6PPD Washington State Interagency Webinar Follow-Up

Thank you for your interest in the June 2023 6PPD interagency webinar. This document provides a list of resources shared during the webinar, as well as written responses to select questions answered live at the event. Please contact 6PPD@ecy.wa.gov with any questions.

Resources

Below is a list of online resources shared during the 6PPD interagency webinar. The resources are organized by department.

Department of Ecology

- Webinar materials prepared by participating Washington State Departments
- Ecology's 6PPD webpage
- Sign up for Ecology's 6PPD and 6PPD-quinone email list
- Sign up for Ecology's Stormwater Work Group 6PPD Subgroup email list
- 6PPD hazard criteria for alternatives assessment
- Online comment form for 6PPD hazard criteria (*note: comment period is now closed)
- Safer Products for Washington Draft Priority Chemicals Report
- Stormwater Best Management Practices (BMP) Effectiveness report
- SAM BMP effectiveness study descriptions
- Ecology's Toxics Studies webpage
- Interstate Technology & Regulatory Council (ITRC) Tire Anti-Degradants (6PPD) Team Information

Department of Health

- OECD (2012) is a great resource for information on the physical chemistry of 6PPD and human health toxicity.
- Johannessen & Metcalfe (2022) sampled for 6PPD-q in wastewater treatment plants and drinking water treatment plants in Ontario, Canada. 6PPD-q was not detected at the drinking water treatment plants.
- Zhang et al. (2023) discusses the physical characteristics of 6PPD that indicate it is unlikely to transfer to groundwater.

Department of Transportation

- Washington DOT folio on stormwater retrofit, funding, and 6PPD-quinone

- WSDOT Stormwater Retrofit
- WSDOT Stormwater Retrofit: 2023/2024 Prioritization Update Survey123
- WSDOT Move Ahead Washington Funding & Prioritization Opportunities

Non-Departmental

- CA DTSC Safer Consumer Products: Proposed Priority Product: Motor Vehicles Containing 6PPD (submitted by California Department of Toxic Substances Control representative)

Written Responses to Webinar Questions

Below are written responses to select questions we received in advance of the webinar and live during the event. The responses are organized by department.

Department of Ecology

What does the timeline and process for finding a safer alternative to 6PPD look like?

To find a safer alternative to 6PPD, we need to conduct an alternatives assessment (AA)**.** An alternatives assessment is a process for comparing chemicals that perform a similar function to a chemical of concern and identifying those that are safer. To this end, we recently published draft 6PPD hazard criteria. These criteria set specific guidelines so we collect the right data and analyze each chemical's safety in the same way.

The timeline for the alternatives assessment depends on the pace of ongoing research into possible alternatives to 6PPD. We are currently funding research to help us learn more about what chemicals to include in the alternatives assessment and to fill data gaps around these chemicals. As we receive the results of this research, we will be able to establish a more firm timeline for our AA.

Additionally, 6PPD was proposed as a priority chemical under the Safer Products for Washington program. If the listing of 6PPD as a priority chemical is finalized, we will identify priority products that are significant sources or uses of 6PPD. We could consider tires sold separately from vehicles as a priority product. If 6PPD and tires are chosen as a priority chemical/product, work on alternatives could begin between 2025-2027. Safer Products for Washington would leverage the 6PPD hazard criteria and subsequent alternatives assessment during alternatives work.

Is Ecology considering agency-recommended legislation to phase out 6PPD in tires?

Ecology does not have the authority to impose a ban or phase out of chemicals in consumer products unless we have determined that safer alternatives are feasible and available. That's why our work to date has focused on identifying safer alternatives.

We regulate chemicals in consumer products through our Safer Products for Washington program. In June 2023, we proposed listing 6PPD as a priority chemical under this program. This could kick of a five-year process that could regulate 6PPD in tires, either through a reporting requirement or a restriction, if safer alternatives are feasible and available. You can stay informed about this process on SPWA's stakeholder page.

How has the tire industry engaged with Ecology and others on this issue?

Ecology has shared phone calls and meetings with several industry members around the feasibility of possible alternatives, including performance requirements of antiozonants. We cannot speak to how the tire industry has engaged with others on this issue.

I am aware of an alternatives analysis on 6PPD in tires that is soon to kick off in California. How is Ecology collaborating with regulators in California on this to leverage the information in this AA?

We are in active communication with the California Department of Toxic Substances Control (DTSC) and their Safer Consumer Products program. As part of their program, industry is responsible for conducting the alternatives assessment – not the state. As of now, it looks like industry will be required to submit their alternatives assessment to DTSC in March 2024. We will use the information in those alternatives assessments to inform our AA.

In conducting an AA of 6PPD in tires in Washington, how does Ecology plan to ensure tire safety and performance?

We understand that tires are an essential safety component of automobiles, and we don't want to do anything to jeopardize the safety of passengers. To be used in tires, an alternative chemical would still need to uphold all Federal Motor Vehicle Safety Standards prior to use by industry.

For the 2nd added criteria seeking acute toxicity information for transformation products, can you describe what type of acute toxicity testing would be required? Would this include acute aquatic toxicity?

Only acute aquatic toxicity would be required. Whereas Safer Products for Washington hazard criteria require data on acute aquatic toxicity or chronic aquatic toxicity, the 6PPD alternatives assessment will require data on acute aquatic toxicity to coho salmon (and two other trophic levels) for both the parent compound and ozonated parent compound. We will revise the language in our hazard criteria to better clarify this requirement.

Is Ecology considering road pavement types in terms of mitigation options to reduce tire wear?

We are following ongoing research and maintaining communication with other state agencies, including WSDOT, as we consider ways to reduce the threat of 6PPD and 6PPD-quinone. If data show that certain types of pavements significantly prevent the transport of tire wear particles and/or 6PPD-quinone, we could explore the option further.

