PUGET SOUND NATIONAL ESTUARY PROGRAM

Toxics in Fish Vital Sign

Base Program Analysis

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EXECUTIVE SUMMARY

The Toxics in Fish Vital Sign is a metric that compares the concentration of toxics present in fish species with threshold levels thought to be protective of human or ecological health as an indicator of water quality in the Puget Sound. There are four classes of toxic contaminants tracked under the indicator: PAHs (polycyclic aromatic hydrocarbons), PBDEs (polybrominated diphenyl ethers), PCBs (polychlorinated biphenyls), and EDCs (endocrine disrupting compounds). These contaminants are widespread in the marine environment and have a variety of anthropogenic sources, including, among others, vehicular emissions, flame retardants in consumer products, legacy building materials, and personal care products and pharmaceuticals, respectively. They have been found to elicit detrimental impacts on the health of benthic and pelagic species, including salmonids, along with their mammalian predators – most notably the Southern Resident Killer Whale.

In 2011, the Puget Sound Partnership developed the Toxics in Fish Vital Sign as one of several indicators to communicate the health of Puget Sound, gauge improvements or declines, and specify regional recovery goals in the context of coordinated efforts supported by the National Estuary Program (NEP). The Toxics in Fish Vital Sign has one recovery target: by 2020, "toxics in fish are below threshold levels" (i.e. levels considered harmful to fish health, or harmful to the health of people who consume them).

Development of a regional recovery strategy intended to accelerate progress toward this indicator goal began in 2017. This Implementation Strategy was led by the Stormwater Strategic Initiative, a partnership between the Washington Department of Ecology, Washington Department of Commerce, and the Washington Stormwater Center. A volunteer Interdisciplinary Team (IDT) of fourteen technical experts generated five strategies using a collaborative process based on guidelines presented by the *Open Standards for the Practice of Conservation*. These strategies are:

1. Chemicals of Emerging Concern (CEC) prioritization, prevention and management: Identify and prioritize CECs that are most likely to cause harm in order to support the development of policy, regulatory, and incentive programs.

2. Incentivize swap-outs: Incentivize removal of legacy sources of toxics in infrastructure and consumer products (e.g. caulks and capacitors), and replace them with products that contain less harmful chemicals.

3. Find and fix hotspots: Identify and prioritize high-loading land use areas and activities, and apply targeted source control efforts and engineered stormwater retrofits. High-loading land use areas typically are cities, industrial zones, and areas where a high concentration of toxics flow into water from the land.

4. Incentivize redevelopment in high-loading areas to reduce toxic loading: Develop and implement incentive programs to encourage redevelopment of brownfields and the use of Low Impact Development techniques for urban infill projects.

5. In-and near-water cleanup: Prioritize and accelerate cleanup of toxics in the water and nearshore based on risk to species.

This Base Program Analysis is one of several appendices to the Toxics in Fish Implementation Strategy Narrative prepared by the Strategic Stormwater Initiative. It assesses ongoing programs relevant to the Toxics in Fish indicator goal and is intended to help regional partners operationalize the four strategies developed by the IDT. It was developed in accordance with U.S. Environmental Protection Agency (1993) guidance for NEP base program analyses.

This report starts with a brief introduction to the Puget Sound NEP recovery planning. The remaining content is grouped into three action-oriented categories that encompass the five strategies: prevention of pollution, mitigation of pollutant sources and loading, and cleanup of contaminated areas and marine habitats. An overview of regulatory tools that can be leveraged to support implementation of these three goals and their associated strategies is provided, with a particular focus on the Clean Water Act and the Washington Model Toxics Control Act.

References to relevant regulations and programs, potential changes to existing programs, and their implications for the implementation of each strategy are made throughout the report. Strategy descriptions are followed by specific priority approaches that the IDT recommended to help attain strategy objectives. These sub-sections include review of supporting literature; discussion of key programs, barriers, opportunities, and innovative models that could be replicated; and recommendations for implementation based on the authors' review and analysis.

STRATEGY 1: CHEMICALS OF EMERGING CONCERN PRIORITIZATION, PREVENTION AND MANAGEMENT

Conventional methods for regulating toxic contaminants in the environment rely on restrictions on production and "end-of-pipe" standards for pollutant releases (EPA, 2008). However, existing data indicate that marine species in the Puget Sound are being exposed to a wide range of dispersed, unregulated chemicals collectively known as Chemicals of Emerging Concern (CECs). These chemicals originate from a variety of consumer products, including pharmaceuticals and personal care products, plastics and detergents. Of particular concern are CECs that exhibit endocrine-disrupting effects (EDCs) among fish populations at low concentrations. This strategy aims to address CECs through 1) enhanced scientific study to prioritize actions (or chemicals needing action), 2) improved regulation at the consumer product level and 3) enhanced voluntary management of CECs.

Information gaps that inhibit effective regulation and management can be addressed through enhanced scientific understanding and occurrence monitoring of CECs. Advanced analytical methods capable of detecting environmentally-relevant, low-concentration toxics in water can provide occurrence data, while high-throughput biological assays and computational models, such as those used by EPA's Endocrine Disruptor Screening Program and the ToxCast and Tox21 research programs, can provide data on chemical-specific impacts to humans and aquatic life, thereby enabling improved prioritization of chemicals.

Significant steps have been taken to support the improved regulation of CECs since the IDT developed this strategy. In 2019, Washington's Legislature passed SSB 5135, which created the Safer Products for Washington Program. This provided Ecology with authority to prioritize CECs and the consumer products in which they are found, and to regulate their use through prohibitions or requirements to provide the agency a notification of use. This new program is consistent with the strategy developed by the IDT. The Puget Sound Ecosystem Monitoring Program (PSEMP), in collaboration with the Columbia River Toxics Reduction Workgroup, have begun developing a scientifically-based prioritization process that will support these regulatory efforts.

Voluntary approaches to the management of CECs, such as Washington's recently-adopted Safe Medication Return Program, provide a promising mechanism for reducing the loading of ubiquitous, therapeutic CECs that results from the improper disposal of unused medications. Consumer-awareness campaigns and labeling rules, such as California's Proposition 65 and the Campaign for Safer Cosmetics, can drive reductions in CEC occurrence through changes in consumer behaviors and market-based incentives for the use of safer alternatives to CECs. Monitoring of CEC occurrence in wastewater streams and consumer products will be necessary to support focused management strategies.

Specific recommendations for this strategy include:

- In order to narrow information gaps and facilitate efficient regulatory efforts, analytical efforts should focus on measuring the environmental occurrence and toxicity of compounds that are likely to pose environmental risk, but for which there remain data gaps and uncertainties that make them difficult to effectively manage or regulate. Consider investment in analytical method development and ecotoxicity evaluation as required.
- Chemical Action Plans (CAPs) provide comprehensive scientific research, policy analysis and guidance for addressing specific toxic chemicals in Washington State. Currently, the pathway for the development of CAPs is governed by the PBT rule for chemicals that are listed as persistent, bioaccumulative and toxic. Consider creating an avenue for the development of CAPs for CECs that are prioritized by Ecology or other rigorous processes, with a particular focus on CECs that exhibit an EDC mode of action.
- Current legislative focus is on regulating CECs at the consumer product (source) level. The IDT has also emphasized the need to address CECs further along the causal pathway. Consider revising water quality standards to include CECs where data and risk are sufficient to support the development of CEC-specific aquatic life criteria.
- Municipalities are not required to treat CECs in waste and stormwater, nor monitor for their occurrence up- or down-stream of treatment plants. Increased monitoring of CEC occurrence would support efforts to manage their presence in municipal wastewater and stormwater.

STRATEGY 2: INCENTIVIZE SWAP-OUTS AND REMOVAL OF LEGACY POLLUTION SOURCES

Some consumer products and older infrastructure are sources of toxic contamination to Puget Sound. Examples include creosote-treated wood pilings, old wood stoves and vehicles (PAHs); old capacitors, electrical equipment and some caulks and paints (PCBs); and flame retardant electronic components and household furniture (PBDEs). The goal of this strategy is to reduce or eliminate these specific sources of toxics by incentivizing their removal through current and/or new voluntary programs.

PCBs in older building materials remain a source of contamination to Puget Sound and are the subject of significant planning and analysis in Ecology's 2015 Chemical Action Plan. The EPA provides detailed guidance and BMPs for removing PCB-contaminated materials and electrical equipment, which may be useful in the development of targeted remediation programs in Washington. Information gaps, such as a lack of comprehensive inventories on the presence of contaminants in commercial and public buildings, remodeling and energy efficiency updating schedules, hinder organized and targeted PCB removal. A New York City PCB abatement pilot program for public schools could serve as a model for program development and monitoring.

Water-based sources of PAHs, such as vehicular leaks and oil spills, creosote-treated wood pilings and creosote-treated railroad ties near watersheds, are the dominant medium for loading of PAHs into the Puget Sound (see Starter Package for more details on PAH loading). Vehicular sources have been targeted through social marketing campaigns encouraging leak repair (Don't Drip and Drive). Significant progress has been made in systematically removing marine pilings through the Washington Department of Natural Resources (WDNR) Piling Removal Program. Additionally, Ecology has begun work on identifying and mapping railroad ties and their proximity to high priority, critical fish habitats, with next steps being field investigations to better understand PAH loading due to railroad ties in priority areas. Continued support and/or expansion of these programs would support progress toward PAH reduction goals.

PBDEs in consumer products, aside from enhanced regulation and product testing as outlined in Strategy 1, can be addressed through voluntary swap-out programs and social marketing to incentivize participation. Existing King County recycling programs for electronics (E-Cycle) and mattresses (LinkUp) may support product disposal efforts; currently, few swap-out programs actively target PBDE-containing products that have not yet reached the end of their useful lives. There is room for the development of a pilot program that would enable furniture swap-outs, and for increased monitoring of PBDE sources from consumer products from production to recycling/disposal.

Specific recommendations for this strategy include:

- PCB-removal projects are currently not prioritized within planned energy efficiency updates for schools and public buildings. Consider accelerating PCB removal projects by developing a state-wide inventory of PCB-containing public buildings to support organized remediation efforts. Adopt EPA's abatement BMPs and track the number of PCB ballasts removed when updating public buildings through energy efficiency programs.
- Provide technical assistance to remove PCB-containing lamp ballasts throughout Puget Sound, with the Canadian ProductCare program as a possible model.

- Compare the cost-effectiveness of long-term campaign commitments with direct financial incentives for vehicle leak repair with regulatory changes for vehicle standards, such as those already in place for air emissions.
- Evaluate PAH loading in priority areas (salmon-supporting habitats and wetlands) associated with railroad ties. Support regulatory and/or voluntary pathways for removal in those priority areas.
- Evaluate the effectiveness of recycling programs in reducing PBDE loading over landfill methods.
- Develop a pilot program for couch removal and recycling to reduce PBDE loading. Incorporate monitoring of PBDEs from consumer products that are traded out into program design.

STRATEGY 3: FIND AND FIX HOTSPOTS

Non-point source pollution associated with stormwater runoff from urban, industrial and commercial areas is a widely recognized source of toxics loading to Puget Sound. Comprehensive loading studies, such as that by Herrera (2011), illuminate land uses and activities that contribute most to high-volume and/or high-concentration loadings of PCBs, PAHs and PBDEs through stormwater pathways. The goal of this strategy is to mitigate these pollutant sources by 1) prioritizing pollution hotspots through source tracing investigations, 2) improving jurisdictions' capacities for source control, pollution prevention and BMPs, and 3) installing pollution control retrofits in existing developments that are not scheduled for redevelopment.

Well-developed source tracing, source control and stormwater monitoring programs in the Cities of Seattle and Tacoma have supported the identification and remediation of toxics hotspots in the Lower Duwamish and Commencement Bay Superfund Sites. MTCA and Washington Stormwater Financial Assistance Program grants provided financial support for the City of Seattle's source tracing projects. Given the expansion of 2019 NPDES Municipal General Stormwater permit requirements to include smaller, Phase II permittees of Western Washington, the two comprehensive programs could serve as a model from which smaller municipalities can develop source tracing and monitoring programs.

Research and monitoring is integral to the effective management of hotspots and the development of pollution control retrofits. Hydrodynamic coastal ocean models, such as the Puget Sound Regional Toxics Model and the Salish Sea Model, are actively being focused on regional toxics fate and transport modeling. Model results could help to prioritize hotspots on a large geographic scale. The Stormwater Action Monitoring Program (SAM) directly supports regional stormwater management efforts by collating historical records of illicit discharges and providing technical guidance and instruction on source tracing, as well as scientific monitoring studies of pollution control retrofits and contaminant-specific treatments. SAM's work addresses a need identified by the IDT for improved collation of toxics loading data and enhanced monitoring of BMP effectiveness and pollution control retrofits.

The IDT has collectively emphasized the need to reduce liability barriers (provide "Safe Harbor") associated with remediation costs to enable information-sharing and the identification and remediation of pollutant hotspots. Economic liability may indeed present a disincentive to source tracing, especially

where it leads to the discovery of legacy contamination for which liability falls on the discoverer regardless of fault. That said, the liability associated with MTCA and/or CERCLA is generally considered an incentive to source control and proactive management of known or suspected contamination associated with one's own activities. Creating liability shields to encourage source tracing may therefore have unintended repercussions for source control efforts upstream of contaminated areas.

Jurisdictional capacity for source control and BMP implementation would be enhanced through increased funding for stormwater management and pollution control. 2019 legislative changes to MTCA led to the creation of a separate account for funding stormwater-specific BMPs and retrofit projects, along with increasing overall funding through changes to the Hazardous Substances Tax (HST). Additional grants and loans are available through Washington's Water Quality Combined Funding Program, which includes the Stormwater Financial Assistance Program.

Numerous organizations, such as the Puget Sound Pollution Reduction Center and ECOSS, provide technical assistance for the development of stormwater BMPs that reduce toxics and enable permit compliance. The Technology Assessment Protocol - Ecology program provides an avenue for the implementation of alternative treatment technologies to improve flexibility in achieving performance-based standards. In terms of hazardous wastes, the Local Source Control Partnership assists Ecology with the oversight and management of small-quantity hazardous waste generators. There is much room for the development of wastewater and stormwater BMPs that are sufficient to reduce the loading of EDCs into the environment; significant information gaps must be addressed before EDCs can be managed in this way.

Specific recommendations for this strategy include:

- There is currently not sufficient evidence to act on the IDT recommendation to reduce or eliminate liability for the purposes of incentivizing source tracing and information-sharing. Given the recent expansion of NPDES requirements to Phase II jurisdictions of Western Washington, along with legislative changes to the funding structure of MTCA, the authors recommend evaluating municipalities' engagement in source control in response to these rulings before making any substantive changes to the current MTCA liability structure.
- Consider prioritized CECs in addition to conventional pollutants when assessing new treatment technologies and BMP effectiveness for contaminant removal from both wastewater and stormwater.

STRATEGY 4: INCENTIVIZE REDEVELOPMENT IN HIGH-LOADING AREAS

Similar to Strategy 3, this strategy focuses on the stormwater runoff pathway for pollutant loading to Puget Sound; however, while the former focuses on source control, stormwater BMPs and treatment retrofits in existing developments, this strategy aims to reduce loading from properties that must be fully redeveloped to incorporate better stormwater management and treatment practices. Brownfield properties are a focus of this strategy because they represent contaminant hotspots for which stormwater treatment is limited or nonexistent, as well as opportunities for the application of Low Impact

Development (LID) techniques and the prevention of urban sprawl into natural landscapes. Two main approaches for accomplishing this strategy are to 1) remove barriers to infill and redevelopment of brownfields in urban growth areas, and 2) enhance the adoption of low-impact drainage methods for redevelopment projects.

High property values in Western Washington create a strong economic incentive to develop on underutilized urban sites. However, regulatory, financial and liability barriers to the redevelopment of brownfield properties persist for both public and private developers. Legislative changes have sought to address these barriers by enabling municipalities to establish Redevelopment Opportunity Zones (ROZs) and associated Renewal Authorities and Trust Fund Accounts. This has been an underutilized tool, primarily due to shortcomings in state funding to support contaminated site cleanups. Recent (2019) legislative changes to MTCA have increased the sum and availability of state funds to specifically support brownfield redevelopment projects and may be sufficient to promote the establishment of ROZs.

The majority of private developers go through Ecology's Voluntary Cleanup Program (VCP) when purchasing and remediating brownfields for the purposes of redevelopment. However, limited agency capacity and legal processes associated with resolution of liability issues combine to limit the number of VCP cleanups that are completed each year. In July 2020, Ecology launched a new Expedited Voluntary Cleanup Program intended to increase the efficiency of the cleanup process and allow Ecology to deliver opinions on a predictable timeline. Expedited VCP customers pay for staff time, thereby funding additional Ecology cleanup project managers.

Current (2019) NPDES Municipal General Stormwater permits, required for Phase I and Phase II municipalities of Western Washington, provide a robust set of development and operational BMPs that are expected to meet water quality goals for stormwater with respect to both volume and pollutant loading. LID goes further in maintaining or restoring natural hydrological characteristics of filtration and infiltration of stormwater. A number of barriers to the adoption of LID for redevelopments exist, including construction and maintenance costs, regulatory burdens, and a lack of clear methodology and standards for development. Ecology's Building Green Cities project aims to address these barriers through research and social marketing and educational campaigns.

STRATEGY 5: IN- AND NEAR-WATER CLEANUP

This strategy focuses exclusively on the cleanup of sources of contaminants that are in or proximate to important receiving waters. Two approaches for accomplishing this strategy are: 1) identify and rank priority areas, especially urban bays, based on risk to species, and 2) accelerate cleanup.

Ecology's Toxics Cleanup Program under MTCA is the primary engine that drives the cleanup of contaminated lands and waterbodies in Washington State. Prioritization of upland sites (e.g., contaminated soil and groundwater) for cleanup is currently based on an outdated methodology that does not provide risk and exposure metrics grounded in bioaccumulation-based toxicity standards or concerns for social equity (Juncjo, 2017). Ecology has proposed to update this ranking method with the

Site Hazard Assessment and Ranking Process (SHARP), which is designed to address these issues through revised exposure metrics and site prioritization.

Ecology revised Sediment Management Standards (SMS), which govern the remediation of contaminated sediments, in 2013. Concerns over sediment cleanup standards that are not protective of Indigenous communities that consume fish for subsistence purposes are tied together with changes to the State's Water Quality Standards for PCBs. Extremely low concentration standards for PCBs that are calculated to be protective of high fish-consuming populations present practical and economic difficulties for remediation professionals and liable parties; Ecology has sought to balance the need for flexibility in achieving tight cleanup standards with regulatory consistency and clarity in the revised SMS.

The Dredged Material Management Program (DMMP) defines standards and approaches for handling sediments that are disposed of in open-water sites in Puget Sound. Bioaccumulation-based toxicities are not typically evaluated in on-going monitoring of disposal sites; however, the DMMP is currently working to revise this aspect of the monitoring framework. This effort to emphasize bioaccumulation-based evaluation approaches is consistent with Ecology's 2013 Sediment Management Standards (SMS) update.

The IDT has suggested that improved funding and the establishment of project deadlines may provide incentives to accelerate in- and near-water cleanups. Large-scale, deadline-driven and coordinated cleanups have indeed been effective in Puget Sound through the Puget Sound Initiative. The Puget Sound Initiative is a bay-wide approach to accelerating the remediation of contaminated sites in high-priority waterways, waterfronts and urban waters in the Puget Sound. Significant state funding and coordinated efforts between the Ports, local agencies and property owners have led to substantial progress toward 2020 cleanup goals. Some overlap exists between a Bellingham Bay ROZ for brownfields and the Puget Sound Initiative, which support both Strategies 4 and 5, respectively.

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ACRONYMS AND ABBREVIATIONS

B-IBI	Benthic Index of Biotic Integrity
BMP	Best Management Practice
CAP	Chemical Action Plan
CEC	Chemical of Emerging Concern
CERCLA	Comprehensive Environmental Response, Cleanup and Liability Act
Commerce	Washington State Department of Commerce
CPSA	Consumer Product Safety Act
CRL	Community Renewal Law
CSO	Combined Sewer Overflow
CSPA	Washington Children's Safe Product Act
CWA	Clean Water Act
DMMP	Dredged Material Management Program
ECB	Ecosystem Coordination Board
Ecology	Washington State Department of Ecology
EDC	Endocrine-disrupting compound
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCR	Fish Consumption Rate
GIS	Geographic Information Systems
HST	Hazardous Substance Tax
IDDE	Illicit Discharge Detection and Elimination
IDT	Interdisciplinary Team
LDW	Lower Duwamish Waterway
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer Systems

MTCA	Model Toxics Control Act
NEP	National Estuary Program
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic aromatic hydrocarbon
PBDE	Polybrominated diphenyl ether
PBT	Persistent, bioaccumulative and toxic
PCB	Polychlorinated biphenyl
PNEC	Predicted No Effects Concentration
PPCD	Prospective Purchaser Consent Decree
PSCAA	Puget Sound Clean Air Agency
PSEMP	Puget Sound Ecosystem Monitoring Program
PSI	Puget Sound Institute
PSP	Puget Sound Partnership
PSRTM	Puget Sound Regional Toxics Model
RCW	Revised Code of Washington
ROZ	Redevelopment Opportunity Zone
SAM	Stormwater Action Monitoring
SHARP	Site Hazard Assessment and Ranking Process
SMS	Sediment Management Standards
SPU	Seattle Public Utilities
SWMMWW	Stormwater Management Manual for Western Washington
TAPE	Technology Assessment Protocol – Ecology
Task Force	Southern Resident Killer Whale Task Force

TMDL	Total Maximum Daily Load
TPCH	Toxics in Packaging Clearinghouse
TSCA	Toxic Substances Control Act
UGA	Urban Growth Area
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VCP	Voluntary Cleanup Program
WAC	Washington Administrative Code
WARM	Washington Ranking Method
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WQS	Water Quality Standards

1. INTRODUCTION

In the 1987 Clean Water Act, Congress established the National Estuary Program (NEP) to protect and restore the water quality and ecological integrity of estuaries of national significance. Puget Sound was one of the original estuaries of national significance. In 2007, the Washington State Legislature re-emphasized its commitments under the NEP, outlining six broad recovery goals for the Puget Sound:

- Healthy Human Population—A healthy population supported by a healthy Puget Sound that is not threatened by changes in the ecosystem.
- Vibrant Quality of Life—A quality of human life that is sustained by a functioning Puget Sound ecosystem.
- Thriving Species and Food Web—Healthy and sustaining populations of native species in Puget Sound, including a robust food web.
- Protected and Restored Habitat—A healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored, and sustained.
- Abundant Water Quantity—An ecosystem that is supported by good groundwater levels as well as river and stream flows sufficient to sustain people, fish, wildlife, and the natural functions of the environment.
- Healthy Water Quality—Fresh and marine waters and sediments of a sufficient quality to support water that is safe for drinking, swimming, and other human uses and enjoyment, and which are not harmful to the native marine mammals, fish, birds, and shellfish in the region.

