United States Environmental Protection Agency
Office of Water
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May 2024

EPA Response to the

External Peer Review of EPA's

"*Draft Acute Aquatic Life Screening Value 6PPD-quinone in Freshwater*"

May 2024

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Washington, D.C.

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) Office of Water (OW) has developed draft screening values to protect aquatic life from the short-term (acute) exposures caused by the presence of 6PPD and 6PPD-quinone (6PPD-q) in freshwater. Because there are only limited data for 6PPD and 6PPD-q in the ecotoxicity literature, the EPA developed aquatic life screening values for acute exposures in freshwater, rather than national recommended Ambient Water Quality Criteria (AWQC). The derivation of these screening values is described in two documents: Acute *Aquatic Life Screening Value for 6PPD-in Freshwater* and *Acute Aquatic Life Screening Value 6PPD-quinone in Freshwater*.

An independent letter peer review of the EPA's draft *Acute Aquatic Life Screening Value for 6PPD-quinone in Freshwater* was conducted in the fall (October through November) of 2023 by Eastern Research Group, Inc (ERG), a contractor for the EPA OW. The external peer review report can be found at the 6PPD-q Aquatic Life Screening Value website (https://www.epa.gov/wqc/acute-6ppd-q-aquatic-life-screening-value-freshwater).). Independent peer review of the draft Acute *Aquatic Life Screening Value for N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD) in Freshwater* document is covered in a separate set of external peer review and the EPA response documents.

This document provides the EPA's responses to external peer review comments on the draft 6PPD-q screening value document. Section 2.0 of this report presents the individual reviewer comments and the EPA's responses organized by charge question.

1.1 Development of the Draft Documents

The EPA obtained toxicity studies primarily via the EPA's ECOTOXicology Knowledgebase through September 2022 (and subsequently updated following the external peer review to studies through December 2023). Toxicity studies were carefully evaluated and thoroughly reviewed to ensure studies were of sufficient data quality to use in the derivation of screening values. For a number of published studies, the EPA consulted primary authors for clarifications on study methods and author-reported raw toxicity data during the data quality review phase to ensure that the studies used to derive the screening values were of high quality. The screening value document identifies those instances where the EPA obtained additional information from study authors.

The purpose of the Acute Aquatic Life Screening Value for 6PPD-q is to provide information under Section 304(a)(2) of the Clean Water Act (CWA) that states and authorized Tribes may consider for use in their water quality protection programs.

There were insufficient data to develop CWA Section 304(a)(1) recommended Aquatic Life Ambient Water Quality Criteria according to the EPA's method for developing criteria (*Guidelines for Developing Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*, U.S. EPA 1985). Rather, acute aquatic life screening values were derived for acute exposures in freshwaters due to the paucity of 6PPD-q data and the fact that many published studies on 6PPD-q were not conducted according to standard toxicity test guidance (e.g., EPA 850 Ecological Effects Test Guidelines; https://www.epa.gov/test-guidelines-pesticides-and-toxic-substances/series-850-ecological-effects-test-guidelines). Study limitations included insufficient testing duration (24 hour-tests instead of the standard 96-hour acute fish test duration), overcrowding of tanks, and a lack of analytical measurements throughout the tests for this unstable compound. There were insufficient data to develop screening value or criteria for estuarine/marine waters or long (chronic) exposures. By

addressing data limitations and extensively reviewing toxicity studies, the EPA derived 6PPD-q Acute Aquatic Life Screening Value via a comprehensive, rigorous process that included collaborations across the EPA scientists in OW, Office of Research and Development (ORD), and Region 10.

The EPA contracted with ERG to organize an independent, external peer review of both draft documents. External peer reviewer comments on the 6PPD-q screening value document and the EPA's responses to those comments are described in this report. Responses to the 6PPD external peer review are documented in a separate report ("EPA Response to the External Peer Review of EPA's "*Draft Aquatic Life Screening Value for 6PPD in Freshwater*"; https://www.epa.gov/wqc/acute-6ppd-aquatic-life-screening-value-freshwater).

1.2 Peer Reviewers

The contractor identified, screened, and selected three experts who met technical selection criteria provided by the EPA and were determined by the contractor to have no conflict of interest in performing this review. The External Peer Review Report for 6PPD-q, including details on the external peer reviewer selection process, can be found at (https://www.epa.gov/wqc/acute-6ppd-q-aquatic-life-screening-value-freshwater).

The EPA's contractor provided reviewers with instructions, the draft *Acute Aquatic Life Screening Values for 6PPD-quinone in Freshwater*, and the charge to reviewers prepared by the EPA. Reviewers worked individually to develop written comments in response to the charge questions. After receiving reviewer comments, the contractor compiled responses by charge question (see Section 2.0) and included the responses organized by reviewer.

1.3 Charge Questions to Peer Reviewers

1) Please comment on the overall clarity of the documents and construction as it relates to assessing the risk of 6PPD-quinone to aquatic life.

2) Please comment on the technical approach used to derive the draft screening vales presented in the EPA's preliminary *Draft Sensitive Salmonid Screening Value for Acute Exposures to 6PPD-quinone (N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine quinone) in Freshwater*.
    a. Is the technical approach used to derive the screening values logical?
    b. Does the science support the conclusions?
    c. Is it consistent with the protection of aquatic life?

3) Please comment on the toxicity data used to derive the screening values presented in the draft 6PPD-quinone document.
    a. Were the data adequately used and sufficiently comprehensive to represent risks to sensitive aquatic life?
    b. Were the data selected and/or excluded from the screening values derivation appropriately utilized?
    c. Are there relevant data that you are aware of that should be included? If so, please provide for derivation of screening values.

4) Are the derived screening values appropriately protective of sensitive aquatic life?

2.0 PEER REVIEWER COMMENTS AND EPA RESPONSES ORGANIZED BY CHARGE QUESTION

This section organizes reviewer comments by charge question.

2.1 Please comment on the overall clarity of the documents and construction as it relates to assessing the risk of 6PPD-quinone to aquatic life.