Has the AG considered taking legal action re: the tire manufacturers?

For questions regarding the Office of the Attorney General, you can find contact information at: https://www.atg.wa.gov/contactus.aspx.

How is the 6PPD alternatives assessment the same or different from Safer Products for Washington?

The 6PPD alternatives assessment is a separate project; however, there is a potential intersection with Safer Products for Washington in a few years. We recently proposed listing 6PPD as a priority chemical under Safer Products for Washington (SPWA). We accepted public comment through July

14, 2023, and may make revisions based on this feedback. If the listing of 6PPD as a priority chemical is finalized, we will identify priority products that are significant sources or uses of 6PPD. We could consider tires sold separately from vehicles as a priority product. If we did that, we could start work on alternatives between 2025-2027. We would leverage the work from the 6PPD alternatives assessment at that time.

What proportion of tire wear particulate as modeled by the MOVES emission model is estimated to be 6PPD?

EPA's MOtor Vehicle Emission Simulator (MOVES) models the emissions that come from mobile sources. A model to determine the amount of 6PPD and 6PPD-quinone released from tire wear particulate (both modeled and measured) is still under development. It is not known whether this information will be incorporated into the MOVES model.

Will you present a list of accredited labs in Washington that are 'certified' to analyze stormwater and creek samples for 6PPD? Also, could you provide an estimate of lab costs per sample to analyze for 6PPD?

No labs are currently accredited for 6PPD-quinone. Some labs have submitted requests for accreditation and are being evaluated by the department. Further information regarding lab accreditations can be viewed on our website using the lab search tool.

Is Ecology developing methods for 6PPD-quinone?

We have developed field and laboratory methods to collect and test freshwater samples for 6PPD-quinone. We are developing methods to detect 6PPD-quinone in sediments from rivers, lakes, and estuaries. The Manchester Environmental Lab supports Ecology's toxics monitoring program.

What are some sampling precautions you take for 6PPD-quinone?

- It is easy to miss the pollutant peak when collecting discreet grab samples. Autosamplers have a greater chance of catching the pollutant discharge peak.
- 6PPD-quinone sticks to many surfaces including silicone and rubber. PTFE tubing and teflon caps are recommended to avoid loss of 6PPD-quinone.
- Amber glass bottles are recommended to avoid photodegradation of the 6PPD-quinone.
- Filling the glass sample bottle to the top with no head space is recommended.

Is there any data on 6ppd-q leaching off of historic tire deposits in/near water bodies? Maybe places where they may have been used as rip rap?

More research is needed to understand the leaching dynamics of tire wear particles and debris in the environment. The tire industry has described 6PPD as being unbound in tires, so as it reacts at the surface with ozone, more 6PPD moves into place. The assumption is that the rubber/tires would eventually run out of 6PPD; however, research is needed to confirm the process and rate of leaching from both tires and tire wear particles that are already released to the environment.

Since tire abrasion results in very small particles being generated, most tire wear is likely transported by wind and vehicle induced turbulence tens to hundreds of meters downwind of the road, with very little likely settling on or next to the road. Will the transport of tire wear particles through the air be considered when evaluating stormwater mitigation options, especially the ability to treat stormwater at the roadside vs at the watershed scale? Will techniques to try and capture tire wear particles in the air near the road be considered as part of best management practices?

Tires themselves, tire debris, and abrasion material all contain 6PPD and are very likely to be found on every road in Washington. Due to this, they are considered ubiquitous pollutants. However, the amount of 6PPD-quinone present in stormwater depends on many factors. Airborne 6PPD-quinone would be the smallest size fraction. There are many other urban pollutants that have an air pathway like PCBs, but the air pathway doesn't have a direct relationship with stormwater until it lands somewhere as dry or wet deposition. The drainage area they end up in may be a road, roof, other impervious surface, forest, wetland, or stream. Therefore, many stormwater BMPs are presumed to be able to help address this pathway, like street sweeping and maintaining infrastructure through cleaning roadside ditches, catch basins, and storm drains.

Understanding how 6PPD-quinone moves through and interacts with the environment, also referred to as "fate and transport," is an active area of research worldwide, and was an important data gap identified in the report Stormwater Treatment of Tire Contaminants: Best Management Practices Effectiveness. Much of Ecology's current research investigates how effective runoff treatment BMPs are at treating and reducing pollutants carried in stormwater.

In Part 1 - 6PPD and 6PPD-quinone: Identification of a Problem and the Cause, a statement is made that "the chemical culprit is discovered among 2000 chemicals", the presenter stated that there were actually 2,260 chemical in stormwater, what about the other 2000 chemicals? 6PPD isn't the only baddie in the bunch. Where can we get a listing of them all, or at least the worst ones.

Our presenter was referencing two important research studies that helped pave the way to identifying 6PPD-quinone. The first of these studies is "Using High-Resolution Mass Spectrometry to Identify Organic Contaminants Linked to Urban Stormwater Mortality Syndrome in Coho Salmon" (Peter et al. 2018). This study documented how analytical advancements allowed researchers to detect thousands of unique chemicals in stormwater. The second study is "A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon" (Tian et al. 2020). This team of researchers was able to identify 2,260 unique chemicals in stormwater using high-resolution mass spectrometry, and of those chemicals, they identified 6PPD-quinone as a product of 6PPD. To learn more about the chemical cocktail described in these studies, please view the studies directly.

Human activities release many chemicals into the environment, which is documented by many studies across disciplines like forestry, agriculture, industrial discharges, and urban municipal waste. The exact composition of runoff depends on the location, as the chemicals washed off into stormwater are a result of human activities occurring nearby. There are also many naturally

occurring chemicals in rainwater and runoff, like carbon, phosphorus, and toxics like mercury. Studies like Peter et al. 2018 and Tian et al. 2020 are important because detecting a chemical allows researchers and decision-makers to start assessing risk.