The Legislature established the Puget Sound Partnership (PSP) to develop strategies for the implementation and monitoring of efforts necessary to accomplishing the recovery goals. The PSP leads the Puget Sound NEP by bringing together partners to mobilize action around a common agenda. The PSP focuses the region's collective effort through development of a shared vision and strategy articulated in the Action Agenda for Puget Sound. This comprehensive plan helps efficiently allocate federal, state, and local recovery investments based on a science-driven, prioritized system.

The PSP has developed 25 Vital Signs that support measurement of progress toward the six recovery goals. Vital Signs represent overarching measures used to communicate the health of Puget Sound and gauge improvements or declines with respect to each recovery goal. Each Vital Sign has one or more specific and measurable metrics known as "indicator targets," which include quantitative milestones that reflect the region's commitments to and expectations for significantly improving the condition of Puget Sound by the year 2020.

1.1 TOXICS IN FISH VITAL SIGN

This section describes Vital Sign and indicator targets in place during development of the Toxics in Fish Implementation Strategy. An effort to revise the Vital Sign indicators for use beyond 2020 began in 2019. The following content provides context for the 2017-2020 planning effort that resulted in the strategies described throughout this document.

In order to track progress toward the Healthy Water Quality recovery goal, the PSP adopted Washington State Department of Fish and Wildlife's (WDFW) 'toxics in fish' metric as an indicator of ecosystem condition, whereby low levels of toxics found in fish tissue indicate healthy marine and fresh water quality sufficient to support ecosystem and human health. The PSP Leadership Council selected the following four classes of toxic chemical groups that WDFW has been monitoring since 1989 as indicators for the Toxics in Fish Vital Sign:

1. Polychlorinated biphenyls (PCBs) – persistent and bioaccumulative chemicals that were designed for various industrial uses (primarily for electrical equipment), and were banned in the US in 1979. Trace amounts still occur in a range of consumer and industrial products .
2. Polybrominated diphenyl ethers (PBDEs) – persistent, bioaccumulative, and primarily flame-retardant compounds that occur in many products such as sofas and television plastics; the primary formulations were banned in 2011 in Washington State.
3. Polycyclic aromatic hydrocarbons (PAHs) - persistent and potentially bioaccumulative hydrocarbons that are produced primarily from burning fossil fuels and from oil spills, and which occur in creosote-treated wood products.
4. Endocrine-disrupting compounds (EDCs) – a broad group of chemicals representing a range of persistence, lipophilicity and hormonal modes of action, defined primarily by their interference with the proper functioning of the endocrine system in biota.

The recovery target for this vital sign, as set by the 2011 Leadership Council is that, by 2020, "toxics in fish are below threshold levels" (i.e. levels considered harmful to fish health, or harmful to the health of people who consume them).[1] The Leadership Council identified concentration thresholds for the four main toxic groups in four fish indicator species/life stages: English sole (adults), Pacific herring (adults), juvenile Chinook salmon, and adult Chinook salmon. These four species/life stages were selected to represent conditions in the benthic and pelagic food webs; in highly migratory, and thus especially vulnerable, fish; and in seafood most consumed by humans. The specific conditions for achievement of the target are presented in Table 1.[2]

[1] O'Neil et al. (2018) provide a history of processes used to select and refine indicators of Puget Sound's biophysical condition, as well as early recommendations for the revision effort underway at time of writing. Human Wellbeing Vital Signs and indicators were developed through a separate process described in Biedenweg (2014), Biedenweg et al. (2014), and Stiles et al. (2015).

[2] The revision effort previously referenced resulted in the addition of an indicator in June of 2020 that is not included in this table or in further analysis: toxics in caged mussels. In light of this, the Leadership Council has also opted to change the Vital Sign name to "Toxics in Aquatic Life." For the purposes of this study, only the former title and associated indicators will be used.

Table 1. Indicators and associated recovery goals for the 2017-2020 planning effort.

Indicator	Recovery Goals				Target habitat/food web	Spatial Scale
	PAHs	PBDEs	PCBs	EDCs		
Pacific Herring	< uncontaminated background (fish health)	95%< 470 ng/g lipid (fish health)	95% < 2,400 ng/g lipid (fish health)	not measured	Pelagic	Basin
English Sole	no PAH related disease (fish health)	95%< 40 ng/g wet wt (human health)	95%< 8 ng/g wet wt (human health)	no contaminant-related reproductive impairment (fish health)	Benthic	Embayment
Chinook Adult	not measured	95%< 40 ng/g wet wt (human health)	95%< 8 ng/g wet wt (human health)	not measured	Pelagic	Puget Sound/ Ocean
Chinook Juveniles	< uncontaminated background (fish health)	95%< 470 ng/g lipid wt (fish health)	95%< 2,400 ng/g lipid wt (fish health)	not measured	River mouth/ nearshore marine	River mouth/ estuary/ watershed

1.2 IMPLEMENTATION STRATEGIES

As of 2020, progress towards Vital Sign goals has been limited. The most recent (2019) State of the Sound Report from the Puget Sound Partnership indicated that Toxics in Fish Vital Sign indicators were either showing mixed results or had insufficient data for evaluation. The U.S. Environmental Protection Agency (EPA), as the federal lead for NEP efforts in Puget Sound, identified a need to further focus regional recovery and protection priorities. The Implementation Strategy is a planning tool developed to provide this focus.

Implementation Strategies describe strategies and approaches necessary to accelerate progress toward reaching individual Vital Sign indicator targets. They are intended to serve as a road map for aligning opportunities across agencies and programs, providing priorities for the Action Agenda, and guiding funding decisions. These Strategies are developed collaboratively with technical, professional and policy experts and with local and regional input.

The creation of an Implementation Strategy follows a PSP-designed process, whereby 1) a volunteer **Interdisciplinary Team,** recruited through a public process, directs the development of Strategy priorities and elements using the *Open Standards for the Practice of Conservation* planning tools for guidance; 2) the strategies and content developed by the IDT are vetted and refined during topical subgroup meetings, a **technical workshop** and a **partner workshop**, enabling broader participation, expert consultation, and

input from organizations and agencies that may bear some responsibility in carrying out the proposed actions; and 3) the Implementation Strategy is published for public and external science review.

A complete Implementation Strategy contains the following elements:

- A narrative that summarizes the eight major content areas; identifies and prioritizes approaches for achieving targets; describes strategies, actions, programs, and policy changes associated with each approach; delineates research and monitoring needs; identifies adaptive management opportunities and estimates strategy costs.
- Three types of *Open Standards for the Practice of Conservation* logic models:
    1. A situation analysis that documents the IDT's common understanding of the factors contributing to problems, barriers, and implementation opportunities. This conceptual model is used to help participants decide where and how to intervene.
    2. **Result chains** that describe the cause-effect changes necessary to make progress under each identified approach. They define the sequence of steps needed to achieve specific outcomes, and document group hypotheses about how approaches are intended to address identified problems.
    3. A schematic overview depicting how the approaches selected by the IDT work together to drive progress towards indicator targets. Priority pathways are also indicated.
- Supporting technical reports/appendices including an analysis of ongoing programs per NEP guidance for "base program analysis" (EPA 1993); a state of knowledge report synthesizing technical information about current conditions and uncertainties; and tables that specify proposed actions to achieve outcomes identified in the results chains.

1.3 DEVELOPMENT OF THE TOXICS IN FISH IMPLEMENTATION STRATEGY

An Implementation Strategy for the Toxics in Fish Vital Sign has been under development since early 2018. The process was led by the Stormwater Strategic Initiative, consisting of personnel from the Washington State Department of Ecology (Ecology), Washington State Department of Commerce (Commerce) and the Washington Stormwater Center. The Puget Sound Partnership (PSP) and Puget Sound Institute (PSI) provided technical support.

The Interdisciplinary Team (IDT) of fourteen technical experts represents several perspectives (local government, tribal, state agency, federal agency, non-profit organization, private sector, academia) and disciplines (chemistry, toxicology, ecology, fish biology, policy, and advocacy).

After developing causal models illustrating pathways from sources to indicator fish species, the IDT identified and prioritized points of intervention along the causal pathways. The IDT ultimately selected and grouped these interventions into five strategies to reduce toxic loading to the marine environment and to reduce toxic levels in indicator fish to target levels.

In this document, the five strategies are organized into the following action-oriented categories: **prevention** of production and use of toxics, **mitigation** of toxics loading, and **cleanup** of existing

contaminated site, in order to facilitate discussion of common regulatory requirements. The strategies are:

PREVENTION

1. Chemicals of Emerging Concern (CEC) prioritization, prevention and management: Identify and prioritize CECs that are most likely to cause harm in order to support the development of policy, regulatory, and incentive programs.

MITIGATION

2. Incentivize swap-outs: Incentivize removal of legacy sources of toxics in infrastructure and consumer products (e.g. caulks and capacitors), and replace them with products that contain less harmful chemicals.

3. Find and fix hotspots: Identify and prioritize high-loading land use areas and activities, and apply targeted source control efforts and engineered stormwater management solutions. High-loading land use areas typically are cities, industrial zones, and areas where a high concentration of toxics flow into water from the land.

4. Incentivize redevelopment in high-loading areas to reduce toxic loading: Develop and implement incentive programs that increase installation of stormwater control retrofits in existing developments and redevelop brownfields.

CLEANUP

5. In-and near-water cleanup: Prioritize and accelerate cleanup of toxics in the water and nearshore based on risk to species.

This report provides a brief overview of the strategies and organizes the programmatic framework according to priority approaches for each strategy. More information on the Implementation Strategy can be found in the Implementation Strategy Narrative and supporting appendices. A description of the Implementation Strategy development process is provided in Appendix IVa. (Strategy Development Review).

1.4 RELATIONSHIP WITH THE SOUTHERN RESIDENT KILLER WHALE TASK FORCE

In March of 2018, Governor Inslee formed, by executive order, the Southern Resident Orca Task Force (Task Force), in the wake of a national media frenzy centered on the orca, Tahlequah, carrying her dead calf for 17 days in the Puget Sound). The visceral display of the fragility of the region's "iconic and treasured species" created a policy window for taking swift and aggressive action to confront threats to the orca. Because the health of apex predators like orca are, in large part, dependent upon the health and abundance of their prey, efforts to restore the estuary for the benefit of the fish species (particularly Chinook, orcas' primary prey) are significant for orca.

Some Toxics in Fish IDT members joined the new Task Force, carrying over relevant work that had been theretofore completed through the Implementation Strategy. The Task Force's subsequent recommendations for action were in part included in the Washington Governor's funding requests in the 2019 budget proposal. The Governor's Office, in conjunction with the Task Force and the PSP, successfully passed bills during the 2019 session of the Washington State Legislature that consequently implemented elements of the strategies previously developed by the IDT. Where relevant, this report describes progress that has already been made toward implementing strategy recommendations as a result of this collaboration.

1.5 SCOPE OF THIS REPORT

This report is one of several appendices to the Toxics in Fish Implementation Strategy narrative. It assesses ongoing programs related to the management of contaminants in Puget Sound, focusing on those that are most relevant to the strategies and approaches described in the Implementation Strategy. It is intended to help regional partners identify the range of policies and programs that may support the prevention, mitigation, and cleanup of toxic contaminants, and operationalize the Implementation Strategy.

The following evaluations began as part of a "Starter Package," prepared to synthesize existing information so that the IDT could begin deliberations with a shared understanding of current conditions (Appendix IIa). New information received and knowledge gained during the Implementation Strategy development process was added to the starter package content.

This report provides an overview of each strategy, 2-4 priority approaches that support each strategy, and several specific actions or conditions that are needed to achieve intermediate results identified by the IDT in the results chains. It identifies existing federal and state regulations, programs, research, funding opportunities, and/or policies that may support these enabling conditions, priority approaches, and overall improved prevention, mitigation, or cleanup of toxic contaminants.

Recommendations provided in this document are derived from results of previous NEP-funded toxics projects summarized by Roberts (2017), suggestions made during IDT meetings and technical/partner workshops, Ecology Chemical Action Plans, unstructured discussions with program implementers, and opportunities identified by the author during review of pertinent literature. Bolded statements are conclusions drawn from the author's own analysis.

2. PREVENTION

Prevention refers to the reduction in the loading of toxic contaminants in the environment by targeting the beginning of the causal chain of exposure: the manufacture, production and use of harmful chemicals, particularly those that are not yet well-regulated. Of the five strategies developed by the IDT, Strategy 1 is considered to be preventative in nature, targeting contaminants whose widespread presence in the environment is primarily associated with consumer products.

2.1 REGULATORY DRIVERS

The regulatory framework for pollution prevention includes federal and state-levels bans on the manufacture and production of pollutants and prohibitions on toxics in consumer products and packaging. The regulatory framework for the prevention of toxics production and manufacture is generally limited by a reactionary, rather than precautionary, approach to rulemaking. Of the chemical groups that are the focus of the Toxics in Fish Vital Sign, only PCBs and some congeners of PBDEs are outright banned by federal regulations; in Washington State, all main congeners of PBDEs are also banned.

2.1.1 TOXIC SUBSTANCES CONTROL ACT

The federal Toxic Substances Control Act (TSCA) requires the EPA to maintain a list of toxic substances that are authorized for manufacture, production, and sale in U.S. markets and which do not present an unreasonable risk to human health or the environment. TSCA has historically been largely ineffectual (Vogel, 2004; Flint, 2012; Toxics Reduction Strategy Workgroup, 2013), but was amended in 2016 through the Lautenberg Chemical Safety Act in an effort to address some of the law's biggest weaknesses.

When TSCA was originally passed, it grandfathered over 60,000 chemicals already in use without evaluation; in order to remove a chemical from this list, the burden rested on the EPA to determine that the chemical presented an unreasonable risk to human health, and that any regulation of the chemical passed a cost-benefit analysis and represented the least burdensome method of reducing the risk (Krimsky, 2017). With respect to novel chemicals, manufacturers were required to submit a notification of intent to manufacture a new chemical or product, which would enable the EPA, within 90 days, to determine if the chemical posed an unreasonable risk and should be regulated subject to the same economic constraints. However, the law did not require manufacturers to provide toxicological information on their chemicals; this deficiency of information, time and resources, combined with strong corporate litigation in the face of ambiguously defined "unreasonable risk," has led to limitations or bans on only 5 chemicals out of the approximately 85,000 that are inventoried and currently in commerce (Krimsky, 2017; Vandenberg, 2016).

The Lautenberg Chemical Safety Act aimed to strengthen the law by moving toward a more precautionary approach to rulemaking. The act did so primarily by requiring the EPA to make an evaluation and affirmative finding of "*no* unreasonable risk" for all new chemicals, with special considerations for vulnerable populations such as women and children, and by disallowing cost-benefit analyses in risk

evaluations, requiring the evaluation of already inventoried chemicals that are considered high priority, and removing the requirement for the least burdensome regulatory approach. The cost of risk evaluations is in part placed on industry (Krimsky, 2017; Vandenberg, 2016). Since the act was passed, 1,440 new chemicals or new uses of chemicals have been reviewed through this process; none have thus far been prohibited from commercialization (EPA, 2020a).

Several complex preemption clauses under the revised TSCA prevent states from imposing stricter regulations on listed chemicals, contributing to their continued presence in consumer products (Baird et al., 2016). The preemption provisions do not, however, prohibit states from implementing stricter reporting or monitoring procedures, such as those promulgated in California's Proposition 65 (see section 2.2.3, for example).

PCBs are included in the short list of limited and banned chemicals; however, EPA rules provide exemptions for certain products containing PCBs at concentrations of fifty parts per million or less as a result of manufacturing processes, which is therefore considered unintended production.[3]

2.1.2 CONSUMER PRODUCT SAFETY ACT

The federal Consumer Product Safety Act (CPSA) regulates and enforces safety standards for consumer products and enables the issuance of recalls when necessary. A recent CPSA amendment, the Consumer Product Safety Improvement Act, adopted as rule voluntary American Society for Testing and Materials standards for children's toys, strengthening chemical limitations for certain children's products. The rule is very similar to, but less stringent and comprehensive as, the Washington State Children's Safe Products Act, described below (Section 2.1.3).

2.1.3 CHILDREN'S SAFE PRODUCTS ACT

The Washington Children's Safe Products Act (CSPA) is a two-part act that aims to minimize the presence of toxics in children's products through either prohibitions or notification requirements. The Department of Ecology must be notified if a children's product (toys, jewelry, cosmetics, safety seats, bottles, etc.), contains a chemical that is listed as a chemical of high concern to children in concentrations exceeding the limit of detection.[4] As of 2017, the list contained 85 chemicals, including metals, formaldehyde, aromatic hydrocarbons and various congeners of phenols, phthalates, parabens and flame retardants (including PBDEs).[5] Enforcement of the reporting rule relies on product testing by Ecology and subsequent civil fines.[6]

The CSPA also outright prohibits lead, cadmium, phthalates, and some flame retardants (including deca-PBDE) in children's products at concentrations exceeding 90, 40, 1000 and 1000 ppm, respectively.[7]

[3] RCW 39.26.280
[4] WAC 173-334
[5] WAC 173-334-130
[6] WAC 173-334-120
[7] RCW 70.240

However, as outlined in Ecology's 2009 CSPA report, "the lead, cadmium and phthalate standards […] were substantially preempted by the passage of the federal Consumer Product Safety Improvement Act by Congress in August, 2008. This federal act limits the amount of lead, cadmium and phthalates permissible in children's products and explicitly preempts states from enacting or implementing similar legislation" (Ecology, 2009a, p. 2). Washington now defers to the Consumer Product Safety Improvement Act regarding the use of lead, cadmium and phthalates in children's products that are expressly covered by the federal law. Washington's CSPA is generally stricter and broader in scope; products such as children's footwear, jewelry, cosmetics and car seats are not pre-empted and are therefore subject to CSPA restrictions (Ecology, 2009a).

A 2014/2015 Ecology study of ~300 children's products revealed frequent exceedances of compliance standards for reporting and prohibition under the CSPA (Mathieu and Sekerak, 2015). For example, out of 50 product samples that were analyzed for metals, 96% contained one or more metals above the reporting limit. This evidence of noncompliance suggests that toxic contaminants in consumer products are not effectively managed under the CSPA. High product testing costs and low penalties for noncompliance (<$5,000 penalty for first-time violations)[8] can undermine the force of these consumer product regulations. Furthermore, manufacturers may be limited in their ability to accurately characterize and report contaminants in their products by technical barriers and compliance costs (Ecology, 2009a).

Lastly, while CSPA requires Ecology, in consultation with the Department of Health, to update the list of chemicals of high concern as necessary, the burden is on Ecology to demonstrate that a chemical meets specified toxicity, persistence, bioaccumulativity, and exposure criteria. [9,10] Because the burden of proof (along with the resource costs associated with testing) lies solely on Ecology, the CSPA is not readily adapted to new contaminants.

2.1.4 TOXICS IN PACKAGING LAW

The Washington Toxics in Packaging Law prohibits the sum of the concentrations of lead, cadmium, mercury, and hexavalent chromium in any package or packaging to exceed 100ppm. The law is modeled after the federal Model Toxics in Packaging Legislation, where a "package" is defined as a container that markets, protects or handles a product; shipping containers of any size; and unsealed receptacles (e.g., cases, crates, cups, foil, trays, wrappers). In Washington, Ecology oversees the implementation of the rule, and expects to prohibit the sale or distribution of any packaging containing PFASs by 2022.[11] While Ecology does not have penalty authority, if a manufacturer fails to produce evidence of compliance upon request they many prohibit the sale of that packaging.[12]

The Toxics in Packaging Clearinghouse (TPCH) supports consistent implementation of the Model Toxics in Packaging Legislation amongst member states and generates impact studies and reports. The most recent

[8] WAC 173-334-120 (4)
[9] WAC 173-334-010
[10] WAC 173-334-070 (2)
[11] RCW 70.95G.070
[12] RCW 70.95G.060

(1998) impact analysis of the Toxics in Packaging Law is, however, outdated, and does not provide an evaluation of the impact of the program on reductions in loading of pertinent toxics to the environment through solid waste (The Council of State Governments, 1998). However, the TPCH has engaged in large-scale laboratory screening projects to coordinate state enforcement of the rule and bring companies into compliance; TPCH activities have led to the withdrawal of 100,000 non-compliant packaging units between 2015 and 2017 (Minnesota Pollution Control Agency, 2018). These screening and enforcement activities by the TPCH have heretofore been focused on heavy metal toxics such as lead and cadmium (TPCH, 2017).

