OREGON HEALTH AUTHORITY
Public Health Division
Environmental Public Health Section

2026

Toxicity Reference Value Support Document

Rules Advisory Committee Version

January 12, 2026

Acknowledgments

The Oregon Health Authority prepared this publication in collaboration with Oregon Department of Environmental Quality staff and in consultation with the 2022-2025 Air Toxics Science Advisory Committee (ATSAC). OHA is very thankful for the time and effort that members of ATSAC contributed to the work documented here. As a volunteer committee, it was no small sacrifice. This work is much better because of their contribution. This document was prepared by Oregon Health Authority.

Authors
Holly Dixon, PhD
Public Health Toxicologist

David Farrer, MS, PhD
Public Health Toxicologist

Dana Crosby, MPH
Environmental Health Assessment Program Coordinator

Technical Reviewer
Ali Hamade, PhD, DABT
Deputy State Epidemiologist
Oregon Health Authority

For more information contact: EHAP.info@odhsoha.oregon.gov

Table of Contents

See list of appendices in Chapter 1.

List of Abbreviations

Abbreviation	Definition
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
6:2 FTS	6:2-Fluorotelomersulfonic acid
ACGIH	American Conference of Governmental Industrial Hygienists
ATSAC	Air Toxics Science Advisory Committee
ATSDR	Federal Agency for Toxic Substances and Disease Registry
BMCL	Lower confidence limit of the benchmark concentration
CalEPA	California Environmental Protection Agency
CARB	California Air Resources Board
CAS RN	Chemical Abstract Service Registry Number
DAF	Dosimetric adjustment factor
DCE	1,2-dichloroethene
DE	Diesel exhaust
DEMS	Diesel Exhaust in Miners Study
OR DEQ	Oregon Department of Environmental Quality
DNA	Deoxyribonucleic acid
DPM	Diesel particulate matter
EGLE	Michigan Department of Environment, Great Lakes, and Energy
US EPA	U.S. Environmental Protection Agency
EQC	Environmental Quality Commission (Oregon)

ERG	Eastern Research Group
HCL	Hydrogen chloride
HEI	Health Effects Institute
HFPO-DA/Gen-X	Hexafluoropropylene oxide dimer acid
IARC	International Agency for Research on Cancer
IRIS	EPA’s Integrated Risk Information System
IUR	Inhalation unit risk
LOAEL	Lowest observable adverse effect level
MDH	Minnesota Department of Health
MRL	Minimal risk level
NAAQS	EPA’s National Ambient Air Quality Standard
NC	Noncancer
NIOSH	National Institute for Occupational Safety and Health
NJDEP	New Jersey Department of Environmental Protection
NOAEL	No observable adverse effect level
NTP	National Toxicology Program
OEHHA	California Office of Environmental Health Hazard Assessment
OHA	Oregon Health Authority
OAR	Oregon Administrative Rules
PAH	Polycyclic aromatic hydrocarbons
cPAH	Carcinogenic polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ether

PBB	polybrominated biphenyls
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBE	Perfluorobutylethylene
PFBS	Perfluorobutane sulfonic acid
PFDoDa	Perfluorododecanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Pefluorohexanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PM	Particulate matter
POD	Point of departure
ppm	Parts per million
PPRTV	Provisional Peer Reviewed Toxicity Value
QC	Quality control
RAA	Risk assessment advice
RAC	Rules Advisory Committee
RDDR	Regional Deposition Dose Relationship
RGDR	Regional Gas Dose Ratio
REC	Respirable elemental carbon
REL	Reference exposure level

ReV	Reference exposure value
RfC	Reference concentration
RfD	Reference dose
RPF	Relative potency factor
RSL	Regional Screening Level
SAS	Synthetic amorphous silica
SEC	Submicron elemental carbon
SRP	Scientific Review Panel
TAC	Toxic air contaminant
TCEQ	Texas Commission on Environmental Quality
TEF	Toxicity equivalency factor
TRV	Toxicity reference value
UF	Uncertainty factor
UF_D	Database uncertainty factor
WHO	World Health Organization

Chapter 1: Executive Summary

Section 1.1 Background

The Oregon Department of Environmental Quality (DEQ) relies on toxicity reference values, or TRVs, adopted in rule by the Environmental Quality Commission (EQC) when regulating a potentially toxic air contaminant (TAC) emitted from facilities regulated under state air quality laws. A TRV is the concentration of a TAC below which health problems are not expected when inhaled, or that corresponds to a one in a million excess cancer risk when inhaled.

DEQ partners with the Oregon Health Authority (OHA) to propose new and update existing TRVs in rule. The EQC adopted current TRVs in a 2018 rulemaking ("the 2018 TRVs") that also included a requirement that the agencies review rules every three years for consistency with the latest available science regarding health risks from exposure to a TAC. The agencies initiated DEQ's TAC Review and Update Rulemaking in order to meet this requirement.

Oregon Administrative Rules (OAR), adopted by EQC, specify sources of toxicity information considered to be authoritative in terms of their scientific rigor and comprehensive methods for deriving TRVs (OAR 340-247-0030). There are four authoritative sources in rule: the U.S. Environmental Protection Agency (EPA), U.S. Agency for Toxic Substances and Disease Registry (ATSDR), California's EPA (CalEPA), and Oregon DEQ in consultation with the Air Toxics Science Advisory Committee (ATSAC).

Candidate TRVs proposed under "DEQ in consultation with ATSAC" are either

- unmodified TRVs issued by other sources,
- modified TRVs from other sources, or
- modified TRVs from EPA, ATSDR, or CalEPA.

There were no instances where OHA calculated a new candidate TRV from primary research studies.

DEQ uses the term TRV when referring to similarly calculated health-based toxicity values developed by other agencies. **All TRV updates proposed based on federal authoritative sources are drawn from TRVs those sources drafted before 2025.**

Section 1.2 Purpose

This TRV Support Document is primarily intended as a resource for the rule advisory committee (RAC) established as part of the rulemaking process to understand the technical background and rationale for the TRVs proposed in this TAC Review and Update Rulemaking. This document is a reference resource to find information about specific TRVs and TRV review processes. Tables 1-1 and 1-2 at the end of this chapter can help readers find information on specific topics.

This document provides transparency about OHA's approach to the TRV review and update process and may inform future TRV updates.

Section 1.3 OHA's role

While the TAC Review and Update Rulemaking is a DEQ rulemaking, the work in this document was led and written by OHA public health toxicologists. This document is included as part of DEQ's larger package of materials related to this rulemaking. DEQ funds OHA to do this work on their behalf through a formal interagency agreement. More information is in Chapter 2.

Section 1.4 OHA's TRV review and update process

Chapter 2 details OHA's eight-step process to review and update TRVs:

- Step 1: Develop and obtain ATSAC feedback on OHA's proposed process to review TRVs
- Step 2: Identify updated scientific assessments from authoritative sources named in rule
- Step 3: Collect information about the research studies and methods used to calculate TRVs ("calculation information")
- Step 4: Apply a third-party quality control process on all TRV information
- Step 5: Select TRV for proposal based on Oregon-specific rules and policies
- Step 6: Evaluate petitions from the public for changes to TRVs
- Step 7: Seek feedback from ATSAC on TRV proposals
- Step 8: Integrate feedback from ATSAC

Section 1.5 Guide to TRV support document

Table 1-1 describes the content of the chapters of this TRV Support Document and Table 1-2 describes additional supplemental materials.

Table 1-1: Descriptions of chapters in the TRV Support Document

Chapter title	Read this chapter for questions on topics such as
Chapter 2: Background on OHA's Process for Reviewing and Selecting TRVs for Proposal	• TAC Review and Update Rulemaking background • TRV review and update technical process • Outcomes of the TRV review and update technical process

Chapter 3: Groupings of Chemicals	• Background on chemical groupings
	• Chemical groups that can be summed and compared directly to a TRV that applies to the group
	• Chemical classes with toxicity equivalency factors or relative potency factors, which include:
	  ○ Chlorinated dibenzodioxins and chlorinated dibenzofurans
	  ○ Polycyclic aromatic hydrocarbons
	• Inorganic TACs and their associated compounds: This section includes information about how to group and evaluate compounds that include metals, metalloids, fluorides, cyanides, and others
	• Silica: This section includes guidance on classifications and categories of different forms of silica (e.g., crystalline silica vs. amorphous silica)

Chapter 4: Authoritative Source Special Cases	• Proposed TRVs using EPA Provisional Peer Reviewed Toxicity Value (PPRTV) screening values as the authoritative source • Proposed TRVs not yet finalized by their authoritative source • Process for monitoring changes in federal authoritative sources

Chapter title	Read this chapter for questions on topics such as

Chapter 5: Proposed TRVs where DEQ is the Authoritative Source	• Calculation information for every TRV where DEQ, in consultation with ATSAC, is listed as the authoritative source
	  ○ Acute TRVs calculated from authoritative and other sources by modifying the exposure time
	  ○ TRVs that OHA calculated for lesser studied TACs by using a better studied, similar TAC as a surrogate
	  ○ TRVs where OHA proposes to modify uncertainty factors
	  ○ TRVs where OHA proposes to apply other types of adjustments to values from authoritative or other sources
	  ○ TRVs proposals from alternate sources without modification

Chapter 6: Agency Highlighted TRVs	• Diesel particulate matter cancer TRV • 1-methylnaphthalene chronic noncancer TRV

Table 1-2: Description of supplemental resources accompanying this TRV Support Document

Supplemental resource title and hyperlink	Read this supplemental resource for questions on topics such as
TRV Support Document Appendices (Appendices A-T)	• **Appendix A**: OHA's Response to ATSAC Feedback • **Appendices B-F**: Meeting minutes from ATSAC meetings 2-8 (meeting 1 was informational only, meeting materials are posted to the ATSAC webpage) • **Appendices G-I**: ATSAC's written responses to discussion questions from meetings 3-8 • **Appendix J**: TRV update and selection process: 2023 process proposal to ATSAC and OHA responses • **Appendix K**: Eastern Research Group 2024 memorandum to DEQ and OHA on quality control process • **Appendix L**: Eastern Research Group 2024 memorandum to DEQ and OHA summarizing

Supplemental resource title and hyperlink	Read this supplemental resource for questions on topics such as
	published inhalation toxicity values on specific contaminants, and annotated by DEQ and OHA • **Appendix M**: Background on uncertainty factors used in Oregon • **Appendices N-Q**: Documents focused on the petition process and outcome of the petition on the acute TRV for manganese • **Appendix R**: ATSAC email exchanges on brominated dioxins and furans, 1-methylnaphthalene, and Perfluorodecanoic acid (PFDA) • **Appendix S**: OHA Deputy State Epidemiologist memorandum on the adoption of the 2022 World Health Organization Toxicity Equivalency Factors for dioxins and furans • **Appendix T**: Brief history on previous Oregon ATSAC for diesel particulate matter background
Workbook 1: DEQ Proposed TRVs	• List of all proposed TRVs along with 2018 TRVs • List of TRVs that are proposed to change from 2018 or are new since 2018 • Percent change, direction, and reason for proposed TRV changes
Workbook 2: TRV Derivation	• Summary calculation information for all candidate TRVs, including the ones proposed for adoption • Links to sources of calculation information for each candidate TRV

Chapter 2: Background on OHA's Process for Reviewing and Selecting TRVs for Proposal

Section 2.1 Rulemaking background

Beginning in 2022, DEQ and OHA reviewed the inhalation TRVs used in DEQ's air quality programs. Examples of DEQ programs that use TRVs are the Air Toxics Program, Air Toxics Monitoring Program and the Cleaner Air Oregon industrial air toxics regulatory program.

2.1.1 Toxicity reference value definitions

A toxicity reference value, or TRV, is the concentration of a TAC below which health problems are not expected when inhaled or that corresponds to a one in a million excess cancer risk when inhaled. OHA uses the term TRV when referring to similarly calculated health-based toxicity values developed by other agencies. There are more details on DEQ's authoritative sources and TRV definitions later in this chapter.

A TAC can have up to three different inhalation TRVs in Oregon:

1. **Chronic cancer TRV** - Air concentration corresponding to a one in one million excess cancer risk, calculated by dividing one in one million (0.000001) by the inhalation unit risk (IUR) when that air is breathed all the time over a lifetime (78 years). Hereafter, these TRVs are referred to as the "cancer TRVs".
2. **Chronic noncancer TRV** - Air concentration below which noncancer health effects are not expected over a year or more of constantly breathing that air. Hereafter, these TRVs are referred to as the "chronic TRVs".
3. **Acute noncancer TRV** - Air concentration below which noncancer health effects are not expected over 24 hours or less from breathing that air. Hereafter, these TRVs are referred to as the "acute TRVs".

The 2018 inhalation TRVs are listed in Oregon Administrate Rule (OAR 340-247-8010) and were adopted by the EQC in 2018 during the original DEQ Cleaner Air Oregon Program Rulemaking.

Cancer TRV Terminology

Throughout this document, OHA writes about cancer TRVs as being calculated by authoritative sources. OHA is referring to cancer TRVs that OHA calculated at one-in-one-million risk using inhalation unit risks (IURs) developed by those authoritative sources.

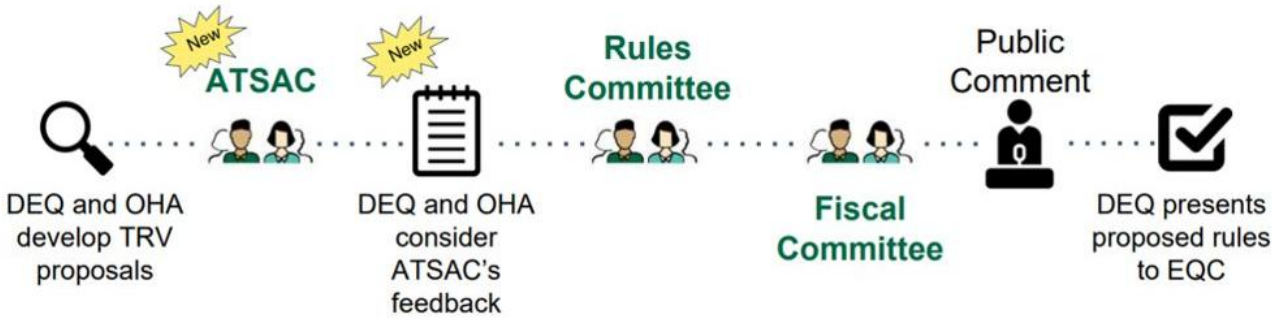
2.1.2 Rulemaking process

This chapter provides an overview of the process OHA followed to review and update TRVs with DEQ support. Prior to this TRV review, DEQ rulemaking was needed to align the use of TRVs among different air toxics programs at DEQ. This resulted in the DEQ rulemaking called The Cleaner Air Oregon and Air Toxics Alignment and Updates, which the EQC adopted in November 2021. For example, rule alignment work included integrating external scientific review into the TRV review and update process by constituting a new Air Toxics Science Advisory Committee (ATSAC, described below), and updating DEQ's list of TRV authoritative sources.

This TAC Review and Update Rulemaking began in 2022; hereafter, referred to as the "rulemaking". This chapter also describes the Air Toxics Science Advisory Committee (ATSAC) and their role in the rulemaking. Appendix A summarizes ATSAC's feedback on OHA's proposed updates and OHA's response to that feedback.

All DEQ rulemakings include a series of committees that provide input on the rules. This rulemaking includes ATSAC, which is made up of national and international scientific experts, a Rules Advisory Committee (RAC) and a Fiscal Advisory Committee (FAC) made up of representatives of Oregon groups interested in the proposed rules (Figure 2-1). Agency staff document and consider feedback from these committees and may revise the draft rules prior to making them available for public comment. Agencies document and consider those public comments and may again revise proposed rules. DEQ submits final proposed rules to DEQ's governing board, the Environmental Quality Commission (EQC), which decides whether to adopt the rules as proposed, with further revisions, or not at all.

Figure 2-1: Graphic of the overall process for the TAC Review and Update Rulemaking



2.1.3 OHA's role in the rulemaking

This TAC Review and Update Rulemaking is a DEQ rulemaking. DEQ and OHA have a longstanding partnership working on DEQ's air toxics programs, including the Cleaner Air Oregon regulatory program. OHA environmental public health staff, including public health toxicologists, regularly work on DEQ projects related to DEQ's TRVs and other aspects of Cleaner Air Oregon, including rule development and risk communication. For example, OHA's public health toxicologists had a lead role in setting the original TRVs in OAR in 2018. OHA's team is funded to do work to support DEQ's Cleaner Air Oregon program and TRVs through a DEQ-OHA Interagency Agreement.

In this rulemaking, the OHA toxicology team's role was to review and recommend updated TRVs for DEQ to include in proposed revised rules. Throughout this document OHA refers to TRV "recommendations" and "proposals" interchangeably. However, the most precise description of respective agency roles is that OHA recommends TRVs for DEQ to propose in their rulemaking process.

As part of that responsibility, OHA played a lead role in recruiting, assembling, and leading the DEQ's ATSAC. OHA staff led the preparation, meeting discussion, and follow up for all ATSAC meetings.

Overall, the work in this document was led and written by OHA staff, and this document is included as part of DEQ's larger package of materials related to this rulemaking. The review and update of TRVs are one component of this larger DEQ rulemaking. This rulemaking also includes DEQ-led components, such as a review and update of the DEQ Toxic Air Contaminant Priority List and Risk Based Concentrations (RBCs); more information on those components can be found on DEQ's rulemaking website.

2.1.4 The lack of a standardized toxicology database for TRV selection

OHA needs to look at calculation information for each candidate TRV to evaluate the candidate TRV's quality and appropriateness for use in Oregon. Calculation information refers to inputs such as point of departure (the dose of a contaminant at which a biological response is first observed) and exposure time (the total time the test subject is in contact with the contaminant) in the critical study (the key scientific study used to calculate the TRV). Calculation information is also a prerequisite to determine if

adjustments to the candidate TRV are necessary and what those adjustments should be. TRV calculation information is important to help OHA and ATSAC determine which TRV is based on the most robust science.

While databases of multiple candidate TRVs exist, there is no database that allows for comparison of TRV calculation information of the same category across agencies that generate TRVs. Agencies that generate TRVs also do not publish their TRV calculation information in a way that is easily downloadable, searchable, and filterable.

OHA sought to remedy this by extracting and compiling calculation information on all candidate TRVs into a database-like format that allows OHA and ATSAC to make efficient comparisons between candidates. This allowed OHA and ATSAC to more quickly reach transparent and scientifically valid TRV decisions.

Section 2.2 TRV review and update process

OHA followed a multi-step process to review and update TRVs. The steps below describe the basic order in which OHA did this work, but there was some overlap between steps, and some of the steps occurred concurrently or iteratively. For example, there was some back and forth between steps 7 and 8 as OHA and ATSAC interacted, and OHA was working on evaluating the petition in step 6 while collecting calculation information in step 3. OHA also sought and responded to feedback from ATSAC (steps 7 and 8) on information in and responses to the petition (step 6).

- Step 1: Develop and obtain ATSAC feedback on OHA's proposed process to review TRVs
- Step 2: Identify updated scientific assessments from authoritative sources named in rule
- Step 3: Collect information about the research studies and methods used to calculate TRVs ("calculation information")
- Step 4: Apply a third-party quality control process on all TRV information
- Step 5: Select TRV for proposal based on Oregon-specific rules and policies
- Step 6: Evaluate petitions from the public for changes to TRVs
- Step 7: Seek feedback from ATSAC on TRV proposals
- Step 8: Integrate feedback from ATSAC

Step 1: Develop and obtain ATSAC feedback on OHA's proposed process to review TRVs

This was the first time for OHA to review and update the TRVs since the rules that contain them were first adopted in 2018. The 2021 Cleaner Air Oregon and Air Toxics Alignment and Updates Rulemaking required major content and process differences between the initial 2018 TRV adoption and the current TRV review and update, requiring the development of new processes and tools.

As noted above, there is no comprehensive database of TRVs together with the research and data from which they are calculated. To support the TRV review, OHA had to review, organize, and address this large body of information. OHA's public health toxicologists searched authoritative source documentation for at least 20,000 data points and manually entered that information into an Excel-based TRV updating tool described later in this section. It took time for OHA and DEQ staff to develop the process, tools, and workflow necessary to accomplish this work. This subsection describes the components of this foundational step in the TRV update process.

ATSAC establishment

DEQ rules adopted by the EQC in 2021 call for the establishment of an external ATSAC to consult with DEQ on proposed TRVs (OAR 340-247-0050). Per rule, OHA and DEQ recruited seven ATSAC members with expertise in toxicology and/or toxicity assessment; environmental and/or atmospheric chemistry; and epidemiology/biostatistics [OAR 340-247-0050(3)]. Once a candidate met one of these threshold qualifications, rules directed DEQ to give special consideration to experts with additional specialization in one or more the following fields: inhalation, reproductive, or developmental toxicology; multi-pathway exposure; bioaccumulation; environmental public health; neonatal and children's health; medicine; or health of vulnerable populations.

OHA and DEQ prioritized recruiting ATSAC members that were affiliated with the following authoritative sources used for Oregon DEQ's inhalation toxicity reference values listed in OAR 340-247-0030:

- United States Environmental Protection Agency (EPA)
- United States Agency for Toxic Substances and Disease Registry (ATSDR)
- California Environmental Protection Agency (CalEPA)

DEQ also recruited ATSAC members from the following groups:

- National Institute of Environmental Health Sciences-funded academic centers.
- Society of Toxicology's Risk Assessment Specialty Section and Occupational and Public Health Specialty Section professional members
- Pediatric Environmental Health Specialty Unit (PEHSU) staff

ATSAC members are volunteers and are public officials. DEQ and OHA ensured that no members of the committee had actual or potential conflicts of interest as required under OAR 340-247-0050(6)(a).

People interested in becoming a member of the ATSAC were encouraged to fill out an interest form by May 31, 2022. The DEQ director appointed ATSAC members with concurrence by DEQ's Environmental Quality Commission on July 22, 2022.

Seven national experts served on the ATSAC during this TRV Review and Update Process. Here is abbreviated information from the ATSAC members' biosketches that they provided at the beginning of their term. Those members marked with an asterisk (*) did not serve the full term:

John Budroe, **PhD**

> Dr. John Budroe is the Chief of Air Toxicology and Risk Assessment Section of the Office of Environmental Health Hazard Assessment (OEHHA) in the CalEPA and has 25 years of experience performing human health risk assessments on environmental chemicals. Dr. Budroe meets the ATSAC expertise requirement with expertise in toxicology, toxicity assessment, and epidemiology, with additional specializations in inhalation toxicology and environmental public health.

Qiaoxiang (Daisy) Dong, **PhD**

> Dr. Qiaoxiang Dong has been a Toxicologist in the Department of Pesticide Regulation at California EPA and Adjunct Professor at The Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University in China for over six years. Dr. Dong meets the ATSAC expertise requirement with expertise in toxicology and toxicity assessment, with additional expertise in inhalation, reproductive, and developmental toxicology.

Jefferson Fowles, PhD*

Dr. Jefferson Fowles was a Staff Toxicologist (Specialist) in the Environmental Health Investigations Branch at the California Department of Public Health. He was in this role for over 11 years. Dr. Fowles meets the ATSAC expertise requirement with expertise in toxicology and toxicity assessment, with additional expertise in inhalation toxicology and environmental public health.

Jessica Myers, PhD*

Dr. Jessica Myers was a senior toxicologist and risk assessor at the Texas Commission on Environmental Quality and was a toxicologist at this agency for nine years. Dr. Myers meets the ATSAC expertise requirement with expertise in toxicology and toxicity assessment, with additional expertise in inhalation and reproductive toxicology.

John Stanek, PhD

Dr. John Stanek is a Toxicologist with the Center for Public Health and Environmental Assessment at the U.S. Environmental Protection Agency (EPA) and been in this position for about 20 years. Dr. Stanek meets the ATSAC expertise requirement with expertise in toxicology and toxicity assessment, with additional expertise in inhalation toxicology.

Susan Tilton, PhD

Dr. Susan Tilton is an Associate Professor within the Environmental and Molecular Toxicology Department at Oregon State University (OSU) and Director of Academic Programs for Toxicology. Dr. Tilton is also a member of the OSU Environmental Health Sciences Center, an affiliated member of the OSU Center for Quantitative Life Sciences, and Principal Investigator on the OSU Superfund Research Program. Dr. Tilton's research focuses on modeling toxicity and disease from environmental factors, including complex chemical mixtures. Dr. Tilton meets the ATSAC expertise requirement with expertise in toxicology, with additional expertise in inhalation toxicology.

John J. Vandenberg, PhD

Dr. John Vandenberg has over 35 years of experience in environmental health risk assessment. He recently retired from the US EPA in 2021, where he served as Director of the Health and Environmental Effects Assessment Park Division of

the Center for Public Health and Environmental Assessment. Dr. Vandenberg meets the ATSAC expertise requirement with expertise in toxicology, toxicity assessment, and epidemiology, with additional expertise in inhalation, reproductive and development toxicology, and environmental public health.

ATSAC review of agencies' proposed plan and workflow for reviewing and updating TRVs

The first ATSAC meeting in October 2022 served as orientation for ATSAC members, where DEQ and OHA shared information about DEQ's air quality regulatory program and the purpose of ATSAC. The recording for that meeting is available on DEQ's ATSAC website. In the second ATSAC meeting (January 20, 2023), DEQ and OHA staff presented the agencies' overall plan for reviewing toxicity information and updating TRVs (Appendix J). ATSAC provided feedback on the agencies' proposed process (Appendix B). The rest of the process described in this chapter was also shared with and supported by ATSAC. ATSAC recommended changes and DEQ and OHA updated their plan based on ATSAC feedback (Appendix J). As a result of ATSAC feedback, OHA:

- Gathered additional calculation information for each candidate TRV beyond what OHA originally proposed to share with ATSAC. One example of additional information not already proposed for collection included exposure time adjustments the authoritative sources had applied to their TRVs. See "Exposure time adjustment policies for acute TRVs" under Step 5 below for more detailed explanation.
- Committed to share **all** candidate TRVs (all TRV options) with ATSAC. OHA had originally proposed to ATSAC to just share the one TRV option that OHA was proposing to select as the TRV proposal.
- Added flexibility to the TRV selection algorithm for **chronic** TRVs. OHA had originally proposed to ATSAC that Oha would consider only the recency of authoritative source publication date. OHA adopted ATSAC's recommendation to consider additional available attributes of a candidate TRV. One example of additional criteria recommended by ATSAC was whether the TRV was calculated using a more robust Point of Departure (POD) method (See Steps 3 and 6 below).
- Added flexibility to the TRV selection algorithm for **acute** TRVs. OHA originally proposed reliance on a strict hierarchy of authoritative sources. OHA adopted ATSAC's recommendation to consider additional criteria, such as how closely the exposures in the underlying study matched DEQ's 24-hour definition of acute

exposure.