2.1. Clarity of Document as it Relates to Assessing the Risk of 6PPD-quinone to Aquatic-Life		
Reviewer	**Reviewer Comments**	**EPA Response**
1	Like the 6PPD document, the 6PPD-quinone document is well written and flows logically. The background summary of environmental fate and distribution of 6PPD-quinone was good. I appreciated the study summaries being described in order from most sensitive to least sensitive species, and separating quantitative and qualitative studies into separate sections. Like the 6PPD document, I have provided a marked-up version with minor editorial suggestions and comments. There are some inconsistencies in the descriptions of experimental procedures when summarizing the various studies. The document must be consistent and specific when describing the control treatments among studies. In all instances, specify "solvent control" or "solvent vehicle control" when such a control was employed, and when known state the solvent concentration occurring in the actual exposure vessel as a percentage volume/volume. In addition, please specify what is meant by a negative control. Is this water-only without solvent added? In the study descriptions (initial sentence of each) be consistent and always state whether 6PPD-quinone was measured or unmeasured.	Thank you for your comments. The EPA received the marked-up version with minor editorial suggestions and comments and has made those edits as suggested. The EPA also made edits to ensure that the inconsistencies in the descriptions of the experimental procedures were addressed so that all of the study summaries are clear and consistent. For instance, the EPA made the edits to clarify the controls used in each study and whether individual tests were measured or unmeasured.

2.1. Clarity of Document as it Relates to Assessing the Risk of 6PPD-quinone to Aquatic-Life		
Reviewer	**Reviewer Comments**	**EPA Response**
2	The document for 6PPD-q follows EPA's current aquatic life criteria framework, which is organized in a similar manner to EPA 's ecological risk assessment guidance. The organization and construction of this document is easy to follow, and the writing is clearly presented for the most part. However, the document has several grammatical and typographical errors which should be corrected using a thorough editorial review before finalizing. This document summarizes what is known about the chemistry, fate, and transport properties of 6PPD-q in the environment. The document limits this discussion to freshwater as opposed to salt water as well, which is due to the paucity of data regarding fate and transport of 6PPD-q in saltwater. While the document later explains the lack of marine toxicity data, perhaps EPA should also acknowledge the current lack of fate and transport information in marine environments as well. This document mentions tire wear and wet weather runoff from roads as a major source of 6PPD-q in surface waters. There has been a fair amount of research in the past three years regarding fate and transport of 6PPD-q in surface waters, including its persistence in ice and snow moved to roadsides (and subsequent input to streams from melting snow) and from runoff of roadside dust, which may be important sources of 6PPD-q to streams. Some recent field data are coincident with Coho salmon pre-spawn mortality in the Pacific Northwest as well. EPA should consider incorporating a brief summary of relevant publications in this regard as some of those data help inform the challenges in controlling sources of 6PPD-q and the	The EPA corrected grammatical and typographical errors throughout the document. The EPA thanks Reviewer 2 for the notes on the chemistry, fate, and transport information presented in the draft document. the EPA has made edits to acknowledge the lack of current fate and transport data in marine environments to better round out the information presented. Lastly, the EPA made edits to the draft 6PPD-q Screening Value Document to incorporate the publications recommended in Reviewer 2's comments as they relate to 6PPD-q. The edits for the draft 6PPD-q Screening Value Document include: *"Like its parent compound 6PPD, the formation and release of 6PPD-q from tires and TWP as tires roll across road surfaces, particularly as vehicles brake, accelerate and turn, presents a direct pathway for the release of 6PPD-q into the environment, with subsequent potential entry into aquatic systems, primarily via surface stormwater runoff (rain and snowmelt) and atmospheric deposition (Challis et al. 2021; Huang et al. 2021; Johannessen et al. 2021; Seiwert et al. 2022; Tian et al. 2021). This is now supported by numerous detections of 6PPD-q in waterways across the United States and elsewhere which clearly indicate that it is present in aquatic systems and represents a potential risk to aquatic organisms (DTSC 2022; Tian et al. 2021). For example, 6PPD-q was detected in 57% (12/21) of stormwater samples with a mean concentration of approximately 600 ng/L and greater than 80% (28/31) of snowmelt samples*

2.1. Clarity of Document as it Relates to Assessing the Risk of 6PPD-quinone to Aquatic-Life		
Reviewer	**Reviewer Comments**	**EPA Response**
	potential persistence of 6PPD-q under certain environmental conditions. This information may help support EPA's SV for 6PPD-q. I included some relevant citations of which I am aware below.	*with mean concentrations of 80 – 370 ng/L in Saskatoon, Saskatchewan, Canada in 2019 and 2020 (Challis et al. 2021). 6PPD-q was detected in 100% (16/16) of Seattle-region roadway runoff samples, with concentrations ranging from 800 to 19,000 ng/L (Tian et al. 2021). Noteworthy among these measurements is that 6PPD-q in receiving water samples (<300 to 3,200 ng/L) during seven storm events in three Seattle-region watersheds highly affected by URMS (Tian et al. 2021) was present at concentrations similar to receiving water samples collected from the Don River in the greater Toronto area in Southern, Ontario, Canada in the fall and winter of 2019 and 2020 (Johannessen et al. 2022). In all cases, mass loadings of 6PPD-q correlated well with roads and residential (urban) land-use area."*
3	Overall this is a well-written report but it seems a bit more "hurried" than the report on the toxicity of 6PPD. Although not numerous, there are more typo's and grammatical errors than in the 6PPD document. There are also a few places where the document is unclear. For example, I am not sure what the statement from Section 2.2.1 "Given that this preliminary SSSV is intended as information to protect sensitive aquatic life species, such as salmonids, this screening value was derived without the use of aquatic plant data." Is describing. The authors seem to be stating that plant data were not used because they were only interested in salmonids, yet in actuality no plant data exists. This report provides a sufficient understanding of the risk assessment of 6PPPD-quinone in the early stages of evaluation on a single taxon of organisms.	Thank you for your comments. The EPA has conducted a thorough review of the draft 6PPD-q Screening Value document and corrected grammatical and typographical errors throughout. The EPA also made edits to reflect the availability of plant toxicity data for 6PPD-q and how it relates to the protectiveness of the draft 6PPD-q Screening Value. These edits are as follows: *"The very limited available data for aquatic plants and algae were reviewed to determine if aquatic plants were likely to be more sensitive than aquatic animals to aqueous 6PPD-q exposure. Toxicity values for freshwater plants were well above the freshwater acute freshwater screening value. Effect concentrations for freshwater*