2.1.5 PERSISTENT BIOACCUMULATIVE TOXICS RULE

As directed by the Washington State Governor in 2004, the Persistent, Bioaccumulative, Toxics (PBT) rule requires Ecology to identify and list chemicals or metals determined to be persistent, bioaccumulative and toxic to humans and/or the environment, in order to support their phase-out under other environmental laws and voluntary programs. The rule defines the criteria and process by which PBTs are listed and selected for development of a Chemical Action Plan (CAP) along with defining the scope and content of CAPs. CAPs are discussed in more detail in Section 2.2.1.

2.2 STATEGY 1: CHEMICALS OF EMERGING CONCERN – PRIORITIZATION, PREVENTION AND MANAGEMENT

Chemicals of emerging concern (CECs) are not limited to the four chemical classes presented in the Toxics in Fish Vital Sign, but rather are inclusive of chemicals that are generally neither well-monitored nor well-regulated within current federal and state frameworks. CECs include chemicals with EDC behavior, pharmaceutical and personal care products (many of which themselves are EDCs), phthalates, plasticizers (including bisphenol A and its congeners), and flame retardants (including PBDEs), among others. The goal of Strategy 1 is to prevent releases of CECs to the environment and subsequent impacts on fish by enhancing scientific understanding of CECs, promulgating preventative regulation, and enhancing voluntary management of CECs. Sections 2.2.1-2.2.3 provide brief descriptions of each of these approaches and their goals, along with specific programs and tools that support each of these approaches and recommendations for their implementation.

2.2.1. APPROACH 1: ENHANCE SCIENTIFIC UNDERSTANDING OF CECS

Scientific research and monitoring is required to prioritize CECs for efficient regulation and management. The IDT proposes implementing a focused monitoring and evaluation program to better understand CEC sources and pathways (wastewater treatment plants, stormwater, septic systems, etc.), occurrence patterns in biota, and biological, ecological and human health impacts. Scientific research also supports the assessment of practicable, less hazardous alternatives, the identification of which is often required before any legislative ban on the production or manufacture of certain chemicals (this requirement is present in Washington's Safer Products for Washington rule (section 2.2.2)).

Table 1 provides a brief overview of catalogues and modeling tools for understanding chemical hazards, pathways, and impacts of CECs, assessing alternatives, and testing consumer products for CECs. The remaining section is devoted to a more detailed discussion of toxicology databases, regional monitoring programs and advanced analytical methods for evaluating the ecotoxicity of CECs.

Table 1. Programs that support scientific and alternatives analysis for CECs

Program	Implementor/funder	Short Description
Business & Academic Partnerships for Safer Chemicals	Green chemistry & commerce council (GC3)	Model for collaborative hazard assessment as a way to pool the costs and knowledge to develop more robust alternative assessments.
Chemical Hazard Data Commons	Healthy Building Network (HBN)	Chemical hazard assessments by level of certainty for various endpoints, literature that supports those assessments, hazard listings, and other properties.
ToxCast	EPA	EPA's Toxicity Forecaster generates data and predictive models on thousands of chemicals using high-throughput screening and computational toxicology methods.
GreenScreen® for Safer Chemicals	Clean Production Action (CPA)	Industry standard for Washington State chemical hazard assessment and safer alternatives.
Hazardous Substance Data Bank (HSDB)	U.S. National Library of Medicine's TOXNET®	Catalog of peer-reviewed records pertaining to human health effects, emergency medical treatments, animal toxicology studies, pharmacology, environmental fate/exposure, etc. of hazardous substances.
Puget Sound Ecosystem Monitoring Program (PSEMP)	Puget Sound Partnership	The Puget Sound Ecosystem Monitoring Program (PSEMP) serves as the PSP's monitoring program to assess its progress at achieving recovery.
QSAR Toolbox	Organization for Economic Co-operation and Development, European Chemicals Agency	Predictive modeling of chemical and biological endpoints. Covers ~85,000 chemicals and 2.5 million experimental data points.
Washington Alternatives Assessment Guide	Ecology	Based on IC2 Alternatives Assessment Guide, this is Ecology's recommended framework for small to medium businesses. Ecology employs this framework in its own assessments.
ChemView	EPA	Health and safety data on chemicals that the EPA has accumulated as part of TSCA.
California's Environmental Chemistry Laboratory	CA's Department of Substances Control	Works closely with departmental regulatory programs to provide analytical data on regulated and unregulated chemicals and CECs. The Lab adapts and develops new methods to analyze contaminants in consumer products such as children's toys, e-waste, glass beads, fabrics and foams (DTSC, 2020).

TOXICOLOGY DATABASES

Toxicology databases provide comprehensive and accessible sources of information on chemical hazard assessments, including physicochemical properties, exposure, and environmental fate and transport.

Both experimental and modeling studies can be used to support estimates of these chemical hazards. For example, EPA's Toxicity Forecaster, ToxCast, is a research program that provides robotic, high-throughput experimental screening data to evaluate various biological effects and direct and indirect toxicity thresholds to support prioritization for further investigation. EPA's COMPTOX chemical dashboard presents this toxicological information alongside chemical profiles, human and environmental exposure data, exposure modeling and other information for some ~750,000 chemicals.

The QSAR Toolbox serves as a model-driven database for the prediction of various biological and ecotoxicity endpoints of chemical compounds. QSAR is one of the most comprehensive chemicals databases and is increasingly used to support regulatory processes.

However, the Puget Sound Ecosystem Monitoring Program's Toxics Workgroup (described below) specifically recommends that toxicity data "should be represented as a 'Predicted No Effects Concentration' (PNEC) based on experimental results on organisms representing at least three trophic levels. Toxicity data should not be obtained through QSAR modeling unless the models have been verified to be representative for the compound in question" (p. 23). Emerging monitoring techniques can provide experimental data to support modeling efforts where data are insufficient. Further description of biological and ecotoxicity endpoint analysis is given in Section 2.2.2.1: Prioritization of CECs.

PUGET SOUND ECOSYSTEM MONITORING PROGRAM

The Puget Sound Ecosystem Monitoring Program (PSEMP) serves as the Puget Sound Partnership's comprehensive monitoring program, established to address research needs and measure progress toward recovery goals. It is a network of subject matter experts from non-governmental organizations, tribes and state agencies that collaborate for the purposes of monitoring ecological parameters, sharing information, eliminating redundancy, improving communication and supporting adaptive management.

PSEMP's Toxics Workgroup is tasked with improving the effectiveness and efficiency of toxics monitoring and assessment throughout Puget Sound. The Toxics Workgroup engages in active scientific research and regional monitoring of CECs, including: measuring CEC occurrence in freshwater, marine sediments, wastewater and stormwater streams; estimating biological and ecotoxicity of CECs in the environment; and evaluating the effectiveness of treatment technologies at removing CECs from wastewater (PSEMP, 2014). This research has been critical to the development of a regionally-specific prioritization strategy for regulation and management of CECs (Section 2.2.2.1).

ADVANCED ANALYTICAL TECHNIQUES

Monitoring capacity for CECs can be expanded by leveraging emerging methods of 1) chemical occurrence profiling and 2) biological effects monitoring. For the first, chemical profiling has heretofore relied on reference standards for known chemicals to analyze samples for their presence. High-resolution mass spectrometry has advanced chemical profiling methods considerably, allowing for the detection of

thousands of organic contaminants in a single water or tissue sample. Recent applications of this technology for identifying chemicals in stormwater samples are promising (Du et al., 2017).

With respect to the second (biological effects monitoring): in-vitro assays are techniques that can be used to evaluate the ecotoxicity of chemicals through an evaluation of their biological endpoints. In the case of EDCs, for example, the endpoint is the observable activation of certain receptors to endocrine-disrupting compounds. Such methods allow for the quantification of PNECs for compounds or compound classes that exhibit endocrine-disrupting effects, genotoxicity, or other specific toxicities. This is especially useful for EDCs, for which current toxicity standards are often not reflective of higher sensitivity, endocrine-disrupting effects (PSEMP, 2015).

EPA's Endocrine Disruptor Screening Program is a chemical screening program specifically designed to assess dose-dependent endocrine activity for the purposes of informing regulatory decisions. EPA intends to advance its analytical methods through the implementation of high throughput endocrine-related assays and computational models in ToxCast.

ALTERNATIVES ASSESSMENT

If a chemical or product is assessed and found to be hazardous, resources to identify safer substitutes are critical in the regulatory process of banning or limiting production or use of a chemical. The IC2 is an association of various government entities formed to promote safer uses of chemicals (IC2, 2017, January). IC2 maintains a database of alternatives assessments, chemical use reporting and chemical use restrictions, environmentally preferable purchasing, pollution prevention and toxics use reduction, and chemical prioritization (IC2, 2017). Ecology's Green Chemistry Program also supports businesses with transitions to safer alternatives through training, tools, and free professional assistance. Ecology's Hazardous Waste and Toxics Reduction Program provides funding for businesses to purchase and sample safer chemical alternatives.

2.2.2 APPROACH 2: ENABLE IMPROVED REGULATION OF CECS

Regulatory changes are a key approach to fulfilling the goals of this strategy, primarily because CECs as a group are largely unregulated. Since development of this strategy, this particular approach has been implemented to a significant extent through a recent bill known as the Safer Products for Washington Act (SSB 5135), which focuses on regulating CECs at the consumer product level, and is described in further detail in the following section.

SAFER PRODUCTS FOR WASHINGTON PROGRAM

Ecology's new Safer Products for Washington Program implements a law passed by the Legislature in 2019 (SSB 5135 – the Pollution Prevention for Healthy People and Puget Sound Act). This program provides a mechanism for addressing CECs through consumer products pathways. From the Implementation Phase 2 document (2020):

> "The Safer Products for Washington program includes a regulatory process designed to keep harmful chemicals out of homes, workplaces, schools, and the environment. The law recognizes that small, steady releases of chemicals coming from millions of consumer products are the largest source of toxics entering Washington's environment. These chemical sources pose a significant threat to human health, the environment, and the future of Washington's residents. Safer Products for Washington creates a systematic approach to reduce exposure to toxic chemicals found in consumer products. The law directs us to take the following actions:
>
> 1. Identify priority chemical classes.
> 2. Identify priority products that are significant sources or uses of those chemicals.
> 3. Determine if safer alternatives are available and feasible in order to decide whether to restrict or require reporting of priority chemical-product combinations.
> 4. Implement restrictions or reporting requirements, if any, through a rulemaking process."

SSB 5135 requires Ecology to complete the four phases listed above over a 5-year timeline, where new priority chemical classes must be identified after completion of the last (regulatory) phase in year 5. The program is thus inherently adaptive to evolving knowledge and environmental states.

While SSB 5135 provides an avenue for the identification of priority chemicals and priority products that are sources of these chemicals, it does not trigger or enable the revision of environmental and cleanup standards, such as water quality, MTCA cleanup, and air quality standards. Because CECs derive from diffuse, consumer-driven sources, end-of-pipe regulations that rely on water quality standards to prevent pollution from more conventional toxic sources (such as industrial releases) are less likely to be effective at reducing CECs (EPA, 2008). However, the IDT highlighted the importance of revising environmental standards to effectively manage CECs across multiple environmental pathways. Enhanced scientific understanding of the occurrence and toxicity of CECs would support these regulatory changes (Vogel, 2004; EPA, 2008; Lopez, 2010; Flint et al., 2012). There may be potential for Endangered Species Act protections for Southern Resident Killer Whales to trigger new requirements for wastewater treatment plant discharges via Section 7 consultations[13] for EPA-issued NPDES permits (L. Barre, NOAA Fisheries, pers. comm.)

2.2.2.1 Prioritization of CECs

For the purposes of the initial 5-year cycle, SSB 5135 prescribed the following priority chemical classes:

- Organohalogen flame retardants and flame retardants identified in RCW 70.240.010
- Perfluoroalkyl and polyfluoroalkyl substances (PFASs)
- Polychrlorinated biphenyls (PCBs)

[13] The Endangered Species Act requires federal agencies to consult with NOAA Fisheries and/or U.S. Fish and Wildlife Service when any action they carry out, fund, or authorize "may affect" a species listed as endangered or threatened. These "Section 7" consultations often result in specific changes the federal agency can make to reduce harm to protected species and their habitats.

- Phenolic compounds (which may also exhibit EDC modes of action)
- Phthalates

According to Section 2 of the Safer Products for Washington Act, every five years, Ecology must identify at least five priority chemicals that meet at least one of the following criteria:

1. The chemical or members of a class of chemicals are a high priority chemical of concern for children under the Children's' Safe Product Act
2. The chemical or members of a class of chemicals are listed as persistent, bioaccumulative toxins under the PBT rule
3. The chemical or members of a class of chemicals are regulated (in consumer products or as a hazardous substance)
4. The department determines the chemical or members of a class of chemicals are a concern for sensitive populations and sensitive species

In order to complete phase 1 in accordance with Section 2 of the bill, Ecology needs a prioritization process that enables identification of chemical classes for which information is adequate and risk is sufficiently high to warrant "priority" classification. PSEMP's Toxics Workgroup, in collaboration with the Columbia River Toxics Reduction Workgroup, have begun developing a prioritization process (PSEMP, 2015) that will be used to support this requirement. The process requires investigating those chemical classes that are thought to present risks to human and/or environmental health, as well as studying biological endpoints to trace those negative manifestations to specific chemicals or chemical classes.

From there, the authors recommend narrowing the list to chemicals that, first, have sufficient occurrence and toxicity data, and, next, pose sufficient risk to warrant prioritization. This process is supported by the scientific programs mentioned previously under Section 2.2.1.

It is worth noting that in California, a similarly-structured regulatory program called California's Safer Consumer Products program, established in 2013, has thus far led to regulatory action on PBDE-containing children's foam sleeping products and a requirement for reporting on the use of methylene chloride. A new group of product classes were selected to evaluate for prioritization by 2020, including beauty and personal care products (Raglin, 2019).

Recommendation: Develop methods to measure occurrence and toxicity for those compounds that pose "sufficient risk" but lack sufficient data (PSEMP, 2015). Consider investment in analytical method development for ecotoxicity evaluation as required.

2.2.2.2 Chemical Action Plans

In pursuant to the PBT rule (Section 2.1.5), Chemical Action Plans (CAPs) are comprehensive analyses that provide scientific and regulatory context on the current sources and environmental pathways of a specific chemical or class of chemicals that is listed as a PBT, along with recommendations for the management of those chemicals in order to protect environmental and human health. While not legally binding, these recommendations provide useful insight and guidance into developing regulatory and non-regulatory strategies to reduce both the production and the loading of toxic contaminants in Puget Sound.

Ecology has completed a CAP for PCBs, PAHs, PBDEs and mercury, and is currently developing one for PFASs. No CAP exists for EDCs as a contaminant class, nor are EDCs included on the PBT rule list for indirect toxicity effects (Lopez, 2010). Continued development and expansion of CAPs for CECs that are prioritized through the Safer Products for Washington Act would support this regulatory process and provide guidance for rulemaking.

Recommendation: Develop CAPs for CECs prioritized by Ecology through the Safer Products for Washington Program, with a particular focus on CECs that exhibit an EDC mode of action.

EPA'S AQUATIC LIFE CRITERIA FOR CECS

Beginning in 2008, the EPA began exploring the subject of managing CECs through revisions to aquatic life criteria, which in turn form the basis of the Clean Water Act, Section 304: national recommendations for water quality standards for water bodies with aquatic life as a designated use, such as salmon spawning or fishing. EDCs in particular have been the subject of EPA scrutiny because field studies around the world have demonstrated population-level impacts on aquatic vertebrates at very low concentrations, both in natural and experimental settings (ex. abnormal sex characteristics, sex ratios and reproductive impacts) (EPA, 2008; Kidd et al., 2014; Kidd et al., 2007; Blanchfield et al., 2015). A 2008 EPA White Paper presents the need for updated technical guidance for developing risk-based aquatic life criteria that are useful for CECs, particularly those with an EDC mode of action.

Currently, the EPA relies on an older (1985) guidance document (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*) for developing aquatic life criteria that are in part based on statistical analyses and extrapolation of chronic toxic effects concentrations from measurements of acute toxicity (EPA, 2008). These guidelines are the subject of EPA re-examination because EDCs have been shown to cause abnormalities in sex characteristics at far lower concentrations than acute lethal toxicity; use of these guidelines has resulted in criteria that are skewed by very high acute toxicities and are not protective of normal endocrine functioning in biota (EPA, 2008).

The EPA does not substantively change the 1985 guidelines in the 2008 White Paper, but recommends additional considerations when developing aquatic life criteria for CECs, including: measuring chronic effects directly, rather than through calculations using acute toxicity concentrations; examining biological endpoints that are relevant at lower concentrations than acute toxicity; using toxicological understanding to guide data needs; and engaging with expert panels to provide judgement when developing criteria. These recommendations can serve as a resource for Washington State and the Tribes to use when developing water quality standards for CECs, which then form the basis for controlling pollutant discharges, for example, through additional treatment requirements for the removal of CECs from wastewater effluent. Improved monitoring of CEC occurrence up and downstream of treatment plants would be key to subsequent management steps.

Recommendation: Consider revising water quality standards to include CECs where data and risk are sufficient to support the development of CEC-specific aquatic life criteria.

Recommendation: Because CECs are unregulated, municipalities are not required to treat these pollutants in waste and stormwater, nor monitor for their occurrence up or downstream of treatment plants. Increased monitoring of CEC occurrence would support efforts to manage their presence in municipal stormwater.

2.2.3 APPROACH 3: ENHANCE VOLUNTARY MANAGEMENT OF CECS

Until regulatory tools are available, the IDT recommends pursuing voluntary approaches and education campaigns to influence consumer behaviors and promote producer responsibility; this strategy is supported in the literature (Roberts, 2017). Some programs, such as the Green Chemistry and Commerce Council, offer businesses strategies, tools and collaborative assistance to support clean chemistry practices throughout supply chains; others, such as Washington State's Safe Medication Return Program, are more specifically targeted toward the reduction of CEC loading from environmentally-harmful disposal practices of pharmaceutical products. Table 4 provides a brief overview of voluntary programs that incentivize producer responsibility and greener chemistry in general, and which may have the potential to support CEC reductions if targeted.

There is much room for the expansion of voluntary programs that specifically target CECs in consumer products. While regulatory bans, such as that in place in the European Union on phthalates in cosmetics, would be most effective, programs that increase consumer awareness, such as the Campaign for Safe Cosmetics and Think Dirty, can create a market for businesses to remove CECs such as phthalates from their products in exchange for non-toxic certifications; the campaign's efforts have contributed to increased corporate transparency and, in some cases, the removal of certain chemicals from cosmetic products on the part of producers (Campaign for Safe Cosmetics, 2020, 2014). Proposition 65 has required the labeling of bisphenol A on products since 2016, leading to product reformulations and "BPA-free" labeling (SGS, 2018); however, the IDT recognizes that bisphenol congeners are also CECs, and consumer-awareness programs should consider expanding bisphenol A labeling to cover all bisphenols, provided sufficient risk and information exists.

WASHINGTON'S SAFE MEDICATION RETURN PROGRAM

Washington's Safe Medication Return Program, signed into law in 2018, requires drug manufacturers to provide, at their own cost, a free, convenient, and environmentally-sound option for the disposal of unwanted medications, in the form of a state-unified return program.[14] The program will be operated by manufacturers but overseen and monitored by the Washington State Department of Health. Participation by consumers will be voluntary.

Pharmaceuticals, especially those with an EDC mode of action, remain a difficult issue to address through voluntary methods; while take-back programs prevent exposures due to unused pharmaceutical

[14] RCW 69.48

products, population-level impacts on aquatic life have been associated with wastewater effluent, indicating a need to enhance treatment measures to specifically remove these compounds from municipal sewage (EPA, 2008).

Table 4. Voluntary programs for incentivizing producer responsibility and green chemistry

Program	Implementor	Brief Description
California's Proposition 65	California Office of Environmental Health Hazard Assessment	Requires the state to maintain a list of chemicals that cause cancer or alter reproductivity. Businesses that use these chemicals must provide a warning on their products to enable informed decision-making.
Chemical Footprint Project CFP	Clean Production Actions	Works with voluntary participants to reform their chemical footprint across their entire supply chain: manufacturing, operations, and packaging. The program has a comprehensive scoring system that guides their improvement process.
EnviroStars	WA State Department of Ecology	A voluntary program that incentivizes businesses to incorporate sustainable practices in exchange for free use of tools to do so and free marketing on their behalf
Safer States	Safer States	Database of state policies to reform toxic use and production
The CGC3 Preservatives Challenge	Green chemistry & commerce council (GC3)	The GC3 held a collaboratively funded competition that inventivized companies to develop safer cosmetic preservatives for the opportunity to win a cash prize.
Toxic Release Inventory Program	EPA	Federal inventory of the use, management, and prevention of toxic chemicals in certain industries
InnoCentive	InnoCentive	A crowdsourcing program where government and private organizations can develop a 'challenge' with calls for innovative solutions to a problem and funding awards for winning 'Solvers.'
Safer Choice Program	EPA	Catalogs alternative products and their ingredients, such as cleaning supplies, that meets certain 'Safer Choice' criteria. Products in relevant functional-use category (such as fragrances, soaps) that meet the criteria can apply and receive a 'Safer Choice' label to incentivize safer purchasing decisions.