Created TRV review tool

DEQ and OHA developed an Excel-based tool for OHA staff to use for aggregating, reviewing, and storing calculation information for all candidate TRVs from their sources. The tool was designed with entry pages focused on one chemical at a time that made it easier for OHA staff to enter information without errors and allowed side by side comparison of previous TRVs and candidates for new ones. Moreover, the tool allowed OHA to track decisions made about TRVs and document the rationale where deviations from the normal process were needed. The tool also exported tables for quality control (QC) to allow for review without compromising the underlying data. The tool created key tables of information that made it easy to query and to export into Workbook 1: DEQ Proposed TRVs and Workbook 2: TRV Derivation.

DEQ and OHA designed this tool with future reviews in mind and plan to continue to evolve this process, potentially turning this tool into a database in the next round of TRV review. DEQ made further improvements to the tool to accommodate ATSAC's feedback to include additional types of information about candidate TRV calculation. Both DEQ and OHA invested significant time and resources in the development process because they intend to use this design to streamline review, minimize input error, and track changes across future TRV update cycles.

Established petition process

As part of the TRV review process, DEQ rules [OAR 340-247-0040(4)] provide an option for members of the public to submit petitions to suggest TRV updates. OHA and DEQ developed fact sheets and online resources that members of the public could use to submit petitions. Through these resources, DEQ welcomed petitions for consideration during the current TRV update process. Petitions were due in November 2022. For this round of TRV review and update, DEQ received one petition to change DEQ's TRV for acute exposure (24-hour) for manganese. See Appendices C, G, and N-Q.

Step 2: Identify updated scientific assessments from authoritative sources named in rule

This step applies to the process of identifying candidate TRV values themselves. Step 3 below describes the process OHA followed to collect information about how each

candidate TRV was calculated. While OHA has described these two concepts as linear steps here, there was significant overlap and interplay between Steps 2 and 3.

In this review DEQ and OHA started from a list of 644 TACs developed by compiling reporting lists from authoritative sources, with a significant number coming from CalEPA. See Priority List Support Document for more details.

Authoritative sources

Oregon Administrative Rules (OAR), adopted by the EQC, specify sources of toxicity information considered to be authoritative in terms of their scientific rigor and comprehensive methods for deriving TRVs (OAR 340-247-0030). The four following authoritative sources are listed in OAR:

(1) United States Environmental Protection Agency (EPA),
(2) United States Agency for Toxic Substances and Disease Registry (ATSDR),
(3) California Environmental Protection Agency (CalEPA), and
(4) DEQ in consultation with the Air Toxics Science Advisory Committee (ATSAC).

Table 2-1 describes how different agencies use different names for the TRV-equivalent values they produce. OHA considered all these values as "candidate TRVs." Chapter 5 discusses candidate TRVs in the context of the various authoritative sources that calculated them.

Table 2-1: Names of candidate TRVs used by authoritative source agencies that calculate them

Authoritative Source	Name of Chronic TRV	Type of Chronic TRV Available	Name of Subchronic TRV*	Name of Acute TRV*
EPA	Inhalation Unit Risk (IUR)	Cancer	Subchronic RfC	None
	Reference Concentration (RfC)	Noncancer		
ATSDR	Chronic Minimal Risk Level (MRL)	Noncancer	Intermediate MRL	Acute MRL

Authoritative Source	Name of Chronic TRV	Type of Chronic TRV Available	Name of Subchronic TRV*	Name of Acute TRV*
CalEPA	IUR	Cancer	None	1-Hour REL
	Chronic Reference Exposure Level (REL)	Noncancer		
DEQ in Consultation with ATSAC	TRV (calculated from IUR)	Cancer	None	Acute TRV
	TRV	Noncancer		

*All noncancer TRVs

Reviewing candidate TRVs from EPA, ATSDR, and CalEPA

OHA first screened EPA, ATSDR, and CalEPA for updates to their TRVs because of their scientific rigor and capacity to develop TRVs. These agencies go through extensive peer-reviewed processes to establish TRVs using the best available science and research. For each chemical, expert panels assembled by these agencies spend years reviewing hundreds of scientific studies to evaluate the weight of scientific evidence. These agencies then share evaluations for public comment. The overall process these agencies use is lengthy and requires a substantial investment of resources.

Other state and local agencies rely on TRVs from EPA, ATSDR, and CalEPA as the basis for health-based industrial TAC programs. For example, programs in the states of Washington, New Jersey, Rhode Island, Massachusetts, New Hampshire, New York, Georgia, Minnesota, Michigan, and North Carolina all rely primarily on TRVs from the EPA and ATSDR.

OHA considered all TRVs produced by EPA, ATSDR, and CalEPA as candidate TRVs. In many cases, more than one agency had a candidate TRV for the same TAC. The process OHA followed to choose between the candidate TRVs is described under Step 5 later in this chapter.

Reviewing alternate sources for candidate TRVs (DEQ in consultation with ATSAC as authoritative source)

Oregon DEQ, in consultation with ATSAC, is on the list of authoritative sources (OAR 340-247-0030), providing OHA and DEQ more flexibility in the TRV update process. DEQ and OHA in consultation with ATSAC can develop TRVs and consider TRVs developed by organizations other than EPA, ATSDR, and CalEPA, hereafter referred to as "alternate sources." ATSAC encouraged OHA and DEQ to check alternate sources of candidate TRVs for a TAC if:

- None of the other authoritative sources (EPA, ATSDR, or CalEPA) had a candidate TRV,
- The TAC was on DEQ's Toxic Air Contaminant Priority List, and
- The alternate source:
    - had publicly available, transparent, and well documented calculation information for their candidate TRVs, and
    - applied similar calculation processes, methods, and policies as EPA, ATSDR, and CalEPA

OHA and DEQ also enlisted the help of an independent consulting company, Eastern Research Group (ERG), in scanning alternate sources of candidate TRVs for ten TACs that OHA and DEQ staff identified as a priority based on existing TRV sources and information about emissions from industrial facilities in Oregon. ERG has provided technical support for environmental and health agencies (such as EPA and ATSDR) for more than three decades. ERG's work is documented as a memo included as Appendix L with annotations from DEQ and OHA indicating agency selections for proposed TRVs.

In all cases where OHA developed a TRV for proposal under the authoritative source category of "DEQ in consultation with ATSAC," OHA either proposed to adopt a candidate TRV directly from an alternate source, as described above, or made a modification to a candidate TRV from an alternate source or from EPA, ATSDR, or CalEPA. **There were no instances where OHA calculated a new candidate TRV from primary research studies.** Chapter 5 describes the details for all proposed TRVs where "DEQ in consultation with ATSAC" is listed as the authoritative source.

Step 3: Collect information about the research studies and methods used to calculate TRVs ("calculation information")

In addition to collecting the value for each candidate TRV (Step 2), OHA staff collected information about how each candidate TRV was calculated from the authoritative source (Step 3). The calculation information is important to help OHA and ATSAC determine which TRV is based on the most robust science in the process described in Step 5 below. Calculation information is also a prerequisite to determine if adjustments to the candidate TRV are necessary and what those adjustments should be.

Extract calculation information

OHA staff reviewed information from authoritative sources about how each candidate TRV was calculated and entered it into the TRV review tool described in Step 1 above. Calculation parameters OHA captured for each candidate TRV included:

- TRV type (e.g., acute, chronic, noncancer, or cancer)
- Source of candidate TRV
- Candidate TRV value
- Publication date of the TRV by the source agency
- Species tested in the critical study
- Target organs
- Citation for the critical study
- Critical effect
- Point of Departure (POD) type [e.g., Lowest Observable Adverse Effect Level (LOAEL), No Observable Adverse Effect Level (NOAEL), Lower confidence limit of the Benchmark Concentration (BMCL)]
- Exposure duration in critical study
- Exposure time adjustments applied
- Interspecies dosimetric adjustments applied
- Uncertainty factors applied
- Links to source agency summary
- IUR for cancer TRVs only

As an output of the TRV review tool, "Workbook 2: TRV Derivation" includes all this information for each candidate TRV. As mentioned earlier, ATSAC had requested several of these calculation parameters be collected and shared (Appendix B and J).

Make necessary modifications and adjustments to TRVs

In cases where DEQ, in consultation with ATSAC, was the authoritative source, it was often necessary for OHA staff to modify TRVs. Common reasons for adjustment included:

- Exposure time adjustment for acute TRVs
- Modification of uncertainty factors to better match OHA policy (See Step 5 for list of OHA policies applied)

Chapter 5: Proposed TRVs where DEQ is the authoritative source describes other types of adjustments and includes detailed descriptions.

Step 4: Apply a third-party quality control process on all TRV information

Steps 2 and 3 required a lot of manual data entry of information into the TRV update tool. While the TRV update tool was designed to minimize risk of data entry errors, there was still potential for errors. DEQ engaged the services of ERG, an independent consulting firm, to check each entry in the TRV update tool. ERG has provided technical support for environmental and health agencies (such as the US EPA and ATSDR) for more than 3 decades. This means that every piece of data currently available in Workbooks 1 and 2 has been independently checked by at least two people (the agency staff who entered it, and a quality control staff with ERG). In cases where OHA staff made an adjustment to a TRV to better match OHA policy, ERG also checked this adjusted TRV for calculation errors. ERG summarized their quality control work in a memorandum, now included as Appendix K.

ERG's memo states "Out of the 327 TACs reviewed, approximately 111 had a potential error and 106 were updated by DEQ as a result." Eleven of those 111 (10%) had errors that changed the proposed TRV. Most of the errors were minor, such as wrong day of the month in the date of publication of a candidate TRV (64 instances), that would have had no bearing on the TRV. OHA integrated error corrections systematically. Even when anomalies identified by ERG were not actually errors, OHA used the feedback to make the presentation of information clearer and more consistent so that it would be less confusing to future reviewers and users. ERG's feedback significantly improved the quality of OHA's work and increased the level of confidence that OHA and DEQ have in the underlying data.

OHA made changes after ERG's contract period was over, including changes prompted by ATSAC review and authoritative source updates. OHA conducted in-house quality control on these changes by having a toxicologist that did not create the initial entry/correction check the work done by the other toxicologist.

Step 5: Select TRVs for proposal based on Oregon-specific process and policies

Once OHA compiled all relevant information for all candidate TRVs, OHA selected TRVs to recommend for each TAC using the process and policies described in this section. OHA checked for candidate TRVs in three categories for each TAC: one for cancer risk from chronic exposure, one for noncancer risk from chronic exposures, and one for noncancer risk from acute exposures. OHA could not find a TRV for every category for every TAC. In many cases, multiple different TRVs were available for the same TAC for the same risk and exposure category from different authoritative sources. ATSAC requested and informed a consolidated set of processes and policies that guided OHA's selection of TRVs (Appendices A through B, E, H, and J). This section contains that consolidated list of processes and policies.

General process for selection of cancer and noncancer chronic TRVs

- **First choice:** Most recently published from among EPA, ATSDR, and CalEPA.
    - OHA deviated from selecting the most recently published value if:
        - An older value from another Authoritative Source was based on newer critical study or more modern POD calculation method, such as BMCL.
        - The only candidate TRV from EPA, ATSDR or CalEPA had a total uncertainty factor (UF) greater than 3,000.
- **Second choice:** If no candidate cancer or noncancer chronic TRVs were available for a given TAC from EPA, ATSDR, or CalEPA, OHA looked to alternate sources, especially other states, like the Texas Commission on Environmental Quality (TCEQ) and Minnesota Department of Health (MDH) because they had thorough, transparent, and readily available documentation. In most cases, OHA adopted candidate TRVs from these sources without modifications. In some cases, OHA modified candidate TRVs from these alternate sources to better fit OHA policy (see policies section below). For example:
    - In consultation with ATSAC, OHA is proposing to adopt TCEQ's chronic reference value for acetone but modified TCEQ's LOAEL to NOAEL UF

from 2 to 10 to better match EPA and California EPA policy.

General process for selection of acute TRVs

The process for choosing acute TRVs was more complex because of the need to select TRV candidates calculated from studies that best matched the 24-hour exposure time definition of DEQ's acute TRVs.

- **First choice:** ATSDR acute MRLs – No exposure time adjustments are necessary for ATSDR acute MRLs because these values are intended to protect up to two weeks, so 24 hours is included in that exposure time.
- **Second choice:** ATSDR intermediate MRLs, subchronic RfCs from EPA, or California EPA 1-hour RELs – whichever has the best balance of recent science and close match in exposure time to DEQ's 24-hour definition of acute. These types of values require an exposure time adjustment, unless the TAC meets the criteria for sensory irritation through the trigeminal nerve or is based on a developmental health effect (see policy below).
- **Third choice:** OHA turned to alternate sources (not EPA, ATSDR, or CalEPA) in consultation with ATSAC when:
    - None of EPA, ATSDR, or CalEPA had a candidate acute TRV for a TAC or
    - Occasionally, when an alternate source had a candidate value based on a study with an exposure time that better matched the DEQ 24-hour definition of acute. For example, in the case of vinylidene chloride, OHA selected a 24-hour TCEQ reference value rather than an ATSDR intermediate MRL because of the exact match to DEQ's 24-hour definition of acute.

List of policies

ATSAC requested that OHA create a consolidated list of policies applied to the TRV selection and calculation process for added transparency (See Appendices A, E and H). This subsection contains the requested consolidated list of policies that OHA applied when selecting TRVs from among candidate values from authoritative sources and when modifying and calculating TRVs. Many of these policies are supported by other authoritative sources like EPA, ATSDR, or CalEPA and many are informed by ATSAC feedback (Appendices A-J). OHA follows the list of policies below unless specifically documented in the TRV Support Document for certain TRVs:

General policies

- Round final TRVs to two significant figures. When calculating or deriving TRVs, OHA used all available digits on inputs for calculations and only rounded for the final TRV.
- Apply a target risk of 1 in a million ($1x10^{-6}$) for cancer and a hazard quotient of 1 for noncancer TRVs.
- Do not adopt a chronic noncancer TRV for a TAC when all candidate chronic noncancer TRVs are higher than the selected acute TRV. Note that acute TRVs are intended to be health protective over relatively short, 24-hour exposures, and a chronic TRV is intended to be health protective over relatively long, 1-year or more, exposures. Usually, an acute TRV is higher than a chronic TRV because it generally takes a larger amount of a TAC to harm health over a short exposure than a long one. When an acute TRV is lower than the candidate chronic TRV it signals that the candidate chronic TRV may not be protective enough of health. (1)

Point of departure (POD) policies

- Do not adopt candidate TRVs calculated by applying additional adjustments to occupational exposure limits.
- Select candidate TRVs based on BMCLs rather than LOAELs and NOAELs as PODs when data quality is adequate to support calculation of a quality BMCL because BMCLs incorporate all the data in a dose-response curve as opposed to just a single point.

Exposure time adjustment policies for acute TRVs

Where applicable, adjust exposure time on acute TRVs to match DEQ's 24-hour definition of acute.

- Do not apply exposure time adjustments to ATSDR acute MRLs because 24 hours is already within the window they are designed to cover.
- Apply a default exponent "n" of 1 to the ten Berge adjustment to "Haber's Law" when adjusting from experimental exposures shorter than 24 hours up to 24 hours. Apply a default of 3 when adjusting from exposures longer than 24 hours down to 24 hours. When adjusting exposure times, there is a concept called "Haber's Law" that equates the length of time a person is exposed to a TAC and the amount of the TAC the person is exposed to over that time. There is also an

adjustment to that concept called the “ten Berge adjustment” which relates to the amount of relative importance of exposure time versus exposure amount. The ten Berge adjustment is represented in mathematical formulas by an exponent called “exponent ‘n’.” See Chapter 5 section 5.2.1 for examples and more details. (2,3)

- When adapting ATSDR intermediate MRLs or subchronic values to acute values, remove the days per week portion of intermittent exposure adjustment, but do not apply “Haber’s Law” to compress total experimental exposure hours down to 24 hours. This policy was directly recommended by ATSAC members as it is more protective of health. See Chapter 5 section 5.2.3 for examples and more detail.
- Do not use empirically derived exponent “n” values unless the empirical study included observations that span the range within which an exposure time is being adjusted. For example, if an empirical study to determine exponent “n” only includes observations from 1 hour to 7 hours, then it should not be applied when extrapolating from a shorter experimental exposure out to 24 hours. In such cases, the default value of 1 should be used for exponent “n.” (3)
- Do not adjust exposure time for acute TRVs if the only effect is eye or mucosal membrane irritation mediated by trigeminal nerve stimulation. (2,3) Note that:
    - Eye or mucosal membrane irritation can also be caused by damage to cells, which may be cumulative. In such cases, it is still appropriate to adjust exposure time.
    - Generally, OHA will adjust exposure time if the authoritative source from which the candidate TRV came did so in their calculation.
    - Generally, OHA will not adjust exposure time if the authoritative source from which the candidate TRV came did not adjust in their calculation.
    - In cases where there is eye or mucosal membrane irritation and it is not clear whether it was caused solely by trigeminal nerve stimulation, OHA will assume there may have been other causes at play and adjust exposure time.
- Do not adjust exposure time if any of the critical health effects are developmental in nature. A developmental effect can be caused by a short exposure if it occurs during a critical developmental window. Most developmental studies are not designed to determine the minimum exposure time required to cause the developmental effect. (2)

Uncertainty factor (UF) policies (see Appendix M for more UF policies)

- Do not adopt any candidate TRV with total UFs greater than 3,000 and do not modify a total UF for the express purpose of making the total UF 3,000 or any other limit.
- Generally, apply the same UFs applied by the EPA, ATSDR, or CalEPA. OHA may modify UF for time adjustment purposes (e.g., adjusting from an intermediate ATSDR MRL to a chronic TRV) or when the candidate value is from a source other than EPA, ATSDR, or CalEPA.

Step 6: Evaluate petitions from the public for changes to TRVs

In this TAC Review and Update Rulemaking, DEQ received one petition (Appendix N). The petition was for consideration of a different candidate TRV for acute manganese exposure. OHA:

- prepared a framing document for ATSAC (Appendix O),
- held a meeting with ATSAC soliciting their feedback in which petitioners presented their materials directly to ATSAC (Appendix C),
- mediated a series of follow-up communications with ATSAC and the petitioners (Appendix G and P),
- considered the petition as well as ATSAC feedback, and
- developed a proposed acute TRV for manganese (Appendix Q and Workbooks 1 and 2).

DEQ's current (2018) acute TRV for manganese is 0.3 micrograms per cubic meter of air ($\mu g/m^3$) (adopted in rule in 2018). Petitioners requested that the acute TRV be modified to 5 $\mu g/m^3$ (Appendix N). After consultation with ATSAC (Appendix C) and addressing follow-up requests from the petitioners with ATSAC (Appendix G and P), OHA is proposing an acute TRV of 1.3 $\mu g/m^3$ for manganese (Appendix Q).

Step 7: Seek feedback from ATSAC on TRV proposals

As OHA staff went through Steps 1-6 above, they encountered themes and topics for ATSAC review and consideration. OHA staff prepared several documents to frame those themes and topics for ATSAC meetings and discussions. Table 2-2 summarizes the materials prepared for ATSAC in advance of meetings and provides a crosswalk to where those materials appear in the current or revised forms in this document. OHA updated all material in the chapters of the TRV Support Document to incorporate ATSAC feedback.

Table 2-2: Materials provided to ATSAC for review and current location of related content

Resource title and website link as presented to ATSAC	Description	Current location of related content
Proposed TRV and Selection Process for ATSAC	Presented ATSAC with OHA's proposed procedures and policies for reviewing and updating TRVs and solicited ATSAC feedback on those procedures and policies.	Step 1-3 and 6 above and Appendix B and J
DEQ and OHA Framing Document for DEQ's ATSAC: Petition for Changes DEQ's Manganese Toxicity Reference Value for Acute Exposure	Framed the manganese petition key points and discussion questions for ATSAC and solicited their feedback.	Step 5 above and Appendix C, G, and N-Q
Overview of TRV Review	Served as table of contents of resources OHA had prepared for ATSAC meetings #4-8 and consolidate links to those resources.	This table and Tables 1-1 and 1-2 in Chapter 1.
QC of Toxicity Reference Values	This document was authored by ERG on behalf of DEQ and describes the process ERG followed to check or QC the entries OHA staff made to the TRV update tool.	Step 4 above and Appendix K

Resource title and website link as presented to ATSAC	Description	Current location of related content
ATSAC Meetings #5-7 Discussion Questions	These are the key questions DEQ and OHA sought ATSAC feedback on. Questions are grouped by topic and correspond to certain documents in this table. After the final meeting in this series, DEQ and OHA requested that ATSAC members record their final thoughts on each question in the worksheet space provided and send them to DEQ and OHA.	Appendix H
Proposed TRVs Where DEQ is the Authoritative Source	This document contained calculation information about every TRV where DEQ was listed as the authoritative source.	Chapter 5 and Appendix E and H
Proposed Groupings of Toxic Air Contaminants	Many TACs belong to families or groups of chemicals, and this document explained how DEQ and OHA proposed to group and apply TRVs in these cases.	Chapter 3 and Appendix E and H
Proposed TRVs Using PPRTV Screening Values as the Authoritative Source	In rare cases, the only candidate TRV available for a TAC came from a “Screening PPRTV.” This document described screening PPRTVs and framed this topic for ATSAC discussion questions related to them.	Chapter 4, section 4.1 and Appendix E and H

Resource title and website link as presented to ATSAC	Description	Current location of related content
Proposed TRVs Not Yet Finalized by Authoritative Sources	In rare cases, DEQ proposed to adopt a candidate TRV from an authoritative source that was still considered a draft value by that authoritative source. This document framed this topic for ATSAC discussion questions related to these cases.	Chapter 4, section 4.2 and Appendix E and H
Diesel Particulate Matter Framing Document	This document framed key scientific points related to OHA's proposed cancer TRV for diesel particulate matter for ATSAC discussion in meeting #8.	Chapter 6, section 6.1 and Appendix F, I, and T
DEQ Proposed TRVs	This workbook contained all proposed TRVs along with information about whether the proposed value was different from the one in existing rule and, if so, a very brief reason for the change.	Workbook 1: DEQ Proposed TRVs revised post-ATSAC

Resource title and website link as presented to ATSAC	Description	Current location of related content
TRV Derivation	This workbook contained calculation information for all TRVs and highlighted those that were proposed to change with this round of revisions, especially when there were multiple candidate TRVs available to choose from. Calculation information was available not only for the TRV selected for proposal, but also for all candidate TRVs. This is so that ATSAC could verify that DEQ and OHA selected the most scientifically robust TRV when there were multiple options to choose from.	Workbook 2: TRV Derivation revised post-ATSAC

Between October 2022 and May 2025, ATSAC members attended a series of eight virtual meetings to discuss updating DEQ's TRVs. These meetings were an average of two hours long. ATSAC members attended over 17 hours of meetings. ATSAC members submitted written responses to over 60 questions and, in preparation, read over 450 pages of technical information. These totals do not include hours or pages that individual ATSAC members may have spent reviewing additional information outside of meetings.

Meeting minutes and recordings for ATSAC meetings #1-8 are available on the DEQ ATSAC website. ATSAC meeting minutes and written responses from ATSAC on discussion questions can also be found as Appendices B-I, and R in this document.

Step 8: Integrate feedback from ATSAC

ATSAC provided OHA with a tremendous amount of valuable input on both (1) the overall process of reviewing and updating TRVs and (2) specific TRVs. Unless noted and documented in this TRV Support Document, ATSAC was supportive of OHA's methods, process, and individual TRV selections.

ATSAC feedback resulted in changes to 113 TRVs across 70 TACs as well as many other technical improvements to the presentation of relevant calculation information and to the transparency of underlying guidelines and policies that OHA followed. OHA integrated ATSAC's feedback into the body of this TRV Support Document and wrote Appendix A to explicitly document how ATSAC feedback was incorporated.

OHA accepted the vast majority of ATSAC feedback and integrated it as thoroughly as possible. In cases where the opinions were split among ATSAC members, OHA staff exercised their best professional judgement to find the most appropriate route forward and provided a written explanation of their decision in the TRV Support Document.

OHA is deferring some of ATSAC's feedback to a future TAC Review and Update Rulemaking (specific ATSAC feedback is provided in Appendix A). None of the ATSAC feedback that OHA proposes to defer has direct bearing on TRVs selected and proposed for this current TAC Review and Update Rulemaking. In other words, had OHA incorporated these pieces of ATSAC feedback none of the numerical values themselves would be different than currently proposed.

The main reason OHA is deferring some of ATSAC's advice is because integrating it now would require OHA staff to return to the authoritative source materials for each TAC to extract the specific supplemental pieces of information requested for display purposes in Workbooks 1 and 2. The additional information is not critical to evaluating or proposing TRVs. This would add significant delay to an already prolonged process of TRV review and update. OHA plans to apply these deferred items of ATSAC input to a future round of TRV review.

OHA is very grateful for the many hours ATSAC members spent reviewing materials, preparing for meetings, attending meetings, and responding to follow up requests. It was a lot of work for a volunteer committee.

Section 2.3 Outcome of review and update process

2.3.1 Summary of TRV proposals

OHA staff have individually reviewed approximately 51 pieces of information for each of 377 TACs, which is around 20,000 data points. The result of that effort is the remainder of this TRV Support Document and two Excel Workbooks: Workbook 1: DEQ Proposed TRVs and Workbook 2: TRV Derivation. Table 2-3 below lists some high-level summary statistics about the 377 TACs for which OHA is recommending at least one TRV.