2.1. Clarity of Document as it Relates to Assessing the Risk of 6PPD-quinone to Aquatic-Life		
Reviewer	**Reviewer Comments**	**EPA Response**
		algae were available for one species (green algae, Chlamydomonas reinhardtii) with a 72-hour LOEC of 250 µg 6PPD-q/L (see below), which is greater than freshwater chronic values for animal species: Daphnia magna NOEC of 30.2 µg 6PPD-q/L and 45-day LC_{50} for Salvelinus namaycush of 0.39 µg 6PPD-q/L (see Section ***Error! Reference source not found.****). The plant LOEC was also greater than all of the freshwater acute SMAVs. Therefore, it was not necessary to develop a screening value based on the toxicity of 6PPD-q to aquatic plants. The 6PPD-q screening value for freshwater is expected to be protective of freshwater plants."*

2.2 Please comment on the technical approach used to derive the draft screening values presented in EPA's Preliminary Draft Screening Value for Acute Exposures to 6PPD-quinone (N-(1,3-dimethylbutyl)-N′ -phenyl-p-phenylenediamine quinone) in Freshwater.

- **2.2.a. Is the technical approach used to derive the screening values logical?**
- **2.2.b. Does the science support the conclusions?**
- **2.2.c. Is it consistent with the protection of aquatic life?**

2.2. The Technical Approach Used to Derive the Draft Screening Values		
Reviewer	**Comments**	**EPA Response**
1	2.2.a. The technical approach generally follows EPA's established procedures for developing a species sensitivity distribution to derive a water quality criterion. However, due to the paucity of acute and especially chronic freshwater toxicity data available at this time, some modifications of these procedures were employed to derive a draft screening value. I agree with using studies that determined acute toxicity (LC50) over a time period of greater than or equal to 24 hours, because this enhances the limited dataset and particularly because this represents an environmentally realistic exposure duration that would occur in freshwaters after precipitation events. I agree with the rationale for separating out the Oncorhynchus data and not using an overall GMAV for this Genus. Coho salmon appear to be exquisitely sensitive to 6PPD-quinone, and this is strengthened by the three independent peer-reviewed studies that reported very similar LC50 values (Tian et al. 2022; Greer et al. 2023; Lo et al. 2023). These values, generating a SMAV of 68 ng/L for coho, indicate that 6PPD-quinone may be the most acutely toxic xenobiotic known to fish, and exemplify the	Thank you for your comments. The EPA's responses are arranged in a manner consistent with the Reviewer's comments by question number from here forward in this document. 2.2.a. In the final screening value document, the EPA retained the modifications to methods traditionally used to derive aquatic life criteria as noted by Reviewer 1 and updated the toxicity data to include recently published data that were unavailable prior to the external peer review. This included double checking the calculation of the FAV to ensure it was correct. The 5th percentile is lower than the SMAV for the most sensitive species, as is typical for nearly all of the EPA's Aquatic Life Criteria calculations for other chemicals. The value is lower than the most sensitive SMAV due to the small number of species/genera in the distribution and the steepness of the slope of the sensitivity distribution, and is an appropriate representation of the projected 5th percentile species toxicity value considering uncertainty due to the limited data available. 2.2.b. Thank you for your comment on the usefulness of the Coho salmon toxicity tests. The EPA agrees and continues

2.2. The Technical Approach Used to Derive the Draft Screening Values		
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	importance of establishing water quality guidelines for this chemical to protect aquatic biota. I also appreciated the additional analysis in section 4.1 that calculated a GMAV to show that this value would underestimate ecological risk and not be protective of coho salmon. Based on this analysis, I agree with not using an Oncorhynchus GMAV in deriving this SSSV. I am not familiar with the approach used to derive the FAV, but suggest that this calculation be double-checked to ensure that the 5th percentile of the SSD is truly an order of magnitude lesser than the SMAV for coho salmon. In my opinion the FAV appears to be overly conservative. 2.2.b. Yes, as mentioned above the strongest science in deriving this SSSV are the three independent peer-reviewed studies that reported very similar LC50 values for coho salmon. 2.2.c. Yes, in my opinion the screening level of 3 ng/L would be protective of aquatic life. I am not sure if this concentration can even be quantitated in water samples using modern analytical chemistry techniques.	to use these data to derive the draft 6PPD-q Screening Value in addition to new toxicity data. 2.2.c. Thank you for your comment on the protectiveness of the draft 6PPD-q Screening Value. The EPA has confirmed that this value is quantifiable in water samples using modern analytical chemistry techniques under development. In particular, the EPA recently released a draft method for the analysis of 6PPD-q in storm and surface waters (U.S.EPA 2023), in which the method detection limit (MDL) from one laboratory ranged from 0.430-0.614 ng/L. The EPA method notes that this value will be updated at interlaboratory results become available. The minimum level of quantitation (ML) is reported as 2 ng/L.
2	2.2.a. The technical approach used to derive the screening value (SV) for 6PPD-q follows EPA's guidelines for deriving aquatic life criteria in general. The document discusses modifications to the guidelines in terms of minimum taxa data requirements, test duration, and some other departures from standard test protocols in terms of test data that are considered acceptable or unacceptable to use quantitatively to derive an SV. Given the fairly low persistence of 6PPD-q in water exposed to oxygen, and the	2.2.a. Thank you for your comments supporting use of the toxicity data to derive the draft screening value for 6PPD-q. Information on known time of death was not provided for the majority of the studies. Therefore, the EPA only included this information when it was available as reported by the study authors.