3. MITIGATION

Mitigation refers to the reduction in the loading of toxics in the environment from on-going sources through the adoption and enforcement of water and air quality standards; municipal stormwater permits, stormwater pollution control retrofits and other non-point source pollution control programs; cleanup and redevelopment of properties that are considered to be toxic 'hotspots'; and consumer product swap-outs. Strategies 2, 3 and 4 are mitigative in nature.

3.1. REGULATORY DRIVERS

This section provides an overview of state and federal regulations that mitigate the loading of toxic contaminants to the environment and their impacts on fish in the Puget Sound. The federal Clean Water Act and the state Water Pollution Control Act provide the legal basis for Ecology to develop and enforce water quality standards in Washington State. The federal Ocean Dumping Act regulates the disposal of marine sediments and other potentially-polluting materials into open-water sites. In Washington State, this program is overseen by both EPA Region 10 and the U.S. Army Corps of Engineers.

3.1.1 CLEAN WATER ACT

The Clean Water Act (CWA) requires the development of programs to support the continued health and restoration of the nation's waters. The EPA can delegate the authority to administer programs that meet the requirements of the CWA to individual states if they demonstrate that their requirements are at least as stringent as those of the EPA's. Otherwise, the EPA will delegate standards and act as the permitting authority. In Washington State, Ecology has been granted the authority to implement the CWA through the development of Water Quality Standards, the identification of impaired waters, the establishment of Total Maximum Daily Loads to achieve standards, the issuance of National Pollutant Elimination System (NPDES) permits to limit discharges of pollutants from point sources, and the development of non-point source pollution management programs. The following sections describe each of these, with a particular emphasis on standards and designation of impairments due to their relevance to toxics in fish. More information on the CWA, NPDES permits and non-point source pollution management in Washington can be found in the regulatory framework section of the Marine Water Quality Starter Package.

WATER QUALITY STANDARDS

Water Quality Standards (WQS) provide the criteria for the maintenance and restoration of the highest possible quality of surface waters in Washington, both freshwater and marine. In accordance with the federal CWA, states have the authority to establish designated uses of waterbodies and corresponding WQS. State WQS must be at least as stringent as the federal standards, and all WQS must be federally-approved by the EPA.

In Washington, the Water Pollution Control Act provides the framework for protecting state waters and establishing WQS and human health criteria. Designated uses include drinking water, recreation, aquatic life, and shellfish harvesting; aquatic life uses are further separated into salmonid and trout spawning,

rearing, migration, and summer habitat uses in freshwater. In general, WQS exist for temperature, pH, turbidity, dissolved oxygen, and some contaminants, and are developed to be protective of the designated use.[15] For toxics, Ecology develops numeric limits on the time-averaged ambient concentrations of pollutants in water. Human health criteria are ambient concentrations that are calculated according to risks associated with drinking and/or consumption of aquatic life. Ecology has designated WQS for PCBs and PAHs but not PBDEs or EDCs.[16]

Where waterbodies are of a higher quality than the criteria, the Water Pollution Control Act provides an antidegradation provision that prohibits most or all sources of pollution that will result in degradation, or a decrease in water quality.[17] Some consider this to be an underutilized provision for the protection of waterbodies from on-going, low-concentration sources of pollution (Hersh, 2009); this has been discussed more in the context of the B-IBI and Marine Water Quality Implementation Strategies.

HUMAN HEALTH CRITERIA AND FISH CONSUMPTION RATES

Human health criteria have been an ongoing issue of environmental and social justice in Washington State. The Toxics in Fish Implementation Strategy Narrative reiterates a commitment to advancing equity and acknowledges a problematic lack of engagement with the tribes during the development of the Implementation Strategy. Of particular importance is an examination of the issue of equitable human health criteria that are protective of populations with disproportionate health effects from toxics in fish due to their consumption of large amounts of fish for subsistence and cultural practice. This section outlines federal and state-level changes to the human health criteria, their derivations, and repercussions for allowable levels of toxics in the environment.

In 2016, the EPA made a final rule that established more stringent WQS for all waters within Washington State. Prior to this change, EPA had approved Washington's previous criteria for the protection of human health in 1992, which used a nationally-averaged fish consumption rate (FCR) of 6.5 grams per day (g/day) in its calculations of human health impacts. This FCR was found to severely underestimate actual fish consumption rates in Washington, specifically among tribes that engage in subsistence fishing (Nicole, 2013; Zwang, 2015).[18] Given that treaties and subsequent court rulings assert the tribes' right to fish in usual and accustomed places, the EPA found that WQS that are not protective of human health among tribal populations would substantially impair the exercise of treaty-reserved rights.

The EPA thus partially-approved Washington's proposed human health criteria, including those calculated using a revised FCR of 175 g/day developed in consultation with the tribes, and a cancer risk threshold of one-in-one million (10^{-6}) for carcinogenic effects among subsistence users, rather than the federal standard of one-in-ten thousand (10^{-4}) for highly exposed sub-populations.[19] These revised standards

[15] WAC 173-201A-240
[16] Ibid.
[17] WAC 173-201A-300
[18] Revision of Certain Federal Water Quality Criteria Applicable to Washington, 81 FR 85417. (November 28, 2016) (to be codified in 40 CFR part 131)
[19] Ibid.

reflect the EPA's and Ecology's decision to treat the tribes as a target general population for protection when establishing human health criteria, rather than a sub-population for which allowable levels of contamination are higher.[20] These human health criteria have implications for allowable levels of toxic contaminants in both point and non-point source pollutant regulations.

In April 2020, EPA withdrew its federal CWA human health criteria for the State of Washington after approving Washington's revised state-level criteria in 2019, which it determined to be protective of its designated uses (including subsistence fishing), based on sound science, and consistent with the CWA. Washington State's updated WQS use an FCR of 175 g/day and a cancer risk level of 10^{-6} for subsistence and all other users.[21] The updated FCR is the same as that which Oregon adopted in 2011, calculated to protect up to the 95th percentile of Oregonians who consume the most fish (Nicole, 2013).

While highly criticized, EPA's withdrawal of the 2016 criteria is consistent with the ruling itself, in which the EPA stated that it would withdraw the federal criteria "if and when Washington adopts and EPA approves corresponding criteria that meet the requirements of section 303(c) of the CWA and EPA's implementing regulations at 40 CFR part 131."[22] These updated criteria have repercussions for water quality and cleanup standards, the latter of which are discussed in more detail in Section 4.2.1.1.

In Oregon, the updated WQS based on the updated FCR of 175 g/day resulted in limits for 48% of chemicals falling below the limit of analytical detection (State of Oregon Department of Environmental Quality, 2011). For PCBs, both the previous and updated human health criteria for waterbodies that support fish consumption were several orders of magnitude below the standard analytical limit of detection (~0.05 ppb)[23] (State of Oregon Department of Environmental Quality, 2011). This is also reflected in Washington's updated human health criteria (Finch, 2020).

However, when evaluating for compliance with WQS, Ecology may approve the use of an updated analytical method (EPA 1668) that allows for quantification at or below the level of the standard (on the order of a part-per-trillion) (Ecology, 2015a). Practical limitations on achieving extremely low concentration standards highlight the importance of pollution prevention and source control strategies, and are discussed further in the context of sediment clean-up projects in Section 4.2.1.1.

NPDES PERMITS

Section 402 of the CWA requires that municipal stormwater discharges into U.S. waters have a National Pollution Discharge Elimination System (NPDES) permit. NPDES requirements are established using water quality and/or technology-based standards. In Washington State, Ecology is granted regulatory authority over NPDES permitting, and does so via what are known as Phase I (medium-to-large municipal separated stormwater, or MS4 systems, owned and operated by public entities) and Phase II (small-to-medium)

[20] Ibid.
[21] WAC 173-201A-240 (5)(b)
[22] 81 FR 85417 (n 15), p. 85432
[23] EPA method 8082, ctd. in Finch (2020), Ecology (2015a)

Municipal General Stormwater Permits.[24] In many cases, state water quality requirements are higher than those promulgated by the EPA. Technical guidance for meeting permit requirements as they pertain to the Puget Sound are described in the Stormwater Management Manual for Western Washington (SWMMWW). More information on the SWMMWW and current BMPs for stormwater management is given in section 3.3.2.2.

WATER QUALITY ASSESSMENTS

WQS are also used to assess whether waters are impaired, and as the target to restore impaired waters through Total Maximum Daily Loads (TMDLs) under section 303(d) of the CWA. This is the CWA's primary mechanism for controlling non-point source pollution that escapes the NPDES permitting system in Section 402. A TMDL serves as the starting point or planning tools for restoring water quality; the required load reduction calculated using a TMDL for a waterbody is allocated among point and non-point pollution sources using NPDES permits for the former, and a combination of other regulatory actions and/or voluntary programs and partnerships for the latter.

As of 2017, there were 86 water quality impairment listings for PCBs and 122 for PAHs in Washington State, 33 and 96 of which had an associated TMDL/pollution control program, respectively (ex. CERCLA record of decision, MTCA Cleanup Action Plan or Source Control Action Plan). This data reveal a need for the development of TMDLs or other pollution control programs for impaired waters through federal and/or state-level regulatory programs. Geographic distributions of impaired waterbodies and TMDLs are available via Ecology's mapping platform, the Water Quality Atlas.

NONPOINT POLLUTION PROGRAM

In 1987, Congress established the non-point-source management program under a new section (319) of the CWA. This program requires states to "identif[y] those navigable waters within the State which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain applicable water quality standards" and identify nonpoint sources that add significant pollution.[25] Once they have identified those waters and sources, they must implement a management program that identifies BMPs, programs to achieve them, and funding sources and assistance that will be available for implementation.[26]

In Washington, non-point sources of pollution, including stormwater runoff from streets, residential and urban areas, farms and forest lands, significantly impair the attainment of water quality standards and the protection of designated uses in hundreds of waterbodies. Washington strategies for managing non-point source pollution include water quality assessments, large-scale water quality planning efforts, and financial assistance to voluntary water quality improvement projects.

3.1.2 OCEAN DUMPING ACT

[24] Water Pollution Control, RCW 90.48
[25] 33 U.S.C. § 13299(a)(1)(A)
[26] 33 U.S.C. § 13299(b)(2)

The Marine Protection, Research and Sanctuaries Act, also known as the Ocean Dumping Act, prohibits the disposal of harmful wastes into ocean waters (including the territorial sea of the U.S. and extending to a line 12 nautical miles beyond the territorial boundary) except by permit. The law broadly prohibits all manner of industrial (including plastics and pharmaceutical manufacturing), municipal (including sewage sludge), radiological, chemical and biological wastes, as well as construction and demolition debris; oil and sewage waste from vessel traffic is not prohibited.[27] General permits to dump can be granted primarily for small volumes of materials that have minimal environmental, human health, aesthetic and economic impacts, and which do not exceed trace levels of carcinogens, organohalogens (inclusive of PCBs and PBDEs), heavy metals and oil in any form.[28] In Washington State these permits are granted by EPA Region 10, while the U.S. Army Corps of Engineers is the permitting agency for all dredged materials.

Dredged materials make up the majority of dumped materials today, and must be characterized for selected contaminants prior to dumping. Dredged material disposal sites must also have a management plan for environmental monitoring and assessment.[29] Allowances in the Ocean Dumping Act for discharge of raw sewage from vessels in the Puget Sound and contiguous marine waters were prohibited by a State-level No Discharge Zone law enacted by Ecology in 2018.[30] More information on the management of dredged materials in the Puget Sound is provided in Section 4.2.1.1.

3.2 STRATEGY 2: INCENTIVIZE SWAP-OUTS AND REMOVAL OF LEGACY SOURCES OF POLLUTION

The objective of this strategy is to reduce legacy sources of pollution associated with contaminated products and materials, as well as ongoing emissions from vehicles and stoves. While pollutants such as PCBs and some congeners of PBDEs have since been phased out of production, their persistence in building materials and consumer products make them difficult to control except through swap-outs and site-specific removal. Programs that address this strategy broadly include BMPs for managing and removing PCB-contaminated building materials and capacitors, electronic and lamp recycling programs, swap-out programs for wood stoves and PBDE-containing furniture, social marketing to encourage vehicle repairs, and the removal of creosote-treated wood pilings from Puget Sound. PCB removal projects could use additional resources for cataloguing, prioritizing and actively removing contaminated materials from buildings, while other programs, such as the Puget Sound wood stove program and the creosote removal project, would benefit from continued funding/renewal or expansion.

3.2.1 APPROACH 1: REMOVE LEGACY SOURCES OF PCBS

Sources of PCBs to the environment can be broadly grouped into two categories: 1) intentionally produced products manufactured prior to the 1979 federal ban, which have not yet been properly disposed of or are still in use; and 2) unintentionally produced, ongoing sources that are bi-products of

[27] 33 CFR 220.1-220.2
[28] 33 CFR 227.6
[29] 33 U.S.C. § 1412(c)(3)
[30] WAC 173-228

manufacturing processes. Both of these sources are ubiquitous and diffuse, and generally lead to contamination of watersheds through stormwater runoff from urban buildings, roads and industrial waste sites. However, where hotspots exist, this strategy approach aims to remove them directly. PCB source prioritization should reflect that higher concentrations have higher impacts. The IDT recommends the following order of importance when targeting PCB sources for removal:

- Aroclor PCBs (pre- federal ban), which most often come from hotspots at hazardous waste sites
- Building materials (caulk and paint) manufactured prior to ban
- Electrical equipment, specifically fluorescent tube lamp ballasts manufactured prior to ban
- Leakage from PCB transformers, small capacitors, and large capacitors manufactured prior to ban
- Inadvertent production
- Trophic transfer
- Global atmospheric sources

This strategy approach aims to address the top four legacy sources of PCBs, which have been highlighted by the 2015 CAP for PCBs and by the IDT in both meetings and the results chain for this strategy. Programs that address each legacy source are described beneath.

3.2.1.1 PCBs in legacy building materials (e.g., caulks, paints)

The following list describes several management-related considerations for addressing PCBs in legacy building materials, with reference to applicable BMPs. Barriers to implementing these BMPs primarily include a lack of information to support targeted removal and remediation efforts. Once PCB contamination is identified, guidance from the EPA can support appropriate remediation efforts.

1. *Targeting and prioritization*: Some historical building materials, such as caulk and paint, are known to be high concentration sources of PCBs that enter the aquatic environment through stormwater runoff. These materials are more common in industrial buildings, including schools, compared to residential buildings. In the 2015 CAP for PCBs, Ecology notes that school buildings should be a focus for PCB removal because they have been found to contain higher concentrations of PCBs compared to other public buildings and because they present a risk to children.

   Ecology (2015b) notes that there is no "easily-accessible source of information on how many buildings are of the age and construction type likely to have [PCB-containing materials]." Ecology therefore suggests surveying the approximately 9,000 school buildings in Washington to identify how many are likely to have PCB-containing materials, collating the information into a comprehensive database that includes construction dates and renovation schedules, and then prioritizing these for testing and remediation according to human and environmental health risk.

   Ecology (2015b) also suggests hiring additional staff to support these projects. However, off-loading site investigations and remediation to third-party professionals may reduce the burden on public agencies and make additional staffing unnecessary; this approach has been successful

for accelerating clean-ups of PCB-contaminated brownfields (Section 3.4.1) and may also be useful for identifying and removing PCB-containing materials from buildings.

2. *Containment and removal:* Ecology (2015b) identifies a need for developing BMPs for containment and suggests hiring additional staff to do so; however, the EPA has developed specific BMPs for preventing PCB exposure during construction, remodeling, repair and demolition of buildings that are suspected to contain PCBs. These BMPs provide guidance for: testing for PCBs in caulk and other materials prior to removing them, minimizing dust, protecting soils, applying encapsulants (epoxy-like coatings that reduce the emission of PCBs into air or onto other surfaces) to PCB-containing surfaces, and cleaning surfaces after repairs (EPA, 2015a).

   More specific guidance is provided for removing caulk (which can contain especially high concentrations of PCBs) in order to minimize the generation of gases and dust. The EPA recommends hiring experienced contractors or specially-trained personnel to carry out BMPs, along with a follow-up consultation with the EPA Regional PCB Coordinator to assess whether contamination persists and if testing of indoor air should be conducted, particularly in schools (EPA, 2015b).

   The EPA has found that the mitigation efforts outlined above, carried out in a controlled experiment involving 6 participating public schools, resulted in < 1% probability of exposure to PCBs above regulatory thresholds (EPA, 2015a). EPA-approved testing and abatement procedures have already been implemented by Ecology, in coordination with King County and Seattle Public Utilities and with EPA guidance, for the large-scale remediation of PCB-contaminated paint from buildings in Rainier Commons, Seattle (EPA, 2018a).

3. *Disposal*: The EPA issues permits for handling PCBs through their PCB Cleanup and Disposal Program, targeted for commercial entities that store, transport, dispose of or conduct research on PCBs in accordance with TSCA. The EPA provides codified guidelines for the appropriate cleanup and disposal of PCB waste depending upon the source, concentration,

Box 1. Case study: PCB cleanup and disposal under the EPA.

In 2000, Boeing began replacement of PCB-containing joint sealant in concrete slabs of the Everett plant's flight line. Deterioration of joints over time led to stormwater contamination and the discharge of PCBs into Possession Sound. Boeing also slated a building for demolition that contained two old substation rooms contaminated with PCBs from former transformers, and which led to contamination of underlying soils. Disposal and remediation of the concrete and soils, respectively, was permitted jointly through the PCB Cleanup and Disposal Program by the EPA and Ecology. Special measures for treating stormwater were put into place. Boeing's demolition of the building and remediation efforts were also completed in accordance with the American Society for Testing and Material's Greener Cleanup Standard, described under bullet

exposure and risk posed by the contamination.[31] Washington State's dangerous waste rules give Ecology the authority to manage, like other listed dangerous wastes, the disposal of PCB wastes from transformers and capacitors not otherwise controlled under the federal Toxic Substances Control Act.[32]

4. *(Voluntary) certification*. American Society for Testing and Material's Greener Cleanup Standard is a voluntary program that creates a standard for environmentally-responsible contaminated site cleanup practices. In order to fulfill the requirements of the standard, the process must aim to: minimize total energy use and maximize use of renewable energy; minimize air pollutants and greenhouse gas emissions; minimize water use and impacts on water resources; reduce, reuse and recycle material and waste; and protect land and ecosystems (EPA, 2019). Boeing was the first facility to implement the standard at a PCB remediation site, demonstrating the usefulness of this standard as a BMP for PCB-contaminated buildings or land sites (see Box 1). Adherence to the Greener Cleanup Standards is now a condition of EPA's cleanup approvals. Voluntary certifications could enhance cleanup standards in Washington if required under MTCA.

3.2.1.2 PCB-containing lamp ballasts in public buildings

Fluorescent lamp ballasts manufactured prior to 1979 may be high-concentration sources of PCBs. These lamp ballasts have reached the end of their useful life, and the EPA has determined that the risk of leakage or rupture is "significant." The EPA suggests removing lamp ballasts as stand-alone projects or as part of planned energy efficiency updates. Washington Energy Efficiency Rebates can be applied toward replacing outdated lighting, among other materials, that are inefficient and pose a risk of exposure to PCBs. The EPA provides distinct BMPs for the identification and safe removal of both leaking or non-leaking PCB-containing lamp ballasts (EPA, 2018b). Currently, the number of PCB-containing lamp ballasts removed from buildings through the Energy Efficiency Rebates program are not tracked or given special consideration (James, A., July 2020, personal communication).

Box 2. Case study: PCB lamp ballast removal in public schools.

Beginning in 2011, the City of New York (NYC) rolled out a 10-year plan to remove all PCB-containing lamp ballasts in public schools as part of a legislated, comprehensive energy efficiency program for public schools (NYC Schools Comprehensive Plan), and in response to EPA testing per TSCA enforcement procedures. NYC conducted a survey to identify schools that were built during, and contained lighting fixtures from, the PCB-era; since the program began, NYC replaced PCB-containing lamp ballasts from over 800 schools. In practice, NYC found that a traditional bidding process for contractors to inspect and remove light fixtures was more cost-effective than bundling light replacement with broader energy efficiency efforts (New York City Department of Education, 2016). However, annual cost savings associated with energy efficiency improvements from lamp replacements were on the order of $11,000-$74,000 annually (EPA, 2016). This programmatic strategy for cataloguing and removing PCB-containing lamp ballasts from public schools could serve as a model for Washington State.

[31] 40 CFR 761 Subpart D
[32] RCW 70.105.105

Recommendation: Develop a state-wide inventory of PCB-containing public buildings to support organized remediation efforts. Adopt EPA's abatement BMPs and track the number of ballasts removed when updating public buildings through energy efficiency programs.

HAZARDOUS WASTE MANAGEMENT PROGRAM

King County's Hazardous Waste Management Program provides drop-off services for hazardous household wastes, including PCB-containing lamp ballasts. King County does not, however, provide free inspection and removal services for lamp ballasts. A Canadian recycling program known as ProductCare Recycling manages PCB-containing lamp ballast waste through a free technical inspection and removal service in addition to its drop-off recycling services. The program provides clear information for owners to help identify PCB-containing lamp ballasts (manufactured prior to 1980). This program could serve as a model for King County to better assist homeowners in disposing of household PCB waste.