Table 2-3: Counts of TACs with proposed changes to TRVs

Parameter	Count
TACs that OHA researched for availability of new or updated TRVs	**644**
TACs for which OHA is not recommending a TRV (41% of 644)	*267*
TACs for which OHA is recommending at least one TRV (59% of 644)	*377*

OHA is recommending a total of 623 TRV proposals for 377 TACs. These 623 TRVs do not include the two 2018 TRVs that OHA is recommending be deleted. Table 2-4 lists high level summary statistics about OHA-recommended TRV proposals.

Table 2- 4: Summary statistics for proposed changes to TRVs

Parameter	Count
Total new, changed and retained TRVs compared to current 2018 Rule (for 377 TACs)	**623**
New: TRV recommendations that are new since the 2018 rule (32% of 623)	*197*
Changed: TRV recommendations that are different from the TRV in 2018 Rule (including two 2018 TRVs recommended for deletion) (21% of 623)	*136*
Retained: TRV recommendations that are the same as the TRV adopted in 2018 Rule (47% of 623)	*292*

Of the 136 TRV proposals that are different from the TRV adopted in 2018 rule, 77 TRV changes (or 57%) were due to more recent science discovered as part of this TAC Review and Update Rulemaking. An additional 25 TRV changes (or 19%) were the result of applying an exposure time adjustment to acute TRVs, which was an approach encouraged and informed by ATSAC. A complete list and summary of reasons for TRV changes is available on the information tab (Tab 1) of Workbook 1: DEQ Proposed TRVs.

Of the 623 proposed TRVs, 276 (44%) had more than one candidate TRV available from authoritative sources. Of the 623 proposed TRVs, 237 (38%) list "DEQ in consultation with ATSAC" as the authoritative source. OHA flagged TRVs in these two unrelated categories for special attention from ATSAC.

2.3.2 TRV review key dates

Authoritative sources are continuously updating TRVs. To manage the process of preparing a large batch of TRV proposals for this rulemaking, OHA paused reviewing authoritative sources for new TRVs on a series of dates throughout the process:

- January 2022: OHA started review of authoritative sources for TRV updates and collecting necessary information to make selections for proposal.
- August 8, 2024: OHA finished incorporating all new updates to inhalation TRV information from all authoritative sources including TRV information that was not yet finalized by authoritative sources.
- December 2, 2024: OHA checked the list of draft TRVs and updated information for those that had been finalized by their authoritative sources in the interim between August 8 and December 2, 2024.
- January 15, 2025: OHA presented all TRV proposals to ATSAC (ATSAC Meeting #4).
- May 14, 2025: Last ATSAC meeting of planned series (ATSAC Meeting #8).
- July 21, 2025: OHA reviewed TRV updates from all authoritative sources again to prepare the TRV proposals for DEQ's RAC. Ten of the TRVs not finalized by authoritative sources at the time of the ATSAC meetings have since been finalized by these sources. None of these TRVs changed between the public comment version and the final version published by the sources (see Chapter 4 for more details).

All TRV updates from federal authoritative sources incorporated for the RAC were originally drafted prior to 2025 and were reviewed by ATSAC in 2025. For more information on the key dates, see Chapter 4.

OHA will continue to monitor TRV updates from authoritative sources and may incorporate more updates from authoritative sources before the public comment period of the current rulemaking (Chapter 4). OHA's priority is to move the set of TRV proposals through the rulemaking process.

Chapter 3: Groupings of Chemicals

Section 3.1 Background

The purpose of this chapter is to describe the different groups and classes of TACs for which OHA is proposing TRVs during this current rulemaking and how DEQ intends for the members of those groups and classes to be compared against their TRVs.

There are many different cases where it is appropriate to group TACs based on structural or toxicological similarities:

- The similarities are sufficient to apply the same TRV to all members of the group of TACs (refer to section 3.2).
- The members of a group, sometimes called a "class," of TACs cause the same specific health effects in the same way (i.e., they have the same mode of action), but members of the class vary in the amount needed to cause those effects (refer to section 3.3).
- In the case of metals and compounds containing those metals, the toxicity is based on the metal component of those compounds (refer to section 3.4).

Section 3.2 Chemical groups that can be summed and compared directly to a TRV that applies to the group

Chemicals within the groups in this section are so structurally and toxicologically similar that toxicologists consider the members of the group equivalent in toxicity. For example, there is one TRV that applies to all three trimethylbenzenes (Table 3-1). All members of the group can affect health at the same level of exposure so their measured or monitored concentrations can be directly compared to a single TRV for the group either individually or in sum.

Table 3-1: Chemical class names, members of class and OHA proposal

Chemical group name in TRV workbook (CAS RN or ID#)	Members of group (CAS RN)	Difference in approach from existing rule
Trimethylbenzene (mixed isomers) (25551-13-7)	1,2,3-Trimethylbenzene (526-73-8)	Existing rule has TRVs from various sources for individual trimethylbenzenes. In

Chemical group name in TRV workbook (CAS RN or ID#)	Members of group (CAS RN)	Difference in approach from existing rule
	1,2,4-Trimethylbenzene (95-63-6) 1,3,5-Trimethylbenzene (108-67-8)	2023, CalEPA published new TRVs and stated that they apply to these three isomers.
1,3-Dichloropropene (542-75-6) Mixtures of *cis*- and *trans*-1,3-dichloropropene	*cis*-1,3-Dichloropropene (10061-01-5) *trans*-1,3-Dichloropropene (10061-02-6)	Existing rule does not distinguish between isomers, and there is no proposed change in TRVs. However, the toxicological studies underlying the existing TRVs were done using "technical grade 1,3-dichloropropene" which is made up of approximately equal parts *cis*- and *trans*-isomers.
Cresols (mixture) (1319-77-3)	*m*-Cresol (108-39-4) *o*-Cresol (95-48-7) *p*-Cresol (106-44-5)	No change in grouping from existing rule.
Polybrominated diphenyl ethers (PBDEs) excluding decabromodiphenyl ether-209 (447)	DEQ proposes to apply the TRV for octabrominated diphenyl ethers (32536-52-0) to all PBDEs except decabrominated diphenyl ether. This is consistent with ATSDR's approach.	No change in grouping from existing rule.

Chemical group name in TRV workbook (CAS RN or ID#)	Members of group (CAS RN)	Difference in approach from existing rule
Total Polychlorinated Biphenyls (PCBs), evaporated mixtures and aerosols and particulates (1336-36-3) Unspeciated mixtures of PCB congeners	This proposed grouping follows OEHHA's approach and allows for use of their TRV, which applies to this class.	No change in grouping from existing rule. However, DEQ proposes to differentiate between evaporated PCBs mixtures and particulate PCB mixtures. This was already suggested by both EPA and OEHHA.
Toluene diisocyanates (2,4- and 2,6-) (26471-62-5)	Toluene-2,6-diisocyanate (91-08-7) Toluene-2,4-diisocyanate (584-84-9)	TRVs in existing rule are from 2016 OEHHA. Neither OEHHA nor ATSDR distinguish between isomers and apply their values to any mixture of the two isomers. OHA is proposing the use of 2018 ATSDR values and to apply them to the mixture of isomers like OEHHA and ATSDR do.
Xylene (mixture) (1330-20-7)	*p*-Xylene (106-42-3) *o*-Xylene (95-47-6) *m*-Xylene (108-38-3)	No change in grouping from existing rule.

Section 3.3 Chemical classes with toxicity equivalency factors or relative potency factors

Groups of TACs described in this section are typically called “classes” of TACs. Individual members of these classes of TACs are called “congeners.” Congeners within these classes share similar chemical structures and similar modes of action as in section 3.2 above, but the congeners differ in the amount needed to activate that common mode of action. In other words, they have different potencies relative to one another. For these classes of TACs, risk assessors identify a representative congener, typically the most toxic or potent in the class, and designate it as the “index congener.” Risk assessors then apply toxicity equivalency factors (TEFs) or relative potency factors (RPFs) to the rest of the congeners in those classes. The TEF or RPF describes how toxic or potent each congener is relative to the index congener in the class.

For these classes of TACs, OHA calculated TRVs for individual congeners by applying the TEF or RPF of the individual congener to the TRV for the index congener. Risk assessors can then assess risk from the whole class by first calculating risk from each congener in the class and then summing the risk from all congeners in the class. The next two subsections identify the common mode of action and index congener for the two classes of TACs that are in this category.

3.3.1 Chlorinated and brominated dioxins and furans & dioxin-like polychlorinated and polybrominated biphenyls

The index congener for the following chemical classes is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) (1746-01-6):

- chlorinated dioxins (PCDDs)
- chlorinated furans (PCDFs)
- brominated dioxins (PBDDs)
- brominated furans (PBDFs)
- dioxin-like polychlorinated biphenyls
- dioxin-like polybrominated biphenyls

The common mode of action for this class is mediated by an intracellular receptor called the aryl hydrocarbon receptor. The TEF for each congener is determined by how efficiently that congener binds and activates that receptor relative to the index congener (2,3,7,8-TCDD), which is the most potent activator of the aryl hydrocarbon receptor. The U.S. Environmental Protection Agency (EPA) and World Health Organization (WHO)

have both recommended a specific set of TEFs for dioxins, furans, and dioxin-like PCBs. (4,5) OHA proposes to use the WHO's updated 2022 TEFs as advised by ATSAC. ATSDR has also formally adopted the 2022 WHO TEFs. (6) The WHO updated these values using more advanced methods that allowed for integration of more data and more advanced statistics that allow for more precise uncertainty estimates. See Appendix S for more justification for adopting the 2022 WHO TEFs (see Tab 7 in Workbook 2: TRV Derivation).

In this rulemaking, OHA proposes to apply TEFs for chlorinated dioxins, furans, and dioxin-like polychlorinated biphenyls (PCBs) to their brominated structural analogues and to include risk from brominated dioxins, furans, and dioxin-like polybrominated biphenyls (PBBs) in the risk for the dioxin/furan class. This approach is recommended in a peer-reviewed publication (7), and ATSAC has previously communicated approval of this proposed approach in a series of email communications documented in Appendix R. OHA applied TEFs from the "2022 WHO-TEF" column in Table 1 of DeVito et al. (4) to the chlorinated and brominated version of each structural analogue to calculate a TRV.

The equations applied for calculating TRVs for individual dioxin/furan congeners are:

Cancer

$$TRV_n = \frac{Target\ Risk}{IUR_I \times TEF_n} = \frac{1 \times 10^{-6}}{38\ (\frac{\mu g}{m^3})^{-1} \times TEF_n}$$

Noncancer

$$TRV_n = \frac{TRV_I}{TEF_n} = \frac{0.00004\ \mu g/m^3}{TEF_n}$$

Where:

TRV_n = the TRV for specific congener "n"

IUR_I = Inhalation unit risk for the index dioxin, which is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). That IUR is 38 $(\mu g/m^3)^{-1}$.

TEF_n = The TEF for specific congener "n"

TRV_I = the noncancer TRV for the index dioxin (TCDD) which is 0.00004 $\mu g/m^3$

3.3.2 Carcinogenic polycyclic aromatic hydrocarbons (cPAHs)

The index congener for carcinogenic PAHs, or cPAHs, is benzo[a]pyrene. All cPAHs can cause mutations, or permanent changes in DNA, which contributes to increased risk of various cancers. OHA proposes to continue using a collection of RPFs used by the Minnesota Department of Health (8) for calculation of congener-specific cancer TRVs. These are the same RPFs that DEQ applied to calculate the 2018 TRVs, so this is not a proposed change. Many of the RPFs Minnesota uses come from the EPA in addition to others from California's Office of Environmental Health Hazard Assessment (OEHHA) for congeners for which EPA did not have values. Similar to the EPA, OHA only applies the RPF system to cPAHs for cancer risk. OHA proposes to continue evaluating noncancer hazard for cPAHs based on congener-specific information. Currently, congener-specific noncancer TRVs are only available for benzo[a]pyrene and no other cPAH congeners.

OHA proposes to continue evaluating both cancer risk and noncancer hazard separately for naphthalene and 1- and 2-methylnaphthalene. They each have their own separate toxicity information outside the RPF system.

Section 3.4 Inorganic TACs and their associated compounds

Metals and other inorganic ions like fluorides and cyanides come in different physical forms (fumes, particulates, aerosols, etc.) and are often combined, or "compounded," with a variety of other substances. In this section, OHA provides clarity about how these types of TACs are grouped and how OHA proposes to apply TRVs to these groups.

3.4.1 Metals and metalloids

In most cases, when applying a TRV to chemical compounds that contain a metal, OHA applies the TRV only to the mass fraction of the metal in that compound. This is the method used by all the authoritative sources OHA considers for evaluating toxicity from metals via inhalation. In limited cases, there are some metal compounds that have individual, specific TRVs. For these compounds the TRV is applied to the entire amount of the compound, not just the metal portion.

In "Workbook 1: DEQ Proposed TRVs" and "Workbook 2: TRV Derivation" where TACs are listed as "metal and compounds" the TRVs are intended to be applied to all compounds in that group. DEQ also has a resource titled Appendix Workbook for the

Priority List that includes specific compounds under these headings and their respective molecular weight fractions.

Metal groupings with TRVs are listed below. In some cases, OHA further subdivided groups of metal-containing compounds by factors such as solubility or form. In other cases, there are compound-specific considerations. The list below makes note of such exceptions and whether those exceptions are newly proposed with this rulemaking or are already being applied under current implementation.

- **Aluminum and compounds (7429-90-5)**
- **Antimony and compounds (7440-36-0)**
- **Arsenic and inorganic compounds (7440-38-2):** Arsine gas (a compound of arsenic and hydrogen) has its own TRVs and should not be grouped with other arsenic-containing compounds. This is not a change from existing rule.
- **Barium and compounds (7440-39-3)**
- **Beryllium and compounds (7440-41-7)**
- **Cadmium and compounds (7440-43-9)**
- **Chromium VI and compounds (7738-94-5 and 18540-29-9):** OHA divides chromium VI compounds into "acid mist aerosols" and "chromate or dichromate particulate." While the cancer and chronic noncancer TRVs are the same for these groups, the acute TRVs differ due to the more intense corrosivity of the acid mist in short-term exposure scenarios relative to the particulate. ATSDR also uses this approach, and it is not a change from existing rule.
- **Chromium, trivalent and compounds (soluble and insoluble) (16065-83-1):** OHA is proposing to divide trivalent chromium into soluble and insoluble compounds with different sets of TRVs consistent with OEHHA's approach. These are new TRVs and metal groups that OHA proposed in this rulemaking.
- **Cobalt and compounds (7440-48-4):** OHA proposes to divide cobalt compounds into soluble and insoluble compounds consistent with OEHHA's approach. This proposal is a change from existing rule.
- **Copper and compounds (soluble and insoluble) (7440-50-8)**
- **Lead and compounds (7439-92-1)**
- **Manganese and compounds (7439-96-5)**
- **Mercury and inorganic compounds (7439-97-6)**
- **Nickel and compounds (7440-02-0):** OHA previously split nickel compounds into soluble and insoluble compounds. However, OEHHA and ATSDR's most recent toxicological information consolidates these compounds into one, and OHA proposes to follow their approach in this rulemaking. Nickel oxide has its own entry and chronic noncancer TRV, separate from "nickel and compounds." The chronic noncancer TRV for nickel oxide is based on a different critical study

and slightly different critical effects than for other nickel compounds. Nickel oxide also has a different interspecies dosimetric adjustment factor (DAF) compared to other nickel compounds. The justification and details for these differences are detailed starting at the bottom of page 110 of OEHHA's 2012 Nickel Reference Exposure Levels document. (9) The noncancer acute and cancer TRVs from the rest of "nickel and compounds" are to be applied to nickel oxide.

- **Selenium and compounds (7782-49-2)**
- **Uranium and compounds (soluble and insoluble) (7440-61-1):** OHA is proposing to divide these into soluble and insoluble because ATSDR has different TRVs available for the different groups.
- **Vanadium and compounds (7440-62-2):** OHA is proposing to consolidate "vanadium fume or dust" and "vanadium pentoxide" into a single "vanadium and compounds" TRV. This is consistent with ATSDR and EPA and is a change to existing rule.

3.4.2 Non-metal inorganic or ionic TACs

In addition to metals there are also inorganic or ionic TACs that tend to form compounds with various other substances. Like metals, DEQ and other authoritative sources have consistently adjusted concentrations of these compounds by molecular weight such that only the relevant portion of the substance is compared against the TRVs. OHA proposes to continue this methodology for these non-metal, inorganic and ionic TACs.

Like metals, DEQ will provide regulated facilities with specific lists of examples of compounds that fall within each group. TACs in this category are listed below with exceptions to the general approach above or compound-specific exceptions noted.

- **Cyanide and inorganic compounds (57-12-5)**
- **Fluoride and inorganic compounds (239):** Previously**,** DEQ separately listed hydrogen fluoride, fluoride, and fluorine gas.
    - OHA proposes to consolidate hydrogen fluoride and fluoride under one heading "Fluoride and inorganic compounds" with the TRV for hydrogen fluoride applied to all compounds. This is consistent with OEHHA's and ATSDR's approaches. OHA proposes to keep fluorine gas separate from fluoride and inorganic compounds in terms of grouping and TRV applications even though the acute TRVs for fluorine gas and "fluoride and inorganic compounds" coincidentally have the same numerical values.
    - OHA also proposes:
        - To follow OEHHA's approach of not applying the acute TRV for "fluoride and inorganic compounds" to the aluminum sodium fluoride or sodium fluorides.

    - To follow ATSAC's advice and adopt California EPA's acute and chronic noncancer TRVs for sulfuryl fluoride and to evaluate risk for this compound separately from other fluoride compounds.
- **Sulfuric acid and Oleum (fuming sulfuric acid) (7664-93-9 and 8014-95-7):** This group includes sulfuric acid or sulfur trioxide, and "oleum" or fuming sulfuric acid. Only the acute TRV for sulfuric acid should be applied to oleum as per OEHHA's approach. This is because oleum is so reactive that a chronic exposure to it is not possible. This grouping is a new proposal for OHA.

Section 3.5 Silica (7631-86-9)

Respirable particles of silica can cause serious respiratory impairment when inhaled. The severity of health effects from inhaled silica depends on the form. In existing rule DEQ only has TRVs for one group of silica compounds, called crystalline silica. OHA reviewed key resources to decide how to group silica compounds for this round of TRV updates:

- ATSDR Tox Profile for Silica (published 2019)
- TCEQ documents for amorphous and other non-crystalline forms of silica (published 2011)
- TCEQ documents for silica, crystalline forms (**24-hour**; published 2020)
- TCEQ documents for silica, crystalline forms (published 2009)
- OEHHA document for silica, crystalline forms chronic value (published 2005)

OHA proposes to add a second group of silica-containing compounds with a TRV. The two proposed groups are "Silica, Crystalline (respirable)" or "c-silica" and "Silica, amorphous and other non-crystalline forms (respirable)" or "a-silica." Each group has its own set of TRVs. Proposed members of the groups are listed in 3.5.1 and 3.5.2 below.

3.5.1 Group 1: Silica, crystalline forms (respirable) "c-Silica"

- Silica (7631-86-9)
- Cristobalite (14464-46-1)
- Flux-calcined diatomaceous earth (68855-54-9)
- Quartz (14808-60-7)
- Tridymite (15468-32-3)
- Tripoli (1317-95-9)

OHA proposes to define c-silica as any of these listed forms of silica in the 4 microns (µm) or less size fraction. Related to this size fraction, the Texas Commission on Environmental Quality (TCEQ) states, "as with acute exposure, the chronic toxicity of

silica particles is related to particle size. The key study evaluated silicosis in miners exposed to silica in the size range of 0.5-5 µm. In addition, CalEPA noted that the chronic reference exposure level (REL) for silica is applicable to particles considered respirable as defined by the occupational hygiene methods described by ACGIH (≤4 µm), noting that this definition differs from the typical environmental definition of respirable as particles ≤ 10 µm (CalEPA 2005)". (10)

3.5.2 Group 2: Silica, amorphous and other non-crystalline forms (respirable) "a-Silica"

- Fused silica or vitreous silica (60676-86-0)
- Silica fume (69012-4-2)
- Uncalcined diatomaceous earth (61790-53-2)
- Calcined diatomaceous earth (91053-39-3)
- Pyrogenic colloidal silica (112945-52-5)
- Precipitated silica (112926-00-8)
- Silica gel (63231-67-4)

TCEQ's Technical Support Document for non-crystalline silica states, "Since no acute or subacute studies of non-synthetic amorphous silica (non-SAS) forms were available, the acute ReV and ESL developed for SAS are used for all forms of amorphous and non-crystalline silica, including fused, silica fume, uncalcined diatomaceous earth, pyrogenic colloidal silica, precipitated silica, and silica gel." (11) OHA proposes to define a-silica as any of these listed forms of silica in the 10 microns or less size fraction. OHA will continue monitor authoritative sources for candidate TRVs for specific members of the amorphous silica group for future updates.

Chapter 4: Authoritative Source Special Cases

Section 4.1 Proposed TRVs using screening PPRTVs as the authoritative source

4.1.1 Background

As described in Chapter 2, OAR specifies sources of toxicity information considered to be authoritative in terms of their scientific rigor and comprehensive methods for deriving TRVs (OAR 340-247-0030). There are four authoritative sources in rule: EPA, ATSDR, CalEPA, and Oregon DEQ in consultation with the ATSAC.

When considering TRV candidates from the EPA, OHA primarily considers TRV candidates generated by two main programs, the IRIS Program as well as the Provisional Peer Reviewed Toxicity Value (PPRTV) Program. PPRTVs are toxicity values that are primarily developed for chemicals of concern in EPA's Superfund Program. (12) PPRTVs are calculated from a robust review of the scientific literature using EPA methods, sources of data, and calculation guidance. (13) To date, over 400 chemicals have PPRTV assessments available (14), and OHA considers all of these PPRTV assessments when reviewing and updating DEQ inhalation TRVs. In 2008, EPA started developing **screening PPRTVs** for chemicals when the data do not meet all the requirements for deriving a PPRTV. (12)

The purpose of this section is to provide background on the EPA screening PPRTVs and how OHA is proposing to use these screening values for the purposes of this rulemaking.

4.1.2 When EPA calculates screening PPRTVs

The EPA has the following information on their website about screening PPRTVs and how these screening values incorporate more uncertainty than other PPRTVs:

> "Screening PPRTVs are derived using the same methodologies and undergo the same development and review processes (i.e., internal and external peer review, etc.) as provisional values [PPRTVs]; however, the screening values are presented in an appendix and characterized such that users of screening PPRTVs are made aware that there is more uncertainty associated with these screening values than for the values presented in the main body of a PPRTV assessment". (12)

The EPA lists the following circumstances where they may calculate a screening PPRTV:

"When some useful human or animal toxicity data are available, but…

- The data are published in non-peer-reviewed sources.
- The data are published and peer-reviewed, but have associated uncertainties such as:
  - The composite Uncertainty Factor is greater than 3,000.
  - The principal study is not comprehensive (e.g., few or one endpoint examined).
  - Other: the principal study has a small number of animals tested, poor study design, incomplete reporting, etc.

When no useful human or animal toxicity data are available for a chemical…

- An expert-driven read-across approach can be applied". (12)

4.1.3 OHA proposal

In previous rulemakings, screening PPRTVs were not considered when developing TRVs. In this rulemaking, OHA is proposing to use screening PPRTVs as the TRV when no other TRVs are available from another authoritative sources. Despite the greater uncertainty behind screening PPRTVs as compared to other PPRTVs, screening PPRTVs allow DEQ and OHA to protect public health from additional TACs for which some toxicity information is known. OHA proposes to use screening PPRTVs as the TRV for 13 TACs (14 TRVs total, see Table 4-1).

