather available information on the use and safety of the remaining eight phthalates authorized for use as plasticizers in food contact applications.

Phthalates are also regulated under the Resource Conservation and Recovery Act (RCRA) as hazardous waste if discarded as a commercial chemical product. The Safe Drinking Water Act regulates DEHP with the maximum contaminant level (MCL) set at 0.006 mg/L. The Clean Air Act also lists DEHP, DMP and DBP as hazardous air pollutants (US EPA, 2012).

Appendix B. Human Health and Phthalates Background

This appendix consists of three sections. First is a summary of the health effects that have been linked to phthalate exposure. Second, we discuss how phthalates get into people. Finally, we propose some conclusions based on exposure and effect taken together that can help prioritize exposure reduction recommendations for specific groups of people, in the context of health equity considerations.

Overview of phthalate health effects

Phthalates have been widely studied in laboratory experiments with animals and in epidemiology studies of people for their potential to harm people's health. There is an adequate base of toxicological and epidemiological evidence to support health hazard assessments.

This action plan considers phthalates as a class of chemicals because people are exposed to multiple phthalates and many phthalates can disrupt the same processes or affect the same target tissues in the body. Phthalates as a chemical class can cause reproductive toxicity and developmental toxicity to the reproductive and nervous systems, as well as organ toxicity, respiratory effects, and dysregulation of thyroid and metabolic functions. The potency to produce health effects and the specific effects reported vary within the chemical class.

There is broad consensus that phthalates are endocrine disrupting chemicals that interfere with the normal function of hormone systems in the body. The strongest evidence is for toxic effects on fetal development of the reproductive system in males. In studies of people, exposure to phthalates in the womb has been linked to brain and behavioral outcomes for children and respiratory symptoms after birth. When exposure occurs later in life, phthalates have adverse effects on semen quality and sperm count in men and on pregnancy outcomes in women. Risk and severity of uterine fibroids in women have been connected to phthalate exposure. Phthalates are also associated with metabolic effects like diabetes, gestational diabetes, insulin resistance, and obesity. In laboratory experiments in animals, phthalates cause liver and kidney toxicity.

There is some disagreement about what level of phthalate intake causes health harms in people. Some people are likely more susceptible to the effects of phthalates, whether because of the life stage when exposure occurs, or because they have health conditions that may make them more vulnerable to the added health harms of phthalate exposure. People are exposed to phthalates at the same time as other chemicals, and this can increase the chance of harmful effects.

Health hazard review by authoritative bodies

To identify health effects of phthalates, we first consulted reports from government agencies, authoritative medical organizations, and widely accepted third-party reviewed hazard assessments. We then updated the findings of these reports with a limited review of recent peer-reviewed primary literature, including epidemiology studies in humans and studies of cumulative effects. This section highlights the key health hazards identified in authoritative reports.

U.S. EPA cited toxic effects on fetal development of the reproductive system as a critical health effect for the development of their 2012 action plan (US EPA, 2012). EPA also noted effects on testosterone production, fetal mortality, and male and female reproductive development later in life.

A Chronic Hazard Advisory Panel (CHAP) convened by the Consumer Products Safety Commission conducted an assessment of phthalates and phthalate alternatives used in children’s toys and child care articles (CPSC, 2008). The CHAP report focused on male developmental toxicity.

Ecology recently reviewed key hazard traits of phthalates as part of our Safer Products for Washington program (Ecology, 2022a). We identified 15 phthalates present on authoritative lists or with existing hazard assessments, such as third-party reviewed GreenScreen® hazard assessments. Our report identified the potential to cause cancer, reproductive toxicity, developmental toxicity, or endocrine disruption as the hazard traits most frequently associated with phthalates. Neurotoxicity is an important data gap for many phthalates.

The European Chemicals Agency (ECHA) lists multiple phthalates as substances of very high concern due to their reproductive toxicity. Ten phthalates are classified by ECHA as category 1B Reproductive toxicants for their potential to damage fertility and the unborn child (ECHA, 2023). ECHA also identifies several phthalates as endocrine-disrupting chemicals (DEHP, DBP, DIBP, BBP, and DCHP).

In 2020, Environment and Climate Change Canada (ECCC) conducted a screening assessment for 14 phthalates (Environment and Climate Change Canada & Health Canada, 2017). The key phthalate health hazards identified by ECCC are consistent with other studies: effects on the development of the reproductive system including male reproductive tract malformations, effects on fertility, and systemic effects related to the liver and kidneys.

The State of California lists several phthalates as carcinogens, reproductive toxicants, and developmental toxicants (OEHHA, 2010).

Health experts have made policy and scientific statements concerning the health harms of phthalates. In 2018, the American Academy of Pediatrics produced a technical report and policy statement that identified endocrine disruption, obesogenic activity, and oxidative stress on children as hazards of concern(Trasande et al., 2018). Similarly, the American Public Health Association (APHA) released a policy statement in 2017 raising concerns about the health risks of phthalates to children (APHA, 2017). An earlier APHA policy statement recommended reducing PVC use in facilities with vulnerable populations, including schools, daycares, medical facilities, nursing homes, public housing, and facilities for special needs and disabled (APHA, 2011).

In the next parts of our health effects review, we provide more detailed discussion of these health endpoints identified by authoritative body reports. We also provide additional findings from our supplemental review of primary literature.

Absorption, metabolism and excretion

Phthalates are rapidly absorbed after ingestion and inhalation. The uptake from oral doses is generally above 50%. The body rapidly absorbs phthalates through ingestion. For oral doses, the body absorbs more than 50 percent, with some differences among phthalates. Uptake after dermal exposure is less than ingestion and inhalation. Dermal absorption decreases with increasing length of the phthalate ester side chain (Elsisi et al., 1989). Dermal absorption of DIDP and DINP is variously reported at levels less than 5 percent, while absorption of DEP was estimated to be 25 percent in volunteers. Skin can also absorb DEP directly from the air (M. Hu et al., 2022). For short chain phthalates, intake from the air through the skin can equal or exceed the exposure from inhalation (Weschler et al., 2015).

Enzymes in the gastrointestinal tract reduce change the diester structure of the parent phthalates to monoester primary metabolites, which are then taken up systemically and distributed widely throughout the body. Phthalates with longer sidechains (e.g., DEHP, DINP, DIDP) are metabolized further into oxidative-secondary metabolites (Calafat et al., 2011). Many phthalate breakdown products join to another molecule before excretion. Excretion of phthalates is largely through urine.

Phthalates have short half-lives in the body that range from a few hours to 24 hours. Half-life is the time needed after exposure ends for the concentration of chemical in the body to decrease by half. For short chain phthalates, the dominant products excreted in urine are conjugates of the monoester metabolites. For example, monoethyl phthalate (MEP) is the observed metabolite for DEP. For phthalates like DEHP, DINP, and DIDP with larger side chains, most of the urinary excretion products are more highly modified secondary metabolites (Calafat et al., 2011).

Endocrine disruption

Authoritative reports identify phthalates as endocrine disruptors. According to the Endocrine Society, a global association of physicians and scientists, endocrine disruptors are chemicals that interfere with hormone production, signaling, or physiological function (Gore et al., 2015).

Endocrine disruption during fetal and early life can irreversibly alter development. Many endocrine-disrupting chemicals act differently in males vs. females, effects can occur at low doses, and the dose-response relationships are often non-linear. This makes the toxic effects of endocrine disruption difficult to study.

Phthalates possess some limited estrogenic activity, and there is strong evidence that they act as antagonists of androgen receptors (Begum & Carpenter, 2021). In addition to sex hormones receptors, phthalates interact with other receptors, including peroxisome proliferator-activated receptor gamma, retinoid X receptor, and aryl hydrocarbon receptors (Begum & Carpenter, 2021; Feige et al., 2007). These receptors are involved with the normal regulation of physiology and development. Phthalates can also alter physiological responses in body fat and the thyroid gland, tissues that contribute to overall endocrine function. Metabolic disruption is now considered a subcategory of endocrine disruption to phthalates (Martyniuk et al., 2022). Metabolic effects associated with phthalate exposure are discussed below.

Developmental toxicity:

Male reproductive development

The most clearly and consistently documented adverse effects of phthalate exposure occur in the developing male reproductive system. In laboratory animals, numerous malformations and feminization of male anatomy occur with exposure to phthalates (Carlson & Szeszel-Fedorowicz, 2017; NRC, 2008). Most of the phthalates with sidechains of 4 to 10 carbons (e.g., DBP, DiBP, DEHP, BBP, DCHP, and DINP) that have been tested have anti-androgenic properties in laboratory animals, although the potency varies (Lioy et al., 2015; NAS, 2017).

Phthalates cross the placenta and can be measured in amniotic fluid, where fetal exposure occurs (Calafat et al., 2006; Jensen et al., 2012). An established mechanism for phthalate-induced male developmental effects is endocrine disruption and toxicity to Leydig cells in the developing testes that reduces fetal testosterone production (National Academies of Science, 2017). The normal development of the male reproductive anatomy requires fetal testosterone. Androgen-independent pathways also likely contribute to developmental toxicity in males (Howdeshell et al., 2008). The Canadian government phthalate assessment concluded that gestational exposure to phthalates in laboratory animals has adverse effects on the development of male anatomy, including decreased anogenital distance (AGD) in pups and nipple retention in juveniles, reproductive tract malformations, and testicular pathological changes (ECCC & HC, 2017).

A review of epidemiological evidence concluded that there is robust evidence for phthalate effects on male reproductive development for DBP and DEHP, moderate evidence for DINP and BBP, and slight evidence for DIDP and DEP (Radke et al., 2018). A National Academy of Science Engineering and Medicine committee conducted a systematic review based on over 2000 papers published up to 2016 on male development and phthalates (NAS, 2017). This committee concluded that at least six phthalates are presumed or suspected to pose a reproductive hazard to humans based on reduced fetal testosterone and reduction of AGD in male offspring of exposed mothers, a marker of feminization. The human epidemiology evidence for effects on male reproduction is strongest for DEHP (Swan et al., 2015); however, DIDP has been linked to cryptorchidism and hypospadias, and DINP has effects on AGD and semen parameters, although results are inconsistent (Radke et al., 2018).

Effects on neurodevelopment

Neurodevelopment is not evaluated separately from other developmental toxicity in standard hazard assessments. Neurodevelopmental effects are difficult to study in laboratory animals because brain functions and behaviors differ highly from humans. The brain is sensitive to hormones and hormone disruption at all life stages. Fetal development is the most studied life stage for the effect of phthalates on the brain.

Three recent reviews conclude that phthalates have the potential to disrupt neurodevelopment and alter neurobehavior (Engel et al., 2021; Radke, 2020; Eales, 2022). Engel et al. (2021) concluded that the combined evidence from human and animal studies is sufficient to call for policy actions to reduce phthalate exposure to pregnant women and children and protect against harm to neurodevelopment and neurobehavior (Engel et al., 2021).

Another recent review of human health effects of phthalates concludes that there is robust evidence that phthalates can affect some neurodevelopmental outcomes but that there is a lack of clarity around susceptibility factors and the developmental stage when exposure has the greatest impact remains unclear (Eales et al., 2022).

A third review of the human epidemiological evidence for phthalate effects on neurodevelopment concluded that there are potential effects of phthalates on cognition, behavior, and motor skills (Radke et al., 2020). The evidence for most of these effects was considered slight or indeterminate. The authors note however that the findings of slight or indeterminate effects does not constitute evidence for a lack of effects of phthalates on these endpoints. Several study design factors such as failure to account for gender differences or the timing of exposure assessment reduced the power of these studies to detect true impacts in neurodevelopmental outcomes. Differences in neurodevelopmental effects in male vs. female children have been reported (Q. Zhang et al., 2019). With regard to timing of exposure, Vilmand et al. (2023) found that phthalate exposures during the third trimester in utero and phthalate exposures at age seven were both associated with lower IQ at age seven.

New publications and methodological approaches add to the evidence of the neurodevelopmental effects of phthalates. Null findings also continue to be reported. A study of infants born with congenital heart defects, who are at increased risk of neurological problems due to health status, found higher overall phthalate exposure significantly worsened language and motor development (Gaynor et al., 2022). Results for individual phthalates were unclear and some evidence for differences between male and female children was noted. Two papers reported some evidence linking phthalates to autism spectrum-related behaviors (Day et al., 2021; Patti et al., 2021). A large study that included 22 metabolites reported mostly null associations on measures of language and IQ in three to six year old children with prenatal exposure (Loftus et al., 2021).

Overall, the review papers and new studies discussed here support our concern for adverse effects on brain development in children with higher phthalate exposures. The adverse neurodevelopmental effects observed in people are supported by results of some toxicology studies in animals (Kougias et al., 2018).

Skeletal malformations

Some phthalates cause skeletal malformations in offspring of exposed laboratory animals. DIDP is listed as a developmental toxicant in California due to evidence of skeletal variations in rats exposed during fetal development (OEHHA, 2010). A third-party reviewed hazard assessment, Greenscreen, categorized DIDP as a high hazard for developmental toxicity. In laboratory animal studies that exposed pregnant females to DINP during pregnancy and lactation, the most pronounced effects noted were skeletal malformations and kidney abnormalities in offspring (CRE & ACC, 2003). DEP, DBP, DHEXP, DCHP, DEHP, and diisoheptyl phthalate have also shown effects on skeletal development in laboratory studies, although in some cases the skeleton was affected only at high doses and the relevance to human development is not clear.

Reproductive toxicity in adults

This section considers the evidence for reproductive toxicity hazards other than the effects on the male reproductive system during fetal development, discussed above. Phthalates can affect reproductive health in both males and females. Authoritative bodies in the U.S. and other countries share a consensus that phthalates are reproductive toxicants based primarily on the toxicological effects in animals. There is also a body of supporting evidence for these effects in people, noted for selected endpoints below.

Female reproductive toxicity

Organs that regulate female reproduction include the brain, pituitary gland, ovary and reproductive tract. Phthalate metabolites were associated with alterations of hormonal levels in middle-aged women (Chiang et al., 2021). Multiple effects on reproductive health and pregnancy in women have been linked to phthalates. The most robust findings currently are those showing association of phthalate exposure with pre-term birth and uterine fibroid tumors. The evidence is limited or mixed for effects on the timing of puberty onset, endometriosis, ovarian follicle development and for some adverse pregnancy outcomes, including gestational hypertension and low birthweight babies.

Preterm birth

Researchers at the National Institute of Environmental Health (NIEHS) assessed the data from 16 studies of phthalate exposure and preterm birth that include a total of 6,000 pregnancies and over 500 preterm births (Welch et al., 2022). Individually, some studies reported positive associations between phthalate exposure and preterm birth, one study did not find an association, and several could not conclude based on available data. When the data from all studies were pooled however, increased urinary concentrations of phthalate metabolites in pregnancy were clearly associated with 12-16 percent increased odds for preterm birth. The individual phthalates selected for measurement and urine collection times varied between studies.

Prior to the NIEHS assessment, other key review papers also concluded that phthalate exposure could increase the risk of pre-term birth, with evidence particularly notable for DEHP, DBP, and DEP (Eales et al., 2022; Radke et al., 2019b).

It is uncertain how phthalates cause pre-term birth. A recent review found that placental development, particularly vascularization and structure of placenta, may be perturbed by phthalate exposure and underlie some phthalate-related adverse pregnancy outcomes (Seymore et al., 2022). A recent paper suggested that preconception exposures to both males and females could contribute to the risk of pre-term birth, extending the relevant time window for exposure outside of pregnancy (Y. Zhang et al., 2021)

Other effects on female reproductive health, such as altered puberty onset, endometriosis, ovarian follicle development, and low birthweight babies, may be important adverse health effects of phthalates, with less evidence at this time. The reviews by Radke et al. (2019b) and Eales et al. (2022) both concluded there is some evidence for phthalate association with low birthweight, endometriosis, and ovarian follicle count.

Uterine fibroids

Uterine leiomyomas are benign tumors in the smooth muscle of the uterus that are commonly known as fibroids. Fibroids are very common in women of reproductive age. When they become symptomatic, they cause significant pain and other symptoms and can lead to a hysterectomy.