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Reviewer	**Comments**	**EPA Response**
	few toxicity test data currently available that enable a statistically derived point estimate endpoint (for example LC or EC50), the modifications employed are scientifically justified. Specifically, an LC or EC50 based on a test duration greater than or equal to 24 hours rather than 48 or 96 hours depending on the species, should be acceptable given the chemical properties of 6PPD-q and observed toxicity responses in laboratory exposures. It may be useful to incorporate what is known regarding time to death or immobility based on test results to further support the use of 24-hour test endpoints to derive an acute SV. 2.2.b. The study by Tian et al (2021) discussed in this document noted the rapidity with which swimming or locomotory effects on Coho salmon were observed in exposures to 6PPD-q (< 6 hours), which inevitably leads to death. This appears to be supported by field data on the urban runoff mortality syndrome affecting especially Coho salmon in the Pacific Northwest as well. While EPA's aquatic life criteria guidelines rely on apical population level effects, for example mortality or immobility, for 6PPD-q an argument could be made that a 24-hour mortality-based endpoint may not be protective enough due to the fast-acting effects on locomotion and loss of equilibrium in Coho salmon juveniles and adults. It is recommended that EPA examine whether an effect endpoint based on abnormal swimming behavior in < 12-hour exposures is protective of an endpoint based on 24 hours using mortality as the measure of effect. 2.2.c. The technical approach used to derive the SV for 6PPD-q appears to be consistent with the protection of	2.2.b. Text was added to the study summaries to incorporate information about the observed effects related to time of death, immobility, and/or locomotory effects. The EPA did not consider the locomotory effects that are anecdotally described in Tian et al. (2021) since this study was considered for qualitative use and was not used in the derivation of the screening value and there was no author-reported effect concentration associated with the locomotory effects. 2.2.c. Thank you for your comment supporting the protectiveness of the draft 6PPD-q Screening Value. The EPA agrees with Reviewer 2 that the text of the draft 6PPD-q Screening Value document should more strongly state the science and understanding of 6PPD-q is evolving with a number of toxicity studies currently underway. Thus, the EPA made edits to the draft 6PPD-q Screening Value document to provide this context. These edits include: *"However, because only limited toxicity test data were available, the screening value is less certain than national recommended aquatic life AWQC or aquatic life benchmarks, which are both developed using more robust empirical data sets (e.g., meet most MDRs and are consistent with testing methods described in the Guidelines or the EPA's 850 Ecological Effects Test Guidelines (or other similar well-accepted test methods)).The science and understanding of 6PPD-q are relatively recent (with 6PPD-q being attributed to causing urban runoff mortality syndrome (URMS) in the past decade) and evolving, with a number of toxicity studies currently underway. As such, the EPA will*

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	aquatic life based on the test data currently available; that is, Coho salmon appear to be the most sensitive species of those tested thus far. Therefore, protecting Coho salmon from acute effects, with a safety margin provided by EPA's acute criterion derivation procedure used in this document, will hopefully protect aquatic life overall. However, relatively few species have been tested thus far although that is likely to change over the next few years given worldwide attention now on 6PPD-q. The document should make it even clearer that the SV for 6PPD-q is based on data obtained thus far and may have high uncertainty.	*continue to monitor the 6PPD-q literature and toxicity data to evaluate the protectiveness of this screening value."*
3	2.2.a. The technical approach in this report generally followed the US EPA guide developed for determining screening value that is outlined in the EPA's "Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (U.S.EPA 1985). Although these guidelines are becoming aged, they provide a logical, stepwise methodology to determine the screening values sought in this report. There were some technical challenges. Several toxicity tests reported only nominal 6PPD-quinone concentrations. Due to the limited availability of 6PPD-quinone toxicity data for aquatic life, these nominal concentrations were used for several studies without measuring 6PPD-quinone concentrations and were combined with studies that measured 6PPD-quinone concentrations. This approach, although not ideal, is consistent with the 1985 Guidelines. Acute toxicity tests on fish, specified by the EPA, should have at least 72 hours of exposure and ideally 96 hour	2.2.a. and 2.2.b. Thank you for the support of the approach used to derive and the protectiveness of the draft 6PPD-q Screening Value based on the available data, despite the technical challenges summarized in the draft document and in the comments. This approach remains the same in the final 6PPD-q Screening Value document. 2.2.c. The draft 6PPD-q Screening Value was updated to include new data that were published after the initiation of the external peer review. As such the draft screening value changed from 3.1 ng/L to 11 ng/L to reflect the new toxicity data, including data for aquatic invertebrates and plants (a freshwater algal species, *Chlamydomonas reinhardtii*). Aquatic invertebrates and plants were determined to be relatively insensitive to acute exposures to 6PPD-q in freshwater when compared to fish. Please see the EPA's response to Reviewer 3's comments above regarding the availability of plant data for specific edits that were made to the draft 6PPD-q Screening Value. The addition of new toxicity data on previously untested taxa increases certainty

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Reviewer	**Comments**	**EPA Response**
	exposures(U.S.EPA 2016a). However, several studies for 6PPD-quinone conducted tests with 24 hours of exposure, with the idea that reduced exposure duration modeled real-world scenarios. Also, several studies exceeded EPA's Test Quality Guidelines for biomass loading in fish toxicity studies (generally of 0.8 g/L in static tests for most fish species; U.S.EPA 2016a). However, if other study variables met test quality guidelines, and the test organisms did not appear to be stressed with acceptable levels of dissolved oxygen and ammonia, then the test was included for quantitative derivation of the acute screening value. The Lo et al. (2023) and Greer et. (2023) studies did not report how they determined the dilution series for the 24-h static renewal test, suggesting no range-finding test was employed. However, the concentration ranges used in the two studies were similar. The Tian et al. (2022) study did employ range-finding tests prior to setting up a definitive static 24-h toxicity test but the actual 6PPD-quinone concentrations used were only reported as "narrowly focused within the concentration range where partial mortality was expected. In summary, for the purposes of developing an early acute toxicity screening value the methodology appears reasonable. 2.2.b. The science does appear to support the goal of this project, which is development of an acute toxicity screening value. The value developed fills a need to quickly establish protective values for 6PPD-quinone,	in the protectiveness of the screening value. However, additional data on other taxa and replication of previous studies following more standard toxicity test procedures would be useful.