Table 4-1: The 13 toxic air contaminants where OHA is proposing to use a screening PPRTV as the TRV

CAS RN	Chemical name, TRV category, and proposed TRV	EPA explanation on why these PPRTVs are categorized as screening PPRTVs
192-97-2	Benzo[e]pyrene Noncancer chronic TRV, 0.002 µg/m^3	Analogue approach: Benzo[a]pyrene was the only potential analogue with an inhalation toxicity value and was selected as the candidate analogue compound for chronic inhalation exposure of benzo[e]pyrene; total uncertainty factor of 3,000 – pages 47-75

CAS RN	Chemical name, TRV category, and proposed TRV	EPA explanation on why these PPRTVs are categorized as screening PPRTVs
92-52-4	Biphenyl Noncancer chronic TRV, 0.4 µg/m^3	A 1977 study by Cannon Laboratories, Inc. was selected as the principal study; this study is unpublished but was submitted to EPA under the Toxic Substances Control Act; study predates current Good Laboratory Principles ; PPRTV document states “Monsanto Chemical Co. (1983) and WHO (Boehncke et al., 1999) reported similar respiratory effects in mice and rats.”; total uncertainty factor of 3,000; used data from subchronic-duration study; no acceptable two-generation reproduction or developmental studies – pages 34-40
156-59-2	*cis*-1,2-Dichloroethene {*cis*-1,2-dichloroethylene} Noncancer chronic TRV, 40 µg/m^3	Analogue approach: *trans*-1,2- DCE was selected as the analogue for *cis*-1,2-DCE for calculation of a screening chronic PPRTV; the screening chronic PPRTV for *trans*-1,2-DCE was calculated by applying a total uncertainty factor of 3,000 and those same uncertainty factors were applied here for *cis*-1,2-DCE – pages 68-69
156-60-5	*trans*-1,2-Dichloroethene Noncancer chronic TRV, 40 µg/m^3	Total uncertainty factor of 3,000; subchronic study used to calculate the screening chronic PPRTV; the inhalation database only includes three studies and none of the studies included immune function assays, and the PPRTV document states that the lack of these assays represents a major source of uncertainty; there are no multigenerational reproductive toxicity studies – pages 36-38
77-73-6	Dicyclopentadiene Noncancer chronic TRV, 0.3 µg/m^3	Total uncertainty factor of 3,000; data in principal study (formation of hyaline droplets) is semiquantitative and not amenable to benchmark dose modeling – pages 38-41

CAS RN	Chemical name, TRV category, and proposed TRV	EPA explanation on why these PPRTVs are categorized as screening PPRTVs
110-54-3	Hexane Cancer TRV, 5 µg/m^3	PPRTV document states that there is "suggestive evidence for carcinogenic potential" when following the *EPA 2005 Guidelines for Carcinogen Risk Assessment* and because of this descriptor, the quantitative inhalation unit risk is provided as a screening value – pages 42-54
78-83-1	Isobutanol {isobutyl alcohol} Noncancer chronic TRV, 400 µg/m^3	Toxicologically relevant effects identified in inhalation studies are limited to a non-peer-reviewed study; total uncertainty factor of 1,000 – pages 41-43
108-87-2	Methylcyclohexane Noncancer chronic TRV, 100 µg/m^3	PPRTV document states "the available inhalation studies have limitations precluding their use in deriving provisional toxicity values (unpublished, not peer-reviewed, written primarily in a foreign language);" total uncertainty factor of 3,000 – pages 49-52
60-34-4	Methyl hydrazine Noncancer chronic TRV, 0.02 µg/m^3 Cancer TRV, 0.001 µg/m^3	Noncancer chronic: Total uncertainty factor of 3,000; examples of uncertainty include no acceptable two-generation reproduction or developmental studies and a no-observed-adverse-effect level cannot be determined with the available data – pages 32-34 Cancer: OHA calculated the proposed cancer TRV from a screening PPRTV. Data from the 1-year bioassay conducted by Kinkead et al. (1985) were used as the basis for the quantitative cancer assessment, as this was the only study that demonstrated increased incidences of tumors after inhalation exposure; individual animal data was not available; incidence of hemangiomas in the high-

CAS RN	Chemical name, TRV category, and proposed TRV	EPA explanation on why these PPRTVs are categorized as screening PPRTVs
		dose group was illegible in the report; mode of action for tumors produced by methyl hydrazine has not been elucidated so default linear methodology was applied – pages 35-38
75-86-5	2-Methyllactonitrile {acetone cyanohydrin} Noncancer chronic TRV, 2 µg/m^3	Total uncertainty factor of 3,000; no acceptable two-generation reproductive or developmental toxicity studies; using data from a subchronic-duration study for the chronic screening PPRTV – pages 29-30
62-75-9	N-Nitrosodimethylamine Noncancer chronic TRV, 0.04 µg/m^3	PPRTV document states the screening value is very uncertain because data did not include weights of individual animals; however, this screening value might be supported by the similarity of the estimated equivalent inhalation daily dose at the point of departure with the information from the study used to calculate the oral toxicity value – page 24
198-55-0	Perylene Noncancer chronic TRV, 0.002 µg/m^3	Analogue approach: Of the 29 structural candidates, only benzo[a]pyrene has a relevant inhalation noncancer toxicity value; total uncertainty factor of 3,000 – pages 44-56
79-00-5	1,1,2-Trichloroethane {vinyl trichloride} Noncancer chronic TRV, 0.2 µg/m^3	Total uncertainty factor of 3,000; critical study has not been peer reviewed; confidence in the database is low due to the lack of reproductive and developmental toxicity testing and absence of supporting chronic-duration systemic toxicity studies; overall confidence in the screening chronic PPRTV is low – pages 15-16

For all the TRVs in Table 4-1, an alternative TRV is not available from our other authoritative sources: ATSDR, CalEPA, DEQ in consultation with ATSAC, or other

programs at the EPA. None of the screening PPRTVs in Table 4-1 are in existing DEQ rule.

OHA sought feedback from ATSAC on this proposal and their feedback is available in Appendix A, ATSAC meeting minutes (Appendices B-F), and ATSAC written feedback (Appendices G-I). All ATSAC members supported OHA's proposal to use screening PPRTVs (see Question 6-2 in Appendix H). For example, OHA asked ATSAC members "Is the science behind PPRTV screening values sufficiently robust to use for DEQ's air quality programs, including regulatory applications, when no other toxicity information is available?" and one ATSAC member answered:

> "Yes. Although they are 'screening' values, the process for development of these values is the same as for more data-intensive, higher-tier values and undergo external peer review. The development of these values utilizes well-documented methodologies and the assessment documents supporting these values are transparently presented for their intended application. In my opinion, not having a value as a guide in considerably more uncertain in evaluating potential risk" (Appendix H).

One ATSAC member also suggested that "DEQ might want to consider applying a composite uncertainty factor [UF] cap of 3000 to the PPRTV calculations and adjusting those values where necessary" (Appendix H). In response to this ATSAC comment, OHA staff took a closer look at the total UF used to calculate the screening PPRTVs. The total UF was 3,000 for all the screening PPRTVs that OHA is proposing to use as the TRV, except for one TRV. In this one case, the screening PPRTV for formic acid (noncancer chronic TRV) was 30,000, which represents more uncertainty in that TRV. As a result of ATSAC feedback, OHA is now proposing a new policy, which is to only use screening PPRTVs when the total UF is 3,000 or below. OHA had proposed a noncancer chronic TRV for formic acid to ATSAC, but OHA is no longer proposing this TRV. Currently, formic acid does not have any proposed TRVs, which is consistent with existing 2018 Rule.

Section 4.2 Proposed TRVs not yet finalized by authoritative sources

4.2.1 Background

The purpose of this section is to highlight which TRV proposals are based on TRVs not yet finalized by authoritative sources, and which TRV proposals have become finalized by authoritative sources during this rulemaking. Not all the inhalation TRVs from

authoritative sources are **final**; some TRVs are in different **draft** stages such as out for public comment or external peer review. Authoritative sources follow a multi-year, comprehensive process to develop TRVs and calculation documentation prior to release for public comment. For example, ATSDR follows several steps to develop MRLs, including review by science experts in two workgroups: an internal ATSDR health effects/MRL group and an external peer review group. (15) The July 2025 ATSDR Newsletter for Health Assessors states, “Provisional [draft] MRLs can be used in making public health decisions because they have gone through peer review at the agency”. (16)

The EPA’s Superfund program uses public comment draft MRLs from ATSDR in their RSL tables:

> “ATSDR provides both 'Final' and 'Draft' values, both of which are utilized in the RSLs. Typically, draft values are excluded from the RSL hierarchy. However, ATSDR's draft values have undergone external peer review and meet the criteria for inclusion in the RSL hierarchy”. (15)

4.2.2 Status of draft TRV proposals when shared with the ATSAC

Timeline

For this rulemaking, OHA toxicologists reviewed all authoritative source information for all current and potential new TRVs by May 2024 for ERG to independently review the TRV information for quality control. To learn more about the TRV update and review process, refer to Chapter 2. Since then, OHA has continued to monitor authoritative sources for new TRVs in development (e.g., looking at email updates from authoritative sources, checking EPA regional screening level spreadsheet updates, and checking authoritative source websites).

To prepare TRVs and related materials for a series of ATSAC meetings from January to May 2025, OHA incorporated all new updates to inhalation TRV information from all authoritative sources as of **August 8, 2024**, including TRV information that was not yet finalized by authoritative sources. OHA checked the list of draft TRVs on **December 2, 2024**, and updated the information for TRVs that had since become final. OHA presented all the TRV proposals and related materials to ATSAC members at ATSAC meeting #4 on **January 15, 2025**.

OHA proposal shared with ATSAC

OHA shared with ATSAC that OHA has been incorporating all TRV information from authoritative sources, including draft TRVs. At the time of the ATSAC meetings in early 2025, there were ten cases where the TRV that OHA proposed to select for a specific TAC was a draft TRV. OHA informed ATSAC that OHA was proposing to use these TRVs regardless of whether the authoritative source finalized the value before DEQ's rulemaking ends. OHA wanted to highlight these cases for ATSAC and get ATSAC's overall feedback on OHA selecting draft TRVs from authoritative sources.

ATSAC feedback

Overall, all ATSAC members were supportive of DEQ and OHA proposing to use TRVs not yet finalized by authoritative sources (Appendices E and H). For example, here are written statements from two ATSAC members:

1. "In general, the development of TRVs from draft authoritative source chemical health values is reasonable and appropriate" (Appendix H)
2. "No concerns noted with using the draft TRVs presented in Table 1 [Table of TRVs not yet finalized by authoritative sources]. All of these draft values are in the later stages of the review process where typically substantial changes to final values do not occur" (Appendix H)

Another ATSAC member also suggested that OHA add notes to the excel workbook to indicate if a TRV proposal is based on a TRV not yet finalized by an authoritative source. OHA agreed with this suggestion (see Appendix A for full responses to ATSAC feedback) and have added a column ("TRV notes") to the Excel workbooks that indicates if a TRV proposal is based on a TRV not yet finalized by an authoritative source. OHA also is updating this chapter periodically to track which TRVs from authoritative sources become final during this rulemaking. Additional responses to other ATSAC member suggestions on this topic are in Appendix A.

4.2.3 Status of draft TRV proposals when shared with the RAC

To prepare the TRV proposals for DEQ's RAC meetings after the ATSAC meetings, OHA again reviewed TRV updates from all authoritative sources (i.e., U.S. EPA, ATSDR, and CalEPA) as of **July 21, 2025**. OHA found that all ten of the TRVs that were not yet finalized by authoritative sources at the time of the ATSAC meetings, have since been officially finalized by the authoritative source (Table 4-2). OHA is proposing to use

the TRVs in Table 4-2 during this rulemaking. **None of the TRVs in Table 4-2 changed between the public comment version and the final version published by the authoritative source.**

Table 4-2: TRVs that were not finalized by DEQ's authoritative sources at the time of the ATSAC meetings but became final after the ATSAC meetings

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* ($\mu g/m^3$)	TRV development background information	Date TRV finalized by source
Acrolein 107-02-8	ATSDR Noncancer chronic = 0.9*	• ATSDR draft for public comment toxicological profile released in May 2024 • ATSDR's public comment period closed in August 2024 • OHA is not proposing to adopt the acute MRL from this ATSDR toxicological profile upon advice from an ATSAC member (see Appendix A for a more detailed explanation)	April 2025
Acrylonitrile 107-13-1	ATSDR Acute = rescinded	• ATSDR draft for public comment toxicological profile released in August 2023 • ATSDR's public comment period closed in November 2023 • The toxicological profile rescinded the previous acute MRL from 1990, so OHA is proposing to remove the previous ATSDR acute TRV from DEQ rules	April 2025

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* ($\mu g/m^3$)	TRV development background information	Date TRV finalized by source
Chloroethane {ethyl chloride} 75-00-3	ATSDR Acute = 34,000	• ATSDR draft for public comment toxicological profile released in January 2024 • ATSDR's public comment period closed in April 2024	January 2025
Hexane 110-54-3	ATSDR **Acute = 21,000**	• ATSDR draft for public comment toxicological profile released in May 2024 • ATSDR's public comment period closed in August 2024	April 2025
Isoprene, except from vegetative emission sources 78-79-5	CalEPA (OEHHA) **Cancer = 0.19**	• OEHHA public review draft for cancer IUR factor technical support document released in February 2024 • OEHHA's public comment period closed in April 2024	January 2025
1-Methylnaphthalene 90-12-0	DEQ in consultation with ATSAC based on ATSDR **Acute = 0.7**	• ATSDR draft for public comment toxicological profile released in May 2024 • ATSDR public comment period closed in August 2024 • OHA calculated the proposed acute TRV by modifying the ATSDR intermediate inhalation MRL for 1-methylnaphthalene (for more details, see Chapter 5)	April 2025

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* ($\mu g/m^3$)	TRV development background information	Date TRV finalized by source
2-Methylnaphthalene 91-57-6	DEQ in consultation with ATSAC based on ATSDR **Acute = 2.8**	• ATSDR draft for public comment toxicological profile released in May 2024 • ATSDR public comment period closed in August 2024 • OHA calculated the proposed acute TRV by modifying the ATSDR intermediate inhalation MRL for 2-methylnaphthalene (for more details, see Chapter 5)	April 2025
Naphthalene 91-20-3	ATSDR Acute = 0.3 Noncancer chronic = rescinded	• ATSDR draft for public comment toxicological profile released in May 2024 • ATSDR public comment period closed in August 2024 • OHA proposes to rescind the chronic noncancer TRV because ATSDR's toxicological profile states there is not adequate data to support a chronic TRV that is lower than the proposed acute TRV • The proposed acute TRV is directly from ATSDR's toxicological profile; ATSDR states that this acute 24-hour TRV is low enough that it is protective against any chronic health noncancer health effects	April 2025

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* (µg/m³)	TRV development background information	Date TRV finalized by source
trans-1,2-Dichloroethene 156-60-5	ATSDR Acute = 12,000	• ATSDR draft for public comment toxicological profile released in August 2023 • ATSDR public comment period closed in November 2023	April 2025
Vinyl acetate 108-05-4	ATSDR Acute = 3,500 Noncancer chronic = 1,100*	• ATSDR draft for public comment toxicological profile released in August 2023 • ATSDR public comment period closed in November 2023	January 2025

*****An asterisk next to the TRV value indicates that more than one TRV option was available from a DEQ authoritative source. Details on TRV options can be found in Workbook 2. For more general information on these specific TRVs, refer to Workbook 1.

Bold text indicates a TRV that is new (i.e., the existing rules from 2018 do not have a TRV for that TAC in that TRV category).

OHA staff also found six new TRVs (for three TACs) that had been posted online by DEQ's authoritative sources since the development of the ATSAC TRV materials and OHA is proposing to use all six of these TRVs. One of these TRVs is not yet finalized by DEQ's authoritative sources (i.e., "draft"; Table 4-3) and two of these TRVs have already been finalized by DEQ's authoritative sources (Table 4-4). OHA did not seek ATSAC feedback on these specific values because this approach follows the same approach that OHA proposed to ATSAC early in 2025. OHA has integrated the information from these new TRV proposals in Workbook 1 and Workbook 2.

Table 4-3: OHA TRV proposals that have not yet been finalized by DEQ's authoritative sources at the time of RAC meeting preparation

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* (µg/m^3)	TRV development background information
Benzene 71-43-2	ATSDR Acute = 30* Noncancer chronic = 6*	• ATSDR draft for public comment toxicological profile released in October 2024 • ATSDR's public comment period closed in February 2025

*An asterisk next to the TRV value indicates that more than one TRV option was available from a DEQ authoritative source. Details on TRV options can be found in Workbook 2. For more general information on these specific TRVs, refer to Workbook 1.

Table 4-4: OHA TRV proposals that were released as drafts after the ATSAC TRV material preparation and have been finalized by DEQ's authoritative sources at the time of RAC meeting preparation

Chemical name and CAS RN	Authoritative source, TRV category, and proposed value* (µg/m^3)	TRV development background information	Date TRV finalized by source
Carbon disulfide 75-15-0	ATSDR Acute = 600* Noncancer chronic = 300*	• ATSDR draft for public comment toxicological profile released in October 2024	July 2025
1,4-dichlorobenzene {p-Dichlorobenzene} 106-46-7	CalEPA (OEHHA) Acute = 8,700* Noncancer chronic = 5*	• OEHHA published the public review draft in November 2024 • OEHHA published the scientific review panel draft in January 2025	July 2025

*****An asterisk next to the TRV value indicates that more than one TRV option was available from a DEQ authoritative source. Details on TRV options can be found in Workbook 2. For more general information on these specific TRVs, refer to Workbook 1.

4.2.4 Plan for draft TRVs or other new candidate TRVs during the rulemaking

OHA will continue to monitor TRV updates from authoritative sources and may incorporate another round of updates from authoritative sources before the public comment period of the current rulemaking.

Draft TRVs that become finalized during this rulemaking

OHA will continue to closely monitor TRV proposals from authoritative sources that become final during this rulemaking process. If there is a change between the draft and final TRV from an authoritative source, then OHA staff will work to understand why there was a change and will closely look at all available TRV documentation, including public comments. OHA may reach out to staff at the authoritative sources if key TRV documentation is unavailable publicly and/or the source of the TRV change is unclear. OHA will summarize findings on authoritative source TRV changes in this chapter of the TRV Support Document after the public comment period.

Uncertainty at EPA and ATSDR beginning in 2025

Based on the recent uncertainty and changes at federal agencies recognized as authoritative sources (EPA and ATSDR), DEQ and OHA are closely monitoring any new candidate TRVs coming from these federal agencies as of 2025**. The current TAC Review and Update Rulemaking will not be affected by revised information from these sources due to the timing of OHA's and ATSAC's scientific review process for the rulemaking**. Specifically,

- To prepare for ATSAC review, OHA incorporated TRV information from all authoritative sources in the summer of 2024 and presented the TRV proposals to ATSAC in January of 2025, and
- All TRV updates incorporated for the RAC were TRVs that federal authoritative sources had originally drafted before 2025.

OHA's priority during this current rulemaking is to move the set of TRV proposals listed in Workbook 1 and 2 forward through the rulemaking process which were all drafted before 2025 by authoritative sources and were reviewed by ATSAC in 2025. OHA will

continue to monitor information issued by federal authoritative sources, assess implications for future DEQ TAC Review and Update Rulemakings and will consult with ATSAC on this issue in the future.

Chapter 5: Proposed TRVs where DEQ is the Authoritative Source

Section 5.1 Background

The purpose of this chapter is to describe the 237 TRVs for which DEQ, in consultation with ATSAC, is the authoritative source during the TAC Review and Update Rulemaking and provide information on how these TRVs were calculated.

As one of the authoritative sources in rule, DEQ, in consultation with ATSAC, can develop TRVs, adapt TRVs from authoritative sources, and consider candidate TRVs developed by alternate sources (i.e., public agencies other than EPA, ATSDR, or CalEPA). In this rulemaking, all TRVs where "DEQ, in consultation with ATSAC," is the proposed authoritative source come from or are modified from either authoritative sources or other public agencies:

- Authoritative Sources:
    - CalEPA's Office of Health Hazard Assessment (OEHHA)
    - EPA's Integrated Risk Information System (IRIS)
    - EPA's Provisional Peer Reviewed Toxicity Value (PPRTV) program
    - ATSDR
- Alternate sources:
    - Texas Commission on Environmental Quality (TCEQ)
    - Minnesota Department of Health (MDH)
    - Michigan Department of Environment, Great Lakes, and Energy (EGLE)
    - New Jersey Department of Environmental Protection (NJDEP).

Throughout the remainder of this chapter the agency from which OHA calculated or adopted a TRV will be referred to as the "source agency." This is because not all the agencies that OHA proposes to adopt TRVs from are listed as "authoritative sources" in rule. In such cases, "DEQ, in consultation with ATSAC" is serving as the authoritative source.

Two hundred thirty-seven (237) of OHA's proposed TRVs list "DEQ in consultation with ATSAC" as the authoritative source. These 237 TRVs are spread across 162 TACs. This document contains calculation information for each of these 237 TRVs. The TRVs are grouped by the methods used to calculate them and then alphabetically within those groupings – the following is a broad summary of the proposed TRVs:

- 64 (27%) TRV proposals are for 24-hour acute exposure noncancer TRVs:

    - 17 acute TRV proposals are from making a time adjustment from a 1-hour acute exposure OEHHA or TCEQ TRV to a DEQ 24-hour acute exposure TRV
    - 24 acute TRV proposals are from making exposure time adjustments to convert a subchronic PPRTV or ATSDR intermediate minimal risk level (MRL) into a DEQ 24-hour acute exposure TRV
    - 7 acute TRV proposals are from a variety of other types of modifications like adding or removing an uncertainty factor
    - 16 acute TRV proposals are adopted directly from an alternate source (not EPA, ATSDR, or CalEPA) without modification
- 82 (35%) TRV proposals are for chronic exposure noncancer TRVs:
    - 4 chronic TRV proposals are from adjusting uncertainty factors from TRVs developed by other sources
    - 64 chronic TRV proposals are from various other types of modifications, many belonging to a class of TACs like brominated dioxins and furans
    - 14 chronic TRV proposals are adopted directly from another source without modification
- The remaining 91 (38%) proposed TRVs where DEQ is listed as the authoritative source are cancer TRVs:
    - 30 cancer TRV proposals are for polycyclic aromatic hydrocarbons (PAHs)
    - 16 cancer TRV proposals are for chlorinated dibenzodioxins or chlorinated dibenzofurans
    - 12 cancer TRV proposals are for dioxin-like polychlorinated biphenyls (PCBs)
    - 18 cancer TRV proposals are for brominated dibenzodioxins and brominated dibenzofurans
    - 15 cancer TRV proposals are for polybrominated biphenyls (PBBs)

OHA sought and carefully considered feedback from ATSAC members on all these potential TRVs.

OHA used different methods and approaches to develop proposed TRVs where DEQ is the authoritative source, which depended on the category of TRV (acute, chronic, cancer) and the type and source of information OHA used to develop the TRV. In the case of acute TRV development, OHA generally tried to follow the Organization for Economic Co-operation and Development's (OECD's) Guidance Document for the Derivation of an Acute Reference Concentration (ARfC) and the CalEPA's Technical Support Document for the Derivation of Noncancer Reference Exposure Levels. (2,3)

Each section in this OHA TRV Support Document represents a different approach or method used to develop TRVs and lists the TRVs developed using that method or approach.

Section 5.2 Acute TRVs calculated from other sources by modifying the exposure time

OHA developed many acute TRVs from other sources by adjusting the experimental exposure times in underlying toxicological studies to better fit DEQ's definition of acute exposure, which is 24 hours. These exposure time adjustments rely on a principle in toxicology usually referred to as "Haber's Law" (Section 5.2.1). In some cases, OHA adjusted a TRV to be protective of a longer exposure (i.e., 24-hour exposure) from a TRV that was originally developed to be protective of a shorter exposure. For example, OHA modified several OEHHA or TCEQ 1-hour TRVs to fit DEQ's 24-hour assumed exposure time for acute TRVs (Section 5.2.2). OHA also modified some subchronic exposure (less than a year of exposure) TRVs from ATSDR and PPRTV to better fit a DEQ 24-hour acute TRV (Section 5.3.3).

5.2.1 "Haber's Law" and ten Berge Adjustment

All DEQ's authoritative sources use a principle called "Haber's Law" when developing TRVs. (2) "Haber's Law" states that the severity of a health effect caused by inhalation of a toxic chemical is influenced equally by the concentration inhaled and the amount of time spent inhaling it.

There are cases when "Haber's Law" may not apply. Empirical evidence for a specific chemical may show that an effect is only concentration-dependent, and that increased exposure time does not influence the outcome. Eye or mucous membrane irritation triggered solely by the activation of the trigeminal nerve is one example where the effect is exclusively concentration dependent and is not dependent on the exposure time. (2) This exception can be complicated because eye and mucous membrane irritation can also be caused by cellular damage, as in a corrosive substance. In such a case, the damage is cumulative and increases with time. Generally, OHA followed the lead of the authoritative sources from which the original reference value came. If they applied "Haber's Law", then so did OHA. If the original source did not, then neither did OHA.

Another situation where OHA did not apply "Haber's Law" was when the health effect was developmental in nature. This practice is consistent with CalEPA. (2)

Developmental effects are caused when an exposure to a chemical occurs during a critical developmental window either *in utero* or during childhood. That exposure can lead to changes in developmental trajectory and long-lasting health effects that persist long after the exposure to the chemical has stopped. In these cases, the timing of exposure during development, rather than the duration of exposure, is the critical factor for determining negative health effects. (2)

In other cases, both concentration and time are important but one is more important than the other. OEHHA and others use an adjustment to "Haber's Law," called the ten Berge adjustment (17), to account for cases when the harmful effect is dependent on both concentration and time, but one is more influential than the other.

Here are some equations representing "Haber's Law" with the ten Berge adjustment that OHA used in deriving or modifying some of the proposed TRVs in this document.

Equation 5-1: "Haber's Law" with ten Berge Adjustment.

$$C_1^n \times T_1 = C_2^n \times T_2$$

Where:

C_1 = Concentration 1: This is the concentration used in the toxicological studies

T_1 = Exposure time 1: This is the daily duration of exposure in the toxicological studies

C_2 = Concentration 2: This is the concentration agencies like OEHHA or DEQ use to calculate their TRVs

T_2 = Exposure time 2: This is the exposure time for which agencies like OEHHA or DEQ want their TRVs to be protective

Exponent "n" = an exponent reflecting the influence of concentration on the health effect relative to the influence of exposure time.

C_2 is the concentration DEQ needs to solve for to generate a revised TRV. When the equation is resolved to solve for C_2, it transforms to:

Equation 5-2: Equation 5-1 resolved to solve for C_2.

$$C_2 = \sqrt[n]{C_1^n \times \frac{T_1}{T_2}}$$

When OHA applied “Haber’s Law” with ten Berge adjustment to adjust another source’s TRVs, OHA used values for exponent “n” provided or specified by the source agency the original TRV came from. However, when the authoritative source applied an empirically derived exponent “n,” OHA checked that the empirical study included a time point that included the target exposure time of 24 hours. In this round of TRV review, none of the empirically derived values for exponent “n” came from studies that included DEQ’s 24-hour target exposure time. Therefore, all values for exponent “n” in OHA’s proposals use the defaults. When the source agency applied a default value for exponent “n,” OHA applied an exponent “n” of 1 when extrapolating from a shorter to a longer exposure time and an exponent “n” of 3 when extrapolating from a longer to a shorter exposure time. This is consistent with OEHHA’s Technical Support Document for the Derivation of Noncancer Reference Exposure Levels. (2) These are the health-protective defaults when making exposure time adjustments in the absence of empirical values for exponent “n.”

An exponent “n” of 3 means that the concentration has more influence on the toxicity than time. An exponent “n” of 1 means that concentration and time are equally weighted in terms of their influence on health effects. When exponent “n” equals 1, equation 5-2 above reduces to:

Equation 5-3: Equation 5-2 reduced when “n” equals 1.

$$C_2 = C_1 \times \frac{T_1}{T_2}$$

5.2.2 Exposure time adjustments from 1-Hour acute TRVs to 24-hour acute TRVs

Seventeen of the acute TRVs that OHA proposes to use are adapted from OEHHA's or TCEQ's 1-hour reference exposure levels (RELs) or Reference Exposure Values (ReVs). DEQ's acute TRVs are intended to protect health over a 24-hour period, while OEHHA and some TCEQ acute TRVs are intended to only protect health over 1-hour of exposure. Table 5-1 summarizes the modifications made to each TRV in this category.