Black women are disproportionately affected by both more frequent and more severe fibroids (Eltoukhi et al., 2014). A 2017 meta-analysis suggested that DEHP metabolites increased the odds of fibroids (Fu et al., 2017). Evidence for other phthalates was lacking. A more recent review (Bariani et al., 2020) summarized the results of four epidemiological studies of fibroids and phthalate exposure, all of which found evidence for an effect. Bariani et al. (2020) also provided a summary of experimental evidence in animal studies that supports the plausibility of uterine effects of phthalate exposure.

Two more recent studies reported some positive and negative associations between phthalate exposure and fibroids (Pacyga et al., 2022; Y. Zhang et al., 2021). Pacyga et al. report that weight gain could be a modifying factor of the effect of phthalate exposure on fibroids, since weight gain is also a risk factor. Their study found small but significant risks of prior fibroid diagnosis with the sum of all phthalates and a subset of antiandrogenic phthalates and DEHP metabolites. Results were stronger in the subset of women who became overweight or obese and were diagnosed in the last five years (Pacyga et al., 2022).

The epidemiological studies generally measured urinary biomarkers of phthalate exposure after the fibroids formed. For fibroids that may take years to diagnose the timing of exposure assessment is likely to be important but due to rapid clearance from the body, urinary metabolites only report very recent exposure. In one study, Fruh et al. (2021) evaluated the relationship between phthalate exposure and any new diagnoses of fibroids over 60 months in a group of Black women. Some association was seen with a DEHP metabolite, but there was little evidence for overall association of phthalate exposure with incidence of fibroids in this population. Overall, the evidence suggests that phthalate exposure could be linked to more frequent or larger fibroids. The disproportionate prevalence and severity of fibroids in Black women is concerning.

Male reproductive toxicity

Phthalate exposure in laboratory animals causes decreases in measurements of sperm and semen quality. Exposure in people affects testosterone levels as well as sperm and semen quality. Multiple reviews using different methods to assess many toxicological and epidemiological studies support this conclusion. A 2022 review concludes there is robust evidence for adverse effects of phthalates on semen quality and moderate evidence for decreased testosterone associated with phthalate exposure (Eales et al., 2022). This recent analysis builds on an earlier analysis that found statistically significant effects of exposure to DBP and BBP on sperm concentration (Cai et al., 2015).

A systematic review of male reproductive outcomes for a subset of phthalates concluded that there is moderate to robust evidence of an association between DBP, BBP, DEHP, and DINP and adverse effects on semen quality parameters (Radke et al., 2018) and moderate evidence of DEHP, DINP and DIDP with reduced testosterone in adult men. The authors emphasize that the exposures in the human studies are at levels common in the general population. Limited evidence for some phthalates may be due to fewer studies or lower exposure levels and should not be viewed as evidence of no effect.

Hoyer et al. (2018) also concluded that there is moderate evidence for testosterone reduction in adult men and some evidence for effects on sperm quality. The Canadian assessment of phthalates concluded that phthalate exposure could reduce fertility parameters such as sperm counts and motility in adult men (ECCC & HC, 2017).

Cancer

The National Toxicology Program conducted cancer studies of DEHP, DBP, and BBP in rats and mice and some limited dermal exposure studies on DEP and DMP. For the most part, animal experiments suggest that phthalates have limited potential to cause cancer. Phthalates are generally not genotoxic. The notable exception is that there is clear evidence of cancer in laboratory animals exposed to DEHP.

Dietary exposure to DEHP caused liver tumors in rats and mice of both sexes, including PPAR-alpha null mice. DEHP also caused benign testicular and pancreatic tumors in male rats and uterine tumors in female rats. Human evidence is inadequate to support a robust evaluation of carcinogenesis by DEHP. The International Agency for Research on Cancer classified DEHP as 2B, or possibly carcinogenic to humans. EPA classifies DEHP as a probable human carcinogen (NTP, 2021b) NTP states there is clear evidence of carcinogenic activity in rats for DEHP (NTP, 2021) and that DEHP is reasonably anticipated to be a human carcinogen (National Toxicology Program, 2021b).

DINP is listed as a carcinogen in California based on neoplastic lesions in liver and mononuclear cell leukemias observed in laboratory rodent studies. EPA recently stated that based on a technical review, the available literature provides evidence that DINP can be reasonably anticipated to cause cancer in humans (CRE & ACC, 2003).

DBP and BBP produced pancreatic adenomas in male rats exposed for two years, but the evidence was considered equivocal by the National Toxicology Program (NTP, 1997, 2021b).

There is some evidence for carcinogenicity in people. Some positive results have been reported for thyroid, colorectal, and prostate cancers. One case-control study of breast cancer cases within a multi-ethnic cohort found that the women in the top two thirds of exposure to DEHP had higher odds of breast cancer (Y. Zhang, Lu, et al., 2021). Exposure in this study was assessed by one pre-diagnostic urine sample and, as such, remains suggestive. Several other studies of breast cancer risk have produced null or inverse findings. For example, a study of breast cancer cases from the larger Women's Health Initiative cohort concluded that urinary phthalate concentrations were not associated with risk of invasive breast cancer (Reeves et al., 2019).

A positive finding comes from a Danish research group with a novel approach to characterizing exposure. They leveraged the availability of national pharmacy data on prescription drugs in Denmark (Ahern et al., 2019). Filled prescriptions for medications that contain DBP in the coating were associated with increased risk for estrogen receptor-positive breast cancer. The same Danish research group also studied childhood cancers, again using phthalate-containing prescriptions as an exposure metric (Ahern et al., 2022). Osteosarcoma, a bone cancer, occurred at higher rates in children who had been prescribed phthalate-coated medications. The authors point out that all the children in their study were exposed to phthalates from other sources in addition to coated medications but argue that the findings are meaningful because medication exposure dominates total dose for people who have that exposure.

Other health effects of concern

Diabetes, glucose tolerance, and insulin resistance

Phthalates may increase the risk of type 2 diabetes, gestational diabetes, and insulin resistance in people. In laboratory animals some phthalates can alter glucose balance and impair glucose uptake. Phthalates are associated with glucose homeostasis disruption in people (T. Huang et al., 2014) and they can interact with receptors that may play a role in the development of type 2 diabetes and obesity (Begum & Carpenter, 2021).

A systematic review of studies on the metabolic effects concluded that there is moderate to strong evidence that phthalate exposure can elevate diabetes risk but only limited evidence for insulin resistance (Radke et al., 2019a). The review findings were driven by large effects on incident diabetes in one high quality study (Q. Sun et al., 2014) that reported type 2 diabetes was associated with prior exposure to phthalates (DEP, DBP, DiBP, and BBP) in middle aged women. The same effect was not observed in older women, and the study did not evaluate metabolites associated with DIDP or DINP.

Similarly, in a large group of women followed prospectively for six years, phthalate metabolites in spot urine samples showed some suggestive association with incident diabetes (Peng et al., 2023). This effect was only observed in white women. In another study though, urinary phthalate metabolites were more strongly associated with diabetic risk measures in Mexican American and non-Hispanic Black study participants compared with Caucasian study participants (T. Huang et al., 2014).

Gestational diabetes

Evidence presented in two recent review papers support an association between phthalates and gestational diabetes mellitus (GDM), or factors that increase risk for GDM. Risk factors linked to phthalates include gestational glucose intolerance and gestational weight gain (Eberle & Stichling, 2022; Yan et al., 2022). Evidence appears slightly stronger for biomarkers of DEP and DBP exposure compared to the other phthalates measured. Few of the reviewed studies included major metabolites of DINP or DIDP, limiting the evidence for or against these phthalates and GDM risk. Other factors play a role in development of GDM too, making it harder to discern the specific role of phthalates.

DEP metabolites in urine, first and third trimester levels averaged, were linked to increased odds of developing gestational diabetes and impaired glucose tolerance (Shaffer et al., 2019). A study of Chinese women reported association of several phthalate metabolites with GDM (Chen et al., 2022). DEP exposure was associated with elevated blood glucose, and gestational weight gain, markers of gestational diabetes risk, in a group of pregnant women (James-Todd et al., 2018), and impaired glucose tolerance in sub fertile pregnant women (James-Todd et al., 2016).

In a Canadian cohort, there was no statistical association with diagnoses of gestational diabetes or glucose tolerance with first trimester phthalate metabolites in urine (Shapiro et al., 2015). A California study of Latina women found no associations between first and second trimester phthalates and GDM or impaired glucose tolerance. There was some association in this population between the DEP metabolite level and gestational weight gain (Zukin et al., 2021). Overall, the evidence linking phthalate exposure with dysregulation of glucose metabolism in pregnancy is suggestive and particularly notable for DEP.

Obesity

A review of the metabolic effects of phthalates considered the toxicological and epidemiological evidence taken together was not adequate at the time of data collection to evaluate the relationship between phthalate exposure and increased adiposity (Radke, Galizia, et al., 2019). Similarly, a meta-analysis of 29 publications from 2007 to 2019 found weak evidence of a positive association between measures of adiposity and phthalate exposures in adults. It also included studies that showed negative associations (Ribeiro et al., 2019). A recent review of 14 studies, which take repeated outcome measures over time and multiple exposure measurements, found some significant associations between prenatal exposure to phthalates and measures of obesity later in life. Mixed and inconsistent results were also noted (H. Gao et al., 2022).

In one positive study, Hatch et al. (2010) found an association between four phthalates (MEP, MEHP, MBP, and MBzP) and waist circumference in U.S. men aged 20-59, but not in women. As with other health endpoints, most of the epidemiological studies linking phthalates to adiposity are observational studies based on a single measurement of exposure and might obscure the relationship with effects. Since data was gathered for the two reviews cited above, some new epidemiologic research into phthalates as contributors to obesity has found associations between obesity and phthalates measured in blood and urine samples (Golestanzadeh et al., 2019).

Dubey et al. (2022) measured 13 phthalate metabolites in urinary samples from pre-and post-menopausal women and found that higher levels of individual metabolites carried a greater relative risk of body mass index (BMI) greater than 30 after adjusting for several factors, including physical activity. This same study found associations between phthalate exposure and metabolic syndrome, defined as three or more abnormal levels of cardiometabolic symptoms, such as dyslipidemia and hypertension (Dubey et al., 2022). A prospective study of women over 10 years reported a significant association between faster weight gain and phthalate exposure (Song et al., 2014).

Among children, a study from the Korean National Health Survey investigated eight phthalate metabolites and found only MECPP to be associated with obesity (by BMI) in children aged 3-17 (Seo et al., 2022), whereas a positive relationship between DNOP metabolites (e.g., MnOP) at 6 years carried a significant risk of obesity among Dutch children at 6 years and 10 years old (Silva et al., 2021). Among several studies in laboratory animals, a comparison of the effects of DEHP and DINP on lipid metabolism found that both phthalates caused dysregulation but that the specific effects were different and affected the sexes differently (Y. Huang et al., 2019).

Possible effects of prenatal exposure on the developing metabolic system also show limited evidence for phthalate effects. In newborns, levels of DEHP metabolites (MEHHP and MEOHP) in umbilical cord blood were associated with a more rapid increase in body mass during the first three months after birth (S. H. Kim & Park, 2014). In 5 year-olds, maternal prenatal exposure to DEP and DIDP were linked to increased BMI and overweight status (Berger et al., 2021).

On the other hand, a meta-analysis of studies investigating pre- and post- natal DEHP exposure concluded that DEHP was associated with lower BMI in children due to impaired muscle mass rather than direct effects on fat mass (Lee et al., 2022).

Thyroid dysregulation

Some evidence in rats and mice show that phthalate exposure can alter thyroid hormone levels and other parameters related to thyroid function (Bereketoglu & Pradhan, 2022; C. Liu et al., 2015; D. Sun et al., 2022). DEHP, DnHP, and DnOP all elevated serum triiodothyronine and decreased serum thyroxine, although these effects were not statistically significant (NTP-CEHRH). Most epidemiological studies of the effect of phthalates on thyroid function in people have focused on exposures in pregnant women.

Pregnant women are a sensitive population because maternal thyroid function is necessary for many aspects of normal fetal development, especially during the first trimester. Fetal thyroid hormone disruption may particularly affect the nervous and metabolic systems after birth, and phthalates have been implicated in toxicity to the developing nervous system. Multiple epidemiology studies have reported that phthalate metabolites in urine are linked to changes in circulating thyroid hormone levels during pregnancy (P. C. Huang et al., 2016; Johns et al., 2016; Nakiwala et al., 2022) (Derakhshan et al., 2021; Donat-Vargas et al., 2021; Romano et al., 2018; Souter et al., 2020; Villanger et al., 2020; Wu et al., 2022).

A review of 13 epidemiology studies of DEHP exposure concluded that the overall evidence suggests a significant association of DEHP with altered thyroid function, particularly altered thyroxine levels (M. J. Kim et al., 2019). Overall, fewer studies on thyroid function have included exposure measurements for DINP and DIDP, which is an important data gap since some evidence has suggested a potential effect of DINP on thyroid function during pregnancy (Derakhshan et al., 2021).

Asthma and related respiratory symptoms

Phthalate exposure has been associated with allergic airways diseases, including asthma, in some epidemiological reports. Potential links between phthalate exposure and childhood asthma and other respiratory illness are of particular interest because childhood asthma causes significant population morbidity. It is also of interest because the prevalence of childhood asthma and use of emergency care are disproportionate by race (Milligan et al., 2016). Epidemiology studies evaluate exposure by collecting urine during specific time windows, including prenatal exposure to mothers that coincides with the development of fetal lungs, or exposure directly to the study participants after birth. There is insufficient evidence to define the exposure window that has the greatest effects.

A Swedish cohort study of prenatal phthalate exposure reported significant association of first trimester maternal urinary levels with wheeze in 24-month-old children for biomarkers of DiDP, DPHP, BBzP, and DiNP, with stronger effects in children whose mothers did not have allergic airways disease (Preece et al., 2022). Asthma has a genetic component that can make it more difficult to detect other causal factors in epidemiological studies. A meta-analysis of 16 studies that assessed phthalate biomarker association with asthma risk found significant relationships of DEHP, BBP, DINP, and DIDP metabolites with increased asthma risk in childhood populations (Wu et al., 2020). A cohort study of children in Washington’s Yakima valley reported that some markers of inflammatory responses and oxidative stress that can indicate worsening asthma were elevated in asthmatic children who had higher levels of phthalates in their urine (Babadi et al., 2022a, 2022b).

Bolling et al. (2020) conducted an extensive review that included epidemiological, experimental toxicology, and in vitro cell culture studies published up to 2019 with relevance to phthalate exposure and allergic disease. They concluded that the body of evidence overall supports an association between phthalates and allergic disease in people, although there are inconsistent and null results too. In the epidemiology studies reviewed by Bolling et al. exposure to phthalates was measured variously as urinary metabolites in pregnant mothers or study subjects, concentration in indoor dust, or the presence of phthalate-containing products such as flooring or wall covering, complicating analysis (Bølling et al., 2020).

Findings in animal models support the association of phthalates with markers of allergic disease risk and the potential to cause respiratory toxicity, although most animal data on lung effects are for DEHP with data gaps for other phthalates (Bølling et al., 2020). Hwang et al. (2017) reported altered immune responses and production of asthma in mice exposed to DINP.

Most studies looked for association of various outcome measures with exposure to individual phthalates. A recent analysis pooled data from two prenatal cohort studies (Adgent et al., 2020). These authors applied statistical methods to assess effects of prenatal exposure to phthalates as mixtures on wheeze and asthma in four- to six-year-old children. In the complete cohort, total phthalates did not increase odds of respiratory endpoints and some protective effects were reported. However, when the analysis was restricted to boys of mothers without asthma, prenatal phthalate exposure significantly increased odds of wheeze or asthma. The association of phthalates with respiratory disease endpoints were also significant when the analysis was conducted for boys only. Maternal MEP contributed the most to the combined effect of phthalates in boys in this combined study. DEHP had mostly protective effects toward respiratory disease in the combined cohort, an unexplained finding.