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	especially for sensitive salmonids. This Final Acute Value (FAV) was calculated using the methods described in the U.S. EPA 1985 and divided by two to develop a Sensitive Salmonid Screening Value (SSSV) for acute exposures of 6PPD-quinone in freshwater was determined to be **0.0031 µg /L** (or 3.1 ng/L). This value is expected to be protective of freshwater genera potentially exposed to 6PPD-quinone. 2.2.c. All available studies relating to the acute toxicological effects of 6PPD-quinone on aquatic life were considered. Data for possible inclusion were obtained from published literature reporting acute and chronic exposures of 6PPD-quinone that were associated with mortality, survival, growth, and reproduction. Acute data meeting quality objectives were utilized quantitatively in deriving the draft SSSV for acute exposures to 6PPD-quinone in freshwater. Thus, for the taxa already tested, the results of the identified studies allow some level of protection of aquatic life. However, not all important taxa were considered. Because of a limited time interval between when the 6PPD-quinone metabolite was identified and a literature search was conducted for freshwater alga or vascular plants, no toxicity data for these taxa were identified. Thus, EPA was unable to determine if aquatic plants may be more sensitive to 6PPD-quinone than aquatic animals. Given that this preliminary SSSV is intended as information to protect sensitive aquatic life species, such as salmonids, this screening value was derived without the use of aquatic plant data and thus photosynthesizing taxa may not be protected. It is unfortunate that no toxicity data on phytoplankton or	

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Reviewer	**Comments**	**EPA Response**
	vascular plants are available, due to their important role as the trophic base of the aquatic ecosystem.	

2.3 Please comment on the toxicity data used to derive the screening values presented in the draft 6PPD-quinone document.

- **2.3.a. Were the data adequately used and sufficiently comprehensive to represent risks to sensitive aquatic life?**
- **2.3.b. Were the data selected and/or excluded from the screening values derivation appropriately utilized?**
- **2.3.c. Are there relevant data that you are aware of that should be included? If so, please provide for derivation of screening values.**

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
1	2.3.a. EPA made the most out of the limited data available at this time. I agree that data were insufficient to currently derive an acute freshwater criterion, and agree with first developing a preliminary draft screening value (in this case a SSSV) for 6PPD-quinone. I am not sure why the SSSV term is being introduced in this case, because certainly the proposed screening level of 3 ng/L would be protective of all freshwater biota? I also agree that data are not sufficient to derive a chronic screening value for freshwater. Given the lack of saltwater/estuarine species data, I also concur with the inability to derive a screening level for these systems. However, a quick literature search of recently published journal articles indicates that there are some limited data available for marine invertebrates (albeit not enough to meet the MDR). 2.3.b. Yes, I agree with the EPA decisions on which data to include or exclude in the derivation of the screening value. As mentioned below in 3(c), a recent study in four additional invertebrate species strengthens the conclusion that freshwater invertebrates are relatively tolerant of acute 6PPD-quinone exposure compared to certain salmonids.	2.3.a. Thank you for your comments. The term Sensitive Salmonid Screening Value was employed since most of the current toxicity data for 6PPD-q in the draft document that underwent external peer review was for salmonids, and this taxon appears to be sensitive compared to other aquatic life. The EPA has updated the draft 6PPD-q Screening Value to incorporate recently published toxicity literature that was previously unavailable prior to external peer review and is now using the term screening value in place of the Sensitive Salmonid Screening Value (SSSV) as this value is more broadly applicable to aquatic life with the incorporation of new toxicity data. 2.3.b. and 2.3.c. The EPA has updated the draft 6PPD-q Acute Screening Value to incorporate recently published toxicity literature that was not available before the external peer review. This update includes the paper noted in Reviewer 1's comments. Acute data from Prosser et al. (2023) as noted by Reviewer 1 was reviewed by the EPA and used quantitatively in the derivation of the draft 6PPD-q screening value. Study summaries from this publication can be found in Section 3.1.3, 4.2.1, and Appendix A of the updated screening value document.

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
	2.3.c. A recently published study determined acute toxicity data for four additional freshwater invertebrate species that could be included in derivation of the screening level (Prosser et al. 2023; cited below). This was a well conducted study published in a top tier journal within this field. Prosser RS, Salole J, Hang S. 2023. Toxicity of 6PPD-quinone to four freshwater invertebrate species. Environmental Pollution 337: 122512. doi: 10.1016/j.envpol.2023.122512	
2	2.3.a. The toxicity data obtained and discussed in this document appears as comprehensive as EPA can be at this time. The document is clear regarding the limitations of the data and it may be worth adding that data are currently limited because it is only very recently (the past 3 years or so) that the significance of 6PPD-q has been identified in terms of aquatic life risk. 2.3.b. The data selected or not selected to derive the SV for 6PPD-q appears scientifically justified and consistent with the goal of protecting aquatic life. As noted in my response to charge question 1, given the low persistence of 6PPD-q and the few test data available, endpoints based on > 24 hour exposures, and/or higher fish loading per test chamber are acceptable to use in this case given other test acceptance rationale applied in the document (e.g., dissolved oxygen and ammonia concentration were acceptably low and control survival met EPA's test acceptability criterion for acute tests despite higher fish loading).	2.3.a. Thank you for your comment. The EPA made an edit to the draft 6PPD-q Screening Value document to note that the limitations to the toxicity data can be attributed to the recent understanding of 6PPD-q toxicity and risk to aquatic life. These edits specifically entail: *"The aquatic life screening value for 6PPD-q derived in this document includes a water-column based acute screening value for freshwaters. A chronic screening value for freshwaters and acute and chronic screening values for estuarine/marine waters could not be derived at this time due to data limitations. However, given the short half-life of 6PPD-q and the rapid mortality of test organisms in studies across several species, acute toxicity is expected to be a more important driver for aquatic risk than chronic toxicity. The screening value for acute exposures of 6PPD-q in fresh water is 11 ng/L (0.011 µg/L) (Table 3-5). The EPA determined that the agency would proceed with generating an acute screening value due to the high toxicity of 6PPD-q,*