Generally, OHA modified the point of departure (POD) from the critical study selected by the source agency to use in deriving their 1-hour TRV. OHA made these modifications using "Haber's Law" with or without ten Berge adjustment (Equation 5-2 or 5-3). OHA then applied any dosimetric adjustment factors (DAF) applied by the source agency and divided it by UFs. OHA used the same total UFs as the source agency unless otherwise noted. Specific DAFs and UFs applied in each case are documented in Table 5-1 and in "Workbook 2:TRV Derivation." In some cases, the POD was expressed in parts per million (ppm). OHA applied a conversion factor from ppm to micrograms per cubic meter (µg/m^3) in those cases. The unit conversion factors integrate the molecular weight of the specific TAC and assume standard temperature and pressure (25 degrees Celsius and 1 atmosphere). This unit conversion is for uniformity across TRVs for all TACs listed in DEQ rule. Equation 5-4 below is an example of the full adjustment for TRVs in this category if all components were necessary.

Equation 5-4: Acute TRV adjustment from 1-hour acute TRV to 24-hour acute TRV.

$$Proposed\ TRV\ \left(\frac{\mu g}{m^3}\right) = \frac{\sqrt[n]{\left(POD^n \times \left(\frac{T_1}{T_2}\right)\right)} \times DAF}{Total\ Uncertainty\ Factor} \times ppm\ to\ \frac{mg}{m^3}\ conversion \times \frac{mg}{m^3}\ to\ \frac{\mu g}{m^3}\ conversion$$

Where:

POD = Point of departure – This is the air concentration from the critical study that the source agency used to calculate their 1-hour acute TRV. Examples of

PODs include no observable adverse effect levels (NOAELs), lowest observable adverse effect levels (LOAELs), and benchmark concentration lower confidence limits (BMCLs). In cases where the source agency had already expanded an exposure shorter than 1 hour to 1 hour, OHA used the 1-hour REL or ReV as the POD and made T_1 equal to 1.

Exponent "n" = Reflects influence of concentration on toxicity relative to the influence of time. When n = 1, concentration and time have equal influence. OHA applied an exponent "n" of 1 unless the source agency had applied an empirically derived exponent "n" specific to a TAC.

T_1 = The daily duration that experimental animals, human subjects, or occupationally exposed workers breathed the air in the critical study selected by the source agency.

T_2 = The amount of time DEQ intends to protect with their acute TRV. For DEQ that is 24 hours of exposure.

DAF = Dosimetric adjustment factor – This is the factor used by the source agency to convert an air concentration from animals to humans using specific toxicokinetic differences between the test species and humans. In each case OHA used the same DAF as the source agency. DAF is an umbrella term that can represent more specific terms like regional deposition dose relationship (RDDR) or regional gas dose ratio (RGDR).

Not all components of Equation 5-4 were necessary for all TRVs. For example, if the concentration of the TAC used in the critical study used by a source agency was expressed in mg/m^3, then no conversion from ppm to mg/m^3 was necessary. If the source agency did not apply a DAF, then OHA did not include one in the adjustment. If the source agency did not apply a ten Berge adjustment to "Haber's Law" for the exposure time adjustment, then OHA did not include one.

Table 5-1: Acute TRVs that OHA modified by adjusting exposure times from shorter to longer

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Acrylic acid	79-10-7	**Source of original value:** 1999 OEHHA 1-hour acute REL **Variables** • POD = NOAEL = 80 ppm • T_1 = 6 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 100 • Unit conversion = 2.95 mg/m^3 per 1 ppm	590
Benzyl chloride	100-44-7	**Source of original value:** OEHHA 1-hour acute REL **Variables** • POD = LOAEL = 20 ppm • T_1 = 2 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 600 • Unit conversion = 5.18 mg/m^3 per 1 ppm	14

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Bromomethane {methyl bromide}	74-83-9	**Source of original value:** 1999 OEHHA 1-hour acute REL **Variables** • POD = LOAEL = 35 ppm • T_1 = 2 hours • T_2 = 24 hours • Exponent "n" = 1 (OEHHA applied an empirically derived exponent "n" of 1.33 specifically for this chemical. However, the empirical studies OEHHA cited did not extend out to 24 hours. OHA proposes to apply exponent "n" of 1) • DAF = NA • UF = 60 • Unit conversion = 3.89 mg/m^3 per 1 ppm	190
Carbonyl sulfide	463-58-1	**Source of original value:** 2023 OEHHA 1-hour acute REL **Variables** • POD = NOAEL = 740 mg/m^3 • T_1 = 6 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 2,000	93

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Hydrogen cyanide	74-90-8	**Source of original value:** 1999 OEHHA 1-hour REL **Variables** • POD = OEHHA 1-hour REL = 340 µg/m^3 • T_1 = 1 hour • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = NA – started from finished OEHHA REL	14
Diethanolamine	111-42-2	**Source of original value:** 2018 TCEQ acute 1-hour ReV **Variables** • POD = NOAEL = 100 mg/m^3 • T_1 = 6 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = 0.1730 • UF = 180	24

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Heptane	142-82-5	**Source of original value:** 2016 TCEQ acute 1-hour ReV **Variables** • POD = BMCL = 2945 ppm • T_1 = 0.5 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 180 • Unit conversion = $\frac{100.2\frac{g}{mole}}{24.45\ L/mole}$	1,400
Hexamethylene-1,6-diisocyanate {HDI}	822-06-0	**Source of original value:** 2019 OEHHA 1-hour acute REL **Variables** • POD = NOAEL = 0.034 mg/m^3 • T_1 = 5 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 200	0.035

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Hydrogen chloride {hydrochloric acid}	7647-01-0	**Source of original value:** OEHHA 1-hour REL **Variables** • POD = OEHHA 1-hour REL = 2,100 µg/m^3 • T_1 = 1 hour • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = NA – started from finished OEHHA REL	88
Methylene diphenyl diisocyanate {MDI}	101-68-8	**Source of original value:** 2016 OEHHA 1-hour REL **Variables** • POD = LOAEL = 0.7 mg/m^3 • T_1 = 6 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = RGDR = 1.71 • UF = 600	0.50

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV ($\mu g/m^3$)
Phenol	108-95-2	**Source of original value:** 1999 OEHHA 1-hour REL **Variables** • POD = LOAEL = 5.2 ppm • T_1 = 8 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 10 • Unit conversion = 3.85 mg/m^3 per 1 ppm	670
Phosgene	75-44-5	**Source of original value:** 1999 OEHHA 1-hour REL **Variables** • POD = OEHHA 1-hour REL = 4 $\mu g/m^3$ • T_1 = 1 hour • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = NA – started from finished OEHHA REL	0.17

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Propylene oxide	75-56-9	**Source of original value:** 1999 OEHHA 1-hour acute REL OEHHA's Appendix G lists two values for exponent "n" in the ten Berge-adjusted "Haber's Law" equation. Both indicate that the acute effects of propylene oxide are slightly more influenced by concentration than by exposure time, although both still play a role. None of the empirical studies referenced OEHHA's appendix D include the 24-hour target exposure time; therefore, DEQ chose the default exponent "n" of 1 (as recommended by ATSAC, see Appendix E of this document), which is the more health-protective approach when adjusting a shorter exposure time to a longer one. **Variables** • POD = LOAEL = 387 ppm • T_1 = 4 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 600 • Unit conversion = 2.38 mg/m^3 per 1 ppm	260

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Selenide, hydrogen	7783-07-5	**Source of original value:** 1999 OEHHA 1-hour REL **Variables** • POD = OEHHA 1-hour REL = 5 µg/m^3 • T_1 = 1 hour • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = NA – started from finished OEHHA REL	0.21
Triethylamine	121-44-8	**Source of original value:** 1999 OEHHA 1-hour acute REL **Variables** • POD = NOAEL = 10 mg/m^3 • T_1 = 8 hours • T_2 = 24 hours • Exponent "n" = 1 • DAF = NA • UF = 10	330

Chemical name	CAS RN	Used Equation 5-4 for all calculations in this table using the inputs listed	OHA proposed acute TRV (µg/m^3)
Trimethylbenzene(mixed isomers)	25551-13-7	**Source of original value:** 2023 OEHHA 1-hour acute REL **Variables** • POD = BMCL1SD = 709 mg/m^3 • T_1 = 8 hours • T_2 = 24 hours • Exponent “n” = 1 • DAF = NA • UF = 600	390
Vinylidene chloride	75-35-4	**Source of original value:** 2007 TCEQ 1-hour acute ReV **Variables** • POD = NOAEL = 10 ppm • T_1 = 6 hours • T_2 = 24 hours • Exponent “n” = 1 • DAF = NA • UF = 100 • Unit conversion = 3.96 mg/m^3 per 1 ppm	99

5.2.3 Exposure time adjustments from subchronic TRVs to 24-hour acute TRVs

For some TACs, OHA proposes to use acute TRVs calculated from subchronic TRVs. Subchronic TRVs refer to TRVs protective of exposures that last less than 12 percent of the test species' average lifetime but are longer than an acute exposure of 24 hours to 2 weeks. DEQ rules do not have a category of TRVs for subchronic exposures, but they often have components that are useful in deriving either an acute or chronic TRV.

In all cases in this subsection, the source of the subchronic TRVs is either ATSDR or PPRTV. ATSDR's subchronic TRVs are called intermediate minimal risk levels (MRLs), and PPRTV's subchronic TRVs are called Subchronic reference exposure concentrations (RfCs).

For TACs in this subsection, the exposure time adjustment is always from longer exposures in the critical studies used by the source agencies down to a 24-hour acute TRV. In each case, the source agency had added a days per week adjustment to calculate their value from studies in which exposure was intermittent over some period of time.

OHA's modification for these values was to remove the days per week adjustment, since DEQ acute TRVs apply to a single, 24-hour exposure. OHA used Equation 5-5 to make these adjustments to all TACs in Table 5-2 below using inputs in the table:

Equation 5-5: Subchronic to 24-hour acute adjustment

$$Proposed\ acute\ TRV = \frac{Subchronic\ TRV}{\frac{days}{week}}$$

ATSAC recommended this approach because it is more health protective than using "Haber's Law" to mathematically compress the exposure duration down to 24 hours. As an example, assume hypothetical "chemical X" had a critical study in which animals were exposed at 5 µg/m^3 for 6 hours/day for 5 days/week over 6 weeks (a total of 180 hours). Applying "Haber's Law" would mean calculating the total hours of exposure and applying equation 5-4 from above as follows, using an exponent "n" of 3 as the health protective default when applying "Haber's Law" to adjust from longer to shorter exposures:

$$\sqrt[3]{(5\ \mu g/m^3)^3 \times \frac{180\ hours}{24\ hours}} = \mathbf{9.8}\ \mu g/m^3$$

Whereas application of Equation 5-5 from above to the same scenario yields:

$$\frac{5\ \mu g/m^3}{\frac{5\ days}{7 days}} = \mathbf{7}\ \mu g/m^3$$

Note that in Table 5-2 below, the exposure duration from the critical study is listed. This is for informational purposes only as the exposure duration was not part of the exposure time adjustment equation used in Table 5-2 (Equation 5-5).

Table 5-2: Acute TRVs that OHA modified by adjusting exposure times from longer to shorter

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m³)
bis(2-Chloroethyl) ether (BCEE)	111-44-4	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration:** 130 days **Variables:** • Subchronic reference value = ATSDR intermediate MRL= 120 µg/m³ • Day per week adjustment = 5/7	170

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
bis(2-Chloromethyl) ether	542-88-1	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration:** 6 months **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 1.4 µg/m^3 • Day per week adjustment = 5/7	2
Chlordane	57-74-9	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration:** 90 days **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 0.2 µg/m^3 • Day per week adjustment = 5/7	0.28
Chlorine dioxide	10049-04-4	**Source of original value:** 2004 ATSDR intermediate MRL **Exposure duration:** 2 months **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 2.8 µg/m^3 • Day per week adjustment = 5/7	3.9

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
Chromium, trivalent and compounds (soluble)	16065-83-1	**Source of original value:** 2012 ATSDR's intermediate MRL **Exposure duration:** 13 weeks **Variables:** • Subchronic reference value = ATSDR's intermediate MRL = 0.1 µg/m^3 • Day per week adjustment = 5/7	0.14
Chromium, trivalent and compounds (insoluble)	16065-83-1	**Source of original value:** 2012 ATSDR's intermediate MRL **Exposure duration:** 13 weeks **Variables:** • Subchronic reference value = ATSDR's intermediate MRL =5 µg/m^3 • Day per week adjustment = 5/7	7
Chromic(VI) acid, including chromic acid aerosol mist and chromium trioxide	7738-94-5	**Source of original value:** 2012 ATSDR intermediate MRL **Exposure duration:** Median 2.5 years **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 0.005 µg/m^3 • Day per week adjustment = 5/7	0.007

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
Diazinon	333-41-5	**Source of original value:** 2008 ATSDR intermediate MRL **Exposure duration:** 3 weeks **Variables:** • Subchronic reference value = ATSDR intermediate MRL =10 µg/m^3 • Day per week adjustment = 5/7	14
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration:** 14 weeks **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 1.9 µg/m^3 • Day per week adjustment = 5/7	2.7
1,3-Dichloropropene	542-75-6	**Source of original value:** 2008 ATSDR intermediate MRL **Exposure duration**: 6 months **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 36 µg/m^3 • Day per week adjustment = 5/7	50

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value ($\mu g/m^3$)
Diethylene glycol monobutyl ether	112-34-5	**Source of original value:** 2009 PPRTV **Exposure duration:** 5 weeks **Variables:** • Subchronic reference value = 2009 PPRTV subchronic p-RfC= 1 $\mu g/m^3$ • Day per week adjustment = 5/7	1.4
Diethylene glycol monoethyl ether	111-90-0	**Source of original value:** 2009 PPRTV **Exposure duration:** 28 days **Variables:** • Subchronic reference value = 2009 PPRTV subchronic p-RfC= 3 $\mu g/m^3$ • Day per week adjustment = 5/7	4.2
1,1-Dimethylhydrazine	57-14-7	**Source of original value:** 1996 ATSDR intermediate MRL **Exposure duration:** 6 months **Variables:** • Subchronic reference value = ATSDR intermediate MRL =0.49 $\mu g/m^3$ • Day per week adjustment = 5/7	0.69
Ethylene glycol monomethyl ether acetate	110-49-6	**Source of original value:** 2011 PPRTV **Exposure duration:** 13 weeks **Variables:** • Subchronic reference value = 2011 PPRTV subchronic p-RfC = 11.3 $\mu g/m^3$ • Day per week adjustment = 5/7	16

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
Hydrazine	302-01-2	**Source of original value:** 1997 ATSDR intermediate MRL **Exposure duration:** 6 months **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 5.2 µg/m^3 • Day per week adjustment = 7/7	5.2
1-Methylnaphthalene	90-12-0	**Source of original value:** 2025 ATSDR intermediate MRL **Exposure duration**: 13 weeks **Variables:** • Subchronic reference value = ATSDR intermediate MRL =0.5 µg/m^3 • Day per week adjustment = 5/7	0.7
2-Methylnaphthalene	91-57-6	**Source of original value:** 2025 ATSDR intermediate MRL **Exposure duration:** 4 weeks **Variables:** • Subchronic reference value = ATSDR intermediate MRL = 2 µg/m^3 • Day per week adjustment = 5/7	2.8

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
2-Nitropropane	79-46-9	**Source of original value:** 2019 PPRTV subchronic RfC **Exposure duration**: 1-3 months **Variables:** • Subchronic reference value = 2019 PPRTV subchronic p-RfC = 66.67 µg/m^3 • Day per week adjustment = 5/7	93
Parathion	56-38-2	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration:** 6 weeks **Variables:** • Subchronic reference value = 2017 ATSDR intermediate MRL = 20 µg/m^3 • Day per week adjustment = 5/7	28
Polybrominated diphenyl ethers (PBDEs) excluding decabromodiphenyl ether-209	447	**Source of original value:** 2017 ATSDR intermediate MRL **Exposure duration**: 13 weeks **Variables:** • Subchronic reference value = 2017 ATSDR intermediate MRL =5.8889 µg/m^3 • Day per week adjustment = 5/7	8.2

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
Propylene glycol	57-55-6	**Source of original value:** 1997 ATSDR intermediate MRL **Exposure duration**: 13 weeks **Variables:** • Subchronic reference value = 1997 ATSDR intermediate MRL =28 µg/m^3 • Day per week adjustment = 5/7	39
Tribufos	78-48-8	**Source of original value:** 2020 ATSDR's intermediate MRL **Exposure duration:** 13 weeks **Variables:** • Subchronic reference value = 2020 ATSDR's intermediate MRL = 40 µg/m^3 • Day per week adjustment = 5/7	56
Uranium and compounds (insoluble particulate)	7440-61-1	**Source of original value:** 2013 ATSDR intermediate MRL **Exposure duration:** 5 weeks **Variables:** • Subchronic reference value = 2013 ATSDR intermediate MRL = 2 µg/m^3 • Day per week adjustment = 6/7	2.3

Chemical name	CAS RN	Used Equation 5-5 for all calculations in this table using the inputs listed	OHA proposed acute TRV value (µg/m^3)
Uranium and compounds (soluble)	7440-61-1	**Source of original value:** 2013 ATSDR intermediate MRL **Exposure duration:** 5 weeks **Variables:** • Subchronic reference value = 2013 ATSDR intermediate MRL = 0.1 µg/m^3 • Day per week adjustment = 6/7	0.12

Section 5.3 TRVs that OHA calculated by using a better studied surrogate

OHA calculated TRVs in this section by applying the TRV for a better studied TAC to these lesser studied TACs. OHA relied on guidance and findings applied by other expert agencies when deciding which better studied TAC to use as a surrogate. These instances were relatively rare, and because each circumstance was somewhat unique, OHA describes the specifics for each case in Table 5-3.

Table 5-3: TRVs that DEQ calculated by applying toxicity information from a better studied chemical as a surrogate

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
Crotonaldehyde	4170-30-3	Chronic	None of DEQ's authoritative sources have inhalation toxicity values for crotonaldehyde. TCEQ has both chronic and acute toxicity values for crotonaldehyde. TCEQ's 24-hour ReV for crotonaldehyde is based on a toxicological study done using crotonaldehyde itself as the test substance and is listed in Table 7. Although, TCEQ could not find subchronic or chronic studies using crotonaldehyde suitable to develop a chronic ReV, they identified acrolein as a suitable index chemical. TCEQ developed and applied a relative potency factor between acrolein and crotonaldehyde such that their chronic ReV for crotonaldehyde is their chronic ReV for acrolein multiplied by the relative potency factor. See Chapter 4 Section 4.1 of TCEQ's Developmental Support Document for	Chronic TRV: 2.7 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
			Crotonaldehyde for TCEQ's justification and methods for calculation of a median relative potency factor to apply. OHA agrees with TCEQ's relative potency factor rationale and development (applying the median *in vivo* chronic relative potency factor of 3 relative to the chronic toxicity of acrolein); however, OHA proposes to apply the relative potency factor to OHA's proposed chronic TRV for acrolein (0.9 µg/m^3 from ATSDR) rather than to TCEQ's chronic ReV for acrolein (2.7 µg/m^3). OHA's proposed chronic noncancer TRV for acrolein comes from one of DEQ's authoritative sources (ATSDR). Therefore, calculation of OHA's proposed chronic TRV for crotonaldehyde is: $$Proposed\ chronic\ TRV\ for\ crotonaldehyde = ATSDR\ chronic\ MRL\ for\ acrolein \times TCEQ\ median\ in\ vivo\ relative\ potency\ factor\ for\ crotonaldehyde = 0.9\ \frac{\mu g}{m^3} \times 3 = \mathbf{2.7}\ \frac{\boldsymbol{\mu g}}{\boldsymbol{m^3}}$$	

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
Total Polybrominated Biphenyls (PBBs), evaporated and PBBs, aerosols and particulates		Cancer	OHA proposes to apply cancer TRVs for unspecified mixtures of polychlorinated biphenyls (PCBs), (evaporated or aerosols and particulates) to their **brominated** analogues. This approach is justified by the similarity in chemical structure and properties and is recommended in a peer-reviewed publication. (7) ATSAC has previously communicated approval of this proposed approach in a series of email communications documented in Appendix R.	Cancer TRV for evaporated mixtures: 0.0091 µg/m^3 Cancer TRV for aerosol and particulate mixtures: 0.0018 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
Polybrominated dibenzo-p-dioxins (PBDDs) & dibenzofurans (PBDFs) TEQ & Dioxin-like polybrominated biphenyls (PBBs)		Cancer and Chronic noncancer	OHA proposes to apply TEFs for **chlorinated** dioxins, furans, and polychlorinated biphenyls (PCBs) to their **brominated** analogues and to include risk from brominated dioxins, furans, and dioxin-like polybrominated biphenyls (PBBs) in the risk for the dioxin/furan class. This approach is recommended in a peer-reviewed publication (7), and ATSAC has previously communicated approval of this proposed approach in a series of email communications documented in Appendix R.	See Workbook 1

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
n-Propylbenzene	103-65-1	Chronic and Acute	Appendix A of the February 2, 2009 PPRTV document for n-propylbenzene applies the EPA chronic RfC for ethyl benzene from the 1991 IRIS assessment to this compound (justification on page 16 of 2009 PPRTV document), stating that ethyl benzene is a reasonable surrogate for n-propylbenzene. ATSDR came out with more recent toxicity values for ethyl benzene since the 2009 PPRTV document for n-propylbenzene. If PPRTV stated that ethyl benzene is a good surrogate for n-propylbenzene, it stands to reason that the updated tox values for ethyl benzene should be applied to n-propylbenzene as well. Therefore, OHA proposes to apply proposed chronic noncancer and acute TRVs for ethyl benzene to n-propylbenzene. The origin of the selected TRVs for ethylbenzene are: • Chronic: ATSDR • Acute: ATSDR	Chronic: 260 µg/m^3 Acute: 22,000 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Chemical name	**CAS RN**	**TRV exposure category**		
Perfluorooctane sulfonamide (PFOSA)	754-91-6	Chronic and acute	OHA proposes to apply the TRV for perfluorooctanoic acid (335-67-1) to this TAC (selected chronic TRV for PFOA comes from Michigan EGLE and is calculated by route-to-route extrapolation from IRIS oral RfD; selected acute TRV for PFOA was adopted from Minnesota Department of Health's short-term Risk Assessment Advice (RAA). This decision is justified by TCEQ as they also used their PFOA toxicity information as a surrogate for this TAC. See Appendix L.	Chronic TRV: 0.0001 µg/m^3 Acute TRV: 0.063 µg/m^3

Section 5.4 TRVs where OHA proposes to modify uncertainty factors

This section describes cases where OHA modified a TRV from another source by adjusting the uncertainty factors applied in their calculation. In each of the cases in this section, OHA agreed with the originating source agency in all other aspects of the calculation. In several of the cases, the purpose of the OHA-proposed additional uncertainty factor was to adjust a subchronic TRV to a chronic TRV.

Table 5-4: TRVs where DEQ proposes to modify uncertainty factors applied by originating source agency

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations for each TAC shown below where applicable**	
Acetone	67-64-1	Chronic	OHA adapted this proposed chronic TRV from TCEQ 2015. DEQ proposes to increase TCEQ's LOAEL to NOAEL UF from 2 to the more standard 10 as recommended by ATSAC (see Appendix A and M), raising the total UF from 20 to 100. The proposed TRV is therefore calculated: $$Proposed\ chronic\ TRV = \frac{LOAEL_{adj}}{UF} \times ppm\ to\ \frac{mg}{m^3}\ adjustment$$ $$= \frac{133.9\ ppm}{100} \times \frac{2.38\ \frac{mg}{m^3}}{1\ ppm} = 3.186\ \frac{mg}{m^3} = 3{,}186\ \frac{\mu g}{m^3}$$ $$\approx \mathbf{3{,}200\ \mu g/m^3}$$	Chronic TRV: 3,200 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations for each TAC shown below where applicable**	
Chromium III water *insoluble* compounds	16065-83-1	Chronic	OHA calculated a chronic TRV from ATSDR's intermediate MRL (2012) for insoluble trivalent chromium compounds. No other authoritative sources had a candidate value for insoluble trivalent chromium for OHA to consider. OHA proposes to adopt all aspects of the intermediate MRL calculation from the same critical study with the addition of an uncertainty factor of 3 (total UF of 300) to extrapolate the results of this 13-week animal study to an annual, chronic TRV. OEHHA applied the same approach in deriving their chronic ReV for water soluble trivalent chromium from the same critical study that ATSDR used (Derelanko et al. 1999). (18) Note that the Derelanko critical study included exposures to both insoluble and soluble trivalent chromium compounds to compare the relative inhalation toxicity of the two. OEHHA only used the water-soluble portion of this study, while ATSDR used both.	Chronic TRV: 1.4 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations for each TAC shown below where applicable**	
Dichlorodifluoromethane {Freon 12}	75-71-8	Chronic	OHA proposes to adapt Minnesota's subchronic risk assessment advice (RAA) value 2016, which was based on a 4 week exposure in humans, to a chronic duration TRV by applying an additional uncertainty factor of 10. This is done by dividing Minnesota's subchronic RAA by 10: $Proposed\ chronic\ TRV = \frac{Minnesota\ RAA}{10} = \frac{11{,}790\ \mu g/m^3}{10} = 1{,}179\ \frac{\mu g}{m^3}$ $\approx \mathbf{1{,}200\ \mu g/m^3}$	Chronic TRV: 1,200 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations for each TAC shown below where applicable**	
Ethylene dibromide (EDB), {1,2-dibromoethane}	106-93-4	Acute	OHA's proposed acute TRV is a modification to the 2017 TCEQ acute ReV. TCEQ has a policy for acute exposure TRVs that the maximum total UF cannot exceed 300. Here, TCEQ had calculated a total UF of 3000, but only used a total UF of 300 due to state policy. DEQ and OHA proposed to adopt the 2017 TCEQ acute TRV with the total UF of 3000 instead of 300. Therefore, to calculate the proposed acute TRV, DEQ and OHA followed this equation: $$proposed\ acute\ TRV\ = \frac{TCEQ\ 24-hour\ ReV}{additional\ factor\ of\ 10} = \frac{510\ \frac{\mu g}{m^3}}{10} = \mathbf{51}\ \frac{\mu \boldsymbol{g}}{\boldsymbol{m^3}}$$	Acute TRV: 51 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations for each TAC shown below where applicable**	
S,S,S-Tributyl phosphorotrithioate {tribufos}	78-48-8	Chronic	Proposed chronic TRV is calculated by applying an additional uncertainty factor of 3 to ATSDR's intermediate MRL (2020), which was based on a 13-week study in rats, to adjust from subchronic to chronic exposure. The proposed chronic TRV is calculated: $DEQ\ Chronic\ TRV = \frac{ATSDR\ intermediate\ MRL}{UF_S} = \frac{40\ \mu g/m^3}{3} = 13.33 \frac{\mu g}{m^3}$ $\approx \mathbf{13}\ \boldsymbol{\mu g/m^3}$	Chronic TRV: 13 µg/m^3

Section 5.5 Other types of adjustments

OHA modified the TRVs in this section in ways that do not fit in the categories described elsewhere. In some cases, OHA did not make an adjustment per se but proposes to apply a TRV in a way that is different than the originating source agency does. Each adjustment in this section is so unique that OHA listed the specific details for each in Table 5-5.