What specific BMPs, regulations, or educational/outreach material have been developed to target heavy use industries, such as airports, raceways, car tire resurfacing and replacement, crumb rubber generating industries? While 6PPD replacements might be a long-term solution, these industries currently generate a lot of material that the Western Washington Stormwater Manual Volume IV doesn't adequately address.

This question spans more than one program at Ecology and includes work outside of Ecology. We can address this question from a stormwater management perspective. Impervious surfaces are already a priority for stormwater management, especially those with high vehicle use roads and parking. Our guidance for stormwater management for these surfaces and activities is already included in the Stormwater Management Manuals (SWMMs). Many heavy use industries are also being regulated under the Industrial Stormwater General Permit (ISGP). This guidance will help cities, counties, and industries manage tire debris in stormwater.

Our 2015 analysis of 2007-2013 PH I monitoring results found that there was evidence of pollutant build-up during the dry season and recommends the following:

> "Stormwater management programs can sweep and conduct other housekeeping best management practices (BMPs) in industrial and commercial areas during the dry season to reduce high stormwater loads of metals, diesel hydrocarbons, and total nutrients during the first-season storms."

Other recent effectiveness monitoring studies have shown that street sweeping reduces conventional pollutants transported by stormwater (phosphorus, nitrogen, bacteria, fine sediment, trash, plastics, and other plastic/sediment bound chemicals). Street sweeping is presumed to be effective at capturing organic matter or plastics that 6PPD-quinone has sorbed onto and tire wear particles that contain the parent material of 6PPD. We will continue to update our guidance in response to new research and emerging information.

Have you looked into tire disposal/recycling sites in WA, where are these? does 6PPDQ get released from these sources? or only from abrasion?

There are still many unknowns about the how 6PPD and 6PPD-quinone move through and interact with the environment (e.g. fate and transport). We are following ongoing 6PPD research to determine whether 6PPD-quinone leaches at tire disposal/recycling sites or only from abrasion. You can find a list of tire disposal and recycling facilities in Washington here. We will also be exploring these issues as part of 6PPD Action Plan development and will add your questions to the list of scenarios we could evaluate.

Some facilities may be covered under the Industrial Stormwater NPDES General Permit. The permit includes best management practices (BMPs) to limit stormwater runoff from sites as well as discharge limits for stormwater leaving sites. BMPs required by permittees are based on the activity conducted on site and are designed to prevent stormwater exposure and decrease the

amount of pollutants leaving the site. Currently, BMPs designed to control sediment, solids, and dust should already be implemented by these permittees and might also be effective at addressing 6PPD-quinone.

Am I right in understanding that bioretention is the only effective approach to reducing 6PPDQ in stormwater? That means that holding tanks for stormwater to settle out some contaminants is ineffective?

Based on a literature review commissioned in 2022, we believe there are a number of stormwater BMPs that can help manage 6PPD-quinone. We also described in a report to the Washington State Legislature that we believe our current strategies for stormwater management will help address 6PPD and 6PPD-quinone at different levels of effectiveness. Capturing tire wear particles before 6PPD and 6PPD-quinone are released is an important part of this work, especially since it takes time for these pollutants to migrate out of the rubber matrix. Therefore, BMPs that help capture solids, like wet ponds with settling areas for rubber particles, will help control the amount of 6PPD particles entering receiving waters.

These publications, especially the literature review, provide a relative ranking across the BMP approaches for high, medium, and low potential effectiveness at capturing and treating tire wear particles. The following BMPs were ranked as having high potential effectiveness:

- Source Control BMPs: Street sweeping and cleaning roadside ditches, catch basins, and storm drains
- Flow Control BMPs: Bioretention and infiltration basins
- Runoff Treatment BMPs: Sorbent media, bioretention soil mix, and media filters

BMPs that were ranked as having a medium potential effectiveness included:

- Source Control BMPs: Education and outreach
- Flow Control BMPs: Detention ponds and permeable pavement
- Runoff Treatment BMPs: Sand filters

In addition to this literature review, our laboratory and academic partners and published research has shown that 6PPD-quinone sorbs onto materials beyond bioretention soil media (which is a 60% sand and 40% stormwater compost mix). Ecology is funding multiple studies exploring how 6PPD-quinone sorbs to and desorbs from natural materials and engineered sorbents. The media choices for these studies are components commonly used in existing stormwater treatment medias.

Has the cost of long-term maintenance of rain gardens and biofiltration swales by individuals, companies, municipalities, etc. been factored? Current planting and soils are a heavy burden on municipalities, expanding would be even more so if it is a primary BMP.

In recent years, we have assessed the operation, maintenance, and longevity of bioretention to prevent toxicity to organisms through the Stormwater Action Monitoring Program. One of our goals within Ecology is to find more affordable infrastructure options to help bring down costs while maintaining effectiveness.

Can you tell us about projects that Ecology's respective Water Quality programs plan to fund or are currently funding related to 6PPD?

Ecology's Water Quality Program manages public funds to address 6PPD-quinone through three research programs: 6PPD Best Management Practices (BMP) Effectiveness Studies, the Stormwater Action Monitoring Program, and National Estuary Program Stormwater Strategic Initiative Lead. These programs distribute and manage funds from the state Legislature, municipal stormwater permittees, and the U.S. Environmental Protection Agency.

6PPD Best Management Practices (BMP) Effectiveness Studies: In 2021, the state Legislature directed Ecology to identify transportation infrastructure and roads of concern for 6PPD and 6PPD-quinone pollution and BMPs to protect aquatic life from 6PPD-quinone. Ecology was required to submit a report to the legislature on findings.