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
	One question I had was whether the study by Hiki and Yamamoto (2022) cited in this document, should be included as quantitatively acceptable test data. This study used only one replicate per concentration, and so It would be important in this case to confirm that the concentration-response relationship observed in this test supports the LC50 reported. 2.3.c. This reviewer is not aware of other toxicity test data that have been published and would satisfy basic requirements of acceptability according to EPA's aquatic life criteria guidelines- for example, test data based on organism exposure to the chemical of interest only and not a field study for example, or studies testing tire leachates without a toxicity identification evaluation similar to what Tian et al (2021) published.	*especially to specific salmonid species. As part of deriving the screening value for 6PPD-q, the EPA made several adaptations to the traditional (Guidelines) approach. These adaptations related to the use of atypical acute study designs and the relatively limited data previously noted inherently make the screening value less certain than criteria derived using the traditional (Guidelines) approach. The screening value for 6PPD-q provides information that states and Tribes can consider in their water quality protection programs. The screening value is expected to be generally protective of 95% of freshwater species potentially exposed to 6PPD-q for short durations (e.g., one hour or less). This screening value is expected to be protective if not exceeded for more than one hour every three years, using the standard acute criteria duration and frequency parameters."* 2.3.b and 2.3.c. The EPA thanks Reviewer 2 for their comments. The EPA retained the data quality review approach of the toxicity data for 6PPD-q and has updated the dataset to include recently published data. The EPA also retained the quantitative use of Hiki and Yamamoto (2022). While this study only included one replicate as noted by Review 2 in the comments, this was considered acceptable by the EPA based on the 850 Test Guidelines (U.S.EPA 2016b) that state: *"Although two replicates are preferred, one replicate is acceptable*."

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
		This justification was stated in the study summary for this test in the draft 6PPD-q Screening Value document that underwent external peer review, and no additional edits were made. Further, the results from this test are consistent with others from other tests for closely related species; confirming the concentration-response relationship observed in this test.
3	2.3.a. To develop a comprehensive data set sufficient for representing the risks of 6PPD-quinone to sensitive aquatic life, the following taxonomic classes need to be evaluated: a. A Salmonid b. A second bony fish, preferably a commercially or recreationally important warmwater species c. A representative Chordate (may be bony fish or amphibian) d. A planktonic crustacean e. A benthic crustacean f. An insect g. A non-arthropod or chordate (e.g., Rotifera, Annelida, Mollusca) h. An insect or any phylum not already represented For the present report, only data from testing salmonids and a zebra fish were used. The salmonids used were: chinook, coho, and sockeye salmon; brook and rainbow trout; and white spotted char. All the tests were acute. The authors state in a "yes we have no bananas" format that chronic toxicity data for 6PPD-quinone were limited. In actuality, there were no chronic studies available. Therefore, no chronic screening value could be derived. Thus, as in the	2.3.a. The EPA concurs and acknowledges that the toxicity data for 6PPD-q are limited and that the minimum data requirements specified in the EPA's *Guidelines* (U.S.EPA 1985) are not met, as noted in Reviewer 3's comments. However, several states and Tribes have raised concerns related to 6PPD-q exposure to aquatic life. It is for this reason that the EPA is developing a screening value, given the lack of available information to develop national Ambient Water Quality Criteria (AWQC) for aquatic life. The EPA has developed a protective value based on all quality toxicity data that is currently available and will continue to monitor the data to determine if an aquatic life AWQC can be developed at a later time. 2.3.b. and 2.3.c. The EPA thanks Review 3 for their comments and agrees that the draft 6PPD-q screening value is intended to protect sensitive salmonid species and other aquatic life. However, the statement in the draft document that this value appears to be protective of aquatic life was made since the draft 6PPD-q screening value appears to be protective of the most sensitive species of those tested, these tests range across nine freshwater fish families,

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
	6PPD study, a valuable data set is not available. Given the lack of sufficient testing among the required animal and plant groups, the risks to sensitive aquatic life are not adequately characterized. The available acute data for salmonids and the zebra fish were, however, available for developing a SSSV value as a "first-pass" evaluation for the toxicity of 6PPD-quinone and thus are useful for protecting what may turn out to be the most sensitive aquatic taxa, salmonid fishes, especially coho salmon. 2.3.b. Acute freshwater toxicity tests with 6PPD-quinone exposures were considered for calculating the 6PPD-quinone screening value. Qualitative studies not included in the numeric screening value derivation were either rejected outright or used as supporting information. Those data deemed acceptable were evaluated for meeting the threshold of the EPA guidelines (1985) for minimum data requirements (MDRs). The MDRs were not met for acute freshwater criteria derivation for either animals or plants. Thus, it is appropriate that the national 304(a) ambient water quality criteria for the protection of aquatic life was not derived for 6PPD-quinone. However, EPA was able derive a protective acute SSSV for 6PPD-quinone in freshwater. Although this report states that this assessment was sufficient to protect aquatic life, at this time it can only protect sensitive salmonids from acute toxic effects of 6PPD-quinone. The only unused data reported was from the "Mahoney, H et al. (2022) study on mitochondrial dysfunction. The	representing four genera and two families, and two invertebrate species (an insect and a mollusk).

2.3. The Toxicity Data used to Derive the Screening Values		
Reviewer	**Comments**	**EPA Response**
	reason offered for this exclusion was that it was an in vitro exposure on excised cell, rather than a whole-body exposure like the other toxicity tests. 2.3.c. I am not aware of additional relevant data that should be considered for this report.	

2.4 Are the derived screening values appropriately protective of sensitive aquatic life?

2.4. The Derived Screening Values' Protectiveness to Sensitive Aquatic Life		
Reviewer	**Comments**	**EPA Response**
1	Yes, in my opinion the screening level of 3 ng/L would be protective of aquatic life.	Thank you for your comment. Since the external peer review draft was developed, EPA added new data to the database and adjusted the values to reflect 6PPD-q loss in test chambers. The acute screening value is currently 11 ng/L. Despite the increase in the screening value after the completion of the external peer review (which was driven by the addition of new data thereby increasing the number of species/genera included in the calculation or the "N", not comments from the peer reviewers), this screening value is considered to be protective of all aquatic life.
2	The EPA chose to separate the different species acute values for the genus *Oncorhynchus* in deriving the final acute value (FAV) rather than base the FAV on genus mean acute values (GMAVs) as typically calculated using EPA's aquatic life criteria guidelines. While the document provides a reasonable rationale for calculating the FAV using the separate species mean acute values (SMAVs) for *Oncorhynchus* I am concerned that the SV may be too conservative given even the lowest species value available for Coho salmon. Note that the proposed SV is more than 10 times lower than the lowest LC50 reported thus far and may be biased low because SMAVs were used. An alternative approach that EPA considered in Section 4.1 of this document is calculating the FAV based on genus mean acute values (GMAV's) as is typically done by EPA in developing aquatic life criteria; but in this case, the FAV should be lowered to protect the commercially important and most sensitive species, Coho salmon. The resulting FAV would then be 67 ng/L based on the Coho salmon	The EPA thanks Reviewer 2 for their comments. The EPA continued to calculate the FAV in a manner summarized in Reviewer 2's comments such that separate species mean acute values (SMAVs) were used as opposed to an *Oncorhynchus* genus mean acute value. This approach is consistent with the EPA's *Guidelines* since the SMAVs are > 10 times different from each other. Further, this ensured the protection of a species that is endangered in Oregon and California and recreationally important across the U.S. Further, the EPA is aware of ongoing toxicity testing by USGS following the EPA's test quality guidelines that may provide additional information on the relative sensitivity of Coho salmon and other species. The EPA expects to update these screening values as additional data become available. The updated screening value increased slightly to 11 ng/L, which reflects the incorporation of recently published data. Thus, dividing the Coho salmon SMAV of 67.91 by 2 yields a Coho salmon low effect value of 33.95 ng/L. This low