Table 5-5: TRVs where OHA made other types of adjustments

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
Benzo[a]pyrene	50-32-8	Acute	OHA proposes to apply EPA's chronic RfC as an acute TRV as well. This is because the health effects are developmental, and the experimental exposure was only 9 days without information on the minimum exposure time necessary to cause the observed effects.	Acute TRV: 0.002 µg/m^3
Boron trichloride	10294-34-5	Acute and Chronic	Both acute and chronic noncancer proposed TRVs for boron trichloride apply the principle described in the 2012 PPRTV document for boron trichloride. It is that the toxicity of boron trichloride is the same as that of hydrogen chloride because each molecule of boron trichloride hydrolyzes to 3 molecules of hydrogen chloride. Therefore, OHA proposes to apply an adjustment to the proposed acute (See Table 5-1) and chronic (see OEHHA) TRVs for hydrogen chloride to boron trichloride. To calculate proposed acute and chronic TRVs for boron trichloride, OHA multiplied the proposed TRVs for hydrogen chloride by the ratio of the molecular weight for boron trichloride to 3 times the molecular weight of hydrogen chloride. That ratio works out to be 1.07. So, the	Acute TRV: 94 µg/m^3 Chronic TRV: 9.6 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
			proposed TRVs for boron trichloride are equal to the proposed TRVs for hydrogen chloride multiplied by 1.07. Calculations here: **Acute TRV** $$Proposed\ acute\ TRV\ for\ boron\ trichloride = Proposed\ acute\ TRV\ for\ HCL \times \left(\frac{Molcular\ weight\ boron\ trichloride}{3 \times Molecular\ weight\ HCL}\right)$$ $$88\frac{\mu g}{m^3} \times \left(\frac{117.17\ \frac{g\ BCL_3}{mol}}{3 \times 36.46\ \frac{g\ HCL}{mol}}\right) = 88\frac{\mu g}{m^3} \times 1.07 = 94.16\frac{\mu g}{m^3} \approx \mathbf{94}\frac{\boldsymbol{\mu g}}{\boldsymbol{m^3}}$$ **Chronic TRV** $$Proposed\ chronic\ TRV\ for\ boron\ trichloride = Proposed\ chronic\ TRV\ for\ HCL \times \left(\frac{Molcular\ weight\ boron\ trichloride}{3 \times Molecular\ weight\ HCL}\right)$$	

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
			$$9\frac{\mu g}{m^3} \times \left(\frac{117.17\ \frac{g\ BCL_3}{mol}}{3 \times 36.46\ \frac{g\ HCL}{mol}}\right) = 9\frac{\mu g}{m^3} \times 1.07 = 9.63\frac{\mu g}{m^3}$$ $$\approx \boldsymbol{9.6\ \mu g/m^3}$$	
Perfluorodecanoic Acid (PFDA)	335-76-2	Chronic	TCEQ 2023 justified a simple route-to-route extrapolation for PFDA based on evidence that the health effects caused by PFDA are systemic and independent of route of exposure. However, TCEQ applied their route-to-route extrapolation for PFDA to their own 2023 oral RfD. Consistent with ATSAC's feedback (see Appendix R), OHA applied TCEQ's simple route-to-route extrapolation for PFDA to EPA's 2024 oral RfD because it incorporates more recent epidemiological studies in its development and because EPA is one of DEQ's authoritative sources. OHA calculated the recommended chronic noncancer TRV for PFDA: $$TRV = 2 \times 10^{-9}\frac{mg}{kg \cdot day} \times \frac{70\ kg}{20\ m^3/day} = 7 \times 10^{-9}\frac{mg}{m^3}$$ $$= \boldsymbol{7 \times 10^{-6}\ \mu g/m^3}$$	7×10^{-6} µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
Perfluorononanoic acid (PFNA)	375-95-1	Acute	OHA calculated the proposed acute TRV by modifying a chronic RfC developed by TCEQ and published 2/24/2023 (See Appendix K). The TCEQ value is based on an inhalation study in which animals were exposed for 4 hours. TCEQ applied a subacute to chronic uncertainty factor and applied the TRV to chronic exposure. They did not make a time adjustment from 4 hours to 24 hours. OHA proposes to adjust the TCEQ chronic RfC to acute by multiplying the RfC by 10 (thus removing the 10-fold subacute to chronic UF that TCEQ applied) and multiply by 4/24 hours/day (0.16667) to adjust the 4-hour exposure to a 24-hour averaging time. The full equation is presented here: $$Proposed\ acute\ TRV = TCEQ\ chronic\ RfC \times subacute\ to\ chronic\ UF \times \frac{4}{24} hours\ day = 0.028\ \mu g/m^3 \times 10 \times 0.16667 = \mathbf{0.047}\ \boldsymbol{\mu g/m^3}$$	Acute TRV: 0.047 µg/m^3

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
Total Polycyclic aromatic hydrocarbons (PAHs)		Cancer	OHA proposes to use the benzo[a]pyrene IUR developed by EPA IRIS in 2017 as the index member of the class. Proposed cancer TRVs for all other members of the PAH family are calculated by multiplying the IUR for benzo[a]pyrene by a relative potency factor (RPF) calculated for the specific PAH in question from the source indicated in the TRV tool and in table 5-6 below. OHA selected RPFs from the Minnesota Department of Health because they had RPFs for the widest range of PAHs and compiled their RPFs from other sources that DEQ considers authoritative. To get the final TRV, OHA divided the target risk of 1 in 1 million by the modified IUR as shown here: $$Cancer\ TRV\ for\ PAHn = \frac{0.000001}{IUR\ for\ benzo(a)pyrene \times RPFn}$$ Specific proposed RPFs for individual PAH species are listed in Table 5-6 below.	See Workbook 1

Toxic air contaminant basic information			OHA narrative supporting information	OHA proposed TRV value
Name	**CAS RN**	**TRV exposure category**	**Specific equations and/or narrative for each TAC shown below where applicable**	
sec-Butyl alcohol	78-92-2	Acute	This proposed acute TRV is the subchronic PPRTV RfC published in 2009. It is the same value as the proposed chronic TRV. Agency staff propose this as a reasonable acute TRV since it is based on a subchronic developmental study (gestation days 1-19 in rats) with no uncertainty factors to adjust for chronic averaging times.	Acute TRV: 30,000 µg/m^3

Table 5-6: Carcinogenic polycyclic aromatic hydrocarbon (PAH) relative potency factors (RPFs) and their sources (chronic, cancer)

PAH	CAS RN	RPF (unitless)	Source of RPF
Anthanthrene	191-26-4	0.4	Minnesota Department of Health 2016
Benz[a]anthracene	56-55-3	0.2	Minnesota Department of Health 2016
Benzo[a]pyrene	50-32-8	1	Index Chemical
Benzo[b]fluoranthene	205-99-2	0.8	Minnesota Department of Health 2016
Benzo[c]fluorene	205-12-9	20	Minnesota Department of Health 2016
Benzo[g,h,i]perylene	191-24-2	0.009	Minnesota Department of Health 2016
Benzo[j]fluoranthene	205-82-3	0.3	Minnesota Department of Health 2016
Benzo[k]fluoranthene	207-08-9	0.03	Minnesota Department of Health 2016
Chrysene	218-01-9	0.1	Minnesota Department of Health 2016
Cyclopenta[c,d]pyrene	27208-37-3	0.4	Minnesota Department of Health 2016
Dibenz[a,h]acridine	226-36-8	0.1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)

PAH	CAS RN	RPF (unitless)	Source of RPF
Dibenz[a,j]acridine	224-42-0	0.1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
7H-Dibenzo[c,g]carbazole	194-59-2	1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
Dibenz[a,h]anthracene	53-70-3	10	Minnesota Department of Health 2016
Dibenzo[a,e]pyrene	192-65-4	0.4	Minnesota Department of Health 2016
Dibenzo[a,h]pyrene	189-64-0	0.9	Minnesota Department of Health 2016
Dibenzo[a,i]pyrene	189-55-9	0.6	Minnesota Department of Health 2016
Dibenzo[a,l]pyrene	191-30-0	30	Minnesota Department of Health 2016
7,12-Dimethylbenz[a]anthracene	57-97-6	64	Minnesota Department of Health 2016
Fluoranthene	206-44-0	0.08	Minnesota Department of Health 2016
Indeno[1,2,3-cd]pyrene	193-39-5	0.07	Minnesota Department of Health 2016

PAH	CAS RN	RPF (unitless)	Source of RPF
1,6-Dinitropyrene	42397-64-8	10	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
1,8-Dinitropyrene	42397-65-9	1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
3-Methylcholanthrene	56-49-5	5.6	Minnesota Department of Health 2016
5-Nitroacenaphthene	602-87-9	0.02	Minnesota Department of Health 2016
5-Methylchrysene	3697-24-3	1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
6-Nitrochrysene	7496-02-8	10	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
2-Nitrofluorene	607-57-8	0.01	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)

PAH	CAS RN	RPF (unitless)	Source of RPF
1-Nitropyrene	5522-43-0	0.1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)
4-Nitropyrene	57835-92-4	0.1	Minnesota Department of Health 2016 And OEHHA (MDH adopted OEHHA's RPF)

Section 5.6 TRVs proposed for adoption from non-authoritative sources without modification

OHA found some TRVs from alternate sources (sources other than ATSDR, EPA, or CalEPA) that were of adequate quality to adopt without modifications. These TRVs along with their sources are shown in Table 5-7. OHA selected these sources because of the transparency of their documentation and robust systematic review processes.

Sources include TCEQ, Minnesota Department of Health (MDH), Michigan Department of Environment, Great Lakes, and Energy (EGLE), New Jersey Department of Environmental Protection (NJDEP), and EPA's National Ambient Air Quality Standards (NAAQS). Blank cells in Table 5-7 indicate the missing TRV is from one of the authoritative sources in rule (ATSDR, CalEPA, or EPA), is addressed in one of the tables above in this document or does not have a TRV for that risk category.

Table 5-7: TRVs adopted from non-authoritative sources without modification

Chemical name	CAS RN	TRV Type	Cancer TRV ($\mu g/m^3$)	Chronic NC TRV ($\mu g/m^3$)	Acute TRV ($\mu g/m^3$)	TRV source
tert-Butyl alcohol	75-65-0	Acute			15,000	TCEQ
Crotonaldehyde	4170-30-3	Acute			29	TCEQ

Chemical name	CAS RN	TRV Type	Cancer TRV (µg/m^3)	Chronic NC TRV (µg/m^3)	Acute TRV (µg/m^3)	TRV source
Ethylene	74-85-1	Chronic NC/Acute		6,100	570,000	TCEQ
Isoprene, except from vegetative emission sources	78-79-5	Chronic NC/Acute		390	3,900	TCEQ
Lead and compounds	7439-92-1	Chronic NC/Acute		0.15	0.15	EPA (NAAQS)
Manganese and compounds	7439-96-5	Acute			1.3	See DEQ 2024 Mn memo
Methyl amyl ketone {2-heptanone}	110-43-0	Chronic NC/Acute		2,800	15,000	TCEQ
1-Methylnaphthalene	1321-94-4	Cancer	0.14			Michigan EGLE
6:2-Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	Chronic NC		1		Michigan EGLE
Perfluorobutanesulfonic acid (PFBS)	375-73-5	Acute			0.3	Minnesota MDH
Perfluorobutanoic acid (PFBA)	375-22-4	Chronic NC/Acute		3.5	10	Chronic from TCEQ; Acute from Minnesota MDH
Perfluorododecanoic acid (PFDoA)	307-55-1	Chronic NC		0.042		TCEQ

Chemical name	CAS RN	TRV Type	Cancer TRV (µg/m^3)	Chronic NC TRV (µg/m^3)	Acute TRV (µg/m^3)	TRV source
Pefluorohexanesulfonic acid (PFHxS)	355-46-4	Acute			0.034	Minnesota MDH
Perfluorohexanoic acid (PFHxA)	307-24-4	Chronic NC/Acute		0.5	1	Minnesota MDH
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	Chronic NC/Acute		0.0004	0.011	Chronic from Michigan EGLE; Acute from Minnesota MDH
Hexafluoropropylene oxide dimer acid (HFPO-DA/Gen-X)	62037-80-3	Chronic NC		0.01		New Jersey DEP
Perfluorobutylethylene (PFBE)	19430-93-4	Chronic NC		2,600		Michigan EGLE
Perfluorooctanoic acid (PFOA)	335-67-1	Chronic NC/Acute		0.0001	0.063	Chronic from Michigan EGLE/Acute from Minnesota MDH
Propionaldehyde	123-38-6	Acute			1,800	TCEQ
Silica, amorphous and other non-crystalline forms (respirable)	1058T	Chronic NC		6.6		TCEQ
Silica, crystalline forms (respirable)	7631-86-9	Acute			24	TCEQ

Chemical name	CAS RN	TRV Type	Cancer TRV (µg/m^3)	Chronic NC TRV (µg/m^3)	Acute TRV (µg/m^3)	TRV source
4-Vinylcyclohexene	100-40-3	Chronic NC/Acute		330	5,800	TCEQ

Chapter 6: Agency Highlighted TRVs

Section 6.1 Diesel particulate matter

6.1.1 DPM summary

The purpose of this section is to provide background information on OHA's cancer TRV proposal for diesel particulate matter (DPM) for this rulemaking. Because DPM exposure is prevalent in Oregon and can have a significant impact on public health, DEQ and OHA held an ATSAC discussion specific to DPM TRVs at ATSAC meeting #8 on May 14, 2025. OHA proposes that the DEQ cancer TRV for inhalation exposure to DPM should be changed from 0.1 µg/m^3 to 0.0033 µg/m^3.

6.1.2 Overview of DEQ's DPM TRVs

OHA is proposing to change the cancer TRV for DPM. Currently, DEQ's cancer TRV is 0.1 µg/m^3 and is calculated from the World Health Organization (WHO) IUR, which was published in 1996. This value was adopted in 2018 by DEQ based on the recommendation from a previously convened ATSAC. However, the WHO withdrew their cancer IUR and have not replaced it. OHA has been unable to find documentation from the WHO on why they withdrew it.

OHA's normal process for reviewing and updating inhalation TRVs is to check all the authoritative sources listed in the OAR for relevant TRVs. DEQ's authoritative sources are listed in Table 6-1. When multiple authoritative sources have TRVs for the same TAC, OHA considers the calculation information behind each value and selects the most scientifically robust option as described in Chapter 2.

Table 6-1: Summary of DPM TRVs available from DEQ's authoritative sources as well as DEQ's current and OHA's proposed DPM TRVs

	Cancer TRV	Noncancer chronic TRV	Noncancer acute TRV
Current DEQ TRV Adopted in 2018	0.1 µg/m^3 WHO*	5 µg/m^3 OEHHA	--

	Cancer TRV	Noncancer chronic TRV	Noncancer acute TRV
U.S. EPA DEQ Authoritative Source	--	5 µg/m^3 EPA 2003	--
U.S. ATSDR DEQ Authoritative Source	--	--	--
CalEPA DEQ Authoritative Source	0.0033 µg/m^3 CalEPA 1998	5 µg/m^3 CalEPA 1998	--
OHA proposal	0.0033 µg/m^3 CalEPA	5 µg/m^3 EPA	--

-- Indicates that a TRV is not available.
* The WHO cancer TRV (0.1 µg/m^3) has been withdrawn and not replaced.

Only one of DEQ's authoritative sources has a cancer TRV for DPM (Table 6-1); CalEPA has a cancer TRV of 0.0033 µg/m^3 based on an IUR of 0.0003 (µg/m^3)$^{-1}$, which was co-developed by the California Air Resources Board (CARB) and the Office of Environmental Health Hazard Assessment (OEHHA). (19) **Therefore, by default, OHA proposes to select CalEPA's cancer TRV for DPM.** OHA acknowledges that this cancer TRV includes uncertainties, which are described in this section of Chapter 6. The calculation of the cancer TRV from the CalEPA IUR is shown in Equation 6-1. As discussed in Chapter 2, OHA calculates cancer TRVs from IURs developed by authoritative sources by calculating the concentration associated with a one-in-one-million risk.

Equation 6-1: The calculation of the cancer TRV from the CalEPA inhalation unit risk

$$TRV_{cancer} = \frac{Target\ Risk}{IUR} = \frac{1 \times 10^{-6}}{0.0003\ (\frac{\mu g}{m^3})^{-1}} = 0.0033\ \frac{\mu g}{m^3}$$

OHA is not proposing to change the noncancer TRV for DPM from what was adopted into DEQ rule in 2018 (5 µg/m^3). OHA is only proposing to change the TRV source attribution from OEHHA (an office within CalEPA) to U.S. EPA (Table 6-1). CalEPA published their value in 1998, and it is equivalent to and references the EPA IRIS

program value. (19) The EPA IRIS noncancer chronic TRV was originally published in 1993 and updated in 2003, with the TRV staying the same at 5 µg/m^3. (20) No other noncancer chronic DPM TRVs are available from DEQ's authoritative sources (Table 6-1). DEQ does not currently have an acute TRV for DPM. In this TRV review process, OHA did not identify an acute TRV to propose for DPM.

6.1.3 Diesel exhaust (DE) vs. diesel particulate matter (DPM)

Organizations not only use the term "DPM", but also often use the term "diesel exhaust" in their documents. These terms are different. The EPA stated in their Diesel Engine Exhaust Chemical Assessment Summary,

> "Diesel engine exhaust (DE) is a complex mixture of airborne particles and gases. Diesel particulate matter (DPM), composed of elemental carbon particles and adsorbed organic compounds, is the most frequently determined measure of DE and the measure reported in toxicological studies of diesel engine exhaust". (20)

The EPA is specific that their noncancer chronic value is based on the lung deposition of DPM. A review article also reported,

> "For older technology diesel engines, these [health] effects are mainly associated with the particulate fraction of the exhaust, making DEP [diesel exhaust particles or DPM] a good exposure indicator candidate". (21)

DEQ currently lists DPM as a TAC and is proposing to maintain this nomenclature. DEQ defines DPM as the particulate fraction, both filterable and condensable. In this Chapter, OHA uses the term "diesel exhaust" when referring to the entire complex mixture of airborne particles and gases released from diesel engines. OHA also uses "DPM" when specifically referring to the particulate fraction of diesel exhaust, usually in reference to toxicological studies and TRVs.

All ATSAC members agreed with OHA that using DPM as an indicator for DE is appropriate. For example, ATSAC members stated:

- "Diesel exhaust is a complex mixture of particles and gases, and yet it is important to have an indicator that can be evaluated straightforwardly, which in this case is DPM… Using DPM in the TRV derivation is exactly what the DEQ-OHA team should do" (Appendix F).

- “When the OEHHA [CalEPA] IUR was developed, there was a realization that even if it were possible to filter 100% of the particulates [DPM] out of the diesel exhaust, then the risk from diesel exhaust would likely be underestimated since there would still be gas phase chemicals (e.g., benzene, acrolein). DPM is still the best metric that can be used” (Appendix F).

6.1.4 Background on exposure to diesel emissions and cancer

Diesel engines and emissions overview

Diesel engines have a wide variety of uses including passenger cars, buses, heavy goods vehicles, construction equipment, trains, ships, mining equipment, and electricity generators. (22) Diesel engines emit complex mixtures, which include chemicals in the gas phase (e.g., carbon monoxide, nitrogen oxides, benzene, and formaldehyde) as well as very small carbon particles, coated with numerous compounds including metals like chromium (VI), known as DPM. (22–24) According to CARB, “diesel exhaust contains more than 40 cancer-causing substances, most of which are readily adsorbed on to the soot particles”. (23) Other common contaminant groups, such as polycyclic aromatic hydrocarbons (PAHs) and nitroarenes, are distributed within both the gas and particle phases of diesel emissions. (22) The portion of diesel emissions that contains particles is the most frequently determined measure of diesel emissions and most frequently reported in toxicological studies. (20) Further, because DPM is a complex, variable mixture that can have significant health impacts as a mixture, it is evaluated differently from other TACs. In response to public comments in 1998, CARB and OEHHA staff wrote why they evaluated diesel exhaust as a mixture rather than as individual air contaminants:

> “In our review of diesel exhaust, we are examining the overall toxicity of the exhaust. The reason we are doing this is because the exposure experienced in most health studies, particularly the human studies, has been to the overall exhaust. The International Agency for Research on Cancer, the National Institute for Occupational Safety and Health, and the United States Environmental Protection Agency have also evaluated diesel exhaust in this way. Until more research is done to identify specific causes of toxicity in diesel exhaust, we believe this approach provides the best public health protection. We have also made it clear that our exposure analysis is based primarily on exposures to diesel exhaust particulate matter”. (25)

There are a number of other factors that can affect the composition of emissions from diesel engines, such as type and age of the engine, fuel, maintenance of the engine,

patterns of use, and use of emission controls. (22) Additionally, diesel engine technology has also changed over time in response to regulations to control engine emissions – these changes include both innovations to engine performance as well emissions reduction systems, including particulate filters and oxidation catalysts, all of which can lead to reductions in pollutant emissions and potential differences in DPM composition. Currently, there is a lack of sufficient toxicological information to assess how these factors may affect health outcomes. It is important to consider exposure and related health effects from both new and older diesel engines because older diesel engines and vehicles can remain in service for long periods of time (i.e., slow rate of turnover). (26,27) The Health Effects Institute (HEI; a nonprofit research organization that receives funding from both the U.S. EPA and motor vehicle industry), has estimated that the turnover to cleaner diesel engine technology is expected to take one to two decades in the U.S (starting from 2015) (26)

Diesel engine emissions and cancer

Over the past several decades, epidemiological and toxicological studies have reported associations between short-term and long-term exposures to diesel exhaust and a range of adverse health effects, including lung cancer. (26) As the CARB explains,

> "…several factors exacerbate the health risks of diesel PM exposure:
> - Diesel PM is often emitted close to people, so high exposures occur
> - Diesel PM is in a size range that readily deposits in the lung
> - Diesel PM contains compounds known to damage DNA and cause cancer". (23)

Certain populations can be more vulnerable and susceptible to health effects from TACs, such as DPM. For example, children can be at greater risk from exposure to DPM emissions than adults because children are growing and breathe more air per pound of body weight. In addition, children's natural defenses for responding to exposure to toxic chemicals are less developed; for example, TACs breathed in through the nose can more easily reach the lungs in children than adults. (28)

This Chapter is focused on cancer; however, information on noncancer health effects can be found in a 2017 review article in Toxicological Sciences and the EPA's IRIS report. (20,21) For cancer health effects, a recent journal article authored by Dr. Silverman, a researcher at the U.S. National Cancer Institute who has done extensive research on diesel exhaust and cancer, concludes: "In the aggregate, experimental, epidemiologic, and mechanistic findings provide clear evidence that diesel exhaust causes lung cancer in humans". (29)

Comprehensive reviews of the scientific evidence by several organizations have reported mounting evidence supporting a causal association between exposure to DPM and lung cancer (Table 6-2). In 2012, the International Agency for Research on Cancer (IARC) reclassified diesel exhaust from Group 2A (probably carcinogenic to humans) to Group 1 (carcinogenic to humans) due to additional evidence of lung cancer in humans. (22) Beyond lung cancer, the IARC working group also noted a positive association between diesel exhaust exposure and increased risk of bladder cancer. (30) While IARC identified DPM exposure as a hazard, IARC did not conduct an exposure-response assessment, the next step necessary for deriving a TRV. The National Toxicology Program (NTP) and EPA also have not calculated a cancer TRV for DPM.

Table 6-2: A summary of some of the organizations that have made statements on the carcinogenicity of DPM (a carcinogen is a substance that causes cancer)

Agency	Year	Findings	Documentation
World Health Organization (WHO) International Agency for Research on Cancer (IARC)	2012, 2014	Carcinogenic to humans (Group 1)	IARC press release (30) IARC working group Lancet summary (31) Full IARC monograph (22)
National Toxicology Program (NTP)	2011	Reasonably anticipated to be a human carcinogen	Excerpt from NTP's report on carcinogens (32)
U.S. EPA	2003	Likely to be carcinogenic to humans	EPA IRIS report (20)

There is a lack of information on the health effects of emissions from relatively newer diesel engines. According to a review article, "No human studies related to the health effects of new technology DE [diesel exhaust] were found. Moreover, the data on the effects of new technology DE in animals are still rather limited". (21) One study of chronic exposure of rodents to new technology diesel emissions, found no evidence of carcinogenicity. (33) More research on new-technology engines is greatly needed.