In 2022 and 2023, the legislature granted to Ecology's Water Quality Program additional funds to research stormwater BMP effectiveness at capturing and treating tire wear particles, 6PPD, and 6PPD-quinone. To date, this funding has supported the following research:

- **Summary of the current knowledge and understanding of 6PPD and 6PPD-quinone (Osborn & Evergreen StormH2O Consulting):** These groups helped support the Stormwater Work Group 6PPD Subgroup, are currently conducting a literature review to understand how particle sizes affect 6PPD-quinone filtration, and wrote the report Stormwater Treatment of Tire Contaminants Best Management Practices Effectiveness. This report evaluated currently published BMPs for presumed effectiveness at capturing and treating tire wear particles, 6PPD, and 6PPD-quinone.

- **Monitoring study to evaluate the capture and treatment of 6PPD-quinone by newly approved bioretention medias (King County):** This study is running column tests with stormwater samples and four different high performance bioretention soil mixes.

- **Monitoring study to evaluate the partitioning of tire wear contaminants to soils and stormwater sorbent media (UW-Tacoma):** This group is comparing contaminant capture of different engineered medias, commercial sorbent components, and simplified soils. This study is testing water and solids to evaluate partitioning.

- **Monitoring study to characterize storm event runoff for a suite of pollutants, including 6PPD-quinone, in stormwater runoff from site draining highway and mixed residential land uses (King County Environmental Lab):** This study is collecting grab samples across 15 storm events at the I-5 Ship Canal Testing Facility to characterize stormwater from residential and highway runoff. These runoff samples will help inform the range of concentrations for stormwater management approaches.

- **Monitoring study to characterize stormwater BMP influent concentrations of 6PPD-quinone and BMP testing protocols suitability for 6PPD-quinone (Herrera Environmental Consultants):** This pilot project is gathering some initial information on whether this pollutant 6PPD-quinone can be reliably evaluated using the established Technology Assessment Program – Ecology (TAPE) protocol for BMP testing. This project

will evaluate runoff treatment of the influent to and effluent from a couple active TAPE studies for 6PPD-quinone concentration reductions.

Stormwater Action Monitoring Program (SAM): This permittee-driven program funds projects that evaluate the effectiveness of stormwater management. The SAM collective allows municipal stormwater (MS4) permittees to pool funds and collaborate on stormwater monitoring needs under the Western WA municipal stormwater permits. Ecology's 6PPD Legislative proviso funds allowed us to add 6PPD-quinone monitoring to two already active SAM studies:

- **A pilot street sweeping effectiveness study (City of Redmond):** The City of Redmond is leading a 10-year watershed-scale stormwater retrofit effectiveness study. A small part of this larger study repeats a short-term street sweeping effectiveness evaluation and adds the parameters of 6PPD-quinone and polycyclic aromatic hydrocarbons. A prior finding from this study suggested that more frequent street sweeping improved the water quality of the small stream in the tested basin.
- **Determining an optimal bioretention media depth and the longevity of toxicity prevention from the bioretention media (Washington State University-Puyallup):** This SAM study will be wrapping up soon with Washington Stormwater Center. This project is a lab-bench project to see how long the default bioretention soil media (60% sand, 40% stormwater compost, also known as a 60:40 mix) can effectively prevent acute mortality to coho salmon. The key questions assessed in this study include:
    - How long can the 60:40 bioretention soil media prevent toxic effects to juvenile coho?
    - Which depths are necessary to provide these treatment benefits?

  Ecology's proviso funds added three more water years to this study, for a total duration of 13 water years.

The SAM program is currently in the middle of its solicitation process. The current pool of proposals has four projects that include the contaminant 6PPD-quinone as a parameter. These include studies on: stormwater characterization (Full Proposal (FP)-08), street sweeping effectiveness (FP-01 and FP-02), and evaluating a newly approved phosphorus treatment media for 6PPD-quinone treatment (FP-03).

National Estuary Program (NEP) Stormwater Strategic Initiative Lead (SIL): The Environmental Protection Agency (EPA) provides the National Estuary Program (NEP) and Puget Sound Geographic Program funding and support to help communities make on-the-ground improvements for clean and safe water, protected and restored habitat, thriving species, and a vibrant quality of life for all, while supporting local jobs. This funding supports the implementation of the Puget Sound Action Agenda, which is the Comprehensive Conservation Management Plan guiding Puget Sound Recovery.

The role of the Stormwater Strategic Initiative Lead (SIL) in Puget Sound recovery is to develop and implement strategies that improve the quality of freshwater and marine waters surrounding the Puget Sound. The Stormwater SIL is a cross-agency team led by the Washington Department of Ecology, WA Department of Commerce, and the Washington Stormwater Center. The Stormwater

SIL works closely with its Strategic Initiative Advisory Team (SIAT) to make strategic and thoughtful decisions in investment, policy, and communications. The Stormwater SIL stewards 3 Implementation Strategies – Toxics in Fish, Benthic Index of Biotic Integrity, and Marine Water Quality – that guide its work and drives investments around the Puget Sound.

As of June 2023, the SIL is funding several projects to reduce toxics in fish. Current projects addressing 6PPD-quinone are:

- **Sampling, Occurrence, and Toxicity of 6PPD-quinone and Related Chemicals (University of Washington – Tacoma):** Awarded in 2023, this project aims to address knowledge gaps in understanding the toxicity of 6PPD-quinone and additional tire-derived chemicals observed in roadway stormwater by 1) Improving storm sample collection and capacity via remote or passive sampler development, 2) Characterizing 6PPD, 6PPD-quinone and other PPD-quinone concentrations and dynamics in key small watersheds of the Puyallup, Nisqually, Deschutes, and deep South Sound, 3) Evaluating individual tires with high or low 6PPD content for their ability to leach tire-derived chemicals which cause or explain acute and sub-lethal toxicity, and 4) Comparing the relative pollution potential and toxicity of subsurface tire reefs in the Puget Sound and above-surface tire embankments in freshwater systems from tire-derived chemicals.