Recommendation: Investigate the possibility of providing technical assistance to remove PCB-containing lamp ballasts throughout Puget Sound using the Canadian ProductCare program as a model.

3.2.2 APPROACH 2: REDUCE ONGOING SOURCES OF PAHS

This strategy approach aims to reduce ongoing loading of PAHs to Puget Sound through social marketing efforts and outreach to reduce individual discharges of vehicular pollutants, basin-scale removal of creosote-treated wood pilings from the Puget Sound near-shore, identification and mapping of creosote-treated railroad ties, and voluntary swap-out programs for pollution-generating stoves.

3.2.2.1 Developing voluntary incentives

SOCIAL MARKETING

The IDT has frequently suggested a social marketing approach to enhance participation in voluntary programs that enable reductions in pollutant-generating activities. Social marketing is a tool that can be used to encourage desired behavioral changes and enhance participation in targeted voluntary programs.

Social marketing strategies can encourage reductions in petroleum-sourced PAHs associated with vehicles. Ecology's Don't Drip and Drive program aims to educate drivers about the importance of checking for vehicle leaks and of regular vehicle inspections in order to reduce the volume of vehicle fluids, including oils, lubricants and fuels, that enter Puget Sound through stormwater runoff. The program provides educational workshops, online resources and maintenance support through free leak checks and discounts on repairs through participating businesses.

In Pierce County, the Don't Drip and Drive program met and in some cases exceeded its goals for promoting behavioral change (namely, increasing the number of leak checks and leak repairs) for a three-month campaign period in 2014; the program steering committee estimates that over 1,600 vehicle leaks were repaired as a result of the campaign (Stormwater Outreach, 2015). However, in order to address the

approximately 450,000 leaking vehicles in the Puget Sound region and effect meaningful water quality improvements, continued investment in and expansion of the campaign will be necessary. The committee also notes that the campaign is unlikely to influence the adoption of high-cost leak repairs without direct financial incentives or systematic regulatory changes to enforce repairs, similar to the emissions-based standards currently in place (Stormwater Outreach, 2015).

Don't Drip and Drive is associated with the larger Puget Sound Starts Here campaign, which seeks to educate Washingtonians on the importance of individual actions to reduce cumulative impacts of pollution on Puget Sound. Puget Sound Starts Here is built on collaborative partnerships between federal, state and local governments; tribes; non-governmental organizations (NGOs) and private businesses. Targeted pollutants include petroleum products, fertilizers, surfactants and pet wastes. Stormwater Outreach (2015) suggests that social marketing strategies require long-term commitment (>10 years) to see large-scale changes in societal behavior and social norms. Such a commitment will require continued investment at regional and local scales of both Don't Drip and Drive and the wider Puget Sound Starts Here campaigns.

FINANCIAL INCENTIVES

Increased direct financial assistance in the form of discounts or vouchers for vehicle maintenance or upgrade may be necessary for achieving behavioral changes where costs are high (Stormwater Outreach, 2015). Tax credits for the purchase of electric and alternative-fuel vehicles would have ancillary benefits for PAH reductions and water quality. In Washington State, individuals and businesses are eligible for tax credits of up to $25,000 or $100,000 per vehicle for the purchase of electric cars or electric commercial vehicle fleets, respectively, through a variety of State grants and incentive programs.

Continue investment in social marketing campaigns that target consumer behaviors around vehicles. Compare the cost-effectiveness of long-term campaign commitments and direct financial incentives for vehicle leak repair with regulatory changes for vehicle standards, such as those in place for air emissions.

3.2.2.3 Creosote-treated wood pilings

Creosote-treated pilings are a known source of PAHs in the marine environment, directly contributing to the mortality of forage fish that spawn in nearshore habitats (Vines et al., 2000; Sol et al., 2008). Creosote pilings are no longer allowed to be installed as part of projects requiring a Section 404 permit from the U.S. Army Corps of Engineers (USACE).[33] The Puget Sound Partnership's new Nearshore Credits Program

[33] Section 404 of the Clean Water Act established a program administered by the U.S. Army Corps of Engineers (USACE) to regulate the discharge of dredged or fill material into waters of the United States. Many types of activities must receive "404 permits" under this program, including the placement of rocks, concrete, pilings, or other materials in navigable waters. In the Puget Sound region, USACE often adds special conditions to their permits as a result of Endangered Species Action Section 7 consultations (described in Section 2.2.2).

is the result of a recent Section 7 consultation with USACE for repair and maintenance of existing nearshore structures in Puget Sound. This program is expected to accelerate removal of creosote pilings.

PUGET SOUND CREOSOTE REMOVAL PROJECT

Washington Department of Natural Resources (WDNR) has actively been removing derelict creosote-treated pilings and overhead structures through the Creosote Removal Project since 2007. The program has removed 14,461 derelict pilings (about 1100 per year) and over 21,300 tons of creosote from Puget Sound (WDNR, 2020). A 2017 King County study estimated piling counts of approximately 63,000 between Lake Union and the Duwamish Estuary; with an estimated PAH leach rate of 0.48 kg/piling/yr; this corresponds to PAH loadings of approximately 33 tons/year (Wright et al., 2017). The WDNR's program has been shown to be effective, but with 63,000 pilings estimated to remain, the program needs to be substantially scaled up, and these pilings prioritized by estimations of PAH loading, in order to address these ongoing sources within a reasonable amount of time.

Recommendation: Develop a prioritization strategy for the removal of creosote-treated wood pilings in Puget Sound using existing inventories and PAH loading estimates; identify information gaps and expand the WDNR's creosote-treated wood piling removal program to target prioritized areas and accelerate removal.

3.2.2.4 Railroad ties

Following the 2012 CAP for PAHs, Ecology completed a GIS study investigating the spatial distribution of creosote-treated wood used in railroad lines in relation to sensitive aquatic areas (near-shore marine and freshwater) in Washington State. The study reveals that about 1% of sensitive habitat statewide lies within a 300-foot buffer or 100-year flood zone near or intersected by railroad lines, while about 4% of identified salmon habitat included railroad lines (Figure 1). The majority of railroad ties (93% nationally-averaged) are constructed using creosote-treated wood (Sandvik, 2013).

Ecology used this information to prioritize areas for further study according to their proximity to either salmonid-supporting areas, priority habitats or wetlands. Highest priority areas included those where railroad lines intersected all three types of sensitive habitat. The author notes that the next step in this analysis is to create a pilot program for sampling and monitoring the priority areas to estimate PAH loading, followed by biological assessments if contamination is found (Sandvik, 2013).

Currently, there are no statewide or national programs to replace active creosote-treated railroad ties; however, railroads are required to submit an environmental report to the U.S. Surface Transportation Board when they begin the process of abandoning a corridor of railway. This assessment can include inspection, testing and sampling of surrounding water and/or soil for railroad-related contaminants, including creosote, in order to determine if the railway section needs to be removed for the purposes of property transference or conversion to a public trail (Rails-to-Trails Conservancy, 2004). In Washington, a little less than half of all railroad miles are inactive (Ecology, 2013).

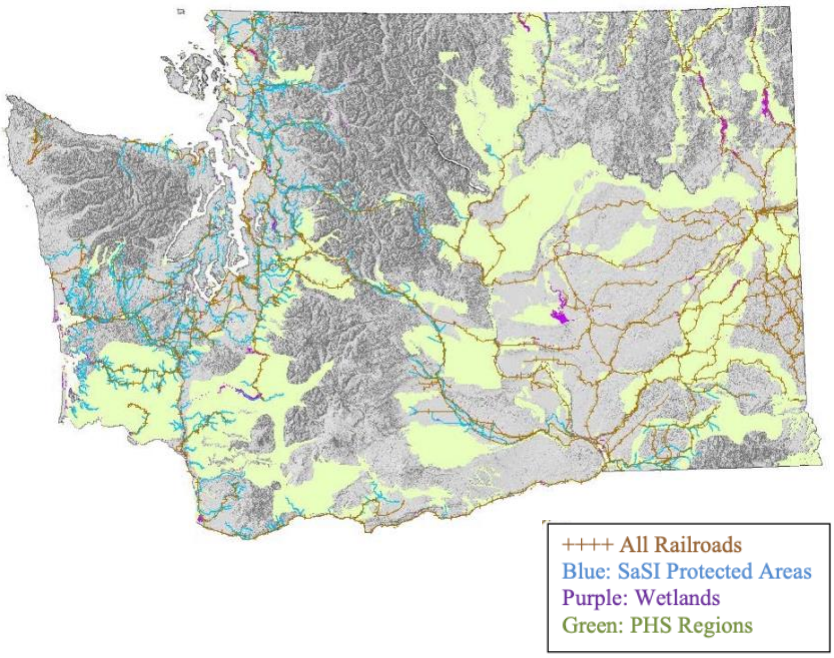

Figure 1. Sensitive Areas near Railroad Lines. SaSI = Salmonid Stock Inventory; PHS = Priority Habitat and Species Areas. Courtesy of: Sandvik, P. (2013, May). *Location of Creosote-Treated Railroad Lines near Sensitive Near-Shore Aquatic Habitats in Washington State*. Washington State Department of Ecology, Toxics Studies Unit. Publication No. 13-03-025.

Recommendation: Evaluate PAH loading in priority areas (salmon-supporting habitats and wetlands) associated with railroad ties. Support regulatory and/or voluntary pathways for removal in these priority areas as necessary.

Discussions of incentivizing removal or replacement of inactive railroad ties through voluntary or regulatory programs may benefit from comparisons to the redevelopment of brownfields (Strategy 4). Abandoned railway corridors have been identified as brownfields, and the repurposing of these sites for public use necessarily triggers state cleanup programs, which are subject to the same limitations as described in Section 3.4.1.

Box 3. Case study: Remediation of a contaminated railway corridor.

Betsie Valley Trail, Benzie, Michigan. An abandoned railway corridor along the shores of Lake Michigan was remediated and repurposed for public use following a legal settlement with adjacent property owners. An environmental assessment of a 3-mile stretch of the corridor revealed soil contamination from arsenic and PAHs. Multiple agencies collaborated to remove or cap the contaminated soils and engineer a natural trail surface. Funding consisted of state and federal grants and local contributions (Rails-to-Trails Conservancy, 2004). This serves as an example of public use as a benefit or incentive to railway removal and corridor remediation.

3.2.2.4 Reducing PAH air emissions

The IDT recognizes that air emissions are the second-largest source of PAH loading to Puget Sound next to surface water, particularly from polluting stoves and internal combustion engines. The following two programs address this environmental pathway in order of importance (relative loading). More information on PAH sources and loading can be found in the Starter Package.

PUGET SOUND WOOD STOVE PROGRAM

As of 2015, old (pre-2000) or uncertified wood stoves are a known source of PAHs in the environment and "are no longer legal to sell, purchase, give away or re-install anywhere in Washington state due to the significant pollution they generate."[34] In King, Kitsap, Pierce and Snohomish Counties, residents can receive $350 for recycling their oil wood stoves through the Puget Sound Clean Air Agency's (PSCAA) Wood Stove Program; Snohomish County residents are eligible for a $1,500 discount toward the purchase of new heating equipment that meets emissions and efficiency requirements (PSCAA, n.d.(a)). These incentives are consistent with the EPA's recommendations for wood stove replacement programs, which suggest a minimum financial incentive of $300- $500 to cover removal costs, with an average appliance replacement cost of $1,500. However, complete stove and flue replacement can average up to $5,000 (EPA, 2014), which may present an added financial barrier that is difficult to overcome among low-income households. Continued investment and direct financial support for replacement among low-income communities is likely needed to realize the pollution-reduction benefits of the program.

The PSCAA estimates that over 800 stoves in Pierce, King, Kitsap and Snohomish counties were scrapped and replaced with a non-wood burning method of heating since the program began. Air quality data suggests that instances of PM2.5 health goal exceedances, when controlling for wildfire days, have modestly declined in King, Pierce and Kitsap County since the rule and swap-out program came into effect (PSCAA, 2018).[35] However, experimental research on wood stoves suggests no correlation between PM2.5 emissions and PAH emissions (EPA, 2014).

New and emerging retrofit technologies may provide more cost-effective options for reducing PAH emissions from wood stoves. The PSCAA, in collaboration with Ecology and funded by the EPA, evaluated the effectiveness of novel retrofits for uncertified wood stoves in an open challenge to manufacturers. Results for the top performers were promising, with experimental PAH emissions reductions between approximately 70 and 90%. The authors recommended continuing research to optimize the installation of the devices and reduce costs (Swartzendruber, 2016).

MARITIME PROGRAMS

The PSCAA engages in a number of projects to reduce pollution from maritime engines, which make up roughly 23% of particulate-containing diesel exhaust in the Puget Sound (PSCAA, n.d.(b)). Projects vary from idle-reduction technology retrofits to incentives/reimbursements for total engine replacements and

[34] WAC 173-433

[35] Particle-bound PAHs are a toxic of concern present in PM2.5 (ex. Mo et al., 2019; Skalska et al., 2019).

land-side clean energy to power ships while at berth. Similar to the Wood Stove Program, the PSCAA targets and keeps track of PM2.5 emissions as a measure of particulate-matter emissions. While diesel combustion engines are a known source of airborne PAH emissions (Ecology, 2012a), PAH reduction efforts would benefit from an additional focus and inventory of PAH-specific emissions from the maritime sector.

3.2.3 APPROACH 3: REMOVE SOURCES OF FLAME RETARDANTS FROM CONSUMER PRODUCTS AND PATHWAYS

Despite state-level bans on deca-, octa-, and penta-PBDE, this class of flame retardants is still frequently found in many longer-lived consumer products, including electronics casings, couches and other upholstered furniture, mattresses and carpets. The IDT has described various pathways of PBDEs from consumer products to aquatic life, including on-going releases to indoor air via dust, followed by atmospheric deposition into the marine environment and/or dissolution into household wastewater streams. Landfills or recycling facilities with insufficient source control practices can create atmospheric and sediment hotspots of PBDEs. This strategy approach is aimed to reduce the loading of PBDEs to Puget Sound by encouraging the removal and safe disposal of PBDE-containing consumer products.

3.2.3.1 PBDE-product recycling and disposal

E-CYCLE WASHINGTON

E-Cycle Washington enables environmentally-responsible recycling of electronics (specifically TVs, laptops, monitors, and tablets) from households, small businesses, small government groups and school districts. The plastic housing components of electronics are a known source of PBDEs, and their disposal can lead to releases of PBDEs into the environment through dust (ex. Park et al., 2014; Petty et al., 2017), leaching from landfills (Osako, 2004) and especially through environmentally-harmful methods of open-air burning and smelting (Someya et al., 2016), which is more common in less economically developed countries. E-Cycle is subject to performance standards outlined in Washington legislation. E-Cycle notes that the majority of plastic waste from electronics are separated and/or shredded and distributed to recyclers for plastic recovery, thus diverting a large volume of potentially PBDE-containing plastic materials from landfills and/or exportation to less environmentally-stringent economies.

While it is generally considered good environmental practice to recycle and reuse consumer products, shredding and manually deconstructing electronics provides more opportunities for the creation and release of PBDE-containing dust than wholesale disposal (Park et al., 2014). Furthermore, sanitary landfills in the U.S. must meet modern standards for mitigating releases of contaminants into air, water and soil through, for example, plastic liners, leachate and gas collection devices (Cifani, 2018). Therefore, an evaluation of PBDE content in air and sediment samples at or near the E-Cycling facilities vs. landfill sites would improve our understanding of the effectiveness of this and other electronics recycling programs at reducing loading of these contaminants into the local environment over direct-to-landfill disposal methods.

Recommendation: Evaluate the effectiveness of recycling programs in reducing PBDE loading over landfill methods.

LINK-UP

The IDT recommended development of a program for removing and recycling household furniture to reduce PBDE loading. A model program that could be expanded to meet this need is Link-up. This King County program works to expand the market for recycled products by facilitating collaboration between businesses, public agencies and other organizations. Link-up is currently focusing on increasing mattress collection and recycling by recruiting additional businesses to the Take it Back Network of responsible recyclers specifically for mattresses.

The IDT has focused on couch removal and replacement as the subject of a potential pilot program that could be expanded to cover other PBDE-containing furniture and consumer products. Link-up's program and results, when available, could serve as a model for such a program. Key to the pilot program would be robust monitoring and evaluation efforts (ex. monitoring the number of additional PBDE-containing products swapped out over baseline per year) to determine if the program is effective and scalable. As with other social marketing approaches, such as those described in Section 3.3.2.2., a long-term commitment may be necessary to observe a meaningful return on program investments.

3.3 STRATEGY 3: IDENTIFY HIGH-RISK LAND USE AREAS AND ACTIVITIES FOR LOADING AND APPLY BEST AVAILABLE SCIENCE TO PREVENTION, SOURCE TRACING, SOURCE CONTROL, AND BMPS

Stormwater runoff is a significant source of dispersed toxic contaminants to the Puget Sound watershed, and has been emphasized as a focus for Puget Sound recovery in IDT meetings, documents, Implementation Strategies and by the Department of Ecology as a whole, the Task Force and the Washington State Governor's Office. Strategy 3 aims to mitigate toxics that are delivered to Puget Sound via non-point source stormwater pathways. The primary approaches for accomplishing this are: 1) identifying hotspots (high loading areas or activities) through source tracing, 2) improving jurisdictions' capacities for enhancing source control, and 3) increasing the installation of stormwater retrofits in developed areas for the purposes of pollution control.

3.3.1 APPROACH 1: PRIORITIZE HOTSPOTS THROUGH SOURCE TRACING

Approach 1 focuses on source tracing for controlling and reducing contaminant loading in the Puget Sound and is the first step in the planning section of the results chain for this strategy. The following section outlines a large scale, land-use focused toxic chemical loading study conducted by Ecology, more localized source tracing efforts conducted by the City of Seattle and the City of Tacoma in conjunction with Ecology, and an overview of modeling-based source tracing efforts in the Puget Sound. The Cities' source tracing efforts represent on-going fulfillments of NPDES operational source control requirements for Phase I permittees. However, given the inclusion of smaller, Western Washington Phase II permittees into the 2019 NPDES Municipal General Stormwater requirements, these programs could serve as a

model for jurisdictions that now need to build source tracing programs to support more rigorous operational obligations.

3.3.1.1 Regional source tracing activities

TOXICS IN SURFACE RUNOFF TO PUGET SOUND

In 2006, Ecology began a multi-year, 3-phase study of toxic contaminants and loading in the Puget Sound ecosystem. Phases 1 and 2 relied on existing data and literature to better understand the sources and transport of toxics to the Puget Sound, ultimately identifying surface runoff as the primary source of toxic chemicals to Puget Sound, "relative to wastewater treatment plants, groundwater, spills, combined sewer overflows and atmospheric deposition" (Herrera, 2011, p. xvii). Phase 3 (Data and Load Estimates) advanced this conclusion and refined estimates of toxic chemical loadings from surface run-off using in-field sample collection and laboratory analysis. Tests of multiple run-off receiving streams in the Snohomish and Puyallup watersheds allowed Ecology to estimate the relative contributions of specific land-use types (commercial/industrial, residential, agricultural, and forest) to the composition and mass of toxic chemicals in Puget Sound (Herrera, 2011).

Results indicate that each land-use area contributes overall mass in proportion to the relative areas covered by each land use, a result supported by national water quality assessments (Herrera, 2011). While contributing to much smaller stormwater runoff by volume, commercial/industrial land uses were associated with the highest concentrations of contaminants in runoff, including metals, PCBs, phthalates, and PAHs.

The study recommends that efforts to reduce loading in areas with diffuse, low-level contamination (e.g. agriculture, forestry, residential) focus on removing contaminants at the source (e.g. consumer and agricultural products, emission controls) while efforts to reduce high-concentration loading from localized sources rely on best management practices to control individual releases (Herrera, 2011). This approach is supported by the IDT's recommended approaches to high volume CECs and PBDEs (Strategies 1 and 2) and high concentration PCB and PAH hotspots (Strategies 2 and 3). The following source tracing programs provide examples of approaches to identify high-concentration areas of individual toxic releases.

CITY OF SEATTLE: SEATTLE PUBLIC UTILITIES

Seattle Public Utilities (SPU) and other City of Seattle departments have developed a 5-year Source Control Implementation Plan for the Lower Duwamish Waterway (LDW) that is designed to meet 2013 NPDES Phase I Municipal Stormwater Permit requirements and MTCA requirements for contamination on City-owned properties, as well as to support Ecology's source control efforts for the LDW Superfund Cleanup (City of Seattle, 2016). Source tracing is an integral first step in controlling or eliminating ongoing sources of contaminants in sediment that are deposited to the LDW through the City-owned municipal separated stormwater system (MS4).

Between 2008 and 2013, SPU collected between 100-180 source tracing samples per year from the MS4 discharging into the LDW. In order to prioritize hotspots, SPU compares end-of-pipe in-line sediments and

solids to in-waterway sediment chemistry to identify matches in chemicals that exceed certain thresholds, such as the Sediment Management Standards benthic criteria "cleanup screening levels" or the "second lowest apparent effects threshold", both of which are indicators of significant pollution. SPU then conducts an iterative process of sampling surrounding facilities and inspecting businesses to identify the source. In their 2015-2020 5-year plan, SPU focused their source control efforts on the following activities: "maintaining existing sediment traps to support long-term trend and source control evaluation; tracing sources in problem areas identified to date; installing new drain traps; re-sampling cleaned lines to ensure sources are controlled; and filling in data gaps" (City of Seattle, 2016, p. ES-6).