6.1.5 CalEPA's cancer TRV for DPM

Calculation documentation for CalEPA's cancer TRV

CalEPA has documentation on their cancer TRV for DPM from their original rulemaking. CARB wrote the documents related to diesel emissions and exposure and OEHHA wrote the documents related to the diesel exhaust health risk assessment. Table 6-3 contains links to key CalEPA documentation. As with other proposed TRVs calculated by DEQ's authoritative sources, DEQ and OHA rely on the expertise of those authoritative sources. DEQ and OHA do not recreate or independently recalculate cancer TRV calculation information produced by authoritative sources. However, Table 6-3 provides links to all the detailed calculation information behind CalEPA's cancer TRV for DPM along with documentation of the public and technical process they followed to generate the TRV. These resources can all be found on the 1998 CARB website titled Rulemaking Identification of Particulate Emissions from Diesel-Fueled Engines as a Toxic Air Contaminant.

Table 6-3: A summary of key documentation from CalEPA on their cancer TRV for DPM

Resource title and brief description	Date	Link and citation
Findings of the Scientific Review Panel (SRP) on the Report on Diesel Exhaust as Adopted at the Panel's April 22, 1998, Meeting (9 pages) • This document summarizes the findings from the SRP in response to CARB's/OEHHA's diesel exhaust report	April 1998	Scientific Review Panel Report (19)
CARB Initial Statement of Reasons for Rulemaking Staff Report (33 pages) • This staff report summarizes the scientific basis for the proposed regulation and includes a discussion of the environmental and economic impacts of the proposal	June 1998	Staff Report (34)

Resource title and brief description	Date	Link and citation
Part B: Health Risk Assessment for Diesel Exhaust by OEHHA (453 pages) • This document is part of Appendix III of the Rulemaking Staff Report and includes extensive background on the health effects of diesel exhaust and OEHHA's quantitative cancer risk assessment work. • This document was revised in response to public comments and SRP comments. • Chapter 7 provides details on their quantitative estimates of the risk of humans developing cancer due to the inhalation of diesel exhaust. • Section 7.2.5. (pages 7-12 to 7-15) contains a list of the sources of uncertainty in the quantitative risk estimates, based on the Garshick et al. studies.	May 1998	Health Risk Assessment Report (35)
California's Responses to Comments for the June 1994 Comment Period (over 200 pages)	1994	CARB Responses (36) OEHHA Responses (37)
California's Responses to Comments for the May 1997 Comment Period (over 200 pages)	1997-1998	CARB & OEHHA Responses (38) OEHHA Responses PDF 1 & OEHHA Responses PDF 2 (39)
California's Responses to Comments for the February 1998 Comment Period (about 150 pages)	1998	CARB & OEHHA Responses, 40 pages (25) OEHHA Responses, 109 pages (40)

There has been criticism of the CalEPA cancer TRV for DPM in the research community. Namely, a biostatistician, Dr. Crump, criticized CalEPA's cancer TRV in journal articles and letters over the years. In addition, the author of the critical studies used by CalEPA to develop the cancer TRV for DPM (Dr. Garshick) had communicated concerns about the use of his studies in TRV development in letters to both the U.S. EPA and CalEPA. Staff at CalEPA have responded to many of Dr. Crump's and Dr. Garshick's comments. OHA assembled a table of the key dates and documents relevant to the CalEPA cancer TRV for DPM (Table 6-4).

Table 6-4: Summary of key commentary between CalEPA staff and other researchers and statements from other organizations on the CalEPA cancer TRV for DPM

Year	Description and link to reference (if available)

1987-1988	**Garshick et al. railroad workers studies**
	• CalEPA used concentration-response information from the following two studies on U.S. railroad workers to calculate their cancer TRV for DPM
	• Critical Study #1
	  ○ Title: A case-control study of lung cancer and diesel exhaust exposure in railroad workers
	  ○ Author: Garshick et al.
	  ○ Published: American Review of Respiratory Disease (41)
	• Critical Study #2
	  ○ Title: A retrospective cohort study of lung cancer and diesel exhaust exposure in railroad workers
	  ○ Author: Garshick et al.
	  ○ Published: American Review of Respiratory Disease (42)

1991	**Dr. Crump assessment of risk from exposure to diesel engine emissions** • Title: Assessment of risk from exposure to diesel engine emissions • Author: Crump KS, Lambert T, Chen C • Published: Report to U.S. Environmental Protection Agency. Contract 68-02-4601 (Work Assignment No. 182, July). Office of Health Assessment, U.S. Environmental Protection Agency, Washington, DC. • DEQ has been unable to find a copy of this report.
1991	**Letter from Dr. Garshick to EPA** • Cited in EPA 2002 as "letter from Garshick, Harvard Medical School, to Chao Chen, U.S. EPA, dated August 15, 1991." • DEQ has been unable to find a copy of the original letter.

Year	Description and link to reference (if available)
1994-1998	**Series of written communications between Dr. Dawson at OEHHA and Dr. Crump on interpretation of data from Dr. Garshick and colleagues** • Several of these written communications are included or summarized in the rulemaking documentation linked in Table 6-3 above
1994-1998	**CalEPA risk assessment documentation during rulemaking process** • See Table 6-3 above
1999	**HEI special report on diesel emissions and lung cancer** • Title: Diesel Emissions and Lung Cancer: Epidemiology and Quantitative Risk Assessment, A Special Report of the Institute's Diesel Epidemiology Expert Panel • Author: HEI Diesel Epidemiology Expert Panel • Published: HEI Website (43)
1999	**Dr. Crump's reanalysis of Dr. Garshick's railroad worker studies** • Title: Lung cancer mortality and diesel exhaust: Reanalysis of the retrospective cohort study of U.S. railroad workers • Author: Crump • Published: Inhalation Toxicology (44) note: full text not online
2001	**OEHHA journal article** • Title: Multi-Stage Model Estimates of Lung Cancer Risk from Exposure to Diesel Exhaust, Based on a U.S. Railroad Worker Cohort • Author: OEHHA Staff, Dawson & Alexeeff • Published: Risk Analysis (45) note: full text not online
2001	**Dr. Crump's commentary in response to OEHHA journal article** • Title: Invited Commentary: Modeling Lung Cancer Risk from Diesel Exhaust: Suitability of the Railroad Worker Cohort for Quantitative Risk Assessment • Author: Crump • Published: Risk Analysis (46) note: full text not online
2001	**OEHHA's response to Dr. Crump on multistage models** • Title: Response to Dr. Crump's Commentary on "Multi-Stage Model Estimates of Lung Cancer Risk from Exposure to Diesel Exhaust, Based on a U.S. Railroad Worker Cohort" • Author: OEHHA Staff, Dawson & Alexeeff • Published: OEHHA Website (47)

Year	Description and link to reference (if available)
2002	**U.S. EPA's final report on diesel engine exhaust** • Title: Health Assessment Document for Diesel Engine Exhaust (Final 2002) • Author: U.S. EPA • Published: U.S. EPA Website (48) • Note: This EPA report does not include a recommended IUR for DPM.

Ramboll Environ US Corporation (an environmental consulting firm) prepared a white paper for Moffatt & Nichol (an engineering firm) on behalf of the Port of Seattle. This paper, titled White Paper on Diesel Exhaust Quantitative Health Risk Assessment Values for Lung Cancer, provides summary information for the key publications related to the cancer TRV options for DPM. (49)

Additional CalEPA cancer TRV strengths

A key reason OHA is proposing to use CalEPA's cancer TRV for DPM is because it follows OHA's normal process for updating inhalation TRVs. This is the same process OHA has followed for setting and reviewing all inhalation TRVs in the program. Generally, OHA collects detailed information on the available TRVs from authoritative sources, ensures the information goes through a quality control process, and shares the information with the ATSAC. **In the case of the DPM cancer TRV, the only external DEQ authoritative source that has a cancer TRV option is CalEPA (0.0033 µg/m^3).**

OHA is also proposing to use CalEPA's cancer TRV because California has extensive, publicly available documentation related to their cancer TRV for DPM (Table 6-3). OHA relies on documentation from its authoritative sources when reviewing and updating all TRVs. In this case, CalEPA agencies developed robust, comprehensive documents on the development of the quantitative cancer TRV. CalEPA also has hundreds of pages available where they responded to three iterations of public comment on this value. OEHHA defended their value outside of their rulemaking process in journal articles and other venues (Table 6-4). While OHA acknowledges that this TRV, like all TRVs, comes with uncertainties, OHA considers CalEPA's cancer TRV to be both protective of health and well justified by CalEPA.

CalEPA requires this cancer TRV, calculated from its IUR, be used in every health risk assessment in the Air Toxics Hot Spots Program. (50) In addition to California, other states and a federal agency also use the CalEPA IUR:

- Washington State uses the CalEPA cancer IUR. (51) For example, in a Diesel Engine Exhaust Particulate Matter Health Risk Assessment Report in Washington, the risk assessors use the IUR from CalEPA. (52)
- New Jersey Department of Environmental Protection (NJDEP) uses CalEPA's DPM IUR as seen in their Technical Support Document: Updating Hazardous Air Pollutant Reporting Thresholds. (53)
- While EPA does not have their own cancer TRV for DPM through IRIS, EPA risk assessment practitioners in the Superfund Program use the CalEPA IUR. The CalEPA IUR is listed in the EPA's Regional Screening Level (RSL) tables used in risk assessments for Superfund Sites. (54) The RSL tables provide comparison values to screen chemicals at Superfund sites and promote national consistency. (55) An ATSAC member also commented "US EPA has sufficient confidence in the OEHHA [CalEPA] DPM IUR that is has listed it in the EPA's Regional Screening Level tables" (Appendix I).

Additional CalEPA cancer TRV uncertainties

OHA acknowledges that the CalEPA cancer TRV has uncertainties. For example, the exposure to DPM in the critical study is not well defined; personal exposure to DPM was estimated using information related to job positions, activities, and locations rather than using air sampling measurements, and Garshick et al., Crump et al., and OEHHA all proposed different approaches for estimating exposure in place of job information. (43) In general, air sampling data are preferred when analyzing the relationship between exposure levels and health response; however, not having exposure data is an issue with many epidemiological studies. In general, cancer studies on people are challenging because of the long time period (i.e., several decades) between when exposure first occurs and when cancer develops.

There are other limitations and uncertainties in this cancer TRV, which are not unique to this TRV. All TRVs have some degree of uncertainty, which is accounted for by the integration of safety buffers (i.e., uncertainty factors). The 1999 HEI report describes various potential sources of uncertainty when using the Garshick et al. critical studies for quantitative risk assessment. (43) For example, the critical study is primarily with healthy male workers, which does not encompass the variability in the human population. As the 1999 HEI report states

> "One more possible source of bias in these data is the 'healthy worker survivor effect' (Arrighi and Hertz-Picciotto 1994). That is, workers who are 'healthier' and

> less susceptible to disease might stay in the work place longer, so that those employed for longer periods might show a smaller elevation in risk than those employed for a shorter duration." (43)

This is not unique to this TRV; many TRVs are based on occupational studies where many of the workers were healthy males (Workbook 2: TRV Derivation). To deal with this, safety factors are integrated into the TRV to protect the health of a larger population, including vulnerable populations such as children and those with health conditions.

As described in Section 6.1.4, another complicating factor is that diesel engines have changed over time. Workers were exposed to DPM in the critical studies for the CalEPA cancer TRV through 1980, with older diesel engine technology used by the railroad industry. (41,42) However, more recent epidemiological evidence that could be used to develop cancer TRVs, also were based on exposure to older diesel engine technology (see Section 6.1.6). In addition, turnover of old diesel engines takes a long time (26), meaning people are currently being exposed to diesel exhaust from older diesel engines. We also do not have much information on health effects from exhaust from newer diesel engine technology. (21,29) OHA needs to protect Oregonians' health from DPM exposure, and in the absence of better information, OHA finds that the CalEPA cancer TRV is the best option.

6.1.6 Recent epidemiological evidence for diesel emissions quantitative risk assessment

There has been interest in looking at recent epidemiological studies (such as the studies that IARC used to reclassify diesel exhaust as carcinogenic to humans) to see if that evidence can be used to calculate a TRV for the quantitative estimation of lung cancer risk. One organization, HEI, summarized these epidemiological studies and their potential use in quantitative risk assessment. (26) The HEI stated,

> "This report is a careful review by an independent scientific panel of two major epidemiological studies of historical exposures to diesel exhaust, the Diesel Exhaust in Miners Study (DEMS) and the Trucking Industry Particle Study (Truckers) to assess whether these studies could provide the basis for quantitative risk assessment". (26)

A high-level summary of these two major epidemiological studies and where to read more about them is in Table 6-5.

Table 6-5: Summary of the two recent major epidemiological studies evaluated by the 2015 Health Effects Institute (HEI) Diesel Epidemiology Panel

Study name	High level study details summarized by the HEI	Original study publications	Where to find the HEI study summary
Diesel Exhaust in Miners Study (DEMS)	A cohort and nested case-control study designed to study associations between retrospective estimates of exposure to diesel exhaust (represented by respirable elemental carbon, REC), and health outcomes in 12,315 miners (mostly white males) working in eight underground non-metal mines in the U.S.	The Diesel Exhaust in Miners Study: A Nested Case-Control Study of Lung Cancer and Diesel Exhaust (56) The Diesel Exhaust in Miners Study: A Cohort Mortality Study with Emphasis on Lung Cancer (57,58)	**Report title** Diesel Emissions and Lung Cancer: An Evaluation of Recent Epidemiological Evidence for Quantitative Risk Assessment **Publisher and date** HEI Diesel Epidemiology Panel, November 2015 **Links and Citations** Full Special Report (26)
Trucking Industry Particle Study (Truckers)	Researchers examined risk of lung cancer in relation to quantitative estimates of personal exposure to submicron elemental carbon (SEC) in 31,135 workers in trucking facilities across the U.S.	Lung Cancer and Elemental Carbon Exposure in Trucking Industry Workers (59)	

The HEI Panel did not calculate a cancer TRV. Overall, the HEI "Panel concluded that the DEMS and data from both the Truckers study and the DEMS can be usefully applied in quantitative risk assessments. The uncertainties within each study should be considered in any attempts to calculate an exposure–response relationship". (26) Here are some of the other conclusions in the HEI Executive Summary:

- "In the Panel's view, both the Truckers and DEMS were well designed and well-conducted studies and each made considerable progress toward addressing a number of the major limitations that had been identified in previous epidemiological studies of diesel exhaust and lung cancer. These limitations related particularly to the need for metrics more specific to diesel, better models

of historical exposures, and ultimately for quantitative estimates of historical exposures to diesel exhaust. They both also demonstrated many of the attributes of high quality epidemiological studies that scientists and regulators value in evidence used to support quantitative risk assessments". (26)

- "The detailed evaluations of these studies by IARC, the HEI Panel, and other analysts lay the groundwork for a systematic characterization of the exposure–response relationship and associated uncertainties in a quantitative risk assessment, should one be undertaken. In addition, the Panel has identified the challenges that should be confronted in extrapolating the results from these studies to different populations and time periods, particularly given the rapid changes in diesel technology and its deployment around the world". (26)

HEI praised the quality of the recent diesel studies in Table 6-5 above. In section 5.2 of their report, HEI described considerations for future quantitative risk assessments of diesel exhaust. HEI states that it is unlikely that a single study or statistical model will provide the sole basis for characterizing the exposure-response relationship for diesel exhaust and lung cancer. (26)

Researchers differ in approaches to calculating inhalation unit risk values for DPM. In 2014, Dr. Vermeulen and colleagues conducted a meta-analysis to develop an exposure-response curve based on a log-linear regression model using relative risk estimates. (60) These authors have affiliations with Utrecht University, the U.S. National Cancer Institute, VA Boston Healthcare System, and Emory University. Vermeulen et al. used data from three case-control studies (56,59,61) to estimate excess lifetime risk of lung cancer mortality in the U.S. in the workplace and in the ambient environment. (60) In response, Crump et al. criticized the methods (specifically related to lag times) used in the Vermeulen et al. meta-analysis in an Environmental Health Perspectives commentary (62); Crump's commentary was funded by a coalition of several trade organizations including the Truck and Engine Manufacturers Association, American Petroleum Institute, European Automobile Manufacturers Association. Alongside Crump's commentary, Vermeulen and colleagues published a commentary in response to Crump where they state that they "firmly stand with the conclusions of our original paper". (63)

In 2015, Dr. Morfeld and Dr. Spallek (with associations to Cologne University, the Institute for Occupational Epidemiology and Risk Assessment, Goethe University Frankfurt, and the European Research Group on Environment and Health in the Transport Sector) reanalyzed Vermeulen's 2014 meta-analysis data with different

modeling approaches. (64) The researchers stated that “The findings of Vermeulen et al. 2014 should not be used without reservations in any risk assessments. This is particularly true for the low end of the exposure scale”. (64) However, the authors of the Ramboll Environ white paper on diesel exhaust chose to use the relative risk estimates in Vermeulen et al.’s original paper (60) and commentary (63) to calculate and present inhalation unit risk values (see Table 1 in Ramboll Environ 2016).

6.1.7 Other options for the DEQ cancer TRV

DEQ and OHA no longer recommend retaining the current (2018) cancer TRV that has been withdrawn by the WHO due to lack of scientific support. Other than adopting CalEPA’s cancer TRV for DPM, there are other options that DEQ and OHA could consider, including deriving a new cancer TRV or not having a cancer TRV as discussed in the following paragraphs.

As discussed in the previous section, there are recent epidemiology studies that have the potential to be used to calculate a cancer TRV. However, DEQ and OHA do not support deriving a new DEQ cancer TRV at this time because this would take a considerable amount of toxicology resources (staff, time, and money), and even with recent higher quality studies available, considerable uncertainties remain and a calculation effort at this time may not result in an alternate, more robust cancer TRV. An ATSAC member highlighted this previous sentence in their written feedback and wrote “DEQ and OHA are entirely correct” (Appendix I). **OHA will continue to closely monitor other organizations that generate TRVs and follow any developments on DPM TRVs. If other options arise, DEQ and OHA will thoroughly review the alternate TRVs for consideration at subsequent TRV rulemakings.**

Another option is that DEQ could not have a cancer TRV. However, DPM exposure in Oregon is prevalent and updated IARC conclusions make it clear that DPM is hazardous (i.e., exposure to DPM can lead to lung cancer), and without a cancer TRV in place, DEQ will not have oversight or authority to regulate DPM emissions to reduce this potential public health risk. DEQ and OHA also consider it important to acknowledge the impact DPM exposure can have on cancer with a quantitative TRV, even if that TRV incorporates uncertainty. In responding to Dr. Crump’s commentary (46), staff at OEHHA wrote:

> “In the face of considerable uncertainties, the assumptions in our paper involve judgment. We maintain that where risk numbers are needed, as they are in

> California procedures for identifying toxic air contaminants, our upper confidence limits are appropriately health protective in that our assumptions permit the estimation of reasonable upper values for human risk." (47)

6.1.8 ATSAC feedback on DPM

DEQ sought feedback from ATSAC on OHA's proposed DPM TRVs, especially the cancer TRV, at ATSAC meeting #8 on May 14, 2025. OHA carefully considered all ATSAC comments on DPM.

ATSAC feedback on OHA's cancer TRV proposal

Overall, four of the five ATSAC members supported OHA's proposal to select CalEPA's cancer TRV for DPM [TRV of 0.0033 $\mu g/m^3$, based on an IUR of 0.0003 $(\mu g/m^3)^{-1}$, see Appendix F and I for all DPM ATSAC comments]. One ATSAC member wrote

> "OEHHA used cancer data from two well-described and well-conducted railroad worker occupational studies (Garshick et al. 1987; 1988) to develop a DPM IUR using appropriate methodology. The OEHHA DPM IUR received multiple rounds of public comments and peer review and was revised in response to received comments…It would be entirely appropriate for DEQ and OHA to use the OEHHA DPM IUR as the basis for a cancer TRV" (Appendix I).

No ATSAC member suggested that OHA propose to keep DEQ's current (2018) cancer TRV for DPM, which is from the WHO and was withdrawn and not replaced. ATSAC members also supported OHA's approach to use DPM as an indicator for DE. OHA added ATSAC's feedback on this topic to Section 6.1.3.

One ATSAC member suggested OHA select the high end IUR (IUR of $1x10^{-3}$ per $\mu g/m^3$) of the proposed range of IUR options in the Ramboll white paper (see Table 1 in Ramboll Environ 2016) because the Ramboll table includes a variety of different sources, including more recent studies than the CalEPA IUR (Appendix I). For context, the IUR options in the Ramboll table include the CalEPA OEHHA 1998 IUR and WHO 1996 IUR. The authors of the white paper also include an IUR that they calculated from the Vermeulen et al. 2014 meta-analysis paper (as discussed in Section 6.1.6). The Ramboll table also includes IURs from other re-analyses of the Vermeulen et al. 2014 data (e.g., Crump 2014) as well as IURs from the EPA.

However, OHA does not think that all the options in the Ramboll table are appropriate for use in the development of DEQ's cancer TRV as described in this paragraph. An

ATSAC member agreed and wrote “at this point in time, there is no DPM IUR contained in the Ramboll white paper that is more appropriate for use by DEQ and OHA to develop a DPM cancer TRV than the OEHHA DPM IUR” (Appendix I). Specifically, for the EPA IURs listed in the table, it is important to note that the EPA does not currently have an IUR for DPM. As the Ramboll white paper explains, “The US EPA chose to take a set of exploratory approaches to estimate the possible magnitude of cancer risk…This exploratory analysis concluded that environmental cancer risks from exposure to diesel exhaust were possibly in the range of 10^{-5} to almost 10^{-3}, while acknowledging numerous uncertainties and assumptions in reaching this conclusion.” (49) In the case of the Vermeulen et al. 2014 analysis and reanalysis by other researchers in the Ramboll Table, OHA agrees with other ATSAC members that these more-recent IURs are not ready for proposal for DEQ’s cancer TRV. ATSAC members wrote:

- “The approach taken by Ramboll could eventually be the starting point for developing a DPM IUR, but a number of details (e.g., conversion of an EC IUR to a DPM IUR) would have to be worked out in order to produce a useable DPM IUR from the Vermeulen et al. (2014) data” (Appendix I).
- “However, the derivation by Ramboll Environ [from Table 2 of Vermeulen et al. (2014)] does not include consideration of Age Dependent Adjustment Factors applied to ages 0-2 and 2-6 from the Supplement to the 2005 EPA Guidelines for Carcinogen Risk Assessment. This is an important omission in the Ramboll Environ white paper” (Appendix I).

OHA thinks the Ramboll table is helpful context to see and compare different IURs, and ATSAC members agreed with the table’s usefulness. As one ATSAC member commented “It is notable that the IUR values shown in Table 1 of the Ramboll Environ white paper are rather similar, despite differences in data and estimate methods employed. This adds confidence that the CalEPA IUR is a scientifically reasonable approach for derivation of TRVs” (Appendix I). Overall, OHA is proposing to keep the original selection of CalEPA’s cancer TRV for DPM (0.0033 $\mu g/m^3$), which the majority of ATSAC members supported.

ATSAC feedback on OHA’s DPM document

All ATSAC members found OHA’s DPM background document (which was originally a separate ATSAC framing document and now is Section 6.1 in this TRV Support Document) helpful and complete:

- As one ATSAC member commented during the meeting, “I found the framing document to be very well done. It was balanced, complete, and provided the information and resources necessary to be able to comment on the decisions that DEQ and OHA need to make” (Appendix F).
- Another ATSAC member wrote “The DPM Framing document did a commendably thorough job of discussing the uncertainties associated with adopting the OEHHA diesel particulate matter inhalation unit risk for use in developing a cancer TRV” (Appendix I).

ATSAC members also suggested specific additions to the DPM background document, which OHA addressed in this DPM section (Section 6.1):

- An ATSAC member recommended adding a description of the calculation of the cancer TRV from CalEPA’s IUR. In response, OHA added additional description of this calculation and added the equation (Equation 6-1) to Section 6.1.2.
- An ATSAC member found a website address for the Ramboll Environ white paper that OHA referenced in this Chapter (49) and encouraged OHA to include this website in the document. OHA added this website address to Section 6.1.5 and to the reference in Chapter 7.
- An ATSAC member shared that the NJDEP also adopted OEHHA’s DPM IUR in the same way that Washington state did. OHA added this information to Section 6.1.5.

ATSAC feedback on the effect of DPM exposure on children

Two ATSAC members raised the concern that the existing DPM cancer TRVs do not consider age as a risk factor (Appendix F and I). One ATSAC member wrote

> “The Supplement to the 2005 US EPA Guidelines for Carcinogen Risk Assessment identifies the potential for additional risk to children due to variety of biological and exposure differences with adults, hence Age Dependent Adjustment Factors (ADAF) are applied to carcinogens that have a mutagenic mode of action, which is relevant for DPM (see IARC). I am not proposing that ADAFs be applied to the OEHHA (1998) or other assessments, but that this consideration be more explicitly discussed in the DPM Framing Document” (Appendix I).

OHA agrees with these ATSAC comments about the risk to children and thinks that the application of these comments is downstream from the development of TRV proposals.

In some DEQ programs that use TRVs, DEQ applies additional factors to the TRVs when assessing risk. For chemicals that the EPA considers carcinogenic by a mutagenic mode of action, DEQ's Cleaner Air Oregon Program applies an early-life adjustment factor (ELAF) to TRVs. ELAFs are important because contaminants that can cause cancer and permanently change genetic material (i.e., mutagen, mutagenic mode of action) can have greater toxicity when people are exposed to those contaminants in early-life stages. (65)

OHA and DEQ are proposing to consider DPM as carcinogenic by mutagenic mode of action. Therefore, DEQ is proposing to apply an ELAF to DPM in DEQ risk assessments (see DEQ's Adjustment Factors Supporting Document for more details). In the case of DPM, several components of DPM, and the larger mixture of DE (and DPM is an indicator for this larger mixture, see Section 6.1.3), are carcinogenic by a mutagenic mode of action (e.g., are mutagens). For example, the EPA has determined that chromium(VI) and benzo[a]pyrene are mutagens. (66)

OHA and DEQ's proposed approach is consistent with CalEPA. CalEPA's OEHHA applies age sensitivity factors (ASFs; which is a similar concept as ELAFs and ADAFs) to all carcinogens (which includes DPM). (67) OEHHA's ASFs account for the increased sensitivity to carcinogens during early-in-life exposure. (67,68) OEHHA's 2009 Technical Support Document for Cancer Potency Factors states

> "Many carcinogens do not have adequate data available for deciding on a specific mode of action, or do not necessarily have a single mode of action. For these reasons, OEHHA will apply the default cancer potency factor age adjustments described above to all carcinogens unless data are available which allow for the development of chemical specific cancer potency factor age adjustments". (68)

6.1.9 OHA and DEQ conclusions on DPM

While there is uncertainty in CalEPA's cancer TRV for DPM, DEQ and OHA support CalEPA's overall process and conclusions related to their cancer TRV. DEQ and OHA believe it is important to have a cancer TRV for DPM exposure and find that CalEPA's cancer TRV is a health protective option. OHA proposes that the DEQ cancer TRV for inhalation exposure to DPM should be changed from 0.1 µg/m^3 (the WHO withdrawn value) to 0.0033 µg/m^3 (the CalEPA value).