- **Multi-Criterion Decision Tool to Address 6PPD-quinone/Tire Wear Particles (King County and the University of Washington):** Awarded in 2023, this study will use emerging data to create a GIS tool that will identify road segments that are potential sources of toxic tire wear particle pollutants. The project will create a logical user interface to support clear decision-making for stormwater retrofits that remove tire-derived pollutants. Existing road and traffic attribute data will be selected for their potential to predict tire-derived pollutant input into coho streams. The best-performing attributes will be used in the model to generate a heat map predicting the highest concentrations of 6PPD and 6PPD-quinone. The heat map will provide a relative ranking of the pollution potential of road segments in concert with salmon habitat in the associated receiving waters. The heatmap will be incorporated into an open-source web-based tool for prioritizing stormwater retrofits. Furthermore, the tool will be scalable beyond unincorporated King County and adaptable to other jurisdictions and stakeholder inputs.

- **Chemicals of Emerging Concern (CECs) in Salmon Spawning and Rearing Habitat (King County):** This project was initially awarded funds in 2019 and was amended in 2022 to conduct stream sampling for 6PPD-quinone. This project will provide a better understanding of the presence and magnitude of CECs in freshwater salmon spawning and rearing habitat. CECs are rarely monitored in the aquatic environment and results of this project will help fill this data gap. These results will also help inform the potential impacts of exposure to these chemicals on salmon, including Chinook and Coho.

Should people expect new regulations in stormwater permits to address 6PPD?

The Municipal Stormwater Permits and Stormwater Management Manuals address transportation runoff, which contains many pollutants. These manuals are designed to provide guidance to permittees in Eastern and Western Washington. We are currently in the process of reissuing the Municipal Stormwater Permits and the Stormwater Management Manuals.

Many of the stormwater BMPs already implemented as part of Ecology's stormwater manuals are presumed to be effective at capturing and treating 6PPD-quinone. We are expanding upon these efforts by researching how effective new and existing BMPs are at capturing and treating 6PPD and 6PPD-quinone and supporting on-the-ground efforts through increased grant funding to local governments.

The Industrial Stormwater General Permit is another permit where the areas covered are likely to have 6PPD onsite. We are in the early stages of planning our public involvement and draft updates to the permit. We plan to hold listening sessions this Fall to help inform our draft permit changes, with the goal of reissuing the permit in 2024.

Is Ecology considering either a water quality standard or a stormwater benchmark for 6ppd-quinone? If so, what level?

Ecology announced a rulemaking to update Washington's aquatic life toxics criteria in June 2022. In the aquatic life toxics criteria rulemaking, we are continuing to evaluate the feasibility and timing of developing a 6PPD-quinone criterion based on the available science. For a timeline, please see the aquatic life toxics rulemaking webpage.

How will 6PPD/6PPD-q be considered as it enters wastewater treatment pathways, for example though the fluid captured from street sweeping? Will monitoring and testing be employed at CSO outfalls or from bypass events?

Unlike accounts of Urban Runoff Mortality Syndrome (URMS) caused by stormwater runoff from roads, there has been an absence of documented fish kills associated with wastewater effluent discharge potentially caused by 6PPD-quinone. Similarly, though CSO discharges are a mixture of stormwater runoff with wastewater flows, there have been no accounts of URMS occurring near these sources. Therefore, we are prioritizing research efforts on understanding the fate and transport of these chemicals and their impacts in relation to untreated and treated stormwater runoff. Additionally, treatment processes employed at wastewater treatment plants are likely to reduce concentrations of solids, including tire debris, and 6PPD-quinone to some extent through sorption and abiotic and biotic transformations.

Are there discussions on further regulating businesses who store used tires outside?

Ecology's subject matter experts are currently unaware of any ongoing conversations to further regulate businesses that store waste tires outside based on 6PPD criteria. The rule for waste tire storage is in WAC 173-350-350, and the rule for waste tire transportation is WAC 173-350-355. These rules are based off the statute RCW 70A.205. Under this statute, local jurisdictions have the primary enforcement capabilities over the enforcement of solid waste regulations.

Department of Fish and Wildlife

Does TBiOS work look at the relationship between the location of tire use (reefs, bumpers, boats, etc) and fish habitat and soil contamination?

TBiOS has not yet looked at this relationship. Our approach is to sample indicator species from the different Puget Sound habitats (i.e., the benthic, pelagic, and nearshore marine zones) and assess the extent of contaminants in their tissues. The results from our studies may help guide follow-up, including more detailed and localized studies that can answer specific questions about contaminant sources in our indicator species and their habitat.

What sort of a decrease in fishable salmon has there been due to 6PPD-quinone?

We cannot tell how many fishable, or adult salmon, have died because of 6PPD-q exposure. A study from the NOAA NWFSC predicted a widespread loss of spawning coho salmon across Puget Sound due to stormwater exposure from urbanization (Feist et al. 2017). Any loss of spawners or juveniles in a population decreases their abundance and can impact the number of fish available for fisheries. Coho salmon likely experience a larger impact from 6PPD-q exposure because of their increased sensitivity, while other less sensitive species (Chinook and chum) are not as impacted. However, we still don't know if 6PPD-q has sublethal effects that could affect the survival of Chinook salmon, chum salmon, and other salmonids, so we don't yet fully understand the broad-scale effect 6PPD-q is having on salmon fisheries.

Are hatchery fish in danger of this contaminant?