Non-cancer organ toxicity

Both the liver and kidney aretargets of phthalate toxicity in rodents. EPA's 2022 Technical Review of DINP concluded that DINP produces chronic liver and kidney toxicity in rats. Thus, DINP can reasonably be anticipated to cause serious or irreversible chronic health effects in humans at moderately low to low doses. These include developmental effects, kidney toxicity, and liver toxicity (US EPA, 2022a). DEHP also caused non-cancerous kidney lesions in male and female rats. The CHAP committee concluded that DIDP and DnOP cause adverse effects on the liver and kidney in laboratory animals at high exposure levels (CHAP, 2014). Weaver et al. (2020) concluded that there is moderate evidence DEP causes liver toxicity.

Animal studies have also shown some limited effects of phthalates on other organs, including the pancreas, testis, uterus, heart and bone marrow.

Few studies of overt liver or kidney toxicity in people were identified. Phthalates are associated with altered kidney function in some studies (X. Zhang et al., 2023). An assessment of markers of liver injury in a nationally representative sample of people reported significant associations of several liver function tests with phthalates (Yu et al., 2021). Associations were significant for both the urinary concentration of phthalate metabolites analyzed individually and when the analysis was done using methods that account for the effects of the mixture of phthalates. Overall, there is concern for how effects of multiple phthalates could together produce liver or kidney toxicity at relevant levels, particularly in people with existing health conditions that affect these organs.

Cumulative effects of multiple phthalates and co-exposure with other chemicals

Phthalates can act together to disrupt similar physiological pathways and produce similar toxic endpoints (Howdeshell et al., 2017), and most people are exposed to multiple phthalates daily. The CHAP committee concluded that the toxicological effects of phthalate mixtures exceeded the effects of the most potent chemical in the mixture for the studies evaluated (CHAP, 2014).

Authoritative bodies in the U.S. have prioritized evaluation of cumulative risks, meaning risks of concurrent exposure to multiple phthalates (NRC, 2008; US EPA, 2011). Several cumulative assessments from authoritative bodies are available (CHAP, 2014; ECCC & HC, 2017; Silano et al., 2019). Disruption of male fetal development in the rat is the most used critical endpoint to develop health guidance for exposure to multiple phthalates. EPA is currently developing an updated cumulative risk assessment and draft results are expected in 2023.

It is important to note that phthalates and phthalate mixtures do not act in isolation in the human body. Not only are people exposed to multiple phthalates simultaneously, but there are many other environmental chemicals that pose similar health hazards. These combined effects may reduce the safe levels of exposure that are determined from considering one chemical exposure in isolation.

Experimental studies in animals to assess cumulative impacts across different chemical classes that share toxic effects on androgen signaling demonstrated cumulative effects on male reproductive development. A recently published group of experiments exposed rats to complex mixtures of chemicals including several phthalates and some pesticides (Conley et al., 2021). When pregnant rats were exposed to a mixture in which the individual chemicals were at half the level that caused an effect in previous single chemical studies, effects were significant. Fetal testosterone production was affected by the mixture when exposure to each individual chemical was eight times lower than individual chemical effect levels. Conley et al. (2021) estimated that current health protective levels may need to be lowered by an average of 25-fold to protect against these complex mixture effects (Conley et al., 2021).

A Danish research group developed a tool to support predicting the toxic effects of human exposure to common chemical mixtures and applied it to six phthalates as a case study (Boberg et al., 2021). They compiled a database of hazard and exposure estimates and health guidance values for a large set of chemicals. Chemicals were grouped into mixtures that affect similar organs or health. When co-exposure to other chemicals that affect similar endpoints was included, phthalates were predicted to contribute to mixture risks that were above effect thresholds for toxicity to the kidney, liver, thyroid, and reproductive systems (Boberg et al., 2021).

The tool is strictly experimental at this time but serves to emphasize that the real-world complex mixtures people are exposed to can lead to health effects even when the exposure level of an individual chemical is not considered to exceed available health guidance values. The additional uncertainties of chemical mixture effects support a prudent and conservative public health approach to phthalate hazards.

Human exposure to phthalates

Exposure summary

Phthalates can enter the body from eating food and drinking beverages, using personal care products on the skin, breathing indoor air and intaking dust, and undergoing some medical procedures. Diet is the dominant source of exposure for most people to most phthalates. Ingestion of phthalates that get into indoor dust from consumer products is especially important for infants and small children. Personal care products are a dominant source of DEP. Information about how much additional exposure occurs from outdoor sources like air, soil, and water is limited but suggests that these are not major exposure pathways. Some medical procedures and medications can result in high phthalate exposure. Children generally have higher body burdens for most phthalates than adults. They eat more food for their body weight and ingest more dust during play.

Since phthalates are present in different kinds of products and nearly everyone has exposure from multiple sources, the relative contribution of specific sources to total population exposure is complex. We know that phthalate exposure can vary by age, race, occupation, and health status, leaving some people with a disproportionate exposure burden.

Biomonitoring data

Phthalates are rapidly cleared from the body after uptake, with half-lives generally less than 24 hours and primarily excreted in the urine. Exposure assessment for phthalates is most frequently based on measurement of metabolic breakdown products in urine samples. Urinary metabolites are widely used as biomarkers of total intake of phthalates across multiple sources and pathways of exposure. Urinary metabolites are the exposure metric of choice for correlation with health effects in most epidemiological studies. Phthalates metabolites are detected in nearly all urine samples that are collected and analyzed as part of routine biomonitoring surveillance programs.

The National Health and Nutrition Examination Survey collects and analyzes biomarker concentrations of chemical contaminants in urine samples from U.S. residents and reports representative data for U.S. populations by race, age, and gender. Urinary metabolites of several phthalates were included in NHANES from 1999 – 2018 (CDC, 2022). Over the time period for which NHANES has analyzed phthalates, the age groups of participants included in the survey and the specific phthalate analytes measured have changed. For example, analyses of DIDP and DINP were initially limited to a metabolite that was later found to represent only a fraction of the total intake of these phthalates.

Highlights from NHANES national biomonitoring results:

- Phthalate metabolites are detected in over 90 percent of urine samples.
- The DEP metabolite MEP has the highest urinary concentration of the phthalates that are measured.

- The concentration of most phthalate metabolites in people has been declining over the two decades of NHANES data. Concentration levels of DEHP metabolites have declined substantially over the last decade.
- The metabolites of the longer chain phthalates DINP and DIDP that are included in NHANES changed with time as science clarified which metabolites of these phthalates dominate excretion in people. The data indicate that exposure rose dramatically from 2005-2015. Since 2015, exposure to DINP and DIDP has now begun to trend down.
- DIBP exposure increased until 2010 but has declined since that time.
- U.S. exposure to DOP and DBP is often below detection limits, reflecting the lower use of these phthalates in U.S. products.
- Children are more highly exposed than adults for most of the phthalates in NHANES. The metabolites of DIDP and DINP are particularly notable for an inverse relationship with age. DEP is an exception: concentrations are higher in adults.
- In the last two cycles, NHANES included younger children in the sampled population, aged three to five years. This age group tends to have the highest concentration in urine for most phthalates other than DEP.
- Racial disparity in DEP exposure levels is apparent, with higher mean exposure levels in Blacks and Hispanics. One of the DINP metabolites is also elevated in Black relative to white race.
- DEP exposure is higher in females, while exposure to some other phthalates is higher in males.

A biomonitoring survey conducted in Washington shows that exposure levels are generally similar to those in the larger NHANES sample of the U.S. The results of this survey were reported to CDC in 2014 but remain unpublished. Unpublished results are described here because of their relevance to phthalates in Washington. The Washington Environmental Biomonitoring Survey (WEBS) was a random sampling of state residents aged six and older during 2010-2011. In comparison to urinary concentrations in the U.S. as reported in NHANES, women of childbearing age in Washington had comparable exposure to most phthalates, with some lower levels of DINP and DIDP metabolites noted.

A later module of the Washington program sampled an additional 585 women and children who lived in subsidized housing to examine lifestyle, housing, and dietary correlates of chemical exposures in this population. The low-income housing study included analysis of nine phthalate metabolites in urine samples. Stored samples from comparable age and gender participants in the WEBS study were analyzed for the same nine phthalate analytes.

Most phthalate analytes were detected in 98 to 100 percent of samples in both the WEBS and subsidized housing groups. The median concentration of urinary metabolites of DEP, DBP and DIDP were elevated relative to the matched samples from randomly selected Washington residents. The two groups were not sampled concurrently, but for context, U.S. phthalate concentrations in urine declined from 2010 to 2014, yet the subsidized housing population in Washington sampled in 2014 was more highly exposed than the 2010 comparison group.

This was particularly true for DEP. The median DEP concentration in urine of women in the subsidized housing study was 2.5 times higher than the national median concentration. The participants in the subsidized housing study identified as 59 percent Black or African American, 15 percent Asian, 11 percent Caucasian, and 22 percent other racial background. Overall, our Washington data show that U.S. patterns of phthalate exposure are useful surrogates for statewide averages, but there are highly exposed subpopulations within our state.

Sources and pathways of exposure for people

Because phthalates have such widespread use in manufactured products, exposure to many different sources at home, work, school, outdoors, and even at the doctor's office all contribute together to the level of phthalates in our bodies at a given point in time. Phthalates are inhaled, ingested, absorbed through the skin, and received directly into body systems from medical procedures.

Pathways of exposure to phthalates

- **Ingestion:** The primary route of exposure to phthalates for most people is ingestion. Ingestion of phthalates occurs primarily via the diet, although ingestion of phthalate-containing medication and inadvertent ingestion of dust also contribute to exposure. Phthalates have been measured in a wide variety of foods and plastic articles that contact foods on their way from farm to table. Inadvertent ingestion of dust also contributes to total phthalate intake and is especially important in young children (CHAP, 2014). Direct mouthing of phthalate-containing items is relevant to ingestion by infants and toddlers. Hand-to-mouth behavior can introduce dust to the mouth in young children. Certain medications contain phthalates in the coating. People who require these medications can ingest relatively large doses this way. See the section on phthalates in health care for more information.

- **Inhalation:** People can breathe in phthalates when they are present in the air. Indoor air can be a significant source of exposure to phthalates (Adibi et al., 2008; Preece et al., 2021). However, inhalation is thought to contribute less to total phthalate exposure than ingestion. As described in the section on chemical properties and section on environmental fate, phthalates are semi-volatile chemicals with a range of physical-chemical properties that dictate how likely they are to be found in the air. Phthalates released from consumer products may be present in the vapor phase or bound to particulate matter in the air (Weschler et al., 2008; Weschler & Nazaroff, 2008, 2010).

  Phthalates are commonly detected in indoor air sampling (Adibi et al., 2008; Preece et al., 2021). They partition variably between the gas phase and airborne particulate, with the lower molecular weight phthalates like DEP and DMP being more common in the gas phase and phthalates with longer side chains such as DINP partitioning primarily into particulate matter.

Estimates from one study of the fraction of total daily phthalate intake attributable to indoor air and dust ranged from 0.7 to 28 percent in pregnant women (Preece et al., 2021). Estimated contribution of indoor air and dust was greater for the more volatile phthalates. Median inhalation exposure doses of nine phthalates were computed from air sampling in a range of indoor environments measurements (Tran & Kannan, 2015). The authors estimated that exposure doses from inhalation are ten times higher for infants compared with adults. They also estimated that inhalation is an important route of exposure to DEP but less so for other phthalates. Phthalates are also detected in outdoor air, but at levels that are estimated to be approximately ten times lower than typical indoor air studies (Rudel et al., 2010). People can be exposed to phthalates in the air while in transport too because many components of vehicle interiors contain phthalate plasticizers.

- **Dermal uptake:** Phthalates can be absorbed through the skin to some extent, although uptake by this route varies substantially across phthalates. Phthalates with longer side chains have low dermal absorption (below five percent for DINP and DIDP). For smaller phthalates molecules, dermal uptake is more likely. Wormuth et al. (2006) suggested that over 80 percent DEP exposure could be due to dermal application of personal care products. Skin uptake may be of particular importance for infants whose skin is more permeable and who have a high surface area to body weight ratio (Sathyanarayana et al., 2008).
- **Direct systemic exposure:** Surgical procedures, IV therapy, and respiratory therapy produce some of the highest known phthalate exposures. The greatest concern are exposures received in neonatal intensive care. See the section on reducing exposure to phthalates in health care for more discussion of this route of exposure.
- **Exposure in utero:** Developing fetuses are directly exposed to phthalates that cross the placenta from maternal circulation.

Sources of phthalate exposure

The CHAP report identified seven key sources of phthalate exposure to pregnant women and children: diet, prescription medications, toys, childcare articles, personal care products, indoor sources as a group, and outdoor sources as a group. Their purpose was to assess risk for toys and childcare articles, so these were explicitly identified. Exposure patterns have change in the decade since this panel convened, but in general, the sources identified by the CHAP assessment guide our work in this action plan. Some selected sources are highlighted below.

- **Food** is the dominant source of exposure to most phthalates for most people (US EPA, 2022a). A detailed exposure assessment by the CHAP (CHAP, 2014) concluded that ingestion of food and beverages dominated exposure for women and all age groups of children. For infants, exposure can occur via breast milk. Some infant formulas are reported to have detectable levels of phthalates. The Reducing Dietary Exposures to Phthalates section summarizes reports on measurement of phthalates in foods and biomarker studies of the association of dietary patterns with urinary metabolites of phthalates in people.

- **Coated medications** can result in exposure much higher than typical U.S. averages (Hernández-Díaz et al., 2013). The CHAP exposure assessment concluded that women and older children could have significant exposure through medications. That panel did not assess exposure to men. The section on phthalates in health care environments provides more background information.
- **Consumer products and dust:** Most house dust sampled in the U.S. contains multiple phthalates (Dodson et al., 2017; Mitro et al., 2016). Phthalates get into dust after they are released by volatilization or wear from a wide range of consumer products, including building products. As described, phthalates are semi-volatile, and after they are released from products into the air, they tend to gather onto particles (Weschler et al., 2008; Weschler & Nazaroff, 2008, 2010). They are found in dusts that settle on floors and surfaces (Dodson et al., 2017). A systematic analysis of data aggregated from multiple studies of US indoor dust samples concludes that phthalates are dominant contaminants, with levels in dust samples that exceed the levels of other environmental chemicals (Mitro et al., 2016).

  There is a substantial literature focused on vinyl flooring as a contributor to human exposure via dust and indoor air. We have previously assessed the findings and concluded that vinyl flooring is a significant source of phthalate exposure for SPWA (Ecology, 2022a). Contributions of residential dust and air to total phthalate intake were estimated.

  Biomarker studies demonstrate that dust is a relevant exposure route for phthalates, especially for young children who can ingest more dust than adults as a result of spending more time near the floor and direct mouthing and hand-to-mouth behaviors (CHAP, 2014; US EPA, 2011). The relevance of dust as an exposure pathway for children is emphasized in a recent intervention study (Sears et al., 2020). Interventions put in place to remove and reduce household dust resulted in lower urinary phthalate metabolite concentrations in children compared to children living in homes without the intervention (Sears et al., 2020). Ingestion of phthalates via dusts is also discussed further in some of our recommendations about specific products and exposure scenarios in this action plan. See the recommendations on Consumer Products, Building Materials, and Day Care and Early Childcare Facilities for more information.
- **Vehicle interiors** can be an important microenvironment for exposure (Lexén et al., 2021). Automobile interiors contain many phthalate containing materials (primarily DINP and DIDP) in the upholstery, dashboards and door panels, floor mats, window gaskets, molded parts like armrests or cupholders (ACC, 2021b). Volatilization and wear of these materials result in phthalate containing dusts in vehicles. Volatilization of phthalates from vehicle interior materials is accelerated when vehicles are parked closed in hot or sunny conditions.