SPU's source tracing activities have enabled the detection of significant sources of PCBs, phthalates, PAHs, metals, and dioxins/furans in the LDW. This information has directly supported the cleanup of over 77,000 feet of city-owned storm drain lines and the majority of the high priority drainage systems in the LDW (City of Seattle, 2016). SPU's projects have been supported in part through Washington's Stormwater Financial Assistance Program and MTCA grants (Section 3.3.2.1).

CITY OF TACOMA

The City of Tacoma employs similarly extensive source tracing methods to meet NPDES Phase I permit requirements as part of a comprehensive monitoring and source control strategy for the Thea Foss and Wheeler-Osgood Waterways, a former Superfund site remediated under the auspices of the EPA in the early 2000's. Between 2012 and 2017, the City of Tacoma conducted investigations into possible sources of intermittent mercury, PCBs, PAHs and phthalates in outfall drainage basins of the Thea Foss Waterway (City of Tacoma, 2017). Source tracing relied on stormwater drain sediment traps to identify hotspots in the drainage areas, followed by progressively more geographically-constrained sampling of catch basins upstream of the contamination. PCBs were traced back to caulking materials in buildings and sidewalks, which the City of Tacoma ultimately concluded were the source of PCBs to the stormwater system (King County, 2016). Source control actions for removing contaminated materials are site-specific and on-going; at the end of the investigation period (2017), the City of Tacoma was continuing to work with regulatory agencies and property owners to develop remediation plans.

3.3.1.2 Regional toxics modeling

Models may be able to support regional source tracing efforts by providing information on the relative importance of different source pathways and removal processes to the long-term fate of contaminants in Puget Sound. In general, improved understanding of toxics fate and transport in the Puget Sound would support scientific monitoring efforts.

PUGET SOUND REGIONAL TOXICS MODEL

Ecology began developing the Puget Sound Regional Toxics Model (PSRTM) in 2009 with a focus on PCBs. The PSRTM was later expanded to address PAHs, PBDEs, copper, lead, and zinc. The 2015 PSRTM included a fate and transport model and bioaccumulation model of PCBs and PBDEs. The bioaccumulation model was shown to be useful for management purposes where it was able to predict the regions in which the contaminants in biota exceeded adverse effects threshold established in the Vital Sign Indicator. While

the bioaccumulation model was relatively accurate at predicting biota concentrations, the fate and transport model had significant gaps that needed to be filled before the model could be useful. These gaps included more knowledge of the transport of contaminants associated with air deposition and suspended sediments and knowledge of contaminants entering the Puget Sound from the ocean boundary (Strait of Juan de Fuca) (Ecology, 2015c).

SALISH SEA MODEL

In collaboration with the Department of Ecology, modelers at the Pacific Northwest National Laboratory (now the Salish Sea Modeling Center housed at the Puget Sound Institute) have applied a Finite Volume Coastal Ocean Model toward modeling oceanographic features in the Puget Sound through the Strait of Juan de Fuca to Yaquina Head in Oregon, around Vancouver Island, and through the Columbia River. The Salish Sea Model simulates algal growth cycles, nutrient consumption, pH, and dissolved oxygen. Hydrodynamic models can be used to track surface transport of oil spills, debris, or other contaminants.

Heretofore, the Salish Sea Model has been focused on modeling dissolved oxygen and water quality as it relates to nutrient loading and the Puget Sound Nutrient Source Reduction Project (McCarthy et al., 2018); however, recent work has supported the development of a toxics fate and transport module with a particular focus on PCBs, potentially addressing the technical limitations identified in the PSRTM. The model allows for regional assessments of the timing and spatial distribution of PCBs in the environment given physio-chemical transformation processes such as atmospheric deposition, absorption, volatilization and decay. While not granular enough to support site-level source tracing, the model is expected to allow for the synthesis and re-analysis of Puget Sound monitoring data for the purposes of basin-scale water quality management. The Salish Sea Model also supports the Marine Water Quality Implementation Strategy.

KING COUNTY WATER QUALITY ASSESSMENT AND MONITORING

King County (2017) conducted an extensive study of contaminant loading in Puget Sound, including estimations of future contaminant loadings through 2030 associated with projected urban growth and land use change. This study was conducted in pursuant to King County's updated long-term combined sewer overflow (CSO) control plan, required by Ecology every 5 years. The study examines the Lake Union/Ship Canal and the Duwamish Estuary/Elliott Bay specifically, estimating changes in contamination from both inorganic and organic compounds, including PAHs, PBDEs and PCBs, from sources such as stormwater runoff, CSOs (controlled and uncontrolled), leaching from creosote-treated pilings, atmospheric deposition, and highway bridge runoff, among others.

3.3.1.3 Illicit Discharge Detection and Elimination

Illicit Discharge Detection and Elimination (IDDE) programs support the prevention, identification and elimination of non-stormwater, illicit pollutant discharges. IDDE BMPs are included in the 2019 SWMMWW, in pursuant to general municipal stormwater Phase I and Western Washington Phase II permit requirements; implementing an IDDE program is therefore an on-going obligation for municipalities with 2019 permits.

For the City of Seattle, a Phase I jurisdiction, the prioritization of drainage basins for IDDE field screening considers a variety of factors, including existing data on basin size, whether the receiving waters are 303(d) listed sites under the Clean Water Act or are in the vicinity of public water access, and previous data collection efforts. IDDE field screening relies on direct observation, field and laboratory analysis of dry weather discharges to identify and characterize possible contaminants; if a screening parameter such as color, odor, pH, etc., is detected above a certain threshold, laboratory analysis and source tracing is triggered in response (City of Seattle, 2016). Further actions listed in the SWMMWW include identifying polluting industries and mapping associated stormwater plumbing systems to support source control, conveying unpermitted discharges to a sanitary system, or permanently plugging or disconnecting stormwater connections where illicit discharges are found.

STORMWATER ACTION MONITORING PROGRAM

Ecology's Stormwater Action Monitoring Program (SAM) funds and conducts research related to stormwater impacts on the environment and the effectiveness of management practices at reducing these impacts. SAM provides technical guidance and support for source tracing and source control through the following:

- Updates to King County's Field Screening and Source Tracing Guidance Manual (King County, 2013)
- Research on IDDE inspection practices, BMP effectiveness and stormwater receiving waters status and trends
- Analysis of pollutant loading using biological endpoint and sediment chemistry studies
- In-house training for new management approaches
- Wholesale analysis of IDDE incidents in Western Washington for the purposes of enhancing municipalities' capacity for source tracing and IDDE prevention

SAM's work addresses a need identified by the IDT for improved collation of toxics loading data and enhanced monitoring of BMP effectiveness.

VOLUNTEER MONITORING

Volunteer organizations can support the identification of illicit discharges and source tracing activities. The Puget SoundKeepers, for example, engage in civic monitoring and reporting of illegal pollution on and around the Puget Sound, along with training volunteers to look for unusual discharges from pipes, industrial and construction sites, and vessels, with a particular focus on oil spills and sheens.

3.3.1.4 Addressing liability barriers to source tracing

The IDT has collectively emphasized the need to encourage potentially liable parties to engage in source tracing activities for the purposes of enhancing the identification and remediation of hotspots that occur within their jurisdictions or on their own property. Removing barriers to information-sharing of known or suspected contamination by providing "Safe Harbor" from the liability of associated remediation costs and damages is expected to improve data availability and enable prioritization of hotspots. "Safe Harbor,"

or relief from liability associated with remediating contamination, is described in the context of CERCLA and MTCA provisions for brownfield redevelopment in Section 3.4.1.2.

With respect to source tracing, "Safe Harbor" can refer to reduced liability for municipalities or industries that discover contamination on their sites and who would then normally be responsible for cleaning up the site per CERCLA or MTCA rules. IDT members discussed liability being a disincentive for parties to actively look for hotspots because those parties would likely be held accountable for remediation projects; therefore, reduced liability should encourage the development of source tracing programs and information-sharing both within municipalities and private industry.

However, others involved in site remediation take a different view. When it comes to contamination for which responsibility is unambiguous and the liability associated with CERCLA and MTCA is unavoidable, responsible parties face a strong incentive to proactively address any known or suspected contamination, develop a cleanup plan and coordinate with Ecology and/or EPA as quickly as possible (C. Patmont, personal communication, June 25, 2020). Research from EPA Region 10 (1992) supports this; at the federal level, liability for possible recontamination of cleanup sites "should provide an incentive for [potentially liable parties] to eliminate and/or reduce the release of contaminants to [affected] waterways as soon as possible" (p. 43). The liability associated with cleanups also presents an economic incentive for preventing environmental contamination in the first place through effective source control measures (National Center for Environmental Economics, 2001); creating liability shields may therefore have the unintended consequence of relaxing source control efforts.

That said, because MTCA and CERCLA liability is joint and several, a potentially liable party that looks for and discovers contamination for which they are only partially to blame may find themselves liable for the full costs of remediation if other responsible entities are defunct or insolvent (Kilbert, 2012; Ferguson, 2014). While industries and municipalities may be incentivized by a threat of liability to control for their own sources of pollution, they may be disincentivized to engage in source tracing where such activities become an "exercise in chemical archeology," i.e., where one is likely to uncover legacy contamination that they must then pay to remediate regardless of fault (E. Seaman, personal communication, June 19, 2020; Scheller, 2005).

Short of providing Safe Harbor, Voluntary Cleanup Programs (Section 3.4.1.2), provide a less legally-burdensome avenue for dealing with toxic contamination, and could serve as a good model for source tracing and subsequent cleanup processes for known or suspected contamination insofar as industries can rely on being released from liability when regulatory compliance is met. Complaints over tighter-than-regulatory and/or inconsistent cleanup standards were presented by private remediation professionals (C. Patmont, personal communication, June 25,2020) and the City of Tacoma (E. Seaman, personal communication, June 19, 2020).

Incentives aside, some form of source tracing, such as illicit discharge detection and elimination, remains a required BMP for NPDES Municipal General Stormwater Permits, which, as stated previously, were expanded in 2019 to include Phase II permittees of Western Washington. Grants and loans from MTCA and the Stormwater Financial Assistance Program supported large-scale source tracing projects in the

Duwamish; additional funding could be used to support new source tracing programs, especially for Phase II municipalities that were not previously required to develop them. Regulatory consistency and capacity for the Voluntary Cleanup Program is discussed further in Section 3.4.1.2.

Recommendation: Given the recent expansion of NPDES requirements and legislative changes to the funding structure of MTCA, the authors recommend evaluating the effectiveness of these changes before developing Safe Harbor options for the purposes of incentivizing source tracing.

3.3.2 APPROACH 2: IMPROVE JURISDICTIONS' CAPACITY FOR SOURCE CONTROL AND BMPS FOR HIGH-IMPACT LAND USE AREAS AND ACTIVITIES

Source control activities are largely carried out using existing local, state, and/or federal authorities. The primary regulatory mechanism is Ecology's NPDES Phase I and Western Washington Phase II Municipal Stormwater Permit program, the requirements for which guide selection of BMPs to be implemented in pursuant to source control requirements and enforcement procedures that are sufficient to reduce the discharge of pollutants into stormwater to the maximum extent practicable (City of Seattle, 2016). Funding mechanisms to meet these requirements are outlined in the following section, followed by programs that support the implementation of new technologies or stormwater BMPs for improved pollution control. Solid wastes are also addressed in this section.

3.3.2.1 Funding and support

The IDT has identified adequate funding and programmatic support as necessary to bolster source control activities for high-impact land use areas and activities sufficient to reduce loading. The following legislative changes and programs can provide financial and technical support for source control activities for both stormwater and solid waste.

SENATE BILL 5993: MTCA AMENDMENT, STORMWATER CAPITAL ACCOUNT

A 2018 MTCA amendment (Senate Bill 5993) made substantive changes to the funding and structure of MTCA, including the creation of a separate account to be used exclusively for stormwater pollution control. This includes direct financial support for stormwater retrofits and/or remedial action projects and funding for stormwater financial assistance to local governments to support compliance with MTCA and NPDES permits.[36] Other changes included an increase in the Hazardous Substance Tax (HST) and the creation of a separate capital account that supports brownfield redevelopment. More information on these changes is provided in Section 3.4.1.1.

[36] RCW 70.105D.210

STORMWATER FINANCIAL ASSISTANCE PROGRAM

The Stormwater Financial Assistance Program funds municipal projects and activities that have been proven effective at reducing contaminant loading from existing infrastructure and development or which enhance existing stormwater programs. Eligible projects and activities include Ecology-approved retrofits, inspections of stormwater treatment facilities that were installed prior to NPDES requirements for inspections, street sweeping programs, and legacy pollutant source identification, tracing and removal (Ecology, 2017a). The Stormwater Financial Assistance Program provided key support for Seattle Public Utilities in their source tracing and control program for the LDW, as described previously (City of Seattle, 2016). The grants also support BMPs that address or correct non-point source water quality degradation through facility or activity-focused projects. More details on stormwater BMPs are described in Section 3.3.2.2 and in the B-IBI Base Program Analysis.

OTHER STORMWATER FUNDING MECHANISMS

Stormwater utility fees, public-private partnerships, and NGOs are other funding sources for stormwater control programs in Washington, and are discussed in greater detail in the B-IBI Base Program Analysis (2020).

STATE SOLID AND HAZARDOUS WASTE PLAN

Under Washington law, Ecology is required to "develop and regularly update a state solid and hazardous waste plan, [which] guides the future management of waste and materials in the state." At present, Ecology's work focuses primarily on end-of-life activities: waste reduction, improving and increasing recycling and re-use, and enforcing regulations for the appropriate management of state-listed dangerous wastes; these regulations act to control the release of toxics from solid and hazardous waste streams (Ecology, 2015d). Of the indicator contaminants emphasized in the Implementation Strategy, PCB, PAH and CEC sources such as capacitors, paints, motor oils, and pharmaceutical products, respectively, are considered dangerous wastes in Washington.

Ecology is responsible for inspecting over 1000 businesses that generate medium and large quantities of dangerous waste (Ecology, 2015d). Business compliance with dangerous waste regulations has increased due in part to increased staffing for inspections. A dangerous waste producer or treatment/disposal facility must have waste management permits for compliance with state and federal regulations. Inspection and management of small quantity generators of dangerous waste is generally overseen by the Local Source Control Partnership.

LOCAL SOURCE CONTROL PARTNERSHIP

Ecology's Local Source Control Partnership assists local governments with the management of small quantity generators of hazardous materials and waste through free local inspections and technical assistance for pollution prevention. Specialists with the Partnership have completed more than 26,000 technical assistance visits to support the management and reduction of wastes from sources that are otherwise too small to be overseen through the State Solid and Hazardous Waste Plan (ex. gas stations,

auto repair shops, building contractors, etc.) (Ecology, 2018a; State Solid and Hazardous Waste Plan, 2015). The Source Control Partnership was developed via State legislation in 2008; Ecology has since requested funding renewals to support the program beyond 2019 (see B-IBI Base Program Analysis for details).

LOCAL SOLID WASTE FINANCIAL ASSISTANCE PROGRAM

The Local Solid Waste Financial Assistance Program provides MTCA grant funding to local governments to assist in the development and maintenance of a solid and hazardous waste management plan and the enforcement of solid waste rules and regulations.

3.3.2.2 Stormwater treatment technologies and BMPs

The IDT identified research and investment in stormwater treatment technologies and BMPs as a key activity for enhancing the efficacy of treatment methods and therefore reducing pollutant loading through stormwater runoff. The following programs and organizations support this activity.

STORMWATER MANAGEMENT MANUAL FOR WESTERN WASHINGTON (SWMMWW)

The SWMMWW provides guidance on the selection of treatment BMPs for stormwater runoff. Treatment options vary and may use differing technologies to obtain the same goals, but basic treatment BMPs are, at a minimum, intended to achieve 80% removal of total suspended solids from influent (Ecology, 2019a, p. III-1.2). Enhanced treatment BMPs are intended to achieve higher rates of removal of dissolved metals and are required where project sites discharge directly to freshwaters designated for an aquatic life use or indirectly through a freshwater tributary; where the project sites are industrial, commercial, or multifamily residential areas; or where stormwater is discharged from within urban growth areas or from high-traffic roads.

Specific contaminant treatment BMPs also exist for phosphorous and oil and are designed to reduce loading to within acceptable concentration criteria. Oil control BMPs are required for project sites that include areas of high vehicular traffic, railroad yards, fueling stations, and vehicle maintenance and repair sites, among others, and may support the reduction of PAH loading in Puget Sound (Ecology, 2019a, p. III-1.2).

3.3.2.3 Other contaminant-specific treatment

The IDT has recommended evaluating the effectiveness of stormwater treatment methods for the removal of specific contaminants. While stormwater filtration technologies are designed to remove contaminants that are contained within sediment and other suspended solids, there are currently no recommended BMPs that are targeted for the removal of PCBs, PBDEs and/or EDCs from non-point source runoff. Stormwater management practices for these contaminants appear to be conducted in response to source tracing reports, and rely on individual source control measures such as those taken by the Cities of Seattle and Tacoma with respect to PCBs found in buildings and concrete joints, a method that is supported by Herrera (2011) (see Section 3.3.1). That said, stormwater BMPs may be capable of

removing a wide variety of toxic contaminants from influent; for example, bioretention has been shown to be an effective strategy for substantially reducing PAH and PCB loading and preventing lethal impacts on salmonid embryos (SAM 2017, 2020). Bioretention is recommended as a basic treatment BMP in the 2019 SWMMWW where natural infiltration is practicable.

The IDT has found that a lack of data on the occurrence of PBDEs in stormwater, combined with a lack of water quality standards for this contaminant group, is a barrier to developing stormwater BMPs that are targeted for controlling PBDE loading. With respect to EDCs, while wastewater appears to be the dominant mode of transport for personal-care, hormonal and pharmaceutical products, the IDT has identified stormwater pathways for other uses of medications and pesticides, and a general lack of occurrence data to support stormwater treatment BMP development.

Recommendation: Evaluate prioritized CECs and EDCs in addition to conventional pollutants when assessing new treatment technologies and BMP effectiveness for contaminant removal from both stormwater and wastewater.

TECHNOLOGY ASSESSMENT PROTOCOL – ECOLOGY (TAPE)

Emerging stormwater treatment technologies are reviewed through Washington state Technology Assessment Protocol –Ecology, or TAPE. TAPE allows for emerging treatment technologies that meet performance goals for removal of solids and pollutants to replace installation of traditional stormwater treatment mechanisms, allowing for increased innovation and efficiency in the public sector. An external board of expert reviewers are consulted to review treatment design and performance data and to recommend certification of the technology (Ecology, 2018b).

NON-GOVERNMENTAL ORGANIZATIONS

The Pacific Northwest Pollution Prevention Resource Center is a non-profit research organization that provides practical information and programmatic guidance for the enhancement of pollution prevention in the Pacific Northwest. The organization focuses on addressing upstream sources of toxic contaminants through partnerships to reduce toxics in consumer products, business practices and stormwater management. They have developed publicly available resources to support the implementation of emerging BMPs, including, for example, a review of new filtration methods, technical expertise on street and surface sweeping methods, and BMP manuals for highly paved sports facilities (Stormwater Pollution Prevention, n.d.).

Washington Stormwater Center is a research organization that is partnered and grant-funded through Ecology to assist municipalities in managing stormwater and meeting NPDES requirements. Technical tools include: IDDE field screening and source tracing guidance manual; LID operations and maintenance guidance; stormwater system mapping to support regional stormwater inventory; in-house trainings; and BMP review and evaluation in partnership with TAPE (Washington Stormwater Center, 2020).

ENHANCED MAINTENANCE

Methods of enhanced maintenance for stormwater management include line cleaning, enhanced street sweeping, piping retrofits and replacement, among others. The City of Tacoma (2017) developed an enhanced street sweeping pilot program that demonstrated PAH reductions of 66-73% associated with bi-monthly as opposed to once-monthly sweeping. Line cleaning and pipe replacement in the City of Tacoma's MS4 system were incorporated as per NPDES requirements and in instances where source tracing led to the discovery of contaminant hotspots in the stormwater system (City of Tacoma, 2017).

3.3.3 INCREASE THE INSTALLATION OF STORMWATER CONTROL RETROFITS IN EXISTING DEVELOPMENTS

The intent of this strategy approach is to promote the installation of stormwater control and treatment retrofits for the purposes of reducing pollution from existing developments. Pollution control retrofits for stormwater treatment include bioretention and soil infiltration, as well as systems that are in accordance with updated 2019 NPDES requirements outlined by Ecology in the SWMMWW. New developments and redevelopments are subject to updated 2019 requirements, but properties developed prior to the mid-1990's often lack stormwater controls. Increasing the installation of pollution control retrofits in these systems will require financial and technical incentives for landowners, improved coordination between municipalities and expert groups, as well as an improved understanding of hotspots in need of retrofitting (Chaffin et al., 2016; Gao et al., 2018; BenDor et al., 2018).

3.3.3.1 Support for businesses and municipalities

Some programs that provide expert advice and services for stormwater management include the Pacific Northwest Pollution Prevention Resource Center, the Washington Stormwater Center (Section 3.3.2), and SAM (Section 3.3.1). ECOSS is another technical support group that provides design and engineering solutions for low impact stormwater pollution control and management in the Puget Sound area, along with brownfield redevelopment assistance. The organization has partnered with Seattle businesses such as Boeing and Equinox Studios to create high-visible, "industrial strength" green stormwater infrastructure.