Hatchery salmon are in danger from exposure to 6PPD-q. We know this because most, if not all, of the toxicity testing done with 6PPD-q has been on hatchery salmon. Once the salmon leave the hatchery, there is potential for exposure to 6PPD-q. Both hatchery and wild salmon migrate through the rivers at times when there is increased rain, whether it is in the spring for the juveniles or the fall for the adults. Furthermore, in our rivers, adult hatchery coho are as susceptible to urban runoff mortality syndrome, or prespawn mortality, as wild coho are. As a result, the less coho that make it back to the hatchery to spawn, the less coho can be produced by the hatchery.

How widespread is exposure to 6PPD-Q and other tire related compounds in Puget Sound?

Partners at NOAA and Ecology are developing a risk map to predict exposure to 6PPD-q in surface water after storm run-off events. Exposure to tire related compounds (TRC) in general is concentrated in urbanized areas with more impervious surfaces and in streams that receive significant run-off from major roads. At WDFW, we are working with NOAA NWFSC partners to develop an analytical method to test for these compounds in fish and shellfish tissue. This will give us an idea of how widespread exposure is to critical fish species, such as salmon.

Does 6PPD-q accumulate in aquatic life like plankton, shellfish and fish and biomagnify up the food web to predators like Southern Resident killer whales (SRKWs)?

Right now, we cannot say. This is something we will be trying to answer with our expanded funding for CEC monitoring. For now, we are working with NOAA NWFSC to develop analytical methods to

test for 6PPD-q in aquatic life and hope to share initial results this fall. These results will help us to guide future monitoring.

Why does TBiOS primarily monitor 6PPD-q in Chinook salmon rather than other salmon species?

TBiOS monitors Chinook salmon in Puget Sound because they are listed as threatened under the Endangered Species Act (ESA) and they are also the primary prey for the Southern Resident killer whales (SRKWs), another ESA-listed, endangered species in the region. It is important to assess how Chinook salmon are accumulating contaminants and if the contaminants are affecting their health, potentially reducing the food supply of SRKWs. Monitoring contaminants in adult Chinook salmon from Puget Sound also tells us if they are a source of contamination to SRKWs. Furthermore, compared to other salmon species, juvenile Chinook salmon are highly susceptible to contaminant exposure because they rear and feed longer in estuaries as juveniles, which are receiving waters for many toxic contaminants.

For many years, TBiOS has been monitoring Chinook salmon for a whole suite of contaminants and only recently added 6PPD-q to the program. While Chinook salmon aren't as sensitive to 6PPD-q as coho salmon, they will allow us to determine where in the environment salmon are being exposed to 6PPD-q and in the future may help us assess potential sublethal effects from exposure. Through our monitoring of 6PPD-q in Chinook salmon and other species, we will be able to document areas of concern for 6PPD-q in the region. Going forward, our monitoring program can serve as a platform to collect coho salmon and other salmonids to further investigate any potential 6PPD-q exposures and effects.

Is the high sensitivity of the Coho salmon to 6PPD-Q unique to 6PPD-Q or are Coho generally more sensitive to environmental substances? Is anything known about the underlying mechanisms for the sensitivity of Coho to 6PPD-Q?

Multiples studies show that coho salmon are the most sensitive to 6PPD-q exposure compared to other salmon species (McIntyre et al. 2018; French et al. 2022; Lo et al. 2023). Recent research has shown the toxic mode of action of acute mortality from 6PPD-q and stormwater runoff exposure in coho salmon is disruption of the blood-brain and blood-gill barriers. Under normal physiological conditions, the blood-brain and blood-gill barriers are impermeable, but when exposed to stormwater and 6PPD-q, the barriers were breached, and tracer molecules were able to penetrate the sensitive tissues. The researchers hypothesize that the disruption of the blood-brain barrier is the initiating event that leads to acute mortality of the coho salmon (Blair et al. in prep).

However, for other contaminants, coho salmon are not universally more sensitive than other fish species. In previous studies, coho salmon have been shown to be more sensitive to some contaminants (Katz and Chadwick 2011; Hamilton and Buhl 1990; Porter 2022), and less sensitive to other contaminants (Buhler et al. 1969; Buhl and Hamilton 1990).

Department of Health

Ecology's emphasis is on "fish water," but our interest is drinking water. What little I can find online suggests 6PPD is more of a surface water issue, but mobility in soil & potential for groundwater contamination is limited. Is that accurate? Can you suggest some resources focused on 6PPD/drinking water concerns?

This is something we are concerned about too and we plan to develop a complete analysis and plan in our state action plan. When we hear from our stakeholders where your concerns lay, it helps us know what to dig into for the action plan. Drinking water in Washington comes from either groundwater or surface water. Concerning groundwater, 6PPD sticks to soil and is not expected to move into underground water sources. That said, this problem is new enough that there aren't any testing programs for 6PPD or its transformation products such as 6PPD-q in drinking waters in Washington state. Ecology is in the process of developing an action plan that will assess the need for groundwater monitoring.

Concerning surface water, in Washington most of our surface waters used for drinking come from highly protected upstream watersheds. But there are systems that access the Columbia River and other lowland surface waters that could potentially be affected by road runoff. There is no current requirement for monitoring, and so we don't know if concentrations of 6PPD and 6PPD quinone are high enough to cause health problems in people.

I can point you to a few resources we have found useful:

- Johannessen & Metcalfe (2022) sampled for 6PPDQ in wastewater treatment plants and drinking water treatment plants in Ontario, Canada. 6PPD-q was not detected at the drinking water treatment plants.
- Zhang et al. (2023) discusses the physical characteristics of 6PPD that indicate it is unlikely to transfer to groundwater.
- OECD (2012) is another great resource for information on the physical chemistry of 6PPD and human health toxicity.

Do you have any indication as to whether the carcinogenic content comes from the aniline/MNB, or from other elements that make up the 6PPD? Thank you.