  A study in Saudi Arabia found that dust from cars had higher levels of DEHP than house dust (Albar et al., 2017). Car interior dust sampled in Barcelona found DMP, DEP, DIBP, DBP BBP, and DEHP in 100 percent of samples (Velázquez-Gómez et al., 2019), and a Chinese study found that DBP and DEHP in vehicle air could make a substantial contribution to total exposure (Bu et al., 2021). None of these studies measured DINP and DIDP which are the primary phthalates used in vehicle interiors in the U.S. We did not find useful studies of potential for phthalate exposure in U.S. vehicle interiors, nor for public transit vehicles which may have phthalates in vinyl seating and interiors.

- **Personal care products:** Numerous studies have linked personal care product use to phthalate metabolites in people's urine. CHAP found that personal care products were a significant source of DEP exposure for pregnant women. DEP is widely used in fragrances in personal care products intended for use on skin or hair, and in fragrances household and clearning products that contact skin during use. People are exposed to more DEP than other phthalates, and women are more highly exposed than men. Personal care product use has been clearly linked to urinary excretion of MEP in numerous studies (Buckley et al., 2012; Parlett et al., 2013; Philippat et al., 2015). Intervention studies can generate evidence of association between a suspected source and biological exposure. An intervention study that provided phthalate-free personal care products to Hispanic teenage girls reduced MEP in urine by 24 percent (Harley et al., 2016). Personal care product use varies with race (Collins et al., 2021), see below for a discussion of racial disparities in phthalate exposure from personal care products.
- **Medical devices** made of PVC often contain high concentrations of DEHP to confer characteristics that are functionally important. Patients undergoing medical procedures such as extracorporeal membrane oxygenation, cardiopulmonary bypass, dialysis, blood transfusion, enteral or parenteral nutrition, and IV therapy can receive high exposures to DEHP that leaches from medical plastic products. Tubing and bags containing DEHP are used in many of these applications. Fat-containing nutritional fluids have been shown to be effective at leaching DEHP. Medical exposure to DEHP in premature infants in intensive care units is a high concern (Mallow & Fox, 2014) and may be linked to development of neonatal hypertension (Jenkins et al., 2019).

  Most exposure in the NICU was estimated to be from IV bags and tubing or respiratory therapy including endotracheal tubes (Jenkins et al., 2021). Pregnant women undergoing critical medical procedures also have high concern because of potential exposure to the developing fetus (Marie et al., 2017). DEHP exposures received during medical procedures can be very high, tens of times higher than average exposures, and well over health guidance values (Mallow & Fox, 2014; SCENIHR, 2017). See the section on reducing exposures in health care for more discussion of the products, exposures, and opportunities for exposure reduction from this source.

Occupational exposure to phthalates

Because phthalates are ubiquitous, many people are likely exposed at work. We did not identify any studies of occupational exposure in Washington workplaces, a significant data gap.

A survey of occupational biomonitoring for phthalates identified 22 studies, only four of which were from U.S. and represented a limited range of workplace types (Fréry et al., 2020). In one of these studies workers, engaged in PVC compounding, manufacturing PVC film, and manufacturing some rubber products had post-shift urinary phthalate metabolite levels significantly higher than general population averages (Hines et al., 2009, 2012).

Custodian and janitorial occupations could be exposed through phthalates in cleaning products, adhesives and sealants used for repairs, and other products. A study of custodian exposure found that MEP exposure was significantly associated with use of certain cleaning chemicals, but exposure was multifactorial and not clearly associated with the work shift (Cavallari et al., 2015).

Salon workers have been a focus of occupational exposures to phthalates, due to the phthalate use in nail, skin, and hair products. Boyle et al. (2021) measured post-shift exposure to hair salon and office workers and found MEP was ten times higher in the hairdressers. A study of Toronto salon workers assessed exposure through air measurements in both the workplace and personal exposure collected via silicone wristbands and brooches. Lower molecular weight phthalates were highest in the room air, while DEHP, DINP and DIDP were more prevalent in personal exposure zones.

DEP was the dominant phthalate exposure to Korean and Chinese salon workers in New York and New Jersey monitored with silicone wristbands (Han et al., 2022). Varshavsky (2018) compared post-shift phthalate metabolites in urine of Vietnamese salon workers in California to the levels in Asian Americans as reported in NHANES. The salon workers had significantly higher exposure to DBP, DIBP, and DEHP.

Food service and health care workers could be exposed to phthalates in vinyl gloves. Many alternative glove products without phthalates are available, but an NGO study reported that 14 percent of food service gloves collected from restaurants still contained high levels of phthalates (Olson et al., 2019). Reliable measurements of exposure via gloves were not identified.

No studies on occupational exposure to phthalates in retail businesses were identified, but it is plausible that plastic and fragranced products for sale, as well as in-store furnishings and building materials, could together generate exposure to phthalates in air and dust at levels higher than other indoor environments.

Disproportionate and high exposures

Some phthalates exposures occur to greater extent in some groups of people than others. As described previously, children are more highly exposed to phthalates than adults. People with medical exposures to plastic medical devices or phthalate-containing medications have the highest exposure levels.

As described under Biomonitoring Data above, a Washington state study found that women in subsidized housing had higher exposure to some phthalates than a randomly sampled population of Washingtonians. Thus, low-income women could be disproportionately exposed, although the study was not designed to evaluate this question, so inference is limited. Some inverse associations of DBP, BBP, and DEHP metabolite levels with income were reported by EPA for women and children (US EPA, 2022a).

Multiple studies have assessed disparities in exposure to chemicals present in personal care products, including phthalates. Among women, studies that evaluated demographic predictors of DEP exposure have routinely reported that non-Hispanic Black women and women with lower educational attainment have significantly higher concentrations of DEP metabolite in urine (Bloom et al., 2019; Chan et al., 2021; Hoffman et al., 2018; James-Todd et al., 2017; Mitro et al., 2019; Polinski et al., 2018; Wenzel et al., 2018). Findings of elevated urinary MEP in non-Hispanic Black women are consistent with a 2018 analysis of Black haircare products that found DEP in 14 out of 18 products tested (Helm et al., 2018). A study of a cohort of U.S. Black women of reproductive age found that personal care products was a significant predictor of urinary MEP within this population (Schildroth et al., 2022; Wesselink et al., 2020).

People with some lower-wage jobs may experience workplace exposure to phthalates. These include janitorial, food industy, retail workers in enterprises with extensive sales of fragranced and PVC items, and plastics fabrication. Because lower economic status is a risk factor for many health conditions, disproportionate exposure to phthalates in lower income people may contribute to a health equity issue.

Conclusions and health equity considerations

There are many uncertainties and data gaps in what we know about exposure and the actual adverse health effects that exposure will cause. To guide our priorities for the action plan, we can put together toxicology evidence and exposure patterns to highlight potential health impacts in the population. From an exposure point of view, our assessment suggests that the action plan should focus on recommendations that reduce:

- **The highest phthalate exposures**, which can occur from some medical treatments. Neonates and pregnant women are of greatest concern. For more information, please see the section on reducing exposure to phthalates in health care.
- **The most widespread sources of exposures** to the general population:
    - **Food** dominates exposure for most adults and older children. People who have less access to unprocessed and minimally processed foods are likely to have higher exposure through food. For more information, please see the reducing dietary exposure section and the food contact articles section.
    - **Consumer products** that contaminate indoor air and dust are a significant contribution to exposure in young children. Ecology is working toward reducing phthalate exposure in dusts through our recent report that recommends restricting the use of phthalates in vinyl flooring (Ecology, 2022a). The section on day care settings proposes to remove old vinyl from day cares, and the sections on consumer products and building materials propose further actions to reduce phthalates in the products that contribute to indoor dust exposures.

Groups of people who are either highly exposed, disproportionately exposed, or more susceptible to health harms would benefit the most from actions to reduce exposure to phthalates. These groups include:

- **Pregnant women** are susceptible to health harms from phthalate exposure, including effects on the fetus, pre-term birth, and gestational diabetes. Pregnant women are exposed primarily through food, and people with limited access to unprocessed and minimally processed foods may have higher exposure. Very high exposure through critical medical procedures during pregnancy should be reduced to prevent harm to the developing fetus.
- In **women of reproductive age** (outside of pregnancy), the potential association of phthalates with fibroids is a concern given the tremendous morbidity burden attributable to fibroids, and the disproportionate incidence and severity of fibroids in Black women. Foods and personal care products that are consumed disproportionately by Black women should be prioritized. SPWA has is currently acting on phthalates that are used as fragrance in personal care products (Ecology, 2022a). Our consumer product recommendations further address personal care products.
- **Developing fetuses and infants,** particularly males, are the most sensitive population to health effects of phthalates. Reducing dietary exposure to pregnant women, DEHP exposure during medical procedures to protect against prenatal exposure and reducing phthalates that accumulate in house dust to protect infants with crawling and mouthing behaviors are important for this group.
- **Young children** are more highly exposed than other groups and take in phthalates by more routes of exposure. Their developing endocrine and nervous systems are highly vulnerable to disruption. In addition, asthma is associated with phthalates and asthma occurs with greater frequency in black boys compared to other children. Current regulations at the federal and state level restrict the use of some phthalates in toys and other children's products, but children continue to be exposed through foods, personal care products, school and art supplies, apparel, footwear and other sources. Washington should work to further characterize and prioritize reduction children's exposure, with special attention to exposures that could disproportionately affect Black boys.
- **Hospital patients** and people who take medications containing phthalates are the most highly exposed people. Progress toward reducing DEHP in medical supplies and equipment has resulted in some exposure reductions to the most vulnerable neonates in the past two decades but other exposures continue to occur, and little attention has been paid to reducing phthalate exposure to critically ill adult patients.
- **Hemodialysis patients** may be an area for further investigation. We were not able to identify what proportion of dialysis centers use plastic tubing that contains phthalates. Because kidney failure is nearly four times higher in African Americans vs white, with smaller elevations in Hispanic vs. non-Hispanic and Native Americans vs Caucasians, these

populations may be of special concern for exposure through hemodialysis procedures (USRDS, 2022).

- **People with occupational exposure** in lower income jobs could have higher exposure to phthalates, another potential exposure inequity, and little is knowns about occupational exposure levels. We consider this an important data gap.

Appendix C. Phthalates in the Environment

Phthalates are a chemical of concern in Washington's environment due to their high production and use volume and their potential to cause adverse effects in ecosystems. Phthalates are used in a wide range of consumer products. We provide more details about these products in Appendix A.

Because pthtalates degrade quickly, they are not categorized as persistent environmental contaminants. However, the continuous release of phthalates from various industrial and municipal sources means they are continually present in our ecosystems. This leads to the potential for chronic exposure in aquatic and terrestrial systems, similar to that of persistent chemicals. Failure to reduce these constant sources of phthalate release has led to the recontamination of sediments in the Puget Sound area following large-scale chemical remediation efforts (Ecology, 2010).

Phthalates enter the environment via the air from industrial production, off-gassing of PVC materials, and water from both industrial and municipal wastewater sources. More specifically, a 2011 Ecology report estimated 34 metric tons of phthalates released annually in the Puget Sound area, including 9.6 metric tons released into the air from industrial sources (Ecology & King County, 2011). From here, the environmental fate of phthalates may differ based on molecular weight. For clarity, when discussing partitioning behavior, this section divides phthalates into three subgroups based on definitions laid out by Environment Canada and Health Canada (EC & HC, 2015a, 2015b, 2015c, 2015d). These categories are general groupings and may have some overlap within chemical properties and toxicities.

Low molecular weight or short-chain phthalates (containing sidechains of three carbons or fewer) may stay in the air for long periods of time. They may travel long distances before depositing in the soil or water. When released into the water or soil, they tend to stay there. Short-chain phthalates also have high-water solubility compared to medium-chain (sidechains of three to seven carbons) and long-chain (sidechains of more than seven carbons) phthalates. This leads to a heightened risk factor for humans, through drinking water, and for aquatic species (EC & HC, 2015c).

High variation in physical and chemical properties of medium-chain phthalates leads to a wide distribution of partitioning scenarios. When discharged to water, most medium-chain phthalates are expected to partition roughly equally between water and sediment. Lower-molecular-weight medium-chain phthalates are more likely to remain in the water. High variation in physical and chemical properties of medium-chain phthalates leads to a wide distribution of partitioning scenarios. The lower molecular weight medium-chain phthalates, when discharged to water, tend to stay in the water rather than partition to water and sediments like most other medium-chain phthalates. Lower molecular weight medium-chain phthalates, when discharged to air, are more likely to stay in the air than most other medium-chain phthalates, which almost always partition to the soil. Medium-chain phthalates discharged to the soil will generally stay in the soil (EC & HC, 2015b).

Long and branched chain phthalates released into the air or water will partition nearly entirely into soil and sediment, although they may also interact with suspended solids in the air or water column (EC & HC, 2015a, 2015d).

Once in the environment phthalates undergo rapid degradation. Phthalates primarily break down by environmental bacteria, fungi, and algae. Phthalates may experience abiotic degradation through hydrolysis, though this is a very slow process. The time needed for biodegradation varies based on the composition of the microbial community, the molecular weight of the phthalate, and suspension media. Degradation is considerably slower in low-oxygen conditions. Given the low oxygen levels present in soil and sediments, phthalates that partition into these substrates will take more time to fully degrade than those in the air or water.

A 2010 study of algal degradation in short-chain phthalates identified a potential concern arising from the environmental fate of phthalates (Babu & Wu, 2010). This study determined that toxin-producing cyanobacteria, *Anabaena flos-aquae* and *Microcystis aeruginosa,* not only rapidly break down short-chain phthalates but can metabolize them and use them as an energy source to enhance growth. This may introduce an additional health hazard to humans and wildlife. These algae can have extremely toxic effects when consumed in contaminated seafood or drinking water or when encountered during recreation activities. A 2009 Ecology report notes that in 2008, nearly 75 percent of algal blooms in the state of Washington produced toxins (Ecology, 2009b). The same report cites a 2008-2009 sampling initiative of Lake Waughop in which the Tacoma-Pierce Health Department identified *Anabaena* and *Microcystis* species as two of the three most common genera of toxin-producing algae collected.

Toxic effects

Phthalates, especially short- and medium-chain phthalates, have well-documented endocrine-disrupting effects on mammals and some aquatic species. Specifically, phthalate exposure is known to drastically decrease sperm production in several species of fish. Phthalate exposure is also assicated with increased mortality of exposed embryos, resulting in severely inhibited reproduction (Corradetti et al., 2013; Mathieu-Denoncourt et al., 2015; Yuen et al., 2020).

Phthalates can cause adverse health effects in aquatic organisms in high quantities; however, the low solubility, rapid biodegradation, and partitioning habits of phthalates result in exposure concentrations below the Probable No-Effect Concentration (PNEC) according to a 2015 State of the Science report from Environment Canada and Health Canada. As such, environmental concentrations of phthalates are unlikely to cause acute or chronic toxic effects in aquatic organisms (EC & HC, 2015a, 2015b, 2015c, 2015d). The report also highlights the uncertainty in effects related to endocrine activity. We need more data to fully understand the effects of phthalates on aquatic ecosystems in Washington. For more details on Ecology's recommendations for this topic, please see the section on Aquatics, surface water, sediment, and biota.

Appendix D. Abbreviations and Acronyms

Abbreviations used in this Action Plan

Table 7: Abbreviations and acronyms for the terms used in this Action Plan.