2.4. The Derived Screening Values' Protectiveness to Sensitive Aquatic Life		
Reviewer	**Comments**	**EPA Response**
	SMAV and the SV would be one half the FAV or 34 ng/L, which is still lower than the most sensitive Coho salmon acute value. Lowering the FAV to protect the most sensitive species is in keeping with EPA's aquatic life criteria guidelines. Furthermore, there is fairly high confidence in the SMAV for Coho salmon because all three published studies obtained very similar LC50s. Field studies that have examined 6PPD-q concentration and pre-spawn mortality of Coho salmon in streams may shed light on an appropriate SV that is protective of aquatic life and yet not overly conservative.	effect level for Coho salmon is only 2.8 times greater than the updated screening value of 11 ng/L. Further, the lowest author-reported Coho salmon LC_{50} of 41 ng/L (Lo et al. 2023) would yield a low effect value ($LC_{50}/2$) of 20.5 ng/L. The updated screening value is less than two times (1.7) lower than the most sensitive Coho salmon calculated low effect level. Given the very limited data available and its associated uncertainty, as well the rapidity of the severe toxicity endpoint of mortality observed in tests (hours), the EPA maintains that the updated screening value is appropriately protective (not overly conservative, as asserted by the commenter).
3	There are insufficient data to derive a national 304(a) freshwater criteria for 6PPD-quinone. There are currently three quantitatively acceptable Genus Mean Acute Values (GMAVs), and the FAV calculation requires at least four (GMAVs) to calculate a criterion value. Thus, sensitive aquatic life *in toto* are not protected by the derived screening values. However, to establish protective values for 6PPD-quinone for sensitive salmonids alone, a preliminary draft SSSV for acute exposures to 6PPD-quinone was derived and the stated procedure for determining this value were appropriate. It is a bit disappointing that the available data for assessing 6PPD-quinone are so limited for the toxic agent causing Urban Runoff Mortality Syndrome, considering the problem was noted as early as 2011 (Spromberg, & Scholz) and the causal agent identified in 2018 (Peter et al.) and clearly linked in 2021 (Tian et al.). It would seem that a toxicant with significant effects on local aquatic	Thank you for your comment. The EPA continues to use the technical approach outlined in the draft 6PPD-q Screening Value document that underwent external peer review and has updated the data to incorporate recently published data from the literature to ensure the protectiveness of the 6PPD-q screening value. The updates to the data for 6PPD-q added toxicity data for several taxonomic groups that were previously not represented. As such there are now data for seven out of the eight MDRs recommended in the EPA *Guidelines* (U.S.EPA 1985), providing a diverse understanding of 6PPD-q toxicity to aquatic life. However, the EPA agrees that data gaps remain for 6PPD-q.

2.4. The Derived Screening Values' Protectiveness to Sensitive Aquatic Life		
Reviewer	**Comments**	**EPA Response**
	ecosystem ecology, the commercial fishing industry, recreational angling and tourism, and native American subsistence groups would have received a faster track to comprehensively determining the environmental risks. Nevertheless, the present report remains a valuable tool for early evaluation of such risks.	

3.0 ADDITIONAL REVIEWER COMMENTS

3.0 Additional Reviewer Comments		
Reviewer	**Comments**	**EPA Response**
1	See minor edits provided in the draft document.	The EPA made the minor edits recommended.
2	Additional literature regarding fate and transport for EPA's consideration • Baensch-Baltruschat, B., Kocher, B., Stock, F., & Reifferscheid, G. 2020. Tire and road wear particles (TRWP) - A review of generation, properties, emissions, human health risk, ecotoxicity, and fate in the environment. Science of The Total Environment, 137823. • Challis, J. K., H. Popick, S. Prajapati, P. Harder, J. P. Giesy, K. McPhedran, and M. Brinkmann. 2021. Occurrences of Tire Rubber-Derived Contaminants in Cold-Climate Urban Runoff Environmental Science & Technology Letters, 8: 961-967 • French, B.F., D. H. Baldwin, J. Cameron, J. Prat, K. King, J. W. Davis, J. K. McIntyre, and N. L. Scholz. 2022. Environmental Science & Technology Letters 9 (9), 733-738 • Johannessen, C. P., Helm, P., Lashuk, B., Yargeau, V., & Metcalfe, C. D. 2021. The Tire Wear Compounds 6PPD-Quinone and 1,3-Diphenylguanidine in an Urban Watershed. Archives of Environmental Contamination and Toxicology. doi:https://doi.org/10.1016/j.envpol.2021.117659 • Johannessen, C., & Parnis, J. 2021. Environmental modelling of hexamethoxymethylmelamine, its transformation products, and precursor compounds:	The EPA reviewed and considered these publications in the updated 6PPD-q Screening Value document. Most of these papers provided information related to fate and transport and are cited in the Problem Formulation.