So a couple of things here. First, the feeding studies in rats fed high doses of 6PPD do not support a determination of carcinogenicity. Based on their review of those studies, the authoritative bodies OECD (Organization for Economic Co-operation and Development) and ECHA (the European Chemicals Agency) concluded that it is unlikely that 6PPD causes cancer. The hazard assessment from GreenScreen also classified 6PPD as a low hazard for carcinogenicity.

Additionally, 6PPD doesn't seem to have the genetic toxicity that could produce cancer. OECD and ECHA concluded that 6PPD is not likely to cause genetic damage that leads to cancer. GreenScreen also classified 6PPD as a low hazard for mutagenicity.

Now, to some of the details of your question. Aniline is a toxic chemical that can be produced as an aquatic transformation product of 6PPD. We don't know if it's produced in people after exposure to 6PPD, though. Overall, the biological metabolites produced from 6PPD have not been evaluated

in toxicity assays, but we will be evaluating all the data and keeping a close eye out for new research as we work to develop the statewide action plan.

Are you aware of any research evaluating human health impacts and when will that be published?

Thank you for your question. People who have skin allergy to other tire additives may be allergic to 6PPD, as shown in a study by Herve-Bazin et al (1977). Herve-Bazin et al (1977) conducted patch tests on the skin of tire workers who were allergic to a similar tire additive called IPPD, and found the workers to be allergic to 6PPD also (called DMPPD in this study). Animal studies support the conclusion that 6PPD causes skin allergy, with or without allergy to similar chemicals (Yamano et al., 2009). We have are not aware of any studies examining the allergic potential of 6PPD-q in humans.

We have not seen any evidence that 6PPD or 6PPD-q can cause respiratory allergy (for example, the type of allergy that makes you sneeze).

Both 6PPD and 6PPD-q have been found in human urine, as reported by a study in China (Du et al., 2022). Human exposure to these chemicals may happen in Washington state, but no similar studies have been done.

Studies in lab rodents have shown that 6PPD can cause difficult births in rats (OSPAR Commission, 2006), and 6PPD and the quinone can both cause liver changes in mice (Fang et al., 2023). However, we don't know if this occurs in humans yet.

Research:

- Du, B., Liang, B., Li, Y., Shen, M., Liu, L.-Y., & Zeng, L. (2022). First Report on the Occurrence of N-(1,3-Dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD) and 6PPD-Quinone as Pervasive Pollutants in Human Urine from South China. Environmental Science & Technology Letters, 9(12), 1056–1062. https://doi.org/10.1021/acs.estlett.2c00821
- Fang, L., Fang, C., Di, S., Yu, Y., Wang, C., Wang, X., & Jin, Y. (2023). Oral exposure to tire rubber-derived contaminant 6PPD and 6PPD-quinone induce hepatotoxicity in mice. The Science of the total environment, 869, 161836. https://doi.org/10.1016/j.scitotenv.2023.161836
- Herve-Bazin, B., Gradiski, D., Duprat, P., Marionac, B., Foussereau, J., Cavelier, C., & Btebr, P. (1977). Occupational eczema from N-isopropyl-N'-phenylparaphenylenediamine (IPPD) and N-dimethyl-1,3 butyl-N'-phenylparaphenylenediamine (DMPPD) in tyres. Contact Dermatitis, 3(1), 1–15. https://doi.org/10.1111/j.1600-0536.1977.tb03580.x
- OSPAR Commission. (2006). Hazardous Substances Series 4-(dimethylbutylamino)diphenylamine (6PPD) 2005 (2006 Update). Available at: https://www.ospar.org/documents?v=7029.
- Yamano, T., & Shimizu, M. (2009). Skin sensitization potency and cross-reactivity of p-phenylenediamine and its derivatives evaluated by non-radioactive murine local lymph

node assay and guinea-pig maximization test. Contact Dermatitis, 60(4), 193–198. https://doi.org/10.1111/j.1600-0536.2008.01500.x

Is there a plan to collect human health data on crumb rubber exposure (used in recreation and other spaces)?

Thank you for the great question. Ecology has plans to sample crumb rubber runoff. The Department of Health is also tracking the science. We are interested in crumb rubber as a human exposure pathway. Ed Kolodziej's team (Zhao at al., 2023) did some preliminary testing of crumb rubbers from local schools and playgrounds and found mixed PPDs and quinones present, with some indication that older crumb infill has lower concentrations. We have not developed estimates of intake or dermal exposure but there is work in CA and at CDC looking at chemical exposures from crumb rubber more broadly.

Research:

- Zhao, H. N., Hu, X., Gonzalez, M., Rideout, C. A., Hobby, G. C., Fisher, M. F., McCormick, C. J., Dodd, M. C., Kim, K. E., Tian, Z., & Kolodziej, E. P. (2023). Screening p - Phenylenediamine Antioxidants, Their Transformation Products, and Industrial Chemical Additives in Crumb Rubber and Elastomeric Consumer Products. Environmental Science & Technology. https://doi.org/10.1021/acs.est.2c07014

If fish have 6PPD in them, are they okay to eat?

Great question and we want to know the complete answer, too.

The short answer is that we still don't know if 6PPD and 6PPD-q are present in the parts of fish and other organisms that people eat or how much of the chemicals might be in those parts. Our agency is responsible for issuing health-based advisories related to chemicals in wild fish: Fish Consumption Advisories | Washington State Department of Health. At this time, the Department of Health does not have any recommendations or advisories concerning 6PPD and we support the consumption of fish as part of a healthy diet.

We are tracking the science on 6PPD toxicology and also communicating closely with our agency partners as they learn more about these chemicals in aquatic species in Washington. The Washington Department of Fish and Wildlife TBiOS program is working with scientists at NOAA and Ecology to develop methods to analyze these chemicals in fish and shellfish tissues in our region. So far, 6PPD and 6PPD-quinone were found in the plasma and bile of some fish, and more studies on whole organisms are in the works. We are also unsure whether swallowing these chemicals would cause more, less, or different effects compared to breathing in dusts that contain 6PPD.