Acronym	Definition
ACC	American Chemistry Council
ACOG	American College of Obstetricians and Gynecologists
AGD	Anogenital distance
APHA	American Public Health Association
AP	Action plan
ATSDR	United States Agency for Toxic Substances and Disease Registry
BMI	Body mass index
CAP	Chemical Action Plan
CBO	Community-based organization
CDC	Center of Disease Control
CEC	Contaminants of concern
CHAP	Chronic Hazard Advisory Panel
COD	Chemical oxygen demand
CPAP	Continuous positive airway pressure
CPSC	United States Consumer Product Safety Commission
CPSIA	United States Consumer Product Safety Improvement Act
CSPA	Washington Children's Safe Products Act
Danish EPA	Danish Environmental Protection Agency
DCYF	Washington State Department of Children, Youth, and Families
DES	Washington State Department of Enterprise Services
DOH	Washington State Department of Health
EAP	Ecology's Environmental Assessment Program

Acronym	Definition
ECCC	Environment and Climate Change Canada
ECE	Early childhood education
ECEAP	Early Childhood Education and Assistance Program
ECHA	European Chemicals Agency
ECMO	Extracorporeal membrane oxygenation
Ecology	Washington State Department of Ecology
EFSA	European Food Safety Authority
EJ	Environmental justice
EPA	United States Environmental Protection Agency
EU	European Union
EU REACH	European Union Registration, Evaluation, Authorization, and Restriction of Chemicals
FDA	United States Food and Drug Administration
FTE	Full-time equivalent
GDM	Gestational diabetes mellitus
GPO	Group purchasing organizations
HAP	Hazardous Air Pollutant
HAWC	EPA Health Assessment Workspace Collaborative
HB	House Bill
HBN	Healthy Building Network
Health	Washington State Department of Health
HPCDS	High Priority Chemicals Data Systems
HVAC	Heating, ventilation, and air conditioning
HWTR	Hazardous Waste and Toxics Reduction
IAA	Interagency agreement?
IQ	Intelligence Quotient

Acronym	Definition
IV	Intravenous
MCL	Maximum contaminant level
MSW	Municipal solid waste
MTCA	Washington State Model Toxic Control Act
NEP	National Estuary Program
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NGO	Non-governmental organization
NHANES	National Health and Nutrition Examination Survey
NICU	Neonatal Intensive Care Unit
NIH	National Institutes of Health
NIEHS	National Institute of Environmental Health Sciences
NLM	National Library of Medicine
ODW	Washington State Department of Health, Office of drinking water
OEPHS	Washington Department of Health, Office of Environmental Public Health Sciences
P2	Pollution Prevention
PBT(s)	Persistent, bioaccumulative, and toxic chemical(s)
PCR	Polymerase chain reaction
Pers. Comm.	Personal communication
PPAR	Peroxisome proliferator-activated receptor
ppb	Parts per billion
ppm	Parts per million
QAPP	Quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RfDs	Reference doses

Acronym	Definition
RSC	Relative source contribution
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks (Europe)
SPWA	Safer Products for Washington
STP	Standard temperature and pressure
TAPs	Toxic Air Pollutants
TBiOS	Toxics biological observation system
TDI	Tolerable daily intake
TDS	Total dissolved solids
TOC	Total Organic Carbon
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particles
TV(s)	Television(s)
U.S.	United States of America
WAC	Washington Administrative Code
WCSP	Washington Choose Safe Places
WDFW	Washington State Department of Fish and Wildlife
WEB	Washington Environmental Biomonitoring Survey
WET	Whole Effluent Toxicity
WQMS	Water quality monitoring schedule
WSDA	Washington State Department of Agriculture
WWTP	Wastewater treatment plant
XRF	X-ray fluorescence

Chemical names

Table 8: Acronyms for the chemicals discussed in this Action Plan.

Acronym	Chemical Name
BBP	Benzyl butyl phthalate
BPA	Bisphenol-A
DBP	Di-n-butyl phthalate
DCHP	Dicyclohexyl phthalate
DEHP	Di(2-ethylhexyl) phthalate
DEHT	Diethylhexylterephthalate
DEP	Diethyl phthalate
DHexP	Di-n-hexyl phthalate
DIBP	Di-isobutyl phthalate
DIDP	Di-isodecyl phthalate
DiOP	Diisooctyl phthalate
DINP	Diisononyl phthalate
DMP	Dimethyl phthalate
DnHP	Di-n-hexyl phthalate
DnOP	Di-n-octyl phthalate
DPENP	Di-n-pentyl phthalate
MBP	Monobutyl phthalate
MEHP	Mono(2-ethylhexyl) phthalate

Appendix E. EPA Chemical Data Reporting

Table 9. EPA Chemical Data Reporting (CDR) on phthalates (filtered to include chemical names containing "1,2-benzenedicarboxylic acid," nationally aggregated product volume). You can access CDR data for this table on EPA's website.[14]

Chemical name	CAS Registry Number	Production Volume (lbs) (2019)	Production Volume (lbs) (2018)	Production Volume (lbs) (2017)	Production Volume (lbs) (2016)
1,2-Benzenedicarboxylic acid, 1,2-bis(2-ethylhexyl) ester	117-81-7	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000
1,2-Benzenedicarboxylic acid, 1,2-bis(2-butoxyethyl) ester	117-83-9	0	0	39,812	0
1,2-Benzenedicarboxylic acid, 1,2-dioctyl ester	117-84-0	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1,2-dimethyl ester	131-11-3	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	1,000,000 - <10,000,000
1,2-Benzenedicarboxylic acid, 1,2-di-2-propen-1-yl ester	131-17-9	<1,000,000	500,000 - <1,000,000	1,000,000 - <20,000,000	1,000,000 - <10,000,000
1,2-Benzenedicarboxylic acid, sodium salt (1:2)	15968-01-1	63,087	82,100	187,378	191,159
1,2-Benzenedicarboxylic acid, 1-[2,2-dimethyl-1-(1-methylethyl)-3-(2-methyl-1-oxopropoxy)propyl] 2-(phenylmethyl) ester	16883-83-3	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000

[14] https://www.epa.gov/chemical-data-reporting/access-cdr-data

Chemical name	CAS Registry Number	Production Volume (lbs) (2019)	Production Volume (lbs) (2018)	Production Volume (lbs) (2017)	Production Volume (lbs) (2016)
1,2-Benzenedicarboxylic acid, 3,4,5,6-tetrabromo-, 1-[2-(2-hydroxyethoxy)ethyl] 2-(2-hydroxypropyl) ester	20566-35-2	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1-[2-(2-hydroxyethoxy)ethyl] ester	2202-98-4	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 4,4'-carbonylbis-	2479-49-4	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 3,4,5,6-tetrabromo-, 1,2-bis(2-ethylhexyl) ester	26040-51-7	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000
1,2-Benzenedicarboxylic acid, 1,2-diisodecyl ester	26761-40-0	<1,000,000	100,000 - <500,000	100,000 - <500,000	100,000 - <500,000
1,2-Benzenedicarboxylic acid, 1,2-diisooctyl ester	27554-26-3	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1-[2-[(2-methyl-1-oxo-2-propen-1-yl)oxy]ethyl] ester	27697-00-3	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1,2-diisononyl ester	28553-12-0	50,000,000 - <100,000,000	100,000,000 - <250,000,000	100,000,000 - <250,000,000	100,000,000 - <250,000,000
1,2-Benzenedicarboxylic acid, 1-[2-[(1-oxo-2-propen-1-yl)oxy]ethyl] ester	30697-40-6	<1,000,000	<1,000,000	<1,000,000	<1,000,000

Chemical name	CAS Registry Number	Production Volume (lbs) (2019)	Production Volume (lbs) (2018)	Production Volume (lbs) (2017)	Production Volume (lbs) (2016)
1,2-Benzenedicarboxylic acid, di-C6-14-branched and linear alkyl esters	309934-69-8	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000
1,2-Benzenedicarboxylic acid, 3,4,5,6-tetrachloro-, 1,2-bis(2-ethylhexyl) ester	34832-88-7	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester	3648-20-2	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000
1,2-Benzenedicarboxylic acid, 1,2-bis(2-propylheptyl) ester	53306-54-0	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000
1,2-Benzenedicarboxylic acid, 1-[1-methyl-2-[(2-methyl-1-oxo-2-propen-1-yl)oxy]ethyl] ester	65859-45-2	19,133	46,981	28,089	27,972
1,2-Benzenedicarboxylic acid, mixed cetyl and stearyl esters	68442-70-6	<1,000,000	1,000,000 - <20,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, benzyl C7-9-branched and linear alkyl esters	68515-40-2	1,000,000 - <20,000,000	1,000,000 - <20,000,000	20,000,000 - <100,000,000	20,000,000 - <100,000,000
1,2-Benzenedicarboxylic acid, di-C9-11-branched and linear alkyl esters	68515-43-5	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000
1,2-Benzenedicarboxylic acid, 1,2-dinonyl ester, branched and linear	68515-45-7	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000

Chemical name	CAS Registry Number	Production Volume (lbs) (2019)	Production Volume (lbs) (2018)	Production Volume (lbs) (2017)	Production Volume (lbs) (2016)
1,2-Benzenedicarboxylic acid, di-C11-14-branched alkyl esters, C13-rich	68515-47-9	1,000,000 - <20,000,000	20,000,000 - <100,000,000	1,000,000 - <20,000,000	20,000,000 - <100,000,000
1,2-Benzenedicarboxylic acid, di-C8-10-branched alkyl esters, C9-rich	68515-48-0	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000
1,2-Benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich	68515-49-1	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000	100,000,000 - <1,000,000,000
1,2-Benzenedicarboxylic acid, mixed decyl and hexyl and octyl diesters	68648-93-1	0	0	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, di-C8-10-alkyl esters	71662-46-9	100,000 - <500,000	100,000 - <500,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 3,4,5,6-tetrabromo-, mixed esters with diethylene glycol and propylene glycol	77098-07-8	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000	10,000,000 - <50,000,000
1,2-Benzenedicarboxylic acid, 1,2-dicyclohexyl ester	84-61-7	500,000 - <1,000,000	<1,000,000	500,000 - <1,000,000	500,000 - <1,000,000
1,2-Benzenedicarboxylic acid, 1,2-diethyl ester	84-66-2	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000
1,2-Benzenedicarboxylic acid, 1,2-bis(2-methylpropyl) ester	84-69-5	407,303	403,833	384,591	440,833

Chemical name	CAS Registry Number	Production Volume (lbs) (2019)	Production Volume (lbs) (2018)	Production Volume (lbs) (2017)	Production Volume (lbs) (2016)
1,2-Benzenedicarboxylic acid, 1,2-dibutyl ester	84-74-2	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000	1,000,000 - <10,000,000
1,2-Benzenedicarboxylic acid, 1,2-dinonyl ester	84-76-4	<1,000,000	1,000,000 - <20,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	85507-79-5	<1,000,000	<1,000,000	<1,000,000	<1,000,000
1,2-Benzenedicarboxylic acid, 1-butyl 2-(phenylmethyl) ester	85-68-7	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000	1,000,000 - <20,000,000
1,2-Benzenedicarboxylic acid, 4-sulfo-	89-08-7	433,527	455,454	533,740	391,038

Appendix F. Preliminary Regulatory Analysis

Cost estimates by recommendation

Table of contents

1.1 Introduction and summary

1.1.1 Approach to estimation

We approached estimating the costs of each of the 38 recommendations with a set of goals in mind:

- **Comparable estimates:** Use consistent underlying assumptions, timeframe, and unit values.
- **Versatile results:** Provide estimates agencies could consider individually by year, or aggregated as needed.
- **Efficiencies:** Consider when agencies could combine recommendations.

The degree and precision of our quantified estimates rely on the specificity and scope of each recommendation. Many recommendations are intended to expand our understanding of the prevalence of phthalates and the pathways via which they travel. Any future efforts will depend on what we learn about those two things. The estimates we present should be considered "high-level" in that they are inherently based on ranges of assumptions intended to capture variable outcomes and needs.

All overhead cost calculations used throughout our estimates account for:[15]

- Benefits.
- Materials.
- Travel.
- Administrative support.

1.1.2 Summary of results

The table below summarizes the costs of each recommendation by year. No efficiencies across recommendations are assumed in the totals presented below across all recommendations. See section 1.1.3 for the potential efficiencies that could result from implementing related recommendations at the same time.

The total estimated annual costs to implement all 38 recommendations range from $1.2 million to $13.0 million, depending on the underlying assumptions we made about how each agency would implement the recommendations. This range of estimated annual costs reflects variation in the:

- Time needed to implement recommendations. (One-year projects through complex multi-year implementation.)

[15] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- Need for ongoing phthalate monitoring. (Initial investigations would determine the need for ongoing monitoring.)
- Use of existing staff resources.
- Assumed staff wages and additional full time employees (FTEs).
- Prices of consultants and analytical work.

State agencies would incur the majority of the estimated costs because they are responsible for implementing the recommendations. Where nongovernmental entities (private businesses or organizations) would incur costs, we have presented total costs across all parties in quantified cost estimates, and we explain the distribution of those costs in the corresponding section below.

Table 10: Low and high costs of each recommendation.

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
CP1	$421,957	$528,045	$421,957	$709,512	$421,957	$784,547	$421,957	$367,329
CP2	$218,129	$6,350,629	$218,129	$6,350,629	$218,129	$6,350,629	$218,129	$6,350,629
BM1	$57,465	$73,925	$57,465	$73,925	$57,465	$73,925	$57,465	$73,925
BM2	$115,124	$116,585	$115,124	$116,585	$115,124	$116,585	$115,124	$116,585
PP1	$8,835	$96,000	$8,835	$96,000	$8,835	$96,000	$8,835	$96,000
PP2	$0	$29,600	$0	$29,600	$0	$29,600	$0	$29,600
PP3	$0	$8,429	$0	$8,429	$0	$8,429	$0	$8,429
HC1	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683
HC2	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323
HC3	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323	$50,323
HC4	$70,000	$100,000	$70,000	$100,000	$70,000	$100,000	$70,000	$100,000
DI1[A]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DI2	$46,597	$46,597	$0	$62,740	$149,060	$198,060	$149,060	$198,060
CH1	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777
CH2	$166,612	$184,597	$166,612	$184,597	$166,612	$184,597	$166,612	$184,597
OA1	$794	$14,430	$794	$14,430	$794	$14,430	$794	$14,430
OA2	$777	$7,065	$777	$7,065	$777	$7,065	$777	$7,065
OA3[B]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BS1	$17,206	$311,753	$17,206	$311,753	$83,561	$83,561	$83,561	$83,561

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
BS2	$17,206	$351,845	$17,206	$351,845	$83,561	$83,561	$83,561	$83,561
BS3	$17,206	$693,762	$17,206	$693,762	$122,986	$122,986	$122,986	$122,986
BS4	$12,607	$52,086	$18,179	$18,179	$18,179	$18,179	$18,179	$18,179
RE1	$265,007	$266,467	$265,007	$266,467	$0	$0	$0	$0
RE2	$265,007	$266,467	$0	$0	$0	$0	$0	$0
RE3	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386
CO1	$441,725	$421,957	$441,725	$421,957	$496,371	$421,957	$275,508	$421,957
CO2	$25,896	$57,824	$0	$0	$0	$0	$0	$0
LF1	$22,805	$67,649	$0	$0	$0	$0	$0	$0
LF2	$7,642	$21,893	$0	$0	$0	$0	$0	$0
DW1[C]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DW2	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298
DW3	$38,368	$38,368	$0	$0	$0	$0	$0	$0
DW4	$38,368	$38,368	$0	$0	$0	$0	$0	$0
SW1	$158,601	$158,601	$158,601	$158,601	$0	$0	$0	$0
SW2	$152,107	$152,107	$152,107	$152,107	$0	$0	$0	$0
SW3	$208,800	$208,800	$148,800	$148,800	$12,000	$12,000	$12,000	$12,000
SW4[D]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SW5[E]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total (millions)	$2.83	$10.68	$2.33	$10.30	$2.06	$8.73	$1.84	$8.31

A: Costs reflected in consumer product recommendations.

B: No additional cost for staff would be needed as this would occur at a location already maintained and supported by Ecology staff.

C: No additional cost for staff would be needed as this would occur as part of existing ongoing work with existing staff.

D: Analytical development and tissue analyses first needed to determine need for endocrine biomarkers. No costs estimated at this time.

E: Uses existing resources and funding sources.

1.1.3 Efficiencies across recommendations

Recommendations resulting in related actions that may either build upon one another, or be consolidated into a single action, could result in cost savings compared to implementing individual recommendations. We identified potential efficiencies across Biosolids-related recommendations, that could reduce costs.

Table 11: Total costs accounting for potential efficiencies (millions of $).

Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
$2.57	$10.15	$2.07	$9.78	$1.76	$8.42	$1.54	$8.00

Additional efficiencies may be possible if recommendations were implemented with other investigations or regulatory efforts occurring for the same facilities, locations, or media. As these opportunities are potentially highly variable, and are not components of the recommendations, we have not reflected any additional efficiencies here. Existing funding sources would also mitigate costs of implementing the recommendations. We have noted relevant funding and regulatory context related to each recommendation below.

1.2 Consumer products

Table 12: Estimated costs of consumer product recommendations.

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
CP1	$421,957	$528,045	$421,957	$709,512	$421,957	$784,547	$421,957	$367,329
CP2	$218,129	$6,350,629	$218,129	$6,350,629	$218,129	$6,350,629	$218,129	$6,350,629

1.2.1 Evaluate additional consumer products that contain phthalates

High-cost estimate

To develop a high-end estimate of staff costs, we based calculations on the wages of FTEs Ecology and DOH would need to do the work.

- Year 1 (product evaluations):
    - Ecology:
        - 1.0 FTE of Chemist 3.
        - 0.5 FTE of Environmental Planner 3.
        - 0.5 FTE of Communications Consultant 3.
        - 0.5 FTE of Environmental Specialist 5.
        - 0.5 FTE of Toxicologist 2.
    - DOH:
        - 0.4 FTE of Toxicologist 3.

- Year 2 (regulatory determinations – first year):
    - Ecology:
        - 2.0 FTE of Chemist 3.
        - 0.5 FTE of Environmental Planner 3.
        - 0.5 FTE of Communications Consultant 3.
        - 0.25 FTE of Economic Analyst 3.
        - 0.1 FTE of Regulatory Analyst 2.
        - 1.0 FTE of Toxicologist 2.
    - DOH:
        - 0.2 FTE of Toxicologist 3.
- Year 3 (regulatory determinations – second year):
    - Ecology:
        - 2.0 FTE of Chemist 3.
        - 1.0 FTE of Environmental Planner 3.
        - 0.5 FTE of Communications Consultant 3.
        - 0.25 FTE of Economic Analyst 3.
        - 0.1 FTE of Regulatory Analyst 2.
        - 1.0 FTE of Toxicologist 2.
    - DOH:
        - 0.2 FTE of Toxicologist 3.
- Year 4: rulemaking
    - Ecology:
        - 0.2 FTE of Chemist 3.
        - 1.0 FTE of Environmental Planner 3.
        - 0.5 FTE of Communications Consultant 3.
        - 0.5 FTE of Toxicologist 2.
    - DOH:
        - 0.2 FTE of Toxicologist 3.

Associated loaded wages (accounting for overhead) are presented in the table below. [16,17]

[16] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[17] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

Table 13: Annual wages, including overhead.

Employee Class	Loaded Wage
Chemist 3	$153,473
Environmental Planner 3	$150,069
Communications Consultant 3	$124,619
Toxicologist 2	$172,640
Economic Analyst 3	$157,193
Regulatory Analyst 2	$153,473

This resulted in overall cost estimates of:

- Year 1: $528,045:
  - Ecology: $452,171
  - DOH: $75,873
- Year 2: $709,512:
  - Ecology: $671,576
  - DOH: $37,937
- Year 3: $784,547:
  - Ecology: $746,610
  - DOH: $37,937
- Year 4: $367,329:
  - Ecology: $329,393
  - DOH: $37,937

Low-cost estimate

To develop a low-end estimate of staff costs, we used the Safer Products for Washington budget estimate of $1.5 million, scaled to three product categories in one chemical class, resulting in an estimate of over $136,000 per product class. Based on the assumption of 10 specific product classes addressed during a five-year development cycle, and adding additional market analysis support from 0.25 FTE of Economic Analyst 3 and 0.1 FTE of Regulatory Analyst 2, we estimated an average annual cost of nearly $422,000.

Regulatory and funding context

We note there is an existing regulatory framework under which Ecology may request data from manufacturers of products about their priority chemical contents, under the Safer Products for

Washington program.[18] Ecology does have existing funding for implementation, but we would need the additional funding above for product certification related to phthalates. We also note we are currently in the process of requesting funding to expand testing facility locations and increase our testing capacity.

We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

1.2.2 Support increased transparency and certifications for consumer products

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed Ecology needs the FTEs below, resulting in a total cost of about $156,000 per year: [19,20]

- 0.1 FTE of Chemist 4: $176,696 annual wage including overhead.
- 0.3 FTE of Environmental Specialist 5: $150,069 annual wage including overhead.
- 0.3 FTE of Communications Consultant 3: $124,619 annual wage including overhead.
- 0.5 FTE of Community Outreach and Environmental Engagement Specialist 2: $111,106 annual wage including overhead.

The overall range of costs associated with product certifications depends on:

- Certification type and necessary hazard assessments.
- Size of businesses involved and numbers of product.
- Relevant subsidies.

To develop a low-end estimate of product certification costs, we assumed:

- An average of 5 businesses with certifications per year.
- Only small business involvement, with an average of 4 products per business.
- A median cost of $7,500 per certification.[21]
- $30,000 maximum subsidy per business: 75 percent for the first $10,000 spent, and 50 percent for the next $40,000 (up to $50,000 total), plus reformulation costs up to $2,500.

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[18] 70A.350.030 (4) RCW

[19] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.

[20] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

[21] Safer choice product assessment range $5-10k.

- A net median cost of $40,500 per cradle-to-cradle certification, including offsets of $1,000 in Ecology staff time per product.[22]

This resulted in a total net certification cost of about $63,000, accounting for total subsidies of about $88,000.

High-cost estimate

To develop a high-end estimate of staff costs, we assumed Ecology needs FTEs below, resulting in a total cost of about $156,000 per year: [23,24]

- 0.1 FTE of Chemist 4: $176,696 annual wage including overhead.
- 0.3 FTE of Environmental Specialist 5: $150,069 annual wage including overhead.
- 0.3 FTE of Communications Consultant 3: $124,619 annual wage including overhead.
- 0.5 FTE of Community Outreach and Environmental Engagement Specialist 2: $111,106 annual wage including overhead.

The overall range of costs associated with product certifications depends on:

- Certification type and necessary hazard assessments.
- Size of businesses involved and numbers of product.
- Relevant subsidies.

To develop a high-end estimate of product certification costs, we assumed:

- An average of 15 small businesses and 5 large businesses with certifications per year.
- An average of 8 products per business.
- A net median cost of $40,500 per cradle-to-cradle certification, including offsets of $1,000 in Ecology staff time per product.[25]

This resulted in a total net cost of $6.2 million, accounting for a subsidy of $525,000 and $160,000 in Ecology staff time costs for hazard assessment.

[22] Ibid.
[23] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[24] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[25] Safer choice product assessment range $5-10k.

Regulatory and funding context

We note there is an existing regulatory framework under which Ecology may request data from manufacturers of products about their priority chemical contents, under the Safer Products for Washington program.[26] Ecology does have existing funding for implementation, but we would need the additional funding above for product certification related to phthalates. We also note we are currently in the process of requesting funding to expand testing facility locations and increase our testing capacity.

1.3 Building materials

Table 14: Estimated costs of building material recommendations.

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
BM1	$57,465	$73,925	$57,465	$73,925	$57,465	$73,925	$57,465	$73,925
BM2	$115,124	$116,585	$115,124	$116,585	$115,124	$116,585	$115,124	$116,585

1.3.1 Leverage existing resources and contribute to standards for state supported building projects

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed Ecology would need the following staff, resulting in a total staff cost of about $41,000 per year: [27,28]

- 0.1 FTE of Environmental Planner 3: $150,069 annual wage including overhead.
- 0.1 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
- 0.1 FTE of Chemist 3: $153,473 annual wage including overhead.

We also assumed we would need a contract to collaborate with partners and deliver two to four virtual or in-person training sessions. The low-end estimate of this cost was about $16,000.

High-cost estimate

To develop a high-end estimate of staff costs, we assumed Ecology would need the following staff, resulting in a total staff cost of about $43,000 per year: [29]

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[26] 70A.350.030 (4) RCW

[27] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.

[28] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

[29] Ibid.

- 0.1 FTE of Environmental Planner 4: $164,675 annual wage including overhead.
- 0.1 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
- 0.1 FTE of Chemist 3: $153,473 annual wage including overhead.

We also assumed we would need a contract to collaborate with partners and deliver two to four virtual or in-person training sessions. The high-end estimate of this cost was approximately $16,000.

1.3.2 Engage building design, construction, and maintenance project teams on material health

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed the following staff necessary at Ecology, resulting in a total staff cost of approximately $41,000 per year: [30,31]

- 0.1 FTE of Environmental Planner 3: $150,069 annual wage including overhead.
- 0.1 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
- 0.1 FTE of Chemist 3: $153,473 annual wage including overhead.

We also assumed a contract would be necessary to provide 1-on-1 technical support for up to six project teams. The estimate of this cost was approximately $74,000.

High-cost estimate

To develop a high-end estimate of staff costs, we assumed the following staff necessary at Ecology, resulting in a total staff cost of approximately $28,000 per year: [32]

- 0.1 FTE of Environmental Planner 4: $164,675 annual wage including overhead.
- 0.1 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
- 0.1 FTE of Chemist 3: $153,473 annual wage including overhead.

We also assumed a contract would be necessary to provide 1-on-1 technical support for up to six project teams. The estimate of this cost was approximately $74,000.

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[30] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[31] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[32] Ibid.

1.4 Preferred purchasing, statewide contracts

Table 15: Estimated costs of preferred purchasing and statewide contract recommendations.

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
PP1	$8,835	$96,000	$8,835	$96,000	$8,835	$96,000	$8,835	$96,000
PP2	$0	$29,600	$0	$29,600	$0	$29,600	$0	$29,600
PP3	$0	$8,429	$0	$8,429	$0	$8,429	$0	$8,429

1.4.1 Provide technical assistance to DES on their preferred purchasing guidance and training for purchasers and contract specialists

Low-cost estimate

To develop a low-end estimate of costs, we assumed the following staff necessary at Ecology, resulting in a total staff cost of approximately $9,000 per year:

- 0.05 FTE of Chemist 4: $176,696 annual wage including overhead.[33]

High-cost estimate

To develop a high-end estimate of staff costs, we used an estimated contract cost of $10,000 per 100 hours of contractor time spent implementing this recommendation. We multiplied this $100 hourly cost by the equivalent of a 6-month full time contract (or one-year half-time contract) of 960 hours. This resulted in an estimated contract cost of approximately $96,000.

Regulatory and funding context

We note that Executive Order 20-01 directs Ecology and DES to work together on guidance for environmentally preferred purchasing to reduce toxics (Section 1f). This recommendation would contribute to this effort, as pertains to phthalates, and potentially offset other costs of implementing the Executive Order.

For existing funding and capacity, we also note Ecology currently has an EP3 and an EP4 position who have some capacity for this work, but the ability to take on this work will depend on agency priorities and timing. As such, we have assumed all costs would be in addition to existing funded FTEs. DES also currently has relevant positions listed and this contract management work would fit into their existing capacity.

[33] Ibid.

1.4.2 Incorporate guidance and technical input from Ecology into new DES statewide contracts and amend contracts when feasible

DES would likely implement this recommendation using existing resources (DES currently has these positions listed) and would not incur additional costs. To reflect a range of uncertainty, we also estimated costs for a small amount resources if DES could not do the work with existing resources, due to agency priorities or timing.

To develop a high-end estimate of staff costs, we assumed the following staff necessary at DES, resulting in a total staff cost of approximately $30,000 per year: [34,35]

- Less than 0.05 FTE of Management Analyst 5: $168,584 annual wage including overhead.
- Less than 0.05 FTE of Program Specialist 3: $130,461 annual wage including overhead.
- Less than 0.1 FTE of Technical Training Consultant: $146,475 annual wage including overhead.

1.4.3 Work with state agencies and the State Efficiency and Environmental Performance Office to track purchasing metrics

This recommendation would likely be implementing using existing staff resources (DES currently has this position listed) and would not incur additional costs. To reflect a range of uncertainty, we also estimated a small amount of necessary staff time if it was not able to be done with existing resources, due to agency priorities or timing.

To develop a high-end estimate of staff costs, we assumed the following staff necessary at DES, resulting in a total staff cost of approximately $8,000 per year: [36]

- Less than 0.05 FTE of Management Analyst 5: $168,584 annual wage including overhead.

[34] WA Office of Financial Management, 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[35] WA Department of Ecology, 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[36] Ibid.

1.5 Healthcare

Table 16: Estimated costs of healthcare recommendations.

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
HC1	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683	$189,683
HC2	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
HC3	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
HC4	$70,000	$100,000	$0	$0	$0	$0	$0	$0

1.5.1 Suggest medical products to Safer Products for Washington for possible identification as priority products

Costs for SPWA work on implementation of this action plan are detailed in cost estimates associated with consumer products (see Section 1.2). As part of developing cost estimates, we identified that SPWA resources may be at their capacity, so we estimated the cost of additional support from 1.0 FTE of Toxicologist 3 to support broad expansion of this work. This position, or its cumulative equivalent, would cost $189,683 annually.

1.5.2 Expand adoption of procurement policies and procedures by health care providers that prioritize reducing the use of phthalate-containing products

This recommendation would be implemented in conjunction with the next recommendation listed ("Promote clinician awareness of opportunities to reduce phthalate exposure;" see Section 1.5.3). To develop an estimate of staff costs, we assumed the following staff necessary at DOH, resulting in a total staff cost of approximately $50,000 per year: [37,38]

- 0.125 FTE of Health Services Consultant 3: $139,855 annual wage including overhead.
- 0.125 FTE of outreach coordinator: $124,619 annual wage including overhead.
- 0.1 FTE of Toxicologist 2: $172,640 annual wage including overhead.

The above calculation assumes that educational materials are included in overhead costs. Overhead cost calculations used throughout our estimates account for benefits, materials,

[37] WA Office of Financial Management, 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[38] WA Department of Ecology, 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

travel, and administrative support.[39] DOH outreach staff could also be combined into single positions with corresponding staff in dietary exposure recommendations (see Section 1.6).

Regulatory and funding context

DOH will need new funding to do this work because existing health education and outreach staff are committed to other work. It is possible funding through foundational public health will provide some additional resources at DOH and local health offices. We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

1.5.3 Increase clinician awareness of opportunities to reduce phthalate exposure

DOH would implement this recommendation at the same time as the recommendation to "Expand adoption of procurement policies and procedures by health care providers that prioritize reducing the use of phthalate-containing products;" (see Section 1.5.2). To develop an estimate of staff costs, we assumed DOH would need the FTEs below resulting in a total cost of about $50,000 per year: [40]

- 0.125 FTE Health Services Consultant 3: $139,855 annual wage including overhead.
- 0.125 FTE outreach coordinator: $124,619 annual wage including overhead.
- 0.1 FTE of Toxicologist 2: $172,640 annual wage including overhead.

The above calculation assumes educational materials are included in overhead costs. DOH outreach staff could also be combined into single positions with corresponding staff in dietary exposure recommendations (see Section 1.6).

Regulatory and funding context

DOH will need new resources because existing health education and outreach staff are committed to other work. It is possible that funding through foundational public health will provide some additional resources at DOH and local health offices. We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

[39] Ibid.
[40] Ibid.

1.5.4 Develop an approach to reducing phthalate exposure through menstrual and incontinence products

We assumed costs associated with this recommendation for an initial laboratory contract, ranging between $70,000 and $100,000. This range reflects existing funding for product testing secured from MTCA funding, of $70,000 for the first phase of implementation. The overall range reflects possible costs of follow-up efforts with about half the effort needed during the first phase.

1.6 Dietary exposure

Table 17: Estimated costs of food contact articles recommendations

Rec #	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
FC1*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FC2	$46,597	$46,597	$0	$62,740	$149,060	$198,060	$149,060	$198,060

* FC1 costs are reflected in estimates for consumer product recommendations.

1.6.1 Evaluate phthalate-containing food contact applications for identification as priority products in a future cycle

These costs are already reflected in cost estimates associated with consumer product recommendations. See Section 1.2 for our explanation and estimates.