The Pierce Conservation District's Depave Puget Sound Program works with community groups and volunteers to remove unnecessary pavement from and re-vegetate commercial properties for the purposes of water quality improvement. The organization was developed with support from the NEP.

3.3.3.2 Grants and loans for retrofits

Grants and loans provide incentives for installing stormwater retrofits in areas not scheduled for re/development.

Table 5. Grants and loan programs that support pollution-control retrofits

Funding program	Funding source	Description
Stormwater Grants of Regional or Statewide Significance Program	MTCA stormwater capital account	Assists with large-scale projects designed to benefit multiple permittees (municipalities); competitive
Stormwater Capacity Grants Program	MTCA stormwater capital account	Awarded to individual Phase I and Phase II permittees to assist with meeting permit requirements; noncompetitive
Water Quality Combined Funding Program	Combined state and federal: Washington's Stormwater Financial Assistance Program; Washington State Water Pollution Revolving Fund Program; EPA's Centennial Clean Water Program, CWA Section 319 program	Grants and low-interest loans for a variety of water quality improvement projects, including non-point source pollution control projects and stormwater retrofits (Ecology, 2019b).

3.4 STRATEGY 4: INCENTIVIZE REDEVELOPMENT IN HIGH-LOADING AREAS TO REDUCE TOXIC LOADING

The redevelopment of contaminated properties provides an opportunity to: 1) clean up existing toxic hotspots, 2) implement better stormwater management and pollution control systems, and 3) reduce development pressures on natural areas outside of urban growth areas (UGAs). Brownfields in particular are a focus of this strategy because, left in their contaminated state, they represent high-loading areas of legacy pollution and wasted space within UGAs. This strategy aims to incentivize the redevelopment of brownfields and high-loading areas in general by alleviating cost, technical and liability barriers, and to promote and incentivize the adoption of low-impact stormwater management methods by developers of these sites.

3.4.1 APPROACH 1: REMOVE BARRIERS TO INFILL AND REDEVELOPMENT OF BROWNFIELDS IN URBAN GROWTH AREAS (UGAs)

The Puget Sound Partnership's Ecosystem Coordination Board (ECB) and the IDT have identified several barriers to the redevelopment of brownfields in the Puget Sound area, including a lack of staff, funding and support for Ecology and the Attorney General's Office; liability and regulatory uncertainty for owners; cleanup costs; and difficulty in securing sufficient loans. This strategy approach is intended to address these barriers by improving the availability of funding and support for municipalities, reducing liability associated with voluntary cleanups and streamlining the regulatory process. Also included in this strategy approach are efforts to identify and map brownfields for the purposes of identifying and prioritizing high-loading contaminated areas and applicable funding mechanisms, and incentivizing redevelopment by promoting successful case studies.

3.4.1.1 Funding and support

The ECB developed a proposal to address resource and funding barriers, recommending changes (legislative or otherwise) to the funding structure provided by MTCA, and increasing the flexibility in the distribution of MTCA funds to jurisdictions.

A previous 2013 amendment to MTCA was intended to provide local governments with additional tools and resources for accelerating the redevelopment of brownfields. These provided a mechanism by which municipalities could create the following:

1) Redevelopment Opportunity Zones (ROZs)
2) Brownfield Renewal Authorities
3) Brownfield Redevelopment Trust Fund Accounts

ROZs are geographic areas that are designated by local governments for redevelopment and contain >50% brownfield property (Ecology, 2018c). The establishment of these zones is intended to streamline and accelerate redevelopment. Local governments are authorized to create Brownfield Renewal Authorities, and to access an associated Trust Fund Account, created within the state's budget (primarily drawn from MTCA). One advantage of the account is the flexibility it allows for mixed funding settlement agreements between public and private entities for projects that provide public benefits (particularly social equity developments), ostensibly providing a solution to the aforementioned resource barrier.

However, Ecology (2018c) notes that the use of these tools has been limited to nonexistent. Since 2013, three ROZs but no associated Brownfield Redevelopment Trust Fund Accounts have been created. Ecology found that the primary reason for this lack of moneys is a MTCA revenue shortfall that prevented the state from participating financially, through both state-directed investments and remedial action grants, in the funding of brownfield cleanups within ROZs. Without state participation, local governments were severely hindered in their ability to fund redevelopment projects.

Given that the major source of funding for MTCA accounts is the Hazardous Substance Tax (HST) (Ecology, 2018c), the Office of Financial Management (2016) recommended, in a report to the Legislature, increasing revenue by imposing a surcharge on the HST, adjusting the HST based on inflation, increasing the number of substances subject to an HST, and/or changing from a value-based to a volumetric tax.

SENATE BILL 5993: MTCA AMENDMENT

This recommendation was for the most part addressed in 2019, when MTCA was amended to update and restructure this primary funding mechanism through Senate Bill 5993. The HST was converted to a volumetric (per barrel) tax for petroleum, subject to inflation, while the distribution of funds to and from MTCA was made more transparent and focused through the creation of separate capital and operational budget accounts.[37] An operating account allows for, among other things, improved financial assistance for both hazardous and solid waste planning, management, regulation, enforcement, technical assistance

[37] RCW 82.21.010

and public education.[38] A capital account is strictly reserved for the improvement, rehabilitation, remediation and cleanup of toxic sites, or for providing financial assistance to local governments to carry out these projects.[39]

As per legislation, of top priority for MTCA capital funds are the redevelopment of brownfield properties within ROZs, the allocation of remedial action grants and loans, public funding to assist potentially-liable persons to pay for the costs of mandated remedial actions, and financial assistance for development projects that provide a public benefit beyond cleanup (e.g. affordable housing). Funding from this account is expected to provide more expeditious redevelopment and cleanup of brownfields and to reduce financial barriers for potentially-liable parties and prospective purchasers.[40] As mentioned previously (Section 3.3.2.1), a separate stormwater capital account was also created through the amendment to support stormwater retrofits.

EPA BROWNFIELDS AND LAND REVITALIZATION PROGRAM

The EPA's Brownfields Program is designed to help accelerate the cleanup and re-use of brownfields through federal grant funding and technical guidance. The program was codified in a 2002 CERCLA amendment: the Small Business Liability Relief and Brownfields Revitalization Act. Grants appropriated through this rule may be used to support site characterization and assessment; to remediate sites; to provide training, research and technical assistance to facilitate assessment and cleanup for non-profit, tribal and governmental entities (expanded to include non-profits in 2018 amendment); and to assist states and tribes in the development of state response programs.

The EPA's Brownfields Program has supported the cleanup of over 8,000 properties as of 2020 (EPA, 2020b). Brownfields State Program funds have supported the cleanup of approximately 150,000 sites and 2 million acres of land, including a large redevelopment project in Everett. Additionally, 7 tribes in Washington have federally-recognized and grant-supported Brownfields Programs, including the Swinomish, Makah and Stillaguamish Tribes. This program should be considered a source of funding and assistance for brownfield redevelopment in Washington State in addition to State MTCA accounts, especially for non-profit entities that may not be eligible for MTCA grants.

3.4.1.2 Addressing regulatory and liability barriers

SAFE HARBOR (UNDER CERCLA AND MTCA)

At the federal level, CERCLA imposes strict, joint and several liability on all parties that are held responsible for the cleanup of Superfund sites. The liability is imposed on all parties regardless of fault and intent, and upon anyone in the chain of title (e.g., purchasers of historically-contaminated sites). This liability represented a strong disincentive to acquiring and redeveloping brownfield properties in particular (Thornhill, 2011). Prior to 2002, liability provisions (collectively known as "Safe Harbor") were

[38] RCW 70.105D.190
[39] RCW 70.105D.200
[40] Ibid.

granted only to innocent buyers who had no knowledge of contamination at the time of property acquisition.

The 2002 Small Business Liability Relief and Brownfields Revitalization Act significantly expanded the scope of Safe Harbor from CERCLA liability to include persons who acquire property with knowledge of contamination, but who also take reasonable steps to prevent further releases and cooperate with all necessary remediation efforts, among other due diligence obligations.[41] Asserting ones' exemption from liability through these provisions (known as the Bona Fide Prospective Purchaser provisions) requires participation in federal court proceedings and have historically been difficult to defend (Ecology, 2011; Thornhill, 2011).

Many states have adopted similar or stronger protections for innocent purchasers as those codified in the federal Bona Fide Prospective Purchaser provisions (Ecology, 2011). In Washington, the process of establishing Safe Harbor from MTCA liability provisions when purchasing a contaminated property is known as the Prospective Purchaser Consent Decree (PPCD); eligibility for a PPCD is limited and priority for its use is given to projects that can demonstrate substantial public benefit.[42] This program has not been updated since 1997, is prohibitively difficult to qualify for, and is rarely used (Ecology, 2011).

Interestingly, the State of Oregon has similar requirements for qualifying for a Prospective Purchaser Agreement; however, Oregon successfully negotiates eight times as many agreements per year as Washington (Ecology, 2011). Ecology (2011) hypothesizes that the subjective qualifications for a PPCD are interpreted too stringently by Washington State agencies, that the bar for achieving a "public good" is impracticably high, and that the economic benefits of redevelopment are undervalued. Recommendations from a Washington State Brownfield Policy Advisory Panel summarized in Ecology (2011) include revising the qualifications to be more objective and/or relaxed in their interpretation and allocating more staff to the management of PPCDs. An alternative is to model the PPCD program after the federal Bona Fide Prospective Purchaser provisions; however, while easier to qualify for, these provisions are open to multiple legal interpretations and require burdensome responsibilities for on-going due diligence.

VOLUNTARY CLEANUP PROGRAM

The vast majority (90%) of brownfield redevelopment projects are led by private parties through the Voluntary Cleanup Program (VCP). The VCP provides technical assistance and authorization of completion for cleanups while allowing developers to control the scope and schedule of cleanup. Entering a VCP, however, does not protect developers from liability even after the cleanup is completed (Ecology, 2018d). The demand for VCPs currently exceeds agency capacity, leading to a back-log of requests for approval and technical support (Ecology, 2011, 2018d). Both the IDT and the ECB recommend increasing staff within Ecology and the Attorney General's office to better handle the volume of VCPs. This recommendation was also supported in Ecology (2011, 2018d).

[41] H.R. 2869 Section 222BPA
[42] RCW 70.105D.040(5)(b)

Legislative action in 2019 enabled Ecology to make significant progress towards implementing these recommendations. House Bill 1290, Concerning Reviews of Voluntary Cleanups, authorized the collection of fees from persons requesting technical advice and assistance from Ecology. In July 2020, Ecology launched a new Expedited Voluntary Cleanup Program intended to increase the efficiency of the cleanup process and allow Ecology to deliver opinions on a predictable timeline. Expedited VCP customers pay for staff time, thereby funding additional Ecology cleanup project managers.

Ecology (2011) also notes that surveys indicate that the greatest needs for private developers in cleanup projects are decreased financial risk and increased predictability and certainty in the regulatory process. The Washington State Brownfield Policy Advisory Panel summarized in Ecology (2011) recommended a number of additional strategies to address these needs, including:

- Creating liability defense for innocent purchasers and/or releasing liability upon completion of a cleanup under a VCP.
- Reforming the PPCD structure and terms for increased efficiency and usability (as previously described).
- Tax credits or other financial incentives to support private sector investment.
- Off-loading cleanup authorizations to licensed professionals and shifting to auditing-based state oversight. This strategy is known as a Licensed Site Remediation Professional Program and has led to a ten-fold increase in cleanups completed each year in other states (Ecology, 2011).

3.4.1.3 GIS analyses and resources for brownfield identification

The IDT has identified geospatial mapping of brownfields as an activity to support the identification of contaminated sites that are not yet redeveloped due to resource constraints (namely, funding and staff). Ecology's What's in My Neighborhood application is a GIS-based resource for identifying specific brownfields and cleanup sites in Washington State. The application provides users with precise cleanup locations and project status (ex, awaiting cleanup, cleanup started, "No Further Action"). This resource could potentially be combined with economic information to identify projects that are limited specifically by resource constraints.

The EPA is also engaged in identifying and mapping cleanups and brownfields. The Cleanups in my Community provides detailed information on cleanup and contamination characteristics, the status of the cleanup, and the type of grant funding that supports the project (ex. EPA Brownfields Assessment grant, Superfund).

Dirt Alert is another GIS-based resource for identifying spatial trends in contamination within a specific 1,000-square mile area impacted by legacy contamination from the former Tacoma Smelter (known as the Tacoma Smelter Plume). The application was developed by Ecology and provides recommendations for individuals on how to avoid contact with heavy metals in soil. Similar modeling methods could be useful for mapping the scope of pollution association with brownfields in UGAs within Puget Sound.

The Puget Sound Clean Air Agency, in collaboration with Ecology, the Department of Health and the University of Washington, among others, has developed a mapping tool for the purposes of illuminating

disproportionate environmental health impacts among communities of socioeconomic minority and enabling targeted environmental justice policy. The Washington State Health Disparities Map color-codes environmental health hazards at the community level using indicators such as exposure to toxics in air, water and/or soil; proximity to contaminated, industrial or Superfund sites; and sensitive populations and socioeconomic factors.

3.4.1.4 Promoting case studies

COMMUNITY RENEWAL LAW

A powerful tool for the redevelopment of "blighted" urban areas, the Washington State Community Renewal Law (CRL) enables the purchase or exercise of eminent domain over private property, including brownfields, and the sale of said property for the purposes of redevelopment. The CRL has been criticized for providing too broad an exception to Washington constitutional law that prohibits the exercise of eminent domain for the purposes of economic development, and for the broad definition and scope applied to the term "blighted." The CRL has been found to be disproportionately leveraged upon residents of socioeconomic and ethnic minority, and thus represents a threat to both private property and civil rights (Peterson, 2009). That said, it has been found to be a useful tool for enabling voluntary purchase or sale of contaminated or hazardous sites for redevelopment without repercussions of liability, and on scales not limited to individual properties. For example, the City of Everett successfully leveraged the CRL to remove and contain contaminated soil from an old smelter plant site, allowing for the development of 90 new homes (Peterson, 2009).

While care should be taken to ensure that use or promotion of the CRL does not result in unjust impacts on communities of color, in truly "blighted," inhabitable areas with excessive toxic contamination, the CRL can be considered as an alternative tool to redevelopment where VCPs or PPCDs present high liability barriers and are too limited in geographic scope to support large-scale cleanup projects.

REDEVELOPMENT OPPORTUNITY ZONES

Section 3.4.1.1 outlined the legal framework for Redevelopment Opportunity Zones (ROZs) and associated Brownfield Renewal Authorities. The establishment of ROZs can also support large-scale cleanups; while their implementation has been heretofore limited, case studies can illuminate the strength of this tool in enabling efficient and coordinated cleanups, especially where recent changes to the MTCA revenue scheme may reduce financial barriers to ROZ development in future.

In 2016, the City of Bellingham created the Bellingham Waterfront Redevelopment Opportunity Zone, encompassing 200 acres of waterfront properties owned by local municipalities. Individual cleanup plans have been completed for contaminated areas within the ROZ. MTCA Remedial Action Grants are expected to contribute funding to the cleanups; however, no Brownfield Redevelopment Trust Fund Account has been created for the project. ROZs such as this may provide case studies for the enhancement of coordinated cleanups.

It is worth noting, however, that many of the near-water cleanup sites in the ROZ overlap with an existing bay-wide cleanup strategy outlined in the Bellingham Bay Comprehensive Strategy, created in 2000 by the multi-agency Bellingham Bay Action Team (Ecology, 2019c). This project encompasses 12 cleanup sites along the shoreline, and has thus far led to the completion of four legal agreements and two cleanup action plans, with significant funding provided in part through MTCA Remedial Action Grants. The project is also included in the wider Puget Sound Initiative, described in Section 4.2.2. The existence of a working strategy with an associated leadership group and state revenue source may make an ROZ and the establishment of an accompanying Brownfield Redevelopment Trust Fund Account and Renewal Authority redundant. Further research is needed to know if ROZs can indeed improve the efficiency of cleanups, or if the added administrative costs are more likely to impede progress on existing large-scale remediation and redevelopment efforts.

Recommendation: Consider developing a comprehensive inventory of current redevelopment projects and associated funding to identify where the creation of an ROZ and associated Trust Fund Account would provide additional support and accelerate redevelopment.

3.4.2 APPROACH 2: ENHANCE THE ADOPTION OF LOW-IMPACT DEVELOPMENT WHEN REDEVELOPING

Low-impact development (LID) is a stormwater management strategy designed to restore or maintain, to the maximum extent practicable, the natural hydrologic characteristics of an area such as flow rates, filtration, infiltration, storage, evaporation and transpiration. Techniques for accomplishing this involve minimizing impervious surfaces, maintaining on-site vegetation, and managing and treating stormwater through distributed systems such as rain gardens, swales, vegetated roofs and bioretention areas. LID is covered in more detail in the B-IBI Base Program Analysis.

For the purposes of reducing toxics in fish, LID methods of stormwater pollution treatment such as infiltration and bioretention are the most relevant. More information on these specific practices for removing contaminants is given in Section 3.3.2.2. However, the IDT has emphasized the importance of incentivizing the adoption of LID strategies when redeveloping contaminated properties. This strategy approach is intended to support this goal by identifying and addressing barriers for LID in general.

3.4.2.1 Incentivizing LID for developers and property owners

BUILDING GREEN CITIES

The Department of Commerce's Building Green Cities program is an ongoing social marketing project aimed toward enhancing the adoption of low impact stormwater management practices in urban development and redevelopment by reducing barriers, improving incentives, and advancing public education.

Intrinsic incentives for low-impact development include the opportunity to develop more buildable lots with the same space, lower paving costs, and higher market and social value (MacMullan and Reich, 2007).

The following barriers to LID have been identified by the Department of Commerce and the IDT, and are supported by the literature (MacMullan and Reich, 2007).

Table 6. Methods/incentives with the potential to reduce barriers to LID

Barrier	Incentive
Increased cost	Subsidies for materials and construction, public-private cost-share programs, reduced stormwater fees, reduced permit and development fees, reduced taxes.
Maintenance, especially when it occurs on private properties and must be overseen by public agencies (Murphy, 2015)	Improve education and training on maintenance Hold public agencies responsible for continued maintenance
Uncertainty in cost and performance of technologies (Murphy, 2015)	Conduct better cost-benefit analyses for entire life-cycle of LID project; evaluate ecosystem services costs associated with traditional ("gray") stormwater infrastructure and increase accountability for developers
Regulatory burdens, including lengthy permitting and inspection processes	More streamlined permitting and inspection. Example: King County "Green Track". Model ordinances
Lack of clear methodology and instruction	Outreach, information and training. Example: California Coastal Commission LID outreach and training
Lack of return on investment	Third-party accreditation can add value to LID projects and enhance company marketing. Salmon-Safe is an eco-label provider that supports improved environmental performance of land management in the Pacific Northwest, with a special focus on protecting salmon-sustaining watersheds through low-impact stormwater management.

Box 4. Case Study: Civic involvement to support LID.

Yarra Ranges Council in Melbourne, Australia. A partnership between municipalities and a regional water authority was created to trial low-impact drainage retrofits in large urban stormwater runoff catchments. Initial efforts in the early 2000s to implement new stormwater control measures, including swales, bioretention systems, and a stormwater-harvesting system, were not successful. Researchers found that the partnership was limited by a lack of knowledge to implement LID. In 2009, a team of researchers engaged the municipality to develop a "catchment-scale experiment that involved retrofitting urban stormwater infrastructure" with the goal of improving local stream health. The retrofits were successful; participants in the project found that collaboration with researchers and technically-specialized engineers improved their knowledge and therefore capacity to design, construct and maintain low-impact stormwater retrofits. Their experience can serve as a lesson in collaborative, research-directed management, and the value of civic experimentation in changing standard practice in stormwater management (Burns et al. 2015).

4. CLEANUP

Cleanup refers to the reduction in toxics loading at the very end of the causal chain of exposure, specifically through the remediation of contaminated waterbodies that pose immediate risks to aquatic life due to contaminated sediments, contaminated soil or groundwater adjacent waterbodies, and/or water. The most heavily-polluted waterbodies in the Puget Sound include the large urban bays adjacent to Seattle and Bellingham, which are the subject of on-going cleanup efforts and the focus of Strategy 5.

4.1 REGULATORY DRIVERS

The most significant regulations that drive cleanups of contaminated sites include the federal level Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), the Washington State Model Toxics Control Act (MTCA), and the Washington Sediment Management Standards (SMS). These comprehensive regulations provide specific and rigorous cleanup protocols that are funded through liability – the "polluter pays" principal. The standards to which a contaminated site must be remediated reflect water quality and human health standards for toxics in sediment, soil, groundwater, water and fish tissue.