Any information that the Department of Fish and Wildlife learns about how much of these chemicals are accumulating in fish and shellfish tissues that are consumed by people will be shared with and evaluated by our Department of Health Fish Advisory program, who will communicate any important findings to the public.

Department of Transportation

What does funding for DOT look like to address 6PPD-q?

WSDOT's budget is set by the Washington State Legislature. The 2022 legislature passed the Move Ahead Washington transportation package, allocating $500 million over 16 years for WSDOT standalone stormwater retrofits. The legislature designated $6 Million solely to treat stormwater at the I-5 Ship Canal Bridge. For the remainder of the $500 million, WSDOT will be reporting biennially to the legislature to propose how to best distribute this funding across the remaining 15-year period.

How is DOT engaging with other groups on 6PPD and 6PPD-quinone?

WSDOT has begun significant outreach with scientists and researchers, federal, state, and local governments, tribes, and other interested parties on developing an update to WSDOT's prioritization for determining high priority locations for stormwater retrofits, with an equitable distribution across the state. We also engage with these same groups on planning and best available science and will incorporate emerging information on this novel chemical into WSDOT's processes and stormwater mitigation and management.

What is DOT doing to advance science to get a better understanding of 6PPD-quinone and how it relates to your work?

WSDOT helped fund the Tian et. al study that originally identified 6PPD-quinone. WSDOT has a monitoring and research program which looks at both required monitoring as well as monitoring projects that go above and beyond our permit-required monitoring. These include stormwater treatment effectiveness studies for highways and other facilities, looking at the pollutant removal effectiveness of different kinds of stormwater treatment facilities. We're doing research on the "first flush" phase of storm events where we see disproportionately high pollutant loads generally occurring. We're partnering with King County on their 6PPD heat map project to help validate the model with field samples. We're participating in and funding a Federal Highway Administration pooled fund research project to test common transportation Best Management Practices and their effectiveness at treating 6PPD-quinone with Oregon and California Departments of Transportation.

We also fund regional stormwater research through the Department of Ecology-led Stormwater Action Monitoring for Puget Sound and the Lower Columbia River and we're continuing to partner with UW Tacoma, WSU, and others on research related to stormwater and 6PPD. When an Environmental Protection Agency or Washington State Department of Ecology-approved test method for 6PPD becomes available, WSDOT will add testing to our research and existing permit-required monitoring sites.

Is DOT targeting sites where I-5 passes over rivers, like the Nisqually or creeks like Clover Creek in Pierce County?

WSDOT is working on a stormwater retrofit prioritization update throughout 2023 and into 2024. We are currently in a significant outreach and engagement phase of development at this point, along with incorporating best available science as it becomes available. Looking at elevated

structures that lack treatment over anadromous fish bearing waters is a factor that will be incorporated into our prioritization. You can provide priority locations for consideration in WSDOT's Survey123. This survey can be accessed from the Washington State Department of Ecology's Addressing 6PPD EZ View page or through the WSDOT Stormwater Retrofit folio.

Move Ahead Washington has a $6 million line item for the Urban Stormwater Partnership - I-5 Ship-Canal Bridge Pilot (Seattle). The intention of the pilot project is to demonstrate the potential for multijurisdictional stormwater facilities in the Puget Sound, to treat high volumes of 6PPD and other pollutants, and for WSDOT stormwater retrofits to integrate with community needs in an urban area. We want to integrate community co-benefits including public access with park-like features into the stormwater treatment area. The project also offers research opportunities for 6PPD-quinone.

All WSDOT projects meet current stormwater requirements for new and redeveloped areas. There is a current I-5 Tumwater to Mounts Road Corridor Planning and Environmental Linkages Study underway. This project spans the Nisqually River and associated floodplain. Addressing stormwater is included in the environmental process and National Environmental Policy Act (NEPA) documentation.

What is Fed DOT doing to treat water from I-5 as it passes over rivers and water bodies like the Nisqually River or Clover Creek in Pierce County?

WSDOT is not in a position to answer for Federal Highways Administration (FHWA). Waters of the US are regulated by federal agencies like the US Army Corps of Engineers (USACE) and often there is a federal nexus between WSDOT projects and federal agencies like FHWA and USACE. We work together to accomplish WSDOT's legislatively mandated projects.

How should we discuss/analyze 6PPD in SEPA/NEPA documentation for state/federal highways projects?

The following is a WSDOT specific response for WSDOT's current approach to address 6PPD in SEPA/NEPA documentation. WSDOT cannot speak for other state or federal agencies.

When applicable, 6PPD-quinone is addressed in Endangered Species Act Section 7 consultation with most of the analysis in the effects section of a biological assessment, which is then incorporated into the NEPA documentation. Most WSDOT projects are NEPA Categorical Exclusions (CEs), which are documented by an Environmental Classification Summary (ECS) to satisfy NEPA. Stormwater and other environmental impacts are noted within an ECS, including 6PPD, if applicable. For non-exempt projects such as an Environmental Assessment (EA) or Environmental Impact Statement (EIS), discussions of stormwater and other impacts are more detailed within the main environmental document.

For the WSDOT SEPA process, SEPA is typically handled one of two ways for NEPA CE projects:

1. The work fits within a categorical exemption (CE) under WAC 197-11-800 or WAC 468-12-800.
    a. This doesn't need to be recorded but can be an optional note within an ECS.

2. The work does *not* fit within a SEPA CE and must be documented with a SEPA Checklist and significance determination.
    a. This is separate from the NEPA ECS and is usually conducted at about 30% design and completed before the NEPA ECS is finalized.