Regulatory and funding context

We note the Washington State Retail Food Code[41] governs retail food operations, and while sections of that rule regulate toxic chemicals, they do not necessarily apply to FDA-allowable food additives used in food contact applications.

Further addressing food safety, the state's Food Safety and Security Act[42] governs Food Safety under Washington State Department of Agriculture (WSDA) authority, and the Milk and Milk Products statute[43] governs safety of milk and milk products. While the WSDA is charged with overseeing general protections from contamination of products, there is no language in the laws that pertains specifically to phthalates.[44]

We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

[41] Chapter 246-215 WAC
[42] Chapter 15.130 RCW
[43] Chapter 15.36 RCW
[44] Further food safety regulations may be found at https://agr.wa.gov/washington-agriculture/laws-and-rules/food-law-regulations

1.6.2 Establish a cross-agency workgroup responsible for identifying the key uses of phthalates and ways to reduce the sources of phthalates in food and beverages

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed DOH and Ecology would need the following FTEs: [45,46]

- Year 1:
    - 0.1 FTE of Chemist 3 3: $153,473 annual wage including overhead.
    - 0.1 FTE of Toxicologist 2: $172,640 annual wage including overhead.
    - 0.1 FTE of Public Health Analyst 3: $139,855 annual wage including overhead.
- Year 3+:
    - 0.5 FTE of Toxicologist 2: $172,640 annual wage including overhead.
    - 0.25 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
    - 0.25 FTE of Health Services Consultant 3: $139,855 annual wage including overhead.

DOH outreach staff could be combined into single positions with corresponding staff in healthcare-related recommendations (see Section 1.5).

These assumptions resulted in the following total cost estimates for staff time:

- Year 1: $47,000
- Year 3+: $149,060

High-cost estimate

To develop a high-end estimate of costs, we assumed DOH and Ecology would need the following FTEs and an external contract to do outreach and disseminate educational materials: [47,48]

- Year 1:
    - 0.1 FTE of Chemist 3 3: $153,473 annual wage including overhead.
    - 0.1 FTE of Toxicologist 2: $172,640 annual wage including overhead.

[45] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[46] WA Department of Ecology, 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[47] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[48] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

    - 0.1 FTE of Public Health Analyst 3: $139,855 annual wage including overhead.
- Year 2:
    - 0.25 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
    - 0.25 FTE of Health Services Consultant 3: $139,855 annual wage including overhead. This position could be combined with the corresponding position for healthcare-related recommendations (see Section 1.5).
- Year 3+:
    - 0.5 FTE of Toxicologist 2: $172,640 annual wage including overhead.
    - 0.25 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.
    - 0.25 FTE of Health Services Consultant 3: $139,855 annual wage including overhead.

DOH outreach staff could be combined into single positions with corresponding staff in healthcare-related recommendations (see Section 1.5).

These assumptions resulted in the following total cost estimates for staff time:

- Year 1: $47,000
- Year 2: $63,000
- Year 3+: $198,000

We based the cost of an outreach contract on funding used for the University of Washington Clean Shift Project, estimated at $49,000 for one year. We assumed this cost would be incurred starting in year 3.

Regulatory and funding context

We note existing funds would support costs for the first year of workgroup activities. Additional funding would be needed for the intern positions, and possibly for technical support.

We could also consider expanding interagency agreement funding to DOH to support chemical action plan implementation to cover a Health Educator position at DOH. For outreach to retail food establishments, DOH can leverage an existing network through local health jurisdictions. Similarly, for food producers, WSDA has food inspectors who could distribute materials, although Ecology and DOH would be primarily responsible for producing the material.

1.7 Childcare

Table 18: Estimated costs of childcare recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
CH1	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777	$27,777
CH2	$166,612	$184,597	$166,612	$184,597	$166,612	$184,597	$166,612	$184,597

1.7.1 Develop educational and outreach materials to reduce the use of phthalate-containing materials in daycares

DOH and DCYF would implement this recommendation using existing resources and would not incur additional costs for material development. DOH would need additional staff time to do outreach and education at daycares. To estimate these costs, we assumed DOH would need the following FTE, resulting in a total cost of about $28,000 per year: [49,50]

- 0.25 FTE of Community Outreach & Environmental Educational Specialist 2: $111,106 annual wage including overhead.

Regulatory and funding context

Implementation of this recommendation will leverage the existing Washington Choose Safe Places program and the current staff resources in that program. WCSP is funded by a grant from ATSDR. Renewal of the grant funding for the upcoming 5 year cycle is expected but implementation of recommendations in this topic area are contingent on renewal.

According to the Children's Environmental Health Network, there currently are no mandated national regulations related to environmental health in early childhood education (ECE) programs. Under the Foundational Quality Standards for Early Learning Programs rule[51], chapter 110-300-0410 WAC, the program space must be located on a site free from known environmental hazards.

In Washington, current ECE licensing requirements do not comprehensively address environmental health. The rule, chapter 110-300-0410 WAC, states that early learning providers must prevent enrolled children from being exposed to certain known hazards within and around the licensed premises. However, ECE program sites are not currently evaluated for phthalate hazards and other harmful substances, and children may still be at risk of exposure. The law does not say that the licensing agency must educate childcare providers against

[49] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[50] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[51] Chapter 110-300-0401 WAC: https://app.leg.wa.gov/WAC/default.aspx?cite=110-300-0401.

chemical hazards (e.g., phthalates) in their facility, nor does it address safety hazards or environmental exposures.

We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

1.7.2 Develop a swap-out project for vinyl flooring in childcare facilities

Ecology and DOH would implement this recommendation. To develop an estimate of staff costs, we assumed Ecology and DOH would need the FTEs below resulting in a total cost of about $167,000 to $185,000 per year: [52,53]

- 1.0 FTE Environmental Specialist 4 or 5: $136,598 to $150,069 annual wage including overhead.
- 0.2 FTE of Toxicologist 2: $172,640 annual wage including overhead.

Regulatory and funding context

We note that there is an existing Interagency Agreement (IAA) between Ecology and DOH that could potentially fund at least a portion of this work. We chose to estimate the full cost of this recommendation, however, since we identified uncertainty in the IAA's capacity to provide this supportive funding across multiple recommendations to which it may apply.

1.8 Outdoor air

Table 19: Estimated costs of outdoor air recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
OA1	$794	$14,430	$794	$14,430	$794	$14,430	$794	$14,430
OA2	$777	$7,065	$777	$7,065	$777	$7,065	$777	$7,065
OA3*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* Uses existing resources and funding sources.

[52] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.

[53] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

1.8.1 Ask our local air agency partners to verify and improve accuracy of emissions reporting

Ecology would be responsible for asking the local clean air agencies (CAAs) to perform the verification activities. We estimate CAAs would need additional staff time to do the work.

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed one hour per facility of additional staff time at local CAAs to verify emissions estimates at about 11 facilities, based on the number of facilities known to have reported some degree of phthalate air emissions in the last decade. We approximated local CAA wages using an Environmental Specialist 5 hourly equivalent wage of $72.15, including overhead. This resulted in a low-end cost estimate of approximately $800.

High-cost estimate

To develop a high-end cost estimate of staff costs, we assumed local CAAs would need an additional 10 hours of staff time, per facility, to verify emissions reporting at up to 20 facilities. Our estimate reflects facilities who have reported air emissions of phthalates in the past and facilities that have potentially emitted phthalates but have not comprehensively reported them or appropriately quantified them. We approximated local CAA wages using an Environmental Specialist 5 hourly equivalent wage of $72.15, including overhead. [54,55] This resulted in a high-end cost estimate of about $14,000.

Regulatory and funding context

We note local CAAs set their fees to reflect costs of providing services, as reflected in staff costs. We assumed these fees would eventually be adjusted to reflect any additional staff costs needed to verify phthalate emissions in response to this recommended request. In allocating costs over time, we assumed this might happen with some lag, if fees are set via local processes that take some time, in which case these costs would need to be covered by other funding or recouped via fees later.

1.8.2 Additional coordination with clean air agencies and facilities

Low-cost estimate

To develop a low-end estimate of staff costs, we estimated the number of additional hours of staff time, per facility, CAAs would need to follow-up with facilities on the results of the verification process recommended in Section 1.8.1.

- 40 hours for a local permit manager (preparation, travel, inspection, documentation.)
- 12 hours for facility staff (preparation, inspection, corrective action.)

[54] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[55] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

We also assumed 10 percent of 11 known phthalate-emitting facilities would require this effort, once per permit cycle. We approximated local CAA wages using an Environmental Specialist 5 hourly equivalent wage of $72.15, including overhead.[56] We estimated an hourly wage of facility staff at $53.88 for environmental compliance engineers, without overhead as this would be part of their regular work.[57] This resulted in a low-end cost estimate of about $800, with over $600 of that cost borne by the local CAA.

Any efforts the facility may take to reduce emissions, based on the verification results, would be facility-specific and we could not confidently estimate them.

High-cost estimate

To develop a high-end estimate of staff costs, we estimated the number of additional hours of staff time, per facility, CAAs would need to follow-up with facilities on the results of the verification process recommended in Section 1.8.1.

- 40 hours for a local permit manager (preparation, travel, inspection, documentation).
- 12 hours for facility staff (preparation, inspection, corrective action).

We also assumed half of known phthalate-emitting facilities and potential additional facilities identified under the previous recommendation would require this effort, once per permit cycle. We approximated local CAA wages using an Environmental Specialist 5 hourly equivalent wage of $72.15, including overhead. [58,59] We estimated an hourly wage of facility staff at $53.88 for environmental compliance engineers, without overhead as this would be part of their regular work.[60] This resulted in a high-end cost estimate of about $7,000, with nearly $6,000 of that cost borne by the local CAA.

Any efforts subsequently undertaken to reduce emissions would be facility-specific and based on a facility's regulatory context and permit requirements, and we could not confidently estimate them.

Regulatory and funding context

We note local CAAs set their fees to reflect costs of providing services, as reflected in staff costs. We assumed these fees would eventually be adjusted to reflect any additional staff costs necessary to verify phthalate emissions in response to this recommended request. In allocating costs over time, we assumed this might happen with some lag, if fees are set via local processes that take some time, in which case these costs would ether need to be covered by other funding or recouped via fees later.

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[56] Ibid.
[57] US Bureau of Labor Statistics. 2021. May 2021 State Occupational Employment and Wage Estimates: Washington. https://www.bls.gov/oes/current/oes_wa.htm
[58] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[59] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[60] US Bureau of Labor Statistics. 2021. May 2021 State Occupational Employment and Wage Estimates: Washington. https://www.bls.gov/oes/current/oes_wa.htm

1.8.3 Evaluate the feasibility and cost of using existing air toxics monitoring infrastructure to collect and analyze air samples for phthalates

We determined our contract laboratory (Eastern Research Group) can analyze 7 phthalate chemicals as part of our regular air toxics monitoring. This would add a cost of about $1,000 per sample, or about $61,000 per year.

No additional cost for staff would be needed as this would occur at a location already maintained and supported by Ecology staff.

1.9 Biosolids

Table 20: Estimated costs of biosolids recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
BS1	$17,206	$311,753	$17,206	$311,753	$83,561	$83,561	$83,561	$83,561
BS2	$17,206	$351,845	$17,206	$351,845	$83,561	$83,561	$83,561	$83,561
BS3	$17,206	$693,762	$17,206	$693,762	$122,986	$122,986	$122,986	$122,986
BS4	$12,607	$52,086	$18,179	$18,179	$18,179	$18,179	$18,179	$18,179

1.9.1 Evaluate the transport and breakdown of upstream-sourced phthalates in Washington state WWTP influent, effluent, sludge, and biosolids

Low-cost estimate

To develop a low-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff cost of about $17,000 per year: [61,62]

- At Ecology:
  - 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.

[61] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[62] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

    - 0.02 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
    - 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.
- At DOH or Ecology:
    - 0.0 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- Six facilities.
- Four media to sample: influent, effluent, sludge, and biosolids.
- One sample per medium.
- Analytic costs of $300 per sample.

High-cost estimate

To develop a high-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff and analytic cost of about $312,000 per year: [63,64]

- At Ecology:
    - 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
    - 0.25 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
    - 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.
- At DOH or Ecology:
    - 0.02 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- 12 facilities.

[63] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[64] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- Four media to sample: influent, effluent, sludge, and biosolids.
- 11 samples per medium.
- Analytic costs of $500 per sample.

Ongoing monitoring costs

For both low-end and high-end cost estimated, we also assumed additional ongoing monitoring would be necessary starting in year 3, assuming average sampling needs for both scenarios:

- 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
- 0.14 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.
- Six facilities.
- Four media per sample.
- Six samples per medium.
- Analytic costs of $400 per sample.

This resulted in an average monitoring cost estimate of $83,000 per year.

Regulatory and funding context

Ecology could do this work at the same time as we are implementing other biosolids-related recommendations to take advantage of efficiencies and cost-reduction opportunities across all four recommendations.

Ecology prioritizes pollutant scans for some municipal wastewater treatment plants which includes testing for some phthalates. We must use EPA's approved sampling methods for priority pollutant scans. For independent samples we may need more sensitive methods.

1.9.2 Evaluate the transfer potential of phthalates from biosolids to soil and groundwater

Low-cost estimate

To develop a low-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff cost of about $17,000 per year: [65,66]

- At Ecology:

[65] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[66] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
- 0.02 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.

- At DOH or Ecology:
  - 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- Six fields.
- Four sampling locations per field.
- One sample per location.
- Analytic costs of $300 per sample.

High-cost estimate

To develop a high-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff and analytic cost of about $352,000 per year: [67,68]

- At Ecology:
  - 0.04 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
  - 0.51 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
  - 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.
- At DOH or Ecology:
  - 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

[67] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[68] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- 12 fields.
- Four sampling locations per field.
- 11 samples per location.
- Analytic costs of $500 per sample.

Ongoing monitoring costs

For both low-end and high-end cost estimated, we also assumed additional ongoing monitoring would be necessary starting in year 3, assuming average sampling needs for both scenarios:

- 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
- 0.14 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.
- Six fields.
- Four sampling locations per field.
- Six samples per location.
- Analytic costs of $400 per sample.

This resulted in an average monitoring cost estimate of $83,000 per year.

Regulatory and funding context

We note we currently provide funds to DOH, through an interagency agreement, to support implementation of chemical action plans. We could do this work at the same time we implement other biosolids-related recommendations to take advantage of efficiencies and cost-reduction opportunities across all four recommendations.

1.9.3 Evaluate plant uptake of phthalates in crops/fodder grown in or on biosolids-amended soils and fields in Washington state

Low-cost estimate

To develop a low-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff cost of about $17,000 per year: [69,70]

- At Ecology:

[69] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[70] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
- 0.02 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.

- At DOH or Ecology:
  - 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- Six fields.
- Four sampling locations per field.
- One sample per location.
- Analytic costs of $300 per sample.

High-cost estimate

To develop a high-end estimate of staff costs, we approximated the types of staff Ecology (and potentially DOH) would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff and analytic cost of about $694,000 per year: [71,72]

- At Ecology:
  - 0.04 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
  - 1.02 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
  - 0.01 FTE of Environmental Specialist 4 for report writing: $136,598 annual wage including overhead.
- At DOH or Ecology:
  - 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

[71] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[72] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- 12 fields.
- Eight sampling locations per field.
- 11 samples per location.
- Analytic costs of $500 per sample.

Ongoing monitoring costs

For both low-end and high-end cost estimated, we also assumed additional ongoing monitoring would be necessary starting in year 3, assuming average sampling needs for both scenarios:

- 0.02 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.
- 0.21 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.01 FTE of Toxicologist 3: $189,683 annual wage including overhead.
- Six fields.
- Four sampling locations per field.
- Six samples per location.
- Analytic costs of $400 per sample.

This resulted in an average monitoring cost estimate of $123,000 per year.

Regulatory and funding context

We note that an interagency agreement with DOH currently provides funding for DOH to support implementation of chemical action plans. This work could be done in conjunction with other biosolids-related recommendations to take advantage of efficiencies and cost-reduction opportunities across all four recommendations.