Section 6.2 1-Methylnaphthalene

6.2.1 Background

OHA staff initiated an email exchange with ATSAC asking for their reaction to an email from a state toxicologist in West Virginia to a national network of state toxicologists (see Appendix R). The West Virginia email raised points critical of the 2024 PPRTV chronic RfC for 1-methylnaphthalene. (69) The PPRTV program is a part of the EPA, and as such is among DEQ's authoritative sources. The PPRTV program follows EPA risk assessment guidance and follows the same systematic literature review methods and peer review processes as EPA's IRIS program. Prior to the West Virginia email, OHA had already proposed the PPRTV chronic RfC for adoption as DEQ's chronic noncancer TRV for 1-methylnaphthalene.

None of the ATSAC members specifically responded to criticisms in the email, but rather gave a close independent evaluation of the work the PPRTV program did to calculate their chronic RfC. One ATSAC member (Dr. Stanek) recused themselves from the email thread because they worked on the PPRTV chronic RfC in some capacity recently as part of their role at EPA.

The PPRTV chronic RfC is the only chronic TRV candidate available from among DEQ's authoritative sources. ATSDR developed an intermediate minimal risk level (MRL) from the same critical study (1), but intermediate MRLs are designed for exposures that last less than one year. ATSDR often does not develop chronic MRLs from subchronic toxicological studies because they have an intermediate MRL category that already fits the subchronic exposure time without modification.

6.2.2 Critical study selection

All four commenting ATSAC members agreed that the study published in Kim et. al. 2020 (70) is the best critical study available to use for a chronic noncancer RfC. This was the study the PPRTV program used as the basis of their chronic noncancer RfC.

6.2.3 Point of departure (POD) selection

One member criticized the PPRTV program's method of deriving a $BMCL_{10}$ as the POD. The member agreed with the authors of the Kim et. al. study (70) that the 23.2 mg/m^3 dose should be considered a NOAEL instead. The authors' argument, with which the ATSAC member agreed, was that the proliferation of mucous cells in the nose and

throat was mild and could have been adaptive rather than adverse, and no other effects were observed in the test animals at this dose.

The other three commenting ATSAC members agreed with PPRTV's use of a $BMCL_{10}$ using proliferation of nasopharyngeal mucous cells as the POD. One member pointed out that ATSDR, another of the authoritative sources listed in rule, also used this same critical study and used the $BMCL_{10}$ as POD for their intermediate MRL.

OHA recommends staying with the POD that PPRTV proposed because it follows the advice of the majority of commenting ATSAC members and another of DEQ's authoritative sources.

6.2.4 Exposure time adjustment factor selection

All four commenting ATSAC members agreed with the PPRTV program's use of exposure time adjustment factors (6 hours/day x 5 day/week).

6.2.5 Dosimetric adjustment factor selection

Two ATSAC members stated that different choices could be made about the dosimetric adjustment factor used to calculate a human equivalent concentration (HEC), however neither they nor any other ATSAC members recommended one option over the other. Therefore, OHA recommends keeping the option selected by the PPRTV program reflected in the current proposed chronic TRV.

6.2.6 Uncertainty factors

Table 6-6 shows all ATSAC member UF recommendations along with the current UFs applied and OHA's proposed UFs.

Table 6-6: ATSAC member uncertainty factor recommendations and OHA's proposal

Parameters	Budroe	Dong	Stanek	Tilton	Vanden-berg	Current PPRTV and DEQ proposed UFs	OHA proposed UFs
UF_A	3	3	Self-recused	3	3	3	3
UF_H	10	10	Self-recused	10	10	10	10
UF_D	3	10	Self-recused	3	10	10	10
UF_S	3	3	Self-recused	3	10	10	10
UF_{TOTAL}	300	1000	Self-recused	300	3000	3000	3000
TRV ($\mu g/m^3$)	**0.03**	**0.009***	**Self-recused**	**0.03**	**0.003**	**0.003**	**0.003**

*Dr. Dong made additional recommendations with respect to point of departure selection that OHA is proposing not to adopt (See "Point of Departure (POD) Selection" section above).

ATSAC members all agreed on the UFs for extrapolation from animals to humans (UF_A) and for variability among humans (UF_H). Commenting ASTAC members were evenly split on whether the database UF should remain at 10 (as adopted by the PPRTV program) or be reduced to 3 as would be the default for OEHHA.

The PPRTV program highlighted that there was only one inhalation study available to use as a critical study and that confidence in the study was low. **OHA recommends retaining the full database UF (UF_D) of 10 to account for the singular and low confidence nature of the critical study.**

Three of four commenting ATSAC members recommended a subchronic to chronic UF (UF_S) of 3 while the fourth recommended the full 10 as used by the PPRTV program (reflected in the currently proposed chronic TRV). The split between ATSAC members reflects **policy defaults** used by different authoritative sources. For example, Dr. Budroe commented that OEHHA's policy would be to select a UF_S of 3 in this case;

however, Dr. Budroe did not say that using a UF_S of 10 is incorrect and he commented that various authoritative sources might approach it differently.

DEQ has adopted TRVs from ATSDR, EPA, and OEHHA as well as other sources. All of them have slightly different policies around defaults for UFs.

EPA's guidance (pg. 4-76) on the use of subchronic to chronic UFs states that the full UF of 10 is more important, "…when either the chemical itself or its damage has the potential to accumulate." (71) The same guidance also states that a subchronic to chronic UF may be considered for reduction, "…if the effect is more dependent on concentration than duration, and progression of the lesion (either in incidence or severity) is not evident…" (71) In an oral exposure study (Murata et. al. 1993), an 81-week exposure led to alveolar proteinosis (a more severe lung effect), while a shorter 13-week exposure did not have this effect at any dose. (72) This suggests that 1-methylnaphthalene requires more time (longer than the 13-week critical inhalation study) to cause this more severe effect of alveolar proteinosis. In other words, there is evidence by the oral exposure route that the damage caused by 1-methylnaphthalene accumulates over time and that time, in addition to concentration, can be a strong factor in the severity of the health effects caused by this TAC. An ATSAC member pointed out this 81-week oral study in their comments to OHA.

One ATSAC member expressed their preference is to follow the PPRTV program's application of uncertainty factors.

OHA recommends retaining the full subchronic to chronic UF_S of 10 because (1) the PPRTV program is part of EPA, one of DEQ's authoritative sources, and their recent 2024 PPRTV assessment recommends a UF_S of 10 and (2) evidence from an oral study indicates that 1-methylnaphthalene-induced respiratory damage does not meet the EPA's criteria for a reduced subchronic to chronic UF_S.

6.2.7 OHA conclusion

OHA recommends keeping the 2024 PPRTV chronic RfC as the proposed chronic TRV for 1-methylnaphthalene.

Chapter 7: References

1. ATSDR. Toxicological profile for naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene [Internet]. Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services; 2025. Available from: https://www.atsdr.cdc.gov/ToxProfiles/tp67.pdf

2. OEHHA. Technical support document for the derivation of noncancer reference exposure levels [Internet]. Oakland, CA: Office of Environmental Health Hazard Assessment (OEHHA), Air Toxics Hot Spots; 2008. Available from: https://oehha.ca.gov/sites/default/files/media/downloads/crnr/noncancertsdfinal.pdf

3. OECD. Environment Directorate Joint Meeting of The Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology: Guidance document for the derivation of an acute reference concentration (ARfC), ENV/JM/MONO(2011)33 [Internet]. Organization for Economic Co-operation and Development (OECD); 2011. Available from: https://one.oecd.org/document/ENV/JM/MONO(2011)33/en/pdf

4. DeVito M, Bokkers B, van Duursen MB, van Ede K, Feeley M, Gáspár EAF, et al. The 2022 World Health Organization reevaluation of human and mammalian toxic equivalency factors for polychlorinated dioxins, dibenzofurans and biphenyls. Regulatory Toxicology and Pharmacology. 2024;146:105525.

5. EPA. Recommended toxicity equivalence factors (TEFs) for human health risk assessments of 2,3,7,8-tetrachlorodibenzo-p-dioxin and dioxin-like compounds [Internet]. U.S. Environmental Protection Agency (EPA); 2010. Available from: https://semspub.epa.gov/work/HQ/190077.pdf

6. ATSDR. ATSDR toxic equivalents procedure for dioxin and dioxin-like compounds evaluation [Internet]. Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services, Public Health Service; 2025. Available from: https://www.atsdr.cdc.gov/pha-guidance/resources/TEQ-for-Dioxin-and-Dioxin-like-Compounds-508.pdf

7. Van den Berg M, Denison MS, Birnbaum LS, DeVito MJ, Fiedler H, Falandysz J, et al. Polybrominated dibenzo-p-dioxins, dibenzofurans, and biphenyls: inclusion in the toxicity equivalency factor concept for dioxin-like compounds. Toxicological Sciences. 2013;133(2):197–208.

8. MDH. Guidance for evaluating the cancer potency of Polycyclic Aromatic Hydrocarbon (PAH) mixtures in environmental samples [Internet]. Minnesota Department of Health (MDH); 2016. Available from: https://www.health.state.mn.us/communities/environment/risk/docs/guidance/pahguidance.pdf

9. OEHHA. Nickel Reference Exposure Levels [Internet]. CalEPA Office of Environmental Health Hazard Assessment (OEHHA); 2012. Available from: https://oehha.ca.gov/media/downloads/crnr/032312nirelfinal.pdf

10. TCEQ. Development Support Document: Silica, crystalline forms [Internet]. Texas Commission on Environmental Quality (TCEQ); 2009. Available from: https://www.tceq.texas.gov/downloads/toxicology/dsd/final/silica_crystalline_forms.pdf

11. TCEQ. Development Support Document: Silica, amorphous and other non-crystalline forms [Internet]. Texas Commission on Environmental Quality (TCEQ); 2011. Available from: https://www.tceq.texas.gov/downloads/toxicology/dsd/final/silica_amorphous.pdf

12. EPA. Basic information about provisional peer-reviewed toxicity values (PPRTVs) [Internet]. 2024 [cited 2024 Oct 8]. Available from: https://www.epa.gov/pprtv/basic-information-about-provisional-peer-reviewed-toxicity-values-pprtvs

13. EPA. Provisional peer-reviewed toxicity values (PPRTVs) [Internet]. 2024 [cited 2024 Oct 8]. Available from: https://www.epa.gov/pprtv

14. EPA. Provisional peer-reviewed toxicity values (PPRTVs) assessments [Internet]. 2024 [cited 2024 Oct 8]. Available from: https://www.epa.gov/pprtv/provisional-peer-reviewed-toxicity-values-pprtvs-assessments

15. ATSDR. ATSDR: Minimal Risk Levels (MRLs) [Internet]. Agency for Toxic Substances and Disease Registry (ATSDR); 2024 [cited 2024 Dec 4]. Available from: https://www.atsdr.cdc.gov/minimal-risk-levels/about/?CDC_AAref_Val=https://www.atsdr.cdc.gov/minimalrisklevels/index.html

16. ATSDR. ATSDR newsletter for health assessors, July 2025. Agency for Toxic Substances and Disease Registry (ATSDR); 2025.

17. ten Berge W, Zwart A, Appelman L. Concentration—time mortality response relationship of irritant and systemically acting vapours and gases. Journal of Hazardous Materials. 1986;13(3):301–9.

18. Derelanko MJ, Rinehart WE, Hilaski RJ, Thompson RB, Löser E. Thirteen-week subchronic rat inhalation toxicity study with a recovery phase of trivalent chromium compounds, chromic oxide, and basic chromium sulfate. Toxicological sciences: an official journal of the Society of Toxicology. 1999;52(2):278–88.

19. CalEPA. Findings of the Scientific Review Panel on the Report on Diesel Exhaust as adopted at the Panel's April 22, 1998, Meeting [Internet]. California EPA Scientific Review Panel (SRP); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/de-fnds.pdf

20. EPA. Diesel engine exhaust: IRIS chemical assessment summary [Internet]. U.S. Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS); 2003. Available from: https://iris.epa.gov/static/pdfs/0642_summary.pdf

21. Taxell P, Santonen T. Diesel engine exhaust: basis for occupational exposure limit value. Toxicological Sciences. 2017;158(2):243–51.

22. IARC. Diesel and Engine Exhausts and Some Nitroarenes. IARC monographs on the evaluation of carcinogenic risks to humans. 2014;105:9.

23. CARB. Summary: Diesel Particulate Matter Health Impacts [Internet]. California Air Resources Board (CARB); 2024 [cited 2024 Nov 4]. Available from: https://ww2.arb.ca.gov/resources/summary-diesel-particulate-matter-health-impacts

24. Weitekamp CA, Kerr LB, Dishaw L, Nichols J, Lein M, Stewart MJ. A systematic review of the health effects associated with the inhalation of particle-filtered and whole diesel exhaust. Inhalation toxicology. 2020;32(1):1–13.

25. CalEPA. Part C: Public Comments and ARB/OEHHA Staff Responses to Part A and Part B of the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant Report [Internet]. California Environmental Protection Agency (CalEPA); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/ptcfeb98.pdf

26. HEI. Special Report 19, Diesel Emissions and Lung Cancer: An Evaluation of Recent Epidemiological Evidence for Quantitative Risk Assessment [Internet]. Health Effects Institute (HEI) Diesel Epidemiology Panel; 2015. Available from: https://www.healtheffects.org/system/files/SR19-Diesel-Epidemiology-2015_0.pdf

27. Health Canada. Health Canada: Human Health Risk Assessment for Diesel Exhaust [Internet]. 2016. Available from: https://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

28. EPA. Children are not little adults! [Internet]. Environmental Protection Agency (EPA); 2024 [cited 2024 Nov 8]. Available from: https://www.epa.gov/children/children-are-not-little-adults

29. Silverman DT. Diesel exhaust and lung cancer—aftermath of becoming an IARC Group 1 carcinogen. American Journal of Epidemiology. 2018;187(6):1149–52.

30. IARC. IARC Press Release: Diesel Engine Exhaust Carcinogenic [Internet]. World Health Organization; 2012. Available from: https://www.iarc.who.int/wp-content/uploads/2018/07/pr213_E.pdf

31. Benbrahim-Tallaa L, Baan RA, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, et al. Carcinogenicity of diesel-engine and gasoline-engine exhausts and some nitroarenes. The lancet oncology. 2012;13(7):663–4.

32. NTP. Report on Carcinogens, Fifteenth Edition: Diesel Exhaust Particulates [Internet]. National Toxicology Program (NTP) Department of Health and Human Services; 2011. Available from: https://ntp.niehs.nih.gov/sites/default/files/ntp/roc/content/profiles/dieselexhaustparticulates.pdf

33. McDonald JD, Doyle-Eisele M, Seagrave J, Gigliotti AP, Chow J, Zielinska B, et al. Part 1. Assessment of carcinogenicity and biologic responses in rats after lifetime inhalation of new-technology diesel exhaust in the ACES bioassay. Boston, MA: Health Effects Institute; 2015 p. 44. (Advanced Collaborative Emissions Study (ACES): Lifetime Cancer and Non-Cancer Assessment in Rats Exposed to New-Technology Diesel Exhaust). Report No.: 184.

34. CARB. CARB Initial Statement of Reasons for Rulemaking Staff Report: Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant [Internet]. California Air Resources Board (CARB); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/staffrpt.pdf

35. OEHHA. Part B: Health Risk Assessment for Diesel Exhaust [Internet]. Office of Environmental Health Hazard Assessment (OEHHA) California Environmental Protection Agency (CalEPA); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/diesltac/partb.pdf

36. CARB. Part C: Summary of Comments for the Diesel Exhaust Part A Report [Internet]. California Air Resources Board (CARB); 1994. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/ptcjun94.pdf

37. OEHHA. Responses by OEHHA Staff to Health Effects Related Comments on the June 1994 Draft Technical Support Document (Including Part B) for Identification of Diesel Exhaust as a Toxic Air Contaminant [Internet]. Office of Environmental Health Hazard Assessment (OEHHA); 1994. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/nwpc5_97.pdf

38. CalEPA. Part C in Response to 1997 Draft Version: Public Comments and ARB/OEHHA Staff Responses to Part A and Part B of the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant Report - Public Comment and SRP Version [Internet]. California Environmental Protection Agency (CalEPA); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/ptcmay97.pdf

39. OEHHA. Responses by the Staff of OEHHA to the March, 1997 Draft Technical Support Document For Identification of Diesel Exhaust as a Toxic Air Contaminant [Internet]. Office of Environmental Health Hazard Assessment (OEHHA); 1997. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/partc-1.pdf

40. OEHHA. OEHHA's Responses to Comments on the Public and Scientific Review Panel Draft Version of Part B: Health Risk Assessment for Diesel Exhaust, Feb. 1998

[Internet]. Office of Environmental Health Hazard Assessment (OEHHA); 1998. Available from: https://ww2.arb.ca.gov/sites/default/files/classic/toxics/dieseltac/pc_5_98.pdf

41. Garshick E, Schenker MB, Muñoz A, Segal M, Smith TJ, Woskie SR, et al. A case-control study of lung cancer and diesel exhaust exposure in railroad workers. American Review of Respiratory Disease. 1987;135(6):1242–8.

42. Garshick E, Schenker MB, Muñoz A, Segal M, Smith TJ, Woskie SR, et al. A retrospective cohort study of lung cancer and diesel exhaust exposure in railroad workers. American journal of respiratory and critical care medicine. 1988;137(4):820–5.

43. HEI. Diesel Emissions and Lung Cancer: Epidemiology and Quantitative Risk Assessment, A Special Report of the Institute's Diesel Epidemiology Expert Panel [Internet]. Health Effects Institute (HEI); 1999. Available from: https://www.healtheffects.org/publication/diesel-emissions-and-lung-cancer-epidemiology-and-quantitative-risk-assessment

44. Crump. Lung cancer mortality and diesel exhaust: reanalysis of a retrospective cohort study of US railroad workers. Inhalation toxicology. 1999;11(1):1–17.

45. Dawson, Alexeeff. Multi-stage model estimates of lung cancer risk from exposure to diesel exhaust, based on a US railroad worker cohort. Risk Analysis. 2001;21(1):1–18.

46. Crump. Invited Commentary: Modeling Lung Cancer Risk from Diesel Exhaust: Suitability of the Railroad Worker Cohort for Quantitative Risk Assessment. Risk Analysis: An International Journal. 2001;21(1).

47. Dawson, Alexeeff. Response to Dr. Crump's Commentary on "Multi-Stage Model Estimates of Lung Cancer Risk from Exposure to Diesel Exhaust, Based on a U.S. Railroad Worker Cohort." California Office of Environmental Health Hazard Assessment (OEHHA) [Internet]. 2001; Available from: https://oehha.ca.gov/air/document/multi-stage-model-estimates-lung-cancer-risk-exposure-diesel-exhaust

48. EPA. Health assessment document for diesel engine exhaust (Final 2002). National Center for Environmental Assessment [Internet]. 2002;2002. Available from: https://iris.epa.gov/document/&deid=29060

49. Ramboll Environ. Appendix B: White Paper on Diesel Exhaust Quantitative Health Risk Assessment Values for Lung Cancer [Internet]. Ramboll Environ US Corporation; 2016. Available from: https://www.portseattle.org/sites/default/files/2018-03/T5_FEIS_volume_II_Appx_B.pdf

50. OEHHA. Air Toxics Hot Spots Program: Appendix D, Guidance Manual for Preparation of Health Risk Assessments [Internet]. Office of Environmental Health

Hazard Assessment (OEHHA); 2015. Available from: https://oehha.ca.gov/media/downloads/crnr/2015gmappendicesaf.pdf

51. WA DOE. Department of Ecology Air Quality Program: Concerns about Adverse Health Effects of Diesel Engine Emissions White Paper [Internet]. State of Washington Department of Ecology; 2008. Available from: https://apps.ecology.wa.gov/publications/documents/0802032.pdf

52. Landau Associates. Revised Diesel Engine Exhaust Particulate Matter Health Risk Assessment Report Quincy, Washington [Internet]. Landau Associates; 2018. Available from: https://ecology.wa.gov/getattachment/d5f02053-2e41-4c14-8417-bb437fc5a010/20180806HealthRiskDieselDataCenter.pdf

53. NJDEP. Appendix C of technical support document: Updating hazardous air pollutant reporting thresholds [Internet]. New Jersey Department of Environmental Protection (NJDEP), Division of Air Quality; 2017. Available from: https://dep.nj.gov/wp-content/uploads/airtoxics/technical-support-document-hap-reporting-thresholds.pdf

54. EPA. Regional Screening Levels (RSLs) - Generic Tables as of November 2024 [Internet]. U.S. Environmental Protection Agency (EPA); 2024. Available from: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

55. EPA. Regional Screening Levels (RSLs) [Internet]. U.S. Environmental Protection Agency (EPA); 2024 [cited 2024 Dec 16]. Available from: https://www.epa.gov/risk/regional-screening-levels-rsls

56. Silverman DT, Samanic CM, Lubin JH, Blair AE, Stewart PA, Vermeulen R, et al. The diesel exhaust in miners study: a nested case–control study of lung cancer and diesel exhaust. Journal of the National Cancer Institute. 2012;104(11):855–68.

57. Attfield MD, Schleiff PL, Lubin JH, Blair A, Stewart PA, Vermeulen R, et al. The diesel exhaust in miners study: a cohort mortality study with emphasis on lung cancer. Journal of the National Cancer Institute. 2012;104(11):869–83.

58. Erratum. JNCI: Journal of the National Cancer Institute. 2014;106(8):dju192.

59. Garshick E, Laden F, Hart JE, Davis ME, Eisen EA, Smith TJ. Lung cancer and elemental carbon exposure in trucking industry workers. Environmental health perspectives. 2012;120(9):1301–6.

60. Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts. Environmental health perspectives. 2014;122(2):172–7.

61. Steenland K, Deddens J, Stayner L. Diesel exhaust and lung cancer in the trucking industry: exposure–response analyses and risk assessment. American journal of industrial medicine. 1998;34(3):220–8.

62. Crump. Meta-Analysis of Lung Cancer Risk from Exposure to Diesel Exhaust: Study Limitations. Environmental Health Perspectives. 2014;122(9):A230–A230.

63. Vermeulen, Portengen, Silverman, Garshick, Steenland. Meta-Analysis of Lung Cancer Risk from Exposure to Diesel Exhaust: Vermeulen et al. Respond. Environmental Health Perspectives. 2014 Sep 1;122(9):A230–1.

64. Morfeld P, Spallek M. Diesel engine exhaust and lung cancer risks–evaluation of the meta-analysis by Vermeulen et al. 2014. Journal of Occupational Medicine and Toxicology. 2015;10:1–18.

65. EPA. Guidelines for carcinogen risk assessment, EPA/630/P-03/001F [Internet]. Washington, DC: Environmental Protection Agency (EPA); 2005. Available from: https://www.epa.gov/sites/default/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf

66. EPA. EPA: Regional Screening Levels (RSLs) - User's Guide [Internet]. U.S. Environmental Protection Agency (EPA); 2024. Available from: https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide

67. OEHHA. Air Toxics Hot Spots Program, Risk assessment guidelines: Guidance manual for preparation of health risk assessments [Internet]. Office of Environmental Health Hazard Assessment (OEHHA), California Environmental Protection Agency (CalEPA); 2015. Available from: https://oehha.ca.gov/sites/default/files/media/downloads/crnr/2015guidancemanual.pdf

68. OEHHA. Technical support document for cancer potency factors: Methodologies for derivation, listing of available values, and adjustments to allow for early life stage exposures [Internet]. Office of Environmental Health Hazard Assessment (OEHHA), California Environmental Protection Agency (CalEPA); 2009. Available from: https://oehha.ca.gov/sites/default/files/media/downloads/crnr/tsdcancerpotency.pdf

69. EPA. Provisional peer-reviewed toxicity values for 1-methylnaphthalene, EPA/690/R-24/001F [Internet]. Environmental Protection Agency (EPA), U.S. EPA Office of Research and Development; 2024. Available from: https://hhpprtv.ornl.gov/issue_papers/Methylnaphthalene1.pdf

70. Kim YS, Lee MJ, Seo DS, Kim TH, Kim MH, Lim CH. Thirteen-week inhalation toxicity study of 1-methylnaphthalene in F344 rats. Toxicological Research. 2020;36(1):13–20.

71. EPA. Methods for derivation of inhalation reference concentrations (RfCs) and application of inhalation dosimetry [Internet]. U.S. Environmental Protection Agency,

Office of Research and Development, Office of Health and Environmental Assessment, Washington, DC, EPA/600/8-90/066F; 1994. Available from: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=71993

72. Murata Y, Denda A, Maruyama H, Konishi Y. Chronic toxicity and carcinogenicity studies of 1-methylnaphthalene in B6C3F1 mice. Fundamental and Applied Toxicology. 1993;21(1):44–51.

You can get this document in other languages, large print, braille or a format you prefer free of charge. Contact the Environmental Public Health Section at EHAP.info@odhsoha.oregon.gov or call 971-673-0482. We accept all relay calls.

Public Health Division
Environmental Public Health Section
800 NE Oregon St Suite 640
Portland, OR 97323
971-673-0482
https://www.oregon.gov/oha/PH/HealthyEnvironments/Pages/index.aspx