3.0 Additional Reviewer Comments		
Reviewer	**Comments**	**EPA Response**
	an emerging family of contaminants from tire wear. Chemosphere. doi:https://doi. org/10. 1016/j.chemosphere.130914 • Johannessen, C., Helm, P., & Metcalfe, C. D. 2021. Detection of selected tire wear compounds in urban receiving waters. Environ. Pollut. • McIntyre, J.F., J. Prat, J. Cameron, J. Wetzel, E. Murdock, K.T. Peter, Z. Tian, C. Mackenzie, J. Lundin, J. D. Stark, K. King, J.W. Davis, E.P. Kolodziej, and N. L. Scholz. 2021. Treading Water: Tire Wear Particle Leachate Recreates an Urban Runoff Mortality Syndrome in Coho but Not Chum Salmon. Environ. Sci. Technol. 2021, 55, 11767−11774 • Peter, K.T., F. Hou, Z. Tian, C. Wu, M. Goehring, F. Liu, and E. P. Kolodziej. 2020. More Than a First Flush: Urban Creek Storm Hydrographs Demonstrate Broad Contaminant Pollutographs. Environ. Sci. Technol. 2020, 54, 10, 6152–6165. • Seiwert, B., Nihemaiti, M., Troussier, M., Weyrauch, S., & Thorsten, R. 2022. Abiotic oxidative transformation of 6-PPD and 6-PPD quinone from tires and occurrence of their products in snow from urban roads and in municipal wastewater. Water Research, 212. • Unice, K. M., Bare, J. L., Kreider, M. L., & Panko, J. M. 2015. Experimental methodology for assessing the environmental fate of organic chemicals in polymer matrices using column leaching studies and OECD 308 water/sediment	

3.0 Additional Reviewer Comments		
Reviewer	**Comments**	**EPA Response**
	systems: Application to tire and road wear particles. The Science of the Total Environment, 533, 476-487.	
3	[None]	

4.0 REFERENCES CITED BY EPA IN RESPONSES

Challis, J., H. Popick, S. Prajapati, P. Harder, J. Giesy, K. McPhedran and M. Brinkmann. 2021. Occurrences of tire rubber-derived contaminants in cold-climate urban runoff. Environ. Sci. Technol. Lett. 8(11): 961-967.

DTSC (Department of Toxic Substances Control). 2022. Product - Chemical Profile for Motor Vehicle Tires Containing N-(1,3-Dimethylbutyl)-N´-phenyl-p-phenylenediamine (6PPD). March 2022. Final Version. pp.102. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://dtsc.ca.gov/wp-content/uploads/sites/31/2022/05/6PPD-in-Tires-Priority-Product-Profile_FINAL-VERSION_accessible.pdf?emrc=9a953d

Hiki, K. and H. Yamamoto. 2022. The tire-derived chemical 6PPD-quinone is lethally toxic to the white-spotted char *Salvelinus leucomaenis pluvius* but not to two other salmonid species. Environ. Sci. Technol. Lett. 9(12): 1050-1055. 10.1021/acs.estlett.2c00683

Huang, W., Y. Shi, J. Huang, C. Deng, S. Tang, X. Liu and D. Chen. 2021. Occurrence of substituted p-phenylenediamine antioxidants in dusts. Environ. Sci. Technol. Lett. 8(5): 381-385.

Johannessen, C., P. Helm and C. D. Metcalfe. 2021. Detection of selected tire wear compounds in urban receiving waters. Environ. Pollut. 287: 117659.

Johannessen, C., P. Helm, B. Lashuk, V. Yargeau and C. D. Metcalfe. 2022. The tire wear compounds 6PPD-quinone and 1, 3-diphenylguanidine in an urban watershed. Arch. Environ. Contamin. Toxicol.: 1-9.

Lo, B. P., V. L. Marlatt, X. Liao, S. Reger, C. Gallilee, A. R. S. Ross and T. M. Brown. 2023. Acute toxicity of 6PPD-quinone to early life stage juvenile chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon. Environ. Toxicol. Chem. 42(4): 815-822. 10.1002/etc.5568

Prosser, R., J. Salole and S. Hang. 2023. Toxicity of 6PPD-quinone to four freshwater invertebrate species. Environ. Pollut. 337: 122512.

Seiwert, B., M. Nihemaiti, M. Troussier, S. Weyrauch and T. Reemtsma. 2022. Abiotic oxidative transformation of 6-PPD and 6-PPD quinone from tires and occurrence of their products in snow from urban roads and in municipal wastewater. Water Research. 212: 118122.

Tian, Z., H. Zhao, K. T. Peter, M. Gonzalez, J. Wetzel, C. Wu, X. Hu, J. Prat, E. Mudrock and R. Hettinger. 2021. A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon. Science. 371(6525): 185-189.

Tian, Z., M. Gonzalez, C. A. Rideout, H. N. Zhao, X. Hu, J. Wetzel, E. Mudrock, C. A. James, J. K. McIntyre and E. P. Kolodziej. 2022. 6PPD-Quinone: Revised toxicity assessment and quantification with a commercial standard. Environ. Sci. Technol. Lett. 9(2): 140-146. 10.1021/acs.estlett.1c00910

U.S.EPA (US Environmental Protection Agency). 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their sses. Office of Research and Development. PB85-227049. https://www.epa.gov/sites/default/files/2016-02/documents/guidelines-water-quality-criteria.pdf

U.S.EPA (U.S. Environmental Protection Agency). 2016a. Ecological effects test guidelines OCSPP 850.1075: Freshwater and saltwater fish acute toxicity test. Office of Chemical Safety and Pollution Prevention. Washington, DC. EPA 712-C-16-007. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100SH65.PDF?Dockey=P100SH65.PDF

U.S.EPA (U.S. Environmental Protection Agency). 2016b. Series 850 - Ecological Effects Test Guidelines. Office of Chemical Safety and Pollution Prevention, Washington, DC. Accessed March 2021. https://www.epa.gov/test-guidelines-pesticides-and-toxic-substances/series-850-ecological-effects-test-guidelines.

U.S.EPA (U.S. Environmental Protection Agency). 2023. Draft Method 1634: Determination of 6PPD-quinone in aqueous matrices using liquid chromatrography with tandem mass spectrometry (LC?MS/MS). Office of Water, Office of Science and Technology. Washington, DC. EPA 821-D-24-001. https://www.epa.gov/system/files/documents/2024-01/draft-method-1634-for-web-posting-1-23-24_508.pdf