4.1.1 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (also known as CERCLA or Superfund) provides a federal "Superfund" for the containment and cleanup of uncontrolled or abandoned hazardous waste sites, toxic spills, and emergency releases of pollutants. As described in Section 3.4.1., EPA has full authority to seek out and impose "strict, several and joint liability" upon responsible parties, which includes assuring cooperation in cleanup procedures through orders, consent

decrees, and settlements. Superfund sites are usually the most contaminated in the nation and are of immediate concern.[43]

4.1.2 WASHINGTON'S MODEL TOXIC SUBSTANCES CONTROL ACT (MTCA)

MTCA is Washington's chief environmental cleanup law. MTCA funds and directs the investigation and removal of sources of hazardous contamination in order to protect human health and preserve natural resources. As stated previously, MTCA is funded primarily through the HST, and additionally through penalties and liability imposed on responsible parties.[44] Ecology has promulgated the MTCA and Sediment Management Standards (SMS) cleanup rules to implement the MTCA and provides regulatory oversight through several programs, including the Toxics Cleanup Program, the Hazardous Waste and Toxics Reduction Program, the Solid Waste Management Program, and others. The MTCA rule sets standards for cleanup of soil, groundwater, and surface water and the SMS sets standards for marine and freshwater sediments.[45] MTCA also provides funding for public and Tribal entities to support cleanup of contaminated sites through the Remedial Action Grants and Loans program.

Section 3.4.1 of this analysis outlined recent substantive legislative changes to the funding structure of MTCA and the creation of separate capital and operational accounts. Currently underway is a MTCA rulemaking process to update the procedures for cleaning up contaminated upland sites. The "exploratory" process began in 2018 and is scheduled to continue in three phases. While the first phase is directed toward revising administrative and procedural requirements, phase two plans to update the technical cleanup standards for soil and groundwater. The rulemaking process involves substantial public dialogue and participation with experienced stakeholders and representatives of tribal interests (the Stakeholder and Tribal Advisory Group).

4.2 STRATEGY 5: PRIORITIZE AND ACCELERATE IN-WATER AND NEAR-WATER CLEANUP BASED ON RISK TO SPECIES

The Puget Sound watershed has been the target of many large-scale cleanup efforts of both in and near-water environments, due to both legacy and continued contamination associated with urban and industrial activities. These areas represent an immediate threat to fish species and the greater pelagic food web through direct exposure to toxics. This strategy aims to accelerate the cleanup of these sites by prioritizing highly contaminated urban sites, monitoring contamination levels and addressing recognized resource and planning barriers.

4.2.1 APPROACH 1: IDENTIFY AND RANK PRIORITY AREAS, ESPECIALLY URBAN BAYS

Monitoring data indicate that urban bays, including the Duwamish River estuary, Elliot Bay in Seattle and Commencement Bay in Tacoma are priority areas for cleanup. The Duwamish River and Commencement

[43] 42 U.S.C. S9601
[44] RCW 70.105D
[45] WAC 173-204, WAC 173-340

Bay are both Superfund sites, meaning that they have been and continue to be subject to large-scale, expensive remediation projects involving multiple liable parties and both state (Ecology) and federal (EPA) agencies. Elliott Bay is proximate the Harbor Island Superfund site, and is also a site for the open-water disposal of dredged materials in the Puget Sound. This strategy approach aims to identify and prioritize these urban bay cleanup areas. Rulemaking and monitoring efforts that support this process and our understanding of the state of the contaminated sites in Puget Sound are described in this section.

ECOLOGY'S TOXIC CLEANUP PROGRAM

Ecology's Toxics Cleanup Program is Washington State's cleanup program for contaminated land, groundwater, and sediment that is not otherwise overseen by the EPA; it has primary responsibility for implementing and enforcing the MTCA and SMS rules. Cleanups follow three avenues: Ecology-led (e.g., orphaned or abandoned sites), Ecology-supervised (e.g, privately and publicly funded formal sites) and independent (e.g., independently managed and voluntary cleanup sites). As a general policy, Ecology does not allow sediment (in-water) and upland waterfront (near-water) sites into the Voluntary Cleanup Program due to the complexity of these types of sites. All cleanups must meet MTCA and/or SMS cleanup standards for environmental and human health before issuance of a "no further action" decree.

Steps in the cleanup process:

1. Discovery and report of site
2. Initial investigation
3. Site Hazard Assessment: evaluate risk to environmental and human health based on severity of hazard and exposure
4. Remedial Investigation: determine the nature and extent of contamination
5. Feasibility Study: Identify methods to eliminate exposure to contamination; create a range of alternatives; apply environmental cost-benefit analysis
6. Cleanup Action Plan: describe applicable cleanup standards and requirements for monitoring, operation and maintenance
7. Engineering design: create detailed design/construction for the cleanup action
8. Cleanup: Complete the cleanup action plan to remove and/or treat contamination
9. Monitoring and institutional controls
10. Reviews and de-listing: Hold periodic reviews to ensure cleanup continues to meet standards. Remove site from hazardous sites listing after it meets all cleanup standards and requirements; site is issued a "No Further Action".

WASHINGTON RANKING METHOD

Site Hazard Assessments provide the data that enable prioritization of cleanup sites in Washington State through the Washington Ranking Method (WARM). WARM provides a consistent, objective means for assessing the relative potential risk posed by contaminated sites to human health and the environment, differentiating between those sites where there may be an environmental threat without a human health threat (Ecology, 2009b). WARM is guided by evaluations of site characteristics, including hydrological

features and proximity to groundwater; substance characteristics, such as contaminant concentration, toxicity, and mobility; and exposure potential for sensitive environments, sensitive populations and/or human health.

While MTCA and the SMS have changed significantly since their introduction 30 years ago, the WARM scoring manual has not been updated, and is considered to be too outdated to serve the needs of cleanup in Washington State (Ecology, 2019d). The IDT has recommended that the ranking process be modified to include modern, bioaccumulation-based measures of toxicity and a framework for considering how cleanups can be prioritized to advance social equity. Ecology is currently implementing revisions to the MTCA Cleanup Rule in three phases that are likely to realize these recommendations. The Sediment Management Standards was revised in 2013 to include a framework for assessing risks from bioaccumulative chemicals and establishing standards consistent with those recommended by the IDT, are currently being implemented in the Sediment Management Standards (described in Section 4.2.1.1, below). In addition, the SMS rule does not include the WARM ranking system and prioritization of sediment cleanup sites is based on risks to ecological and human health from acute, chronic, and bioaccumulation-based toxicity and impairment to critical habitat.

SITE HAZARD ASSESSMENT AND RANKING

Ecology has proposed to replace WARM with the Site Hazard Assessment and Ranking Process (SHARP) for all media regulated under MTCA and the SMS rules, which will differ from WARM in the following substantive ways (Ecology, 2019d):

- *Improved evaluation framework*: SHARP rankings of environmental risk will be absolute, rather than relative to other sites.
- *Improved flexibility*: SHARP rankings will be based on best-available toxicological and environmental science, and can be changed with new/better information or if site conditions change.
- *Improved science:* SHARP rankings will provide separate estimates of exposure-potential, severity, and confidence in data.
- *Vulnerable populations:* SHARP uses demographic analyses to identify and flag communities of socioeconomic minority when prioritizing cleanup sites.

Special consideration is also given for surface waters contaminated with persistent, bioaccumulative toxics and/or multiple contaminants. These changes are consistent with IDT recommendations.

4.2.1.1 Addressing contaminants in sediment

Persistent organic pollutants such as PAHs, PBDEs, dioxins/furans and PCBs tend to bind to particulate matter in the environment and are ultimately deposited in soils and sediment and cleaning up these sources of contamination often requires extensive sediment remediation and control of upland sources. The following programs describe rules, processes and monitoring efforts that are central to in-water and near-water sediment remediation projects and their implications for levels of toxics in fish in the Puget Sound watershed.

SEDIMENT MANAGEMENT STANDARDS

The Sediment Management Standards (SMS) are the primary tools used by Ecology's Toxics Cleanup Program to manage sediment cleanup work, sediment dredging, and to control sources of sediment contamination in Washington State. The SMS rule establishes standards for sediment quality, applies the standards to source control (NPDES) requirements to prevent recontamination, and provides a decision process for the cleanup of contaminated sediment sites,[46] such as those present in the Lower Duwamish Superfund site.

Prior to 2013, lack of clarity in the SMS rule led to delays and inconsistencies in the sediment cleanup process; furthermore, the rule did not clearly address human health and ecological risks posed by bioaccumulative chemicals.[47] After significant dialogue with expert advisory groups and the public, the SMS was revised in 2013 to address these issues, and included: updates to the cleanup decision framework to incorporate bioaccumulation-based standards and background-level evaluations of contamination that are considered to be more protective of human and environmental health; addition of chemical and biological benthic criteria for freshwater sediments; integration of requirements for cleanup from MTCA to make cleanups more efficient; and clarification of requirements for coordinating cleanup and source control actions to avoid recontamination.[48]

It is worth noting that fish consumption rates (FCR) were not included in the 2013 amendments to the SMS rule; however, Ecology included a narrative provision that cleanup requirements be based on a Reasonable Maximum Exposure for human health, and that the default value is a tribal exposure scenario.

As previously described in Section 3.1.1, updates to the Human Health Criteria for WQS under the Water Pollution Control Act resulted in an FCR of 175 g/day and a cancer risk threshold of 1 in 1 million (10^{-6}).[49] Importantly, when fish tissue and sediment concentrations are calculated using these criteria, the resulting risk-based thresholds have been found to be below natural background concentrations (Ecology, 2015e) and frequently below analytical detection limits (Ecology, 2012b; State of Oregon Department of Environmental Quality, 2011; Finch, 2020). Natural background is defined in the SMS as the concentration of a hazardous substance consistently present in an environment that has not been influenced by localized human activities. Non-zero natural background concentrations of PCBs are found throughout much of the state, indicating global distribution of these particularly persistent chemicals through atmospheric and hydrologic pathways.[50]

Due to this apparent incompatibility between the revised Human Health Criteria and any practical application of them to the SMS, Ecology (2015e) incorporated a new term and concept called "regional background," defined as "the concentration of a contaminant within a department-defined geographic

[46] WAC 173-204
[47] Ibid.
[48] Ibid.
[49] WAC 173-201A-240 (5)(b)
[50] WAC 173-204-505 (11)

area that is primarily attributable to diffuse sources, such as atmospheric deposition or stormwater, [and] not attributable to a specific source or release." Regional background levels differ by geography, but are generally calculated by sampling areas that are removed from current or completed cleanup sites, current or historical pollution outfalls, or any other point-source of contamination. The resulting values are generally indicative of the lowest meaningful concentration that can be achieved in an urban bay with developed shorelines (Ecology, 2015e; Ecology, 2017b; C. Potmont, personal communication, June 25, 2020). That said, where natural background levels are documented in areas surrounding a potential cleanup, that lower limit may be used (Ecology, 2015e; Finch, 2020). Sediment cleanup standards are expected to be in part established on a site-specific basis, allowing for improved flexibility and more efficient and practicable clean-ups.

Ecology received numerous comments on its proposal to revise the default FCR and its direct implications for both WQS and SMS. Those who were critical of a higher default FCR appeared to support the idea of site-specific rulemaking that would protect high fish-consuming populations where necessary. However, this may be in conflict with the need to improve regulatory predictability for both water quality (source control/source tracing, Section 3.3.1.4) and cleanup: Ecology (2012b) notes that, "In general, greater predictability requires greater specificity in individual rules… With the SMS rule revisions, Ecology has tried to balance the goals of regulatory consistency, predictability and efficiency with the need to provide flexibility to address individual site situations" (p. 26). Ecology's guidance document, *Sediment Cleanup Users Manual II*, is designed to provide methods for establishing risk-based cleanup standards based on background concentrations and analytical limits.

DREDGED MATERIAL MANAGEMENT PROGRAM

The Dredged Material Management Program (DMMP) is an interagency collaboration between EPA Region 10; the U.S. Army Corps of Engineers, Seattle district (USACE); Ecology and WDNR created for the management of dredged materials in Washington State. DMMP determines the suitability of material for open water disposal through comprehensive source site assessment and physical, chemical and biological evaluations, including, if deemed necessary, in-fauna assessments of bioaccumulation. A total of 8 disposal sites in the Puget Sound are managed by the DMMP agencies; site management includes periodic monitoring at each of the sites. Furthermore, USACE, in coordination with the DMMP agencies, consults with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act (ESA) and with NMFS under Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act as necessary. Transport to and disposal of material at DMMP multiuser sites are covered under this programmatic consultation so that use of the sites does not need to be consulted individually for each project.

In a 10-year Biological Evaluation of Puget Sound sites required as part of this programmatic consultation, USACE (2015), find that, given the rigorous testing requirements and limitations on dumping, the "…effects to listed species [such as salmonids] resulting from contamination of discharged sediments would be extremely unlikely to occur" (p. 49).

With respect to Chinook salmon, the USACE (2015) finds that the impacts of continued operations of all Puget Sound open-water disposal sites are insignificant, and validates a previous 2006 analysis that found that the potential for bioaccumulation of PCBs and polychlorinated dioxins and furans for Chinook were "discountable." Of the DMMP disposal sites, only the Elliott Bay site has detected PCBs during monitoring events prior to 2015; these values were below the sediment effect threshold for bioaccumulation in tissue (Meador et al. 2002, ctd. USACE, 2015) and were not "significantly elevated over the [disposal site] surroundings for PCBs" (p. 55). This suggests that other sources are responsible for the higher ambient PCB levels in Elliott Bay.

While Biological Evaluations required by the ESA include bioaccumulation-related evaluations, direct bioaccumulation testing of dredged materials are not standard monitoring practice (E. Hoffman, personal communication, 2020). However, similar to Ecology's 2013 updates of the SMS, the DMMP has undertaken an effort to update the monitoring framework for disposal sites to shift the emphasis from mortality-based sediment effects testing to bioaccumulation-based evaluation approaches, consistent with the regulatory framework in the 2013 SMS rule update. This shift in focus toward bioaccumulation metrics is consistent with recommendations from the IDT. The DMMP plans to use the upcoming scheduled monitoring event at the Port Gardner, Everett disposal site as a pilot study for implementing proposed changes to the monitoring framework. The framework and monitoring approach will be further refined based on pilot study experience and stakeholder feedback. The DMMP's work is ongoing, and represents an important monitoring and scientific effort for in-water cleanup of contaminated sites in Puget Sound.

NATURAL RESOURCES DAMAGE ASSESSMENT

Natural Resources Damage Assessment (NRDA) is the legal process used to determine the appropriate type and amount of restoration needed to offset impacts to fisheries, wildlife, habitats, and human uses caused by releases of oil and other hazardous substances or events like ship groundings. NOAA's Damage Assessment, Remediation, and Restoration Program works along with tribal and state trustees through a formal process authorized under the Oil Pollution Act and CERCLA to identify, quantify, and compensate for public damages. In Washington, the Department of Ecology is generally authorized by the Governor to represent the state. The largest NRDA cases in the Puget Sound region involve the same urban bays prioritized by the IDT (Elliott and Commencement), and Ecology's Puget Sound Initiative generated several NRDA actions (Salish Sea Wiki, 2021).

4.2.2 APPROACH 2: ACCELERATE CLEANUP

As outlined in Section 3.4.1.1, 2019 legislative updates to the MTCA revenue stream may be sufficient to address the budget shortfall that has been found to be a barrier to cleanups. That said, the IDT notes that establishing funding and project deadlines may provide further incentives to accelerate cleanups. Large-scale, deadline-driven and coordinated cleanups have been effective in Puget Sound through the Puget Sound Initiative.

PUGET SOUND INITIATIVE

The Puget Sound Initiative was a Governor-directed effort began in 2007 with a goal cleaning up multiple sites within high-priority waterways, waterfronts and urban waters in the Puget Sound. Seven important bays were prioritized for coordinated cleanup and restoration by a 2020 implementation deadline, including: Fidalgo and Padilla Bays/Anacortes, Budd Inlet, Port Angeles Harbor, Port Gamble Bay, Port Gardner Bay/Everett, with the common goal of protecting the most sensitive marine habitats in the Sound. Ecology is working together with the EPA to remediate river sediments and control pollution in the LDW Superfund site.

Collaboration with Ports, local agencies and property owners, along with the special allocation of significant state funding has enabled substantial progress toward meeting 2020 cleanup goals, including the remediation of dozens of contaminated sites in Everett, Port Gamble Bay, Fidalgo Bay, and Anacortes. The Port Gamble bay-wide cleanup in particular is one of the largest creosote-removal projects in Puget Sound: over 8,500 creosote-treated pilings and tons of wood waste have been removed the site (Ecology, n.d.).

The complexity of developing legal agreements with PLPs is a known barrier to site cleanups. The Puget Sound Initiative program successfully addressed this barrier and resulted in a number of cleanups that posed high risks to aquatic life and habitat being completed in record time. As part of the Initiative, Ecology was provided with funding to both cleanup the sites and hire new staff to lead those projects. This allowed Ecology to lead the cleanups instead of providing regulatory oversight for PLPs. Cost recovery from PLPs then occurred *after* the cleanups had been completed.

5. CONCLUSION

Since the development of the Implementation Strategy for the Toxics in Fish Vital Sign and the associated 2017-2020 planning effort, many of the IDT's strategy approaches and recommendations have been addressed through recent Washington State regulatory and programmatic changes. The most significant of these include amendments to the funding and structure of MTCA, 2019 updates to Washington's NPDES stormwater permit requirements, the promulgation of SSB 5135 (Safer Products for Washington), and the promulgation of HB 1290 (Concerning Reviews of Voluntary Cleanups).

In 2019, MTCA was amended to incorporate the following changes:

a. Increase in the HST and switch to an inflation-based value
b. Creation of separate capital and operating accounts for stormwater management and brownfield redevelopment

These changes will support both Strategies 2 and 4 by increasing the sum and availability of state funds to support: 1) jurisdictional efforts at source control, pollution prevention and BMPs via stormwater management and pollution prevention grants and loans, and 2) the redevelopment of brownfields through Remedial Action Grants and Loans, respectively.

The 2019 NPDES municipal general stormwater permit requirements for Phase II permittees were expanded to include some conditions previously applicable to only Phase I jurisdictions. This will mean additional requirements in the development of source tracing (ex. IDDE) and source control programs for municipalities that weren't previously included in these permits. These requirements will support the goals of Strategy 2, particularly with respect to improved identification of hotspots through source tracing.

SSB 5135 created the Safer Products for Washington Program, enabling Ecology to prioritize and ultimately regulate CECs and the consumer products in which they are found. This fulfills the more substantive goals of Strategy 1 through the development of a prioritization process and a mechanism for the regulation of CECs.

HB 1290 authorized Ecology to collect fees from persons requesting technical advice and assistance under the Voluntary Cleanup Program. This enabled Ecology to launch a new Expedited Voluntary Cleanup Program in 2020. Expedited VCP customers pay for staff time, thereby funding additional Ecology cleanup project managers.

Where is there a need for enhanced scientific monitoring?

This analysis suggests that scientific study and occurrence monitoring of CECs will be necessary to effectively regulate CECs at the consumer product level and further along the causal pathway of exposure (wastewater and stormwater) via new water quality criteria under the Water Pollution Control Act. Current product testing capacity at Ecology limits the number of consumer products that can be monitored in this way; expanded testing programs would therefore support effective regulation under SSB 5135. For CECs with an EDC mode of action, the characterization of indirect toxicity thresholds will be necessary for the development of water quality criteria that are protective of reproductive health in fish populations.

The IDT has indeed collectively emphasized a need to move away from direct toxicity effects thresholds for sediment and water quality standards and toward indirect toxicity effects and bioaccumulation-based thresholds. In 2013, Ecology underwent the process of revising the SMS to incorporate these changes, while the DMMP is also working toward bioaccumulation-based measures in its evaluation of sediment toxicities at dredged material disposal sites. Biological effects monitoring will be necessary to establish new criteria from which contaminated sites may be more effectively prioritized for cleanup.

PAH loadings from water and air emissions are not currently well-characterized in the Puget Sound (see the Starter Package for estimated loadings). While the emission of particulate matter from diesel combustion engines and wood stoves is associated with PAHs, PAHs are not monitored from these sources. Efforts to reduce PAH loading through electrification and swap-out incentives would benefit from enhanced monitoring of PAHs from these sources.

Where is there a need for continued or added investment?

Voluntary programs that use social marketing to encourage behavioral changes around polluting vehicles, such as the Don't Drip and Drive program, may require larger financial incentives to encourage vehicle repairs where cost barriers are high. Public awareness campaigns around stormwater pollution such as Puget Sound Starts Here may require long-term commitments (> 10 years) before ecological benefits can be observed. In such cases, direct regulatory involvement and/or continued funding for agency participation in source control efforts for small-scale businesses (ex. The Source Control Partnership) may be a more feasible alternative.

This analysis has emphasized the City of Seattle and the City of Tacoma's source control programs for the Duwamish and Commencement Bay Superfund Sites, respectively, as strong examples of source tracing for the purposes of controlling pollutant hotspots, whether they be illicit discharges or stormwater-related sources of PCBs from aging infrastructure. Continued investment in, and renewal of, these programs for the next 5-year cycle is recommended. Furthermore, expanding these programs or replicating them in smaller jurisdictions would support the management of hotspots outside of Superfund-related areas for which source control standards are already high.

Where is there a need for the development of new programs?

The IDT has suggested developing a pilot program that would support the management of PBDEs found in consumer products such as couches and mattresses. This analysis has cited Link Up as a program with the potential to support PBDE-containing mattress swap out; a pilot program targeted toward couches for swap-out could also support PBDE reduction efforts as outlined in Strategy 2.

There is currently not enough information on the age and type of public buildings to support targeted PCB remediation efforts in public schools. A complete inventory of public school buildings that includes building age, materials used, and energy efficiency updates and remodeling schedules would create the necessary foundation for a new PCB remediation program. Washington may want to consider bundling PCB lamp ballast removal with energy efficiency updates, or creating a new program with the NYC PCB abatement program as a possible model.

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