1.9.4 Evaluate the fate of phthalates in composted biosolids in Washington state

Low-cost estimate

To develop a low-end estimate of staff costs, we approximated the types of staff Ecology would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff cost of about $13,000 per year: [73,74]

- 0.1 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.

[73] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[74] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- 0.03 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- One facility.
- Three sampling locations throughout the composting process: non-biosolids feedstock, biosolids feedstock, final product.
- One sample per location.
- Analytic costs of $300 per sample.

High-cost estimate

To develop a high-end estimate of staff costs, we approximated the types of staff Ecology would need to implement the recommendation. We assumed we would need the following FTEs to do the work, resulting in a total staff and analytic cost of about $52,000 per year: [75,76]

- 0.1 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 0.03 FTE of Environmental Specialist 5 for sample collection: $150,069 annual wage including overhead.

This work would also involve lab costs that depend on the unit cost of analytic work, and on the number of samples necessary to analyze each phthalate of interest. These assumptions influence the staff time above. We assumed:

- Two facilities.
- Three sampling locations throughout the composting process: non-biosolids feedstock, biosolids feedstock, final product.
- 11 samples per location.
- Analytic costs of $500 per sample.

Ongoing monitoring costs

For both low-end and high-end cost estimated, we also assumed additional ongoing monitoring would be necessary starting in year 3, assuming average sampling needs for both scenarios:

- 0.05 FTE of Chemist 3 for laboratory analysis: $153,473 annual wage including overhead.
- 1.5 facilities.

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[75] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.

[76] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

- Three sampling locations throughout the composting process: non-biosolids feedstock, biosolids feedstock, final product.
- Six samples per location.
- Analytic costs of $400 per sample.

This resulted in an average monitoring cost estimate of $18,000 per year.

Regulatory and funding context

We note that compost produced using biosolids as a feedstock meets Exceptional Quality standards. In keeping with federal rules, land application of exceptional quality biosolids products are not tracked. For this reason, and to prevent potential contamination from plastic packaging, compost should be sampled before it leaves the compost production facility. There are potential efficiency gains if this recommendation can be performed in conjunction with similar compost sampling recommendations (see Section 1.11).

1.10 Recycling

Table 21: Estimated costs of recycling recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
RE1	$15,007	$16,467	$15,007	$16,467	$0	$0	$0	$0
RE2	$15,007	$16,467	$0	$0	$0	$0	$0	$0
RE3	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386	$37,386

1.10.1 Identify the plastic packaging and plastic durable goods containing phthalates that are recycled and used to remanufacture other products or packaging used in Washington

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed Ecology would need the following contract-management staff resulting in a total staff cost of about $15,000 per year:

- 0.1 FTE of Environmental Planner 3: $150,069 annual wage including overhead. [77,78]

We also assumed we would need a contract to perform the technical and market research required under this recommendation. We estimate this could cost up to $500,000, reflecting broad subject matter expertise and likelihood of subcontractors.

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[77] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.

[78] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

High-cost estimate

To develop a high-end estimate of staff costs, we assumed Ecology would need the following contract-management staff resulting in a total staff cost of approximately $16,000 per year:

- 0.1 FTE of Environmental Planner 4: $164,675 annual wage including overhead.[79]

We also assumed we would need a contract to perform the technical and market research required under this recommendation. We estimate this could cost up to $500,000, reflecting broad subject matter expertise and likelihood of subcontractors.

Regulatory and funding context

To the extent the contracted work done under recycling-related recommendations could be planned and streamlined to connect seamlessly or with as little misalignment as possible, overall cost savings are possible in reduced time costs to adjust outputs of one study to be inputs to the next.

1.10.2 Assess plastic bales at material recovery facilities to gauge the amount of phthalate containing plastic sold to recycling processors

Low-cost estimate

To develop a low-end estimate of staff costs, we assumed the following contract-management staff would be necessary at Ecology, resulting in a total staff cost of about $15,000 per year:

- 0.1 FTE of Environmental Planner 3: $150,069 annual wage including overhead. [80,81]

We also assumed a contract would be necessary to perform the technical and market research required under this recommendation. We estimate this could cost up to $500,000, reflecting broad subject matter expertise and likelihood of subcontractors.

High-cost estimate

To develop a high-end estimate of staff costs, we assumed the following contract-management staff would be necessary at Ecology, resulting in a total staff cost of about $16,000 per year:

- 0.1 FTE of Environmental Planner 4: $164,675 annual wage including overhead.[82]

We also assumed a contract would be necessary to perform the technical and market research required under this recommendation. We estimate this could cost up to $500,000, reflecting broad subject matter expertise and likelihood of subcontractors.

[79] Ibid.
[80] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[81] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[82] Ibid.

Regulatory and funding context

To the extent the contracted work done under recycling-related recommendations could be planned and streamlined to connect seamlessly or with as little misalignment as possible, overall cost savings are possible in reduced time costs to adjust outputs of one study to be inputs to the next.

1.10.3 Request manufacturers and producers disclose their use of priority chemicals in product ingredients

Ecology would need additional staff time to implement this recommendation. To estimate these costs, we assumed Ecology would need the following staff, resulting in a total staff cost of about $37,000 per year: [83]

- 0.3 FTE of Community Outreach & Environmental Educational Specialist 3: $124,619 annual wage including overhead.

Regulatory and funding context

To the extent the contracted work done under recycling-related recommendations could be planned and streamlined to connect seamlessly or with as little misalignment as possible, overall cost savings are possible in reduced time costs to adjust outputs of one study to be inputs to the next.

1.11 Compost

Table 22: Estimated costs of compost recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
CO1	$441,725	$421,957	$441,725	$421,957	$496,371	$421,957	$275,508	$421,957
CO2	$26,707	$59,447	$0	$0	$0	$0	$0	$0

1.11.1 Sample common compostable serviceware to evaluate these materials as a pathway to introducing phthalates to municipal compost

We assumed the costs associated with this recommendation would be similar to, or part of, costs incurred during the development of other product testing and identification work. See Section 1.2 for our explanation of consumer product-related recommendation costs.

[83] Ibid.

1.11.2 Develop a sampling plan and test Washington State produced non-biosolids compost from a variety of facilities that process municipal organic waste

Low-cost estimate

To estimate low-end costs of this recommendation, we estimated the following staff time for 5 compost facilities, in the state:

- 6 hours of staff time spent per facility to perform sampling (including travel).
- 30 hours developing a final report.
- 50 samples per facility.
- Chemist 3: $160,913 annual wage including overhead. [84,85]
- Environmental Specialist 5: $150,069 annual wage including overhead.[86]

This resulted in estimated staff costs of nearly $12,000.

We also assumed a low-end per-sample cost of $300. This resulted in low-end estimated analysis costs of $15,000.

High-cost estimate

To estimate high-end costs of this recommendation, we estimated the following staff time for 5 compost facilities in the state:

- 7 hours of staff time spent per facility to perform sampling (including travel).
- 35 hours developing a final report.
- 50 samples per facility.
- Chemist 3: $160,913 annual wage including overhead. [87,88]
- Environmental Specialist 5: $150,069 annual wage including overhead.[89]

This resulted in estimated staff costs of over $19,000.

We also assumed a high-end per-sample cost of $800. This resulted in high-end estimated analysis costs of $40,000.

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[84] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[85] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[86] Ibid.
[87] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[88] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[89] Ibid.

1.12 Landfills

Table 23: Estimated costs of landfill recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
LF1	$22,805	$67,649	$0	$0	$0	$0	$0	$0
LF2	$7,642	$21,893	$0	$0	$0	$0	$0	$0

1.12.1 Evaluate the occurrence of phthalates in landfill leachate

Low-cost estimate

To estimate low-end costs of this recommendation, we estimated the following staff time for 22 landfills in the state:

- 8 hours of staff time spent per landfill to perform sampling.
- 80 hours developing a final report.
- Hydrogeologist 3: $160,913 annual wage including overhead. [90,91]

This resulted in estimated staff costs of nearly $20,000.

We also assumed ten samples would be taken at each landfill and analyzed at a per-sample cost of $300. This resulted in low-end estimated analysis costs of $3,000.

High-cost estimate

To estimate high-end costs of this recommendation, we estimated the following staff time for 22 landfills in the state:

- 24 hours of staff time spent per landfill to perform sampling, reflecting additional travel time.
- 80 hours developing a final report.
- Hydrogeologist 4: $176,696 annual wage including overhead. [92,93]

This resulted in estimated staff costs of nearly $52,000.

[90] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[91] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[92] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing. Accessed February 2023.
[93] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

We also assumed 20 samples would be taken at each landfill and analyzed at a per-sample cost of $800, reflecting a broad set of analytes that may require specialty lab work. This resulted in high-end estimated analysis costs of $16,000.

1.12.2 Evaluate the occurrence of phthalates in landfill gas

Low-cost estimate

To estimate low-end costs of this recommendation, we estimated the following staff time for 22 landfills in the state:

- 8 hours of staff time spent per landfill to perform sampling.
- 20 hours developing a final report.
- Hydrogeologist 3: $160,913 annual wage including overhead.[94]

This resulted in estimated staff costs of nearly $5,000.

We also assumed ten samples would be taken at each landfill and analyzed at a per-sample cost of $300. This resulted in low-end estimated analysis costs of $3,000.

High-cost estimate

To estimate high-end costs of this recommendation, we estimated the following staff time for 22 landfills in the state:

- 24 hours of staff time spent per landfill to perform sampling, reflecting additional travel time.
- 20 hours developing a final report.
- Hydrogeologist 4: $176,696 annual wage including overhead.[95]

This resulted in estimated staff costs of nearly $12,000.

We also assumed 20 samples would be taken at each landfill and analyzed at a per-sample cost of $500, reflecting a broader set of analytes that may require specialty lab work. This resulted in high-end estimated analysis costs of $10,000.

[94] Ibid.
[95] Ibid.

1.13 Drinking water

Table 24: Estimated costs of drinking water recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
DW1*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DW2	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298	$39,298
DW3	$38,368	$38,368	$0	$0	$0	$0	$0	$0
DW4	$38,368	$38,368	$0	$0	$0	$0	$0	$0

* Uses existing resources and funding sources.

1.13.1 Continue collaboration with Phthalate Action Plan partners to evaluate scientific literature to assess other phthalates with the potential to impact drinking water

DOH monitors public water systems drinking water for phthalates as part of their agreement with EPA relating to implementing the federal Safe Drinking Water Act[96]. DOH will continue assisting with sample collection and analytical oversight using existing resources. No additional funding is needed. This may change if we begin to observe changes in water quality for unregulated phthalate contaminants

1.13.2 Educate partners on the use of phthalate-free sample collection and operational equipment products that could potentially contribute to sample contamination

We expect DOH will incorporate phthalate educational efforts into future guidance they give to their drinking water partners. To reflect the value of the work to develop this future guidance, we assumed DOH would need the following staff, resulting in a total staff cost of about $39,000 per year:

- 0.25 FTE of Outreach Coordinator: $157,193 annual wage including overhead. [97,98]

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[96] EPA Safe Drinking Water Act 40 CFR 141. Drinking water standards are developed based on EPA National Primary Drinking Water Regulations which apply to all Public Water Systems.

[97] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.

[98] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

1.13.3 Evaluate other state's health advisory guidelines for phthalates in drinking water

We expect DOH will use existing resources to evaluate other state guidelines and national public water system occurrence data. In the case this is not possible, we estimated the same resources as in the next recommendation (see 1.12.4) to support this work.

1.13.4 Assess national public water system phthalate occurrence data

We assumed DOH will need additional staff time to implement this recommendation. To reflect the value of this work, we assumed DOH would need the following staff, resulting in a total staff cost of about $38,000 per year:

- 0.25 FTE of Regulatory Analyst 2: $153,473 annual wage including overhead. [99,100]

1.14 Surface water, sediment, biota

Table 25: Estimated costs of surface water, sediment, and biota recommendations

Rec#	Year 1 Low	Year 1 High	Year 2 Low	Year 2 High	Year 3 Low	Year 3 High	Year 4 Low	Year 4 High
SW1	$158,601	$158,601	$158,601	$158,601	$0	$0	$0	$0
SW2	$152,107	$152,107	$152,107	$152,107	$0	$0	$0	$0
SW3	$208,800	$208,800	$148,800	$148,800	$12,000	$12,000	$12,000	$12,000
SW4[A]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SW5[B]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[A] Analytical development and tissue analyses first needed to determine need for endocrine biomarkers. No costs estimated at this time.

[B] Additional evaluation work that may be produced by the collection of phthalate fish data is anticipated to be absorbed by the current position and not require additional FTE. Fish advisory education/outreach support and physical materials are funded through MTCA.

[99] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.

[100] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

1.14.1 Review literature and determine, where possible, thresholds of concern for toxicity in all matrices

To develop an estimate of staff costs, we assumed the following staff necessary at Ecology, resulting in a total staff cost of approximately $159,000 per year: [101,102]

- 0.5 FTE Toxicologist 3: $189,683 annual wage including overhead.
- 0.5 FTE Research Scientist 1: $127,519 annual wage including overhead.

1.14.2 Identify or develop suitable analytical methods as needed

To develop an estimate of staff costs, we assumed Ecology would need the following staff to implement this recommendation, resulting in a total staff cost of about $152,000 per year: [103,104]

- 0.5 FTE Chemist 4: $176,696 annual wage including overhead.
- 0.5 FTE Research Scientist 1: $127,519 annual wage including overhead.

1.14.3 Evaluate the extent and magnitude of phthalate/metabolite exposure in aquatic species

Freshwater Fish Contaminant Monitoring Program

If Ecology makes a decision (based on supporting data) to add phthalate analysis to the Freshwater Fish Contaminant Monitoring Program, it will result in a total estimated cost of $60,000 for laboratory analysis costs.

- $800 per sample, reflecting the potential breadth and complexity of the analytes addressed in the analysis.
- 75 samples.

The associated staff costs for freshwater sample collections are already funded and no additional staff would be required.

Toxics Biological Observation System Program

If WDFW makes a decision (based on supporting data) to add phthalate/metabolite analyses to their Toxics Biological Observation System Program to conduct a complete survey in all

[101] WA Office of Financial Management. 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[102] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.
[103] WA Office of Financial Management, 2023. Classified Job Listing. https://ofm.wa.gov/state-human-resources/compensation-job-classes/ClassifiedJobListing Accessed February 2023.
[104] WA Department of Ecology. 2023. 2023 Standard Costs (Standard Cost Assumptions). Ecology Fiscal Office.

indicator marine species, it would result in a total estimated cost of $297,600 for laboratory analysis over two years, averaging $148,800 per year.

- $800 per sample, reflecting the potential scope and complexity of the chemicals being analyzed.
- 372 samples.

The associated staff costs for marine organism sample collections by WDFW are already funded and no additional staff would be required.

Puget Sound Sediment Monitoring Program

If Ecology makes a decision (based on supporting data) to expand the analysis of phthalates in Ecology's Puget Sound Sediment Monitoring Program,[105] it would result in a total estimated cost of about $12,000 per year for additional laboratory analysis.

Regulatory and funding context

WDFW is asking the state legislature for funding to expand monitoring of contaminants of emerging concern in marine biota. If funding is approved it would cover the analyses of phthalates/metabolites across marine indicator species in Puget Sound (up to $297,600 over 2 years).

1.14.4 Expand tissue monitoring to include biomarkers of endocrine disruption as needed

Funding estimates are not relevant at this time. Ecology would first need to develop analytical methods and collect and analyze tissue samples, to assess the need for endocrine biomarkers.

1.14.5 Evaluate fish tissue data for human health risk, when available

The Department of Health routinely evaluates fish tissue data for contaminants that pose risks to human health. This work falls under duties and responsibilities of Toxicologists at DOH (currently 1.0 FTE dedicated to fish program). Additional evaluation work that may be produced by the collection of phthalate fish data is anticipated to be absorbed by the current position and not require additional FTEs. Fish advisory education/outreach support and physical materials are funded through existing funding sources.

[105] Note there are currently 6 phthalate analytes